PROBLEM SOLVING BEHAVIOR EMPLOYED IN APARTMENT INTERIOR WORKS DESIGN USING INTERACTIVE EVOLUTIONARY COMPUTATION

（対話型進化計算を用いた家装デザインの問題解決行為に関する研究）

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Abstract

Design problem solving behavior refers to the way in which people solve their creative problem of design in their mind. It is one of the basic problems in the area of design methodology, which varies greatly by cases and designers. On the other hand, there are still some general ways or commonness as the core. Because of the complexity of design problem solving behavior, it is still not understood very well.

This dissertation dives into the problem of design problem solving behavior too and tried to provide a general view of it, including both the general strategies and the temporary tactics. But differs from many other researches, it employed a confined and well-structured simulation of manual design process by employing the method of interactive evolutionary computation (IEC) to extract design problem solving behavior objectively. The simulated design process provided a comparable and statistically analyzable model for exploring design problem solving behavior of people, and made the findings of this dissertation more reliable. The design problem of interior works of Chinese residents, which need little special knowledge to solve, was selected as the design problem in this dissertation. The method of IEC was applied in interior works design for helping the Chinese residents to solve the practical interior works design problems, and inducing the design problem solving behavior of them.

The dissertation contains 6 chapters, including the general introduction (chapter 1), the main body (chapter 2 to 5), and the conclusion (chapter 6). The main body can be further divided into two parts. In the first part (chapter 2 and 3) the IEC interior works (IEC IW) design system was developed, and evaluated by a large amount of Chinese residents on its usability and disadvantage. After the preparation of method in the first part, the second part (chapter 4 and 5) presented two parallel researches on participants' design problem solving behavior in design process using IEC in order to approach the design problem solving behavior in common design processes.

Chapter 1 introduces the background and purpose of the research, reviewed related literatures, and the frame work of the dissertation.

In chapter 2, IEC method was tentatively applied in the problem of interior works design. 7 color and texture related factors of the living room of a typical apartment in Beijing were selected as design factors in the IEC IW design system. Through 3

experiments, the IEC IW design system was found effective in interior works design and heuristic for the two tested Chinese students. The effect of increasing population size was also found significantly increasing the efficiency of the system.

In chapter 3, the developed IEC IW design system was tentatively used by 231 Chinese residents to evaluate its usability and disadvantage in real design problems of interior works. It was concluded that the IEC IW design system is useful for the residents, and it was also found that older participants, and those with lower education and family income levels, gave the system better evaluations.

Chapter 4 started to explore problem solving behavior of people in design tasks through simulated design process for interior works using IEC. Data of design process employing IEC of 8 Chinese participants were collected. Through analysis of design problem solving process, it was revealed that people tend to do what they are certain of firstly, and make harder decisions later. It was also found that people did not tend to move their eyes to a faraway image in the interface constantly, which was considered more convenient for them.

Chapter 5 continued to explore problem solving behavior of the 8 participants' interior works design process employing IEC. The method of protocol analysis was employed to analyze verbal reports of the participants. It was revealed that different parts of the interior scene have different influence on people's evaluation, and people tended to use same evaluation criterion continuously on several images, then switch to another evaluation criterion. 3 stages of design problem solving behavior along the process were also explained.

Chapter 6 summarizes the findings in the dissertation, presents the general discussion and perspective, and proposed some research in the future.

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1.1 Background

As a research of design methodology in architectural field, this dissertation focused on the problem solving behavior of people in design activities. The author tried to explore the manual design process by using the method of interactive evolutionary computation (IEC) as a simulation, and explore design problem solving behavior through statistical analysis. The design of interior works for Chinese residents which required little special knowledge to perform was selected as the design problem in this dissertation.

1) Problem solving behavior in design processes

Activity of design usually refers to the process of originating and developing a plan for a product, structure, or component. In the area of design methodology, according to churchman's "Wicked problem"[1)], design problems could be divided into three categories. One is the well-defined problems, for which the ends or goals are already prescribed and apparent; their solution requires the provision of appropriate means. The second one is the ill-defined problems, where both the ends and the means of solution are unknown at the outset of the problem solving exercises, at least in their entirety. The third one is the wicked problems which have incomplete, contradictory, and changing requirements. Problems in this category are so ill-defined that they are without definitive formulation and no explicit basis for the termination of problem solving activities, and differing formulations of the problems imply differing solutions. Most architecture and urban design problems are ill defined problems, even wicked problems[2)].

Nowadays in China, the design of interior works is an important design problem in architectural field. Interior works refer to the equipment, furniture and ornamentation inside apartment, and design of them usually performed by the residents themselves these days. In the field of interior works design, the material selection and combination is an important color-and-texture related design problem that influences the interior feeling greatly. This problem is also an ill-defined problem which related to multiple factors with no unified solution condition and no fixed way for solving it. Because of the complexity of this design problem and the diverse conditions for solving it, the method people solve it is still not clearly revealed yet.

In this dissertation, the design problem solving behavior refers to the behavior or method which people employed in design processes to solve design problems. It is

considered including the general problem solving strategy and the temporary tactics. When solving ill-defined design problems, such as the material selection and combination of interior works, there are no fixed procedures, and the designers have to struggle to approach solutions through different ways in some dynamic sequences. On the other hand, it is known the style of the completed design is determined primarily by both the initial ideas of the designer and the processes employed to solve the problem[2)], and the diverse design problem solving behavior contributes greatly to the creative and impressive design solutions, which have been pursued by many designers. Thus the design problem solving behavior is considered has significant meaning in architecture education and practices, and should be clarified.

Research in the area of design problem solving behavior usually focused in certain kind of design problem, and tried to reveal design problem solving behaviors that have more general meaning. Here the author also dived into the design problem solving behavior in a certain material selection and combination problem of interior works, and tried to find the commonness and variety in participants' design problem solving behavior of color-and-texture related design problem. At the same time, since color-and-texture related design problems could represent ill-defined design problems to certain extent, it was expected the findings would have more general meaning of design problem solving behavior in the field of architectural design.

According to the information processing theory (Newell, Shaw, and Simon 1967)[3)], design problem solving could be considered as process of searching for proper solutions in the problem space through generative process and test process, which provided a general structure for understanding the process of design. In this dissertation, the author tried to employ the intelligent method of IEC to simulate this generate-and-test structure, and provide a confined and comparable condition for exploring design problem solving behavior. On the other hand, since in a design process employing IEC, the generation of design alternatives was performed by computers and people only performed testing of them, researches here mainly focused on the testing behavior in interior works design problem solving process, and tried to reveal how participants filter different design alternatives, and gradually develop their own design ideas.

2) Interactive evolutionary computation (IEC) method

Benefit from the present understanding of design activities, and the development in

computing science and hardware, computers are now widely employed in design practices. Mitchell (1990)[4] proposed a computational device to solve a design problem based on studies of human design procedure, which constituted of a generation mechanism, a test mechanism, and a control strategy. It provides a way of dividing design problem into sub-tasks for human and computer respectively, and allows them to work together.

At the same time, intelligent systems have been applied in solving many complex problems which can only be performed by human originally. Inspired by the biological mechanisms of evolution, methods of evolutionary computation (EC) were invented, such as genetic algorithm (GA), genetic programing (GP), evolution strategy (ES), evolutionary programming (EP), and so on. Generally, EC uses interative progress. It tried to evolve a population or a group of alternatives to achieve the desired end through repeated processes of selection, recombination, and mutation reproduction.

In recent years, the method of interactive evolutionary computation (IEC) was invented, which employed human evaluation in EC to replace the fitness function, and was proved in researches capable in solving subjective design problems.

IEC is an interactive solution searching method which tried to combine the advantage of human in subjective evaluation and that of computer in searching and optimization, and allow them to work together. It is also an evolutionary method which evolves one or a group of design alternatives gradually towards the solution according to human evaluation. In a solution searching process employing IEC, human evaluated a group of design alternatives provided by the computer by scoring them, then the computer generated new alternatives based on the scores, and human evaluated the alternatives again. As the interactive process continued, the preferred design ideas could be achieved effectively. (Figure 1-1) The interactive process of computer generates alternatives and human evaluate them is similar to the generate-and-test process in common design practice, while in which both generating and testing are performed by human.

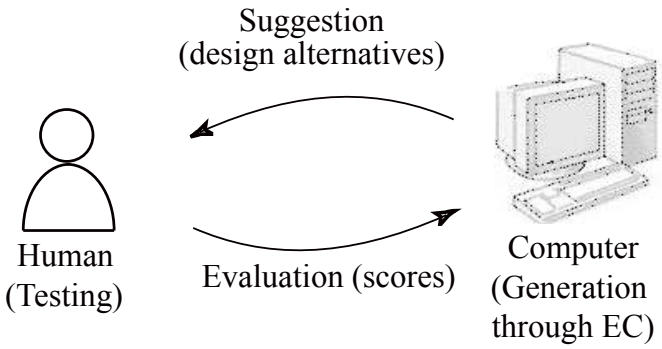

Figure 1-1 Mechanism of IEC method

In IEC method, in order to allow computer to participate in subjective design process,

design alternatives are represented by some feature parameters, and human and computer working cooperatively based on a mapping relationship between the feature parameter and psychological space. The user evaluate design alternatives according to the distance or difference of their target image and the alternatives provided by computer in their psychological space, and computer search for global optimum in a feature parameter space according to the psychological distance. (Figure 1-2)[5)]

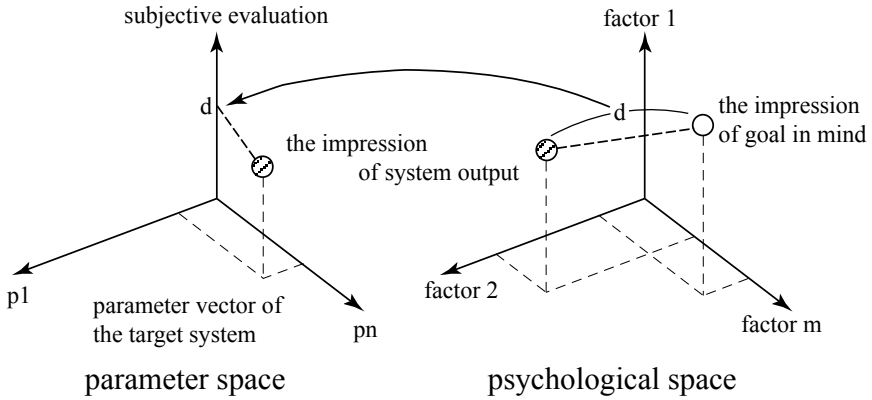

Figure 1-2 Psychological distance of user's target image and design alternative in psychological space become the fitness axis of a feature parameter space where computer search for global optimum in an IEC system (Tagaki, 2001)[5)]

The mechanisms explained above reveal the design process employing IEC is human oriented, and is similar to the iterative generate-and-test process of manual design processes. It is expected in this dissertation that the method is easy for people to understand and use, and the way people solve the design problem in the design process employing IEC is similar to the design problem solving behavior of them in manual design processes.

3) Interior works of Chinese apartment

Due to recent sustained economic growth in China, vast housing production has taken place throughout the country. From 2001 to 2004, a continuous annual increment of approximately 30% has taken place in investment in the apartment market in China[1]. At the same time, per capita floor area in urban area continuously increased in recent decades[6)] as

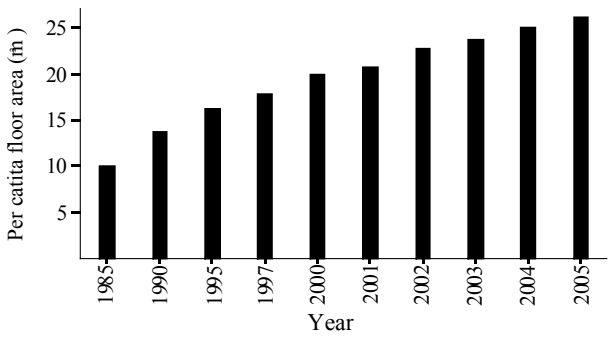

Figure 1-3 Per capita floor area in urban area in China[6)]

shown in figure 1-3. Along with improved living conditions and increases in individual income, people have started to pay more attention to the physical and aesthetic comfort of their living environment. Beginning in 1990, residents started to do interior works by themselves when they moved to a new apartment or as a renovation of their old apartment.[7)]

Aiming at this condition, the developer's completion standards of apartment was promulgated by the Ministry of Construction of the People's Republic of China in 1994[8)9)]. It prescribes that inside the apartment, the developer could only finish the essential works, including the installation of necessary equipments and basic finishing. After purchasing the apartment, the residents may continue to work in the apartment, and finish the interior works according to their own ideas. Zhou et al. (2004)[10)] identified 21 construction items of interior works, and classified them into categories as partition rearrangement, door and window adjustment, finishing, equipment adjustment, and fixed furniture. The author would also add furniture into the above list according to the present situation of Chinese interior works. From the above list, it could be found interior works were performed for both functional and aesthetic purpose.

Although apartments with full completion of interior works by developers were advocated by the government[11)], and have increased gradually in recent years, the apartments with essential interior works are still the majority part in the market[12)]. Nowadays many Chinese residents considered interior works an opportunity for creating individualized living spaces and expressing aesthetic tastes of their own, and put great effort in them. The completed interior works displays a variation in individuality and in family demand. (Figure 1-4)

Figure 1-4 Examples of interior works in Chinese apartment

1.2 Purpose

Researches of human design activities have suggested possible ways for computers to participate in human architectural design process as mentioned above. At the same time, the

application of computers in designing also provides new ways for exploring the human design problem solving behavior.

The main purpose of this dissertation is to approach design problem solving behavior in architecture and interior design area. Different from many previous researches that took the complex real design process as research object, the author of this research tried to employ the design process employing IEC as a simulated design process, in which the problem and the way to solve it were confined and well-structured, and tried to achieve reliable findings of participants' design problem solving behavior through statistical analysis and comparison.

In design process employing IEC, the searching space was defined by the possible combination of design factors which were decided beforehand to be involved in IEC, and the design problem solving behavior was restricted in the defined searching space. Comparing to design process in reality, the design process employing IEC could be said confined and well structured, and could be finished within short period of time. Since the iterative design process employing IEC was similar to the generate-and-test process in common design, it was considered as a simulated design process and employed for exploring design problem solving behavior in this dissertation. Although in the design process employing IEC, generation of design alternatives were performed by computer through evolutionary algorithm and rendering algorithm, the simulation could still provide reliable results on the testing behaviors of the participants, and also those on the general problem solving strategies. In this dissertation, the general intention of researches is to construct a simulated model of design activities by IEC to explore the design problem solving behavior through data analysis.

Aiming at the purpose of exploring design problem solving behavior, IEC method was intended to be applied in a real design problem, which requires no special knowledge or skills, and allows the design problem solving behavior of participants be induced effectively. Among the great variety of design problems, interior works design was considered suitable for the purpose of this dissertation and was selected, because it is a common problem for many Chinese residents in reality which need little special knowledge to finish. In addition, the residents are aware of the design constrains and objective based on their life experience, and have desire of expressing their own preference in it.

An IEC interior work (IEC IW) design system was developed for the purpose of exploring design problem solving behavior. It is essential for the system to be useful for the

residents, because only if so, the design problem solving behavior of the residents in the process could be natural and similar to the usual way they perform interior works design. On the other hand, since interior work in China is a time and money consuming task for the majority of the residents, and as non-professionals, the residents still have difficulties in making interior works design themselves, so the developed system could also be helpful for the residents in solving their own interior works design problems.

1.3 Previous Researches

1) Researches on design problem solving behavior

As an important research theme, the phenomena of human design problem solving behavior have been studied in many researches for decades. There have been some theoretical positions in the area of creative thinking in the past century.

Newell, Shaw and Simon (1957, 1967)[2)13)] gave rise to the information processing theory, which reasserted the primacy of essentially cognitive processes in explaining problem solving behavior. Their postulations are as follow. Firstly, there is a problem space whose elements are knowledge states, some of which represent solutions to a problem. Secondly, the knowledge states were input into the generative processes to produce new knowledge states. Thirdly, there are test procedures that allow the problem solver to compare knowledge states with a specification of solution state, or detect differences among knowledge states. Finally, there are further processes for deciding which generative processes and test procedures to employ. Problem solving behaviors can be divided into three subclasses of activities, which are the problem presentation problem, the solution generation problem, and the solution evaluation problem. Furthermore, problem-solving procedures are described by the solution generation strategy into trial-and-error procedures, generate-and-test procedures, mean-ends analysis, and problem-space planning.

In the book of the Psychology of Architectural Design by Omer Akin (1986)[14)], the theoretical aspects of formalizing the design process was presented. The book brings together view points from cognitive psychology, computer science and architecture and discusses theories for codifying how we design, i.e. may think and create.

Besides the theoretical positions, there were many researches that dealt with manual design process for exploring problem solving behavior of designers. Takamatsu (1997)[15)] studied the design process of a real project, which lasted for three months. Through the

analysis of the verbal report of the designer when explaining the sketches he had drawn, characters of different design phases were clarified. Zhou, Munemoto and Yoshida (2006)[16] performed an interview on preference of interior works in China. The relation between the selection of living room interior decoration by Chinese people and the reason they reported was analyzed by the association rules. Do and Gross (2001)[17] discussed the use of freehand diagrams in architectural design. They found that most empirical studies of design problem solving have been examinations of design protocols.

Different from the above researches, this dissertation employed IEC to simulate the manual design process. Because the design process employing IEC was controlled, well structured, and could be finished within an hour, it is possible to compare design problem solving behavior of different participants, and explore it through data analysis. Furthermore, the problem solving tactics which was not clearly revealed in above researches could be explored in the short lasting design process employing IEC.

2) Researches on IEC method

The IEC, including interactive GA (genetic algorithm), has been successfully applied in many subjective problems. Takagi (2001)[5] surveyed 250 papers of research on IEC. The IEC application fields include graphic arts and animation, 3-D CG lighting, music, editorial design, industrial design, facial image generation, speech processing and synthesis, hearing aid fitting, virtual reality, media database retrieval, data mining, image processing, control and robotics, food industry, geophysics, education, entertainment, social system, and so on. The paper also included surveys on non-applicational researches, which aim at reducing human fatigue, accelerating EC convergence, etc. The future of IEC was also discussed. This survey presented a general view of IEC in recent researches.

Among the application researches of IEC, Aoki and Takagi (1997)[18] applied it to 3-D CG lighting design, and compared its efficiency for professionals and non-professionals. They found that the method effectively worked to assist amateur designers. This result suggests that IEC may work effectively for non-professional Chinese residents in interior works design. Cheng and Kosorukoff (2004)[19] tried to compare the performance of the interactive GA (IGA) and human-based GA (HBGA, which introduced human-based innovation operators in the IGA) in the problem of searching for a fixed goal. The HBGA was proved more efficient in solving such problem.

There were also application researches of IEC in architectural design. Matsushita and Munemoto (2004)[20] applied IEC and CG in searching for façade glass attributes which performed ideally both in day and night. The color, reflectance, and transmittance of glass were adjusted according the designer's subjective evaluation. Another research of Matsushita and Munemoto (2002)[21] used GP as the generation mechanism in IEC to acquire rules in drawing. "Design world" was mad of "primitive" and "design operator", The rules of rhythm, proportion and symmetry were composed as dominant pattern in tree structure, and under this pattern, diverse individuals were acquired. Tagawa and Kawamura (2003)[22] used the IEC method for interior design. Different textures were mapped to an interior space, and the Web3D technique was used to visualize the space.

The special points of IEC in this dissertation are that it was employed and developed to solve the design problem of interior works and its validity and disadvantage was evaluated in real design circumstance by a large amount of participants. These efforts propelled IEC towards a more practical method for real aesthetic design. Furthermore, the relationship of the design process employing IEC and manual design process was discussed, and the developed IEC IW design system was employed as a model to simulate the manual design process. The discovered design problem solving behavior could be helpful in understanding manual design process, and also in the development of IEC method itself.

3) Researches on interior works

Because interior works emerged as a new phenomenon in China only in recent years, and was performed by Chinese families and workers separately, there are not many researches or data available in this area.

Zhou et al. carried out a series of researches on Chinese interior works. The first study (2004)[10] focused on the characteristics of it and customer's evaluations of its realization and satisfaction based on investigation. Four types of interior works were identified, the relationship between customer's evaluation and its items were also discussed. The second research (2005)[7] dealt with the transformation of developers' completion standards of apartment and management regulations of interior works, and their influences in it. Four periods were identified according to the changes in developer's completion standards of apartment. It was also found removal or replacement of parts and materials were reduced, and incremental works increased with the transformation in management regulation. The

third research (2006)[16] studied the rules of interior works decoration selection and its reason through mining of association rules. It was found the selection procedure of living room interior decoration was based on the coordination between plain and decorated, and the process led to the balance point between them.

Different form these researches, this dissertation focused on the aesthetic problems of interior works, especially the color and texture related problems, and developed a practical system of its design for non-professional Chinese residents. In addition, participants' design problem solving behavior in the design process employing IEC was explored, which could be helpful for understanding the way how people solve interior works design problems of their own apartment.

1.4 Framework of Dissertation

This dissertation consists of three parts (Figure 1-5). A general introduction is given at first. Then four researches are presented in detail in the main body. At last, a general conclusion is presented. The main body of the dissertation can be further divided into two consecutive parts. The first part focused on application of IEC method in interior works design of Chinese residents, and a practical IEC IW design system was developed, which is the central method of the dissertation. After that, the system was employed in the second part as a simulation of common design processes, and two parallel researches on the simulated design process were carried out. The two researches were aiming at exploring the design problem solving behavior, which is the main purpose of this dissertation.

1) Development of IEC method in interior works design

Chapter 2 presents the design and implementation of the IEC IW design system which is employed through out the dissertation. The living room of a typical apartment in Beijing was selected as the design objective. 7 color-or-texture-related factors were selected as the design factors involved in the system. A material library which contains real material samples was constructed for the system according to the situation of Chinese interior works design. 3 experiments on the IEC IW design system were carried out. The system was used to search for a designated goal and to solve design problem of participants, and it was found heuristic for the participants. It was also concluded that the development of increasing population size (number of design alternatives in a generation) might enhance the IEC searching process by presenting more variations.

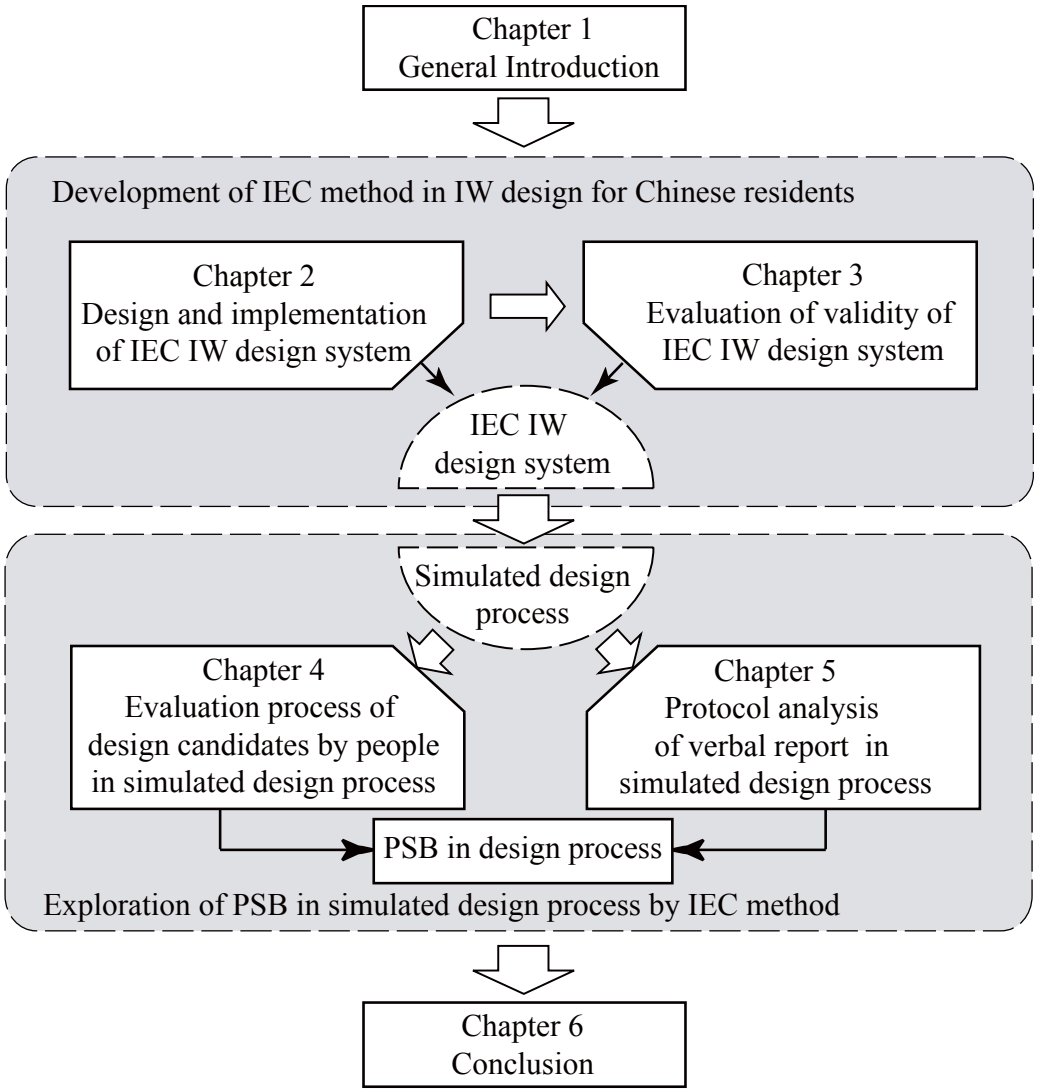

Figure 1-5 The conceptual framework of this dissertation

In order to validate and identify practical problems of the IEC IW design system in real design problem of Chinese residents, in chapter 3, an investigation was performed in Beijing, China. Customers of a construction material market were invited to use the system to search for interior works design ideas for themselves. From evaluation of the 231 participants, it was understood that the system was generally helpful for them, and the process was heuristic and interesting. It was also found that older participants, and those with lower education and family income levels, gave the system better evaluations. Analysis of the evolutionary process suggested there were rules in people's preferred color combination, and the system effectively revealed participants preference.

Through preparation in chapter 2 and 3, the IEC IW design system was ready for inducing the design problem solving behavior. On the other hand, chapter 3 also revealed

the design results were achieved gradually, and different factors in the interior scene had been differently evolved. These phenomena were closely related to the way participants solve the design problem, and the question of design problem solving behavior in design process employing IEC was raised.

2) Design problem solving behavior in design process using IEC method

In chapter 4 and chapter 5, the developed IEC IW design system was regarded as a simulation of manual design processes, and the design problem solving behavior within the process was analyzed for the purpose of understanding design problem solving behavior in real design activities.

In chapter 4, experiment on participants' design problem solving behavior in design process employing IEC was introduced. 8 Chinese speaking scholars or students participated in the experiment. The whole design processes employing IEC of the participants were recorded, including the mouse movement and operation for analysis. The results suggested that the participants tended to do what they were certain of firstly, and what they are not certain of later. This kind of difference reduction strategy helps them to unfold the problem gradually. It was also found after evaluating a certain image, the next image the participants evaluated tended to be one located close to the present one in the interface. It suggested the participants did not tend to move their eyes to a faraway image in the interface constantly, which was more convenient for them.

Chapter 5 continued to focus on the design problem solving behavior in the simulated design process using IEC. The method of protocol analysis was employed to explore the participant's way of thinking by analyzing the verbal report collected from the same experiment of Chapter 4. The simultaneous utterance was analyzed for understanding the problem solving tactics. From the analysis, it was found the participants evaluated images by both single factors and the total appearance of the scene, and they tended to deny the whole image because of a disliked single factor. It was revealed the participants tended to use same evaluation criteria for several images continuously, which suggested that they were grouping images with same properties for evaluation. The tactics was convenient for them because they did not have to change their ideas constantly. Flows of images styles were revealed from retrospective report, which illustrated evolution of design ideas in the process. It was also revealed that although the participants employed different design problem solving behavior in the whole design process employing IEC, it could be

generalized that there were three stages along the whole process. They were “Removing colors too strong or ugly”, “consider the single factors”, and “consider general harmony and effect”.

Note

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Chapter 2

Design and Implementation of IEC IW Design System

2.1 Interior works design of non-professional Chinese residents

2.2 Purpose

2.3 Past studies

2.4 The IEC IW Design System

1) Computer graphics (CG)

2) Interior model as design objective

3) Material library

4) IEC coding and process

5) Mutation-only evolution

6) Interface

2.5 Experiments on IEC IW design system

1) Searching efficiency (experiment 1)

2) Efficiency in design (experiment 2)

3) Increasing population size (experiment 3)

2.6 Summary of Chapter 2

2.1 Interior works design of non-professional Chinese residents

Along with the increment in individual income and living condition in recent years, Chinese resident started to do interior works of their apartment to improve the physical and aesthetic comfort of their living environment. An investigation of habitation in Beijing carried out from 1990 to 1992 (Zhao and Lin 1995 cited in Zhou et al. 2005)[1)] showed that 1 in every 5.1 households performed interior works, while in 1997, the same investigation (Li et al. 1999)[2)] revealed that all households performed interior works in their apartment living spaces. Nowadays, many Chinese residents take an active part in interior works; they design, purchase equipment, materials and furniture, and supervise the construction themselves. The completed interior works displays a variation in individuality and in family demand.

However, lacking professional knowledge and design experience, the problem of interior works design is not an easy task for most residents, especially the aesthetic design. It is hard for most of them to construct proper design ideas by multi-factors according to their own preference, and visualize the interior aesthetic in advance. Furthermore, a great deal of interior works materials come from all over the world, and is now available in Chinese material markets. This availability provides numerous choices for residents, thereby making the comparison and selection of material difficult. Presently, the non-professional residents usually try to get aesthetic design ideas of interior works from magazines or interior works realized in others apartment, some of them also consult professional interior designers. Many of them also have to spend a lot of time in investigating and comparing different materials available in market. Despite of these efforts, the effect of realized interior works is still hard to anticipate, and sometimes unsatisfactory.

2.2 Purpose

IEC method optimizes systems based on human evaluation as introduced in chapter 1, and had been successfully employed in aesthetic design in many researches. In this chapter, IEC method was tentatively applied in interior works design problem of Chinese residents.

In common interior works design process, the residents get ideas from magazines, realized interior works, and professional designers, filter the ideas according to their own consideration, and develop their own ideas gradually. Usually non-professional residents

can not work efficiently in the process because they do not know many design possibilities, and do not know how to construct an idea of their own. In this research, it was expected that IEC method could be applied in interior works design, and provide a practical interior works design system for Chinese residents, which can effectively search through a great deal of materials, predict visual effects of interior space, while at the same time ensuring the individuality of each resident. While improving the interior environment of their apartment, the interior works design system should save time, costs, and energy for the residents.

The development of the IEC IW design system served for the main purpose of this dissertation, which was simulating the common design processes for exploring the design problem solving behavior in later part of this dissertation. The system was developed to be practical and easy-to-use for non-professional Chinese residents, and the design problem was set similar to the common interior works design problem for efficiently and naturally inducing design problem solving behavior of the residents.

2.3 Past studies

There have been several recent studies on Chinese interior works. Zhou et al. (2004)[3)] studied the characteristics of interior works and customer's evaluations of its realization and satisfaction based on investigation. A second study (2005)[1)] focused on the effects of a transformation of developers' completion standards and management regulations on interior works. A third study (2006)[4)] dealt with the rules of its decoration selection and its reason through mining of association rules.

The IEC, including interactive GA (genetic algorithm), has been successfully applied in many subjective problems. Aoki and Takagi (1997)[5)] applied interactive GA to 3-D CG lighting design. They found that the method effectively worked to assist amateur designers, especially those with limited experience or capabilities. This result suggests that application of IEC method in interior works design may help nonprofessional Chinese residents.

Matsushita and Munemoto (2004)[6)] used IEC and CG in searching for façade glass attributes, which perform ideally both day and night. The color, reflectance, and transmittance of glass were adjusted according the designer's subjective evaluation. Images that highly satisfied the customer's expectation were chosen.

Tagawa and Kawamura (2003)[7] used IEC method for interior design. Different textures were mapped to an interior space, and the Web3D technique was used to visualize the space.

To verify the possibility of evaluating architectural space lighting conditions via rendered images, Mahdavi and Eissa (2002)[8] tried to determine if and to what extent the subjective lighting evaluation of computationally rendered images of space is consistent with subjective lighting evaluations of real space. Two groups of people were asked to evaluate several interior spaces and the computer-rendered images of these spaces were displayed on a color computer monitor, respectively. A subjective lighting metric was used for evaluation. The result showed that for the scene and participants tested, the image could reliably represent certain aspects of the lighting conditions in real space.

In order to provide a dependable image to represent the architectural space, a scientific visualization tool that combines photo-realistic rendering with detailed photometric computation is needed. In the research of Mehlika N. Inanici (2001)[9], two physically based software programs, Lightscape and Radiance, were compared. Radiance was found to be more accurate than Lightscape, and highly accurate for a range of realistic sky conditions.

The difference of this research to that of the above-mentioned study is the present study applies IEC method to Chinese interior works design areas, and intends to help non-design-professional residents in designing. Furthermore, the developed system was tested in these experiments, and was developed based on the findings of the experiments.

Although successful commercial software products for interior design are available and some are not difficult for nonprofessional designers to use, the IEC IW design system provides a different way for people to work interactively with a computer, in that the computer takes a more active part in the design procedure. The system also makes interior works design easier, as even novices can use it simply by evaluating images.

2.4 Mechanism of IEC IW Design System

In this research, the searching ability of GA and simulation ability of computer graphics (CG) were integrated into an IEC IW design system. The living room of a typical apartment in Beijing was selected as design objective. Seven interior factors were involved

in the system. The design factors were encoded into a 80 bits long chromosome of GA. A mutation only process was also introduced into this system.

1) Computer graphics (CG)

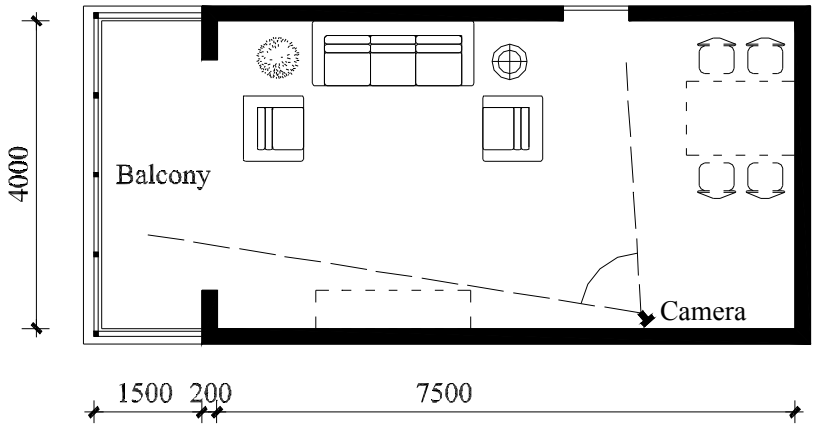
Interior space is an integration of form, material, color, and lighting. Traditionally, interior scene prediction is based upon experience, intuition and drawings. Today, however, because of the development of computer hardware and lighting simulation software, CG has been widely applied to represent the performance of interior space. Although CG images of an interior space cannot convey the exact feeling of the real space in its entirety, it is still an effective way to help people view the performance of a space before it is constructed. In interior works area, CG has been being widely used by designers for presenting designs in China in recent years. In this research, we also employed CG to simulate and present the design alternatives generated by computers to the user.

Radiance[2] is a photo-realistic and photometric ray tracing software, which has been widely used in lighting simulations. It is well-known for its accuracy in lighting simulation both in daylight and under artificial lighting conditions[9]. Radiance was used to provide dependable simulations of interior space in the research. The material properties, such as specularity fractions and roughness values, were decided upon by referring to the standard radiance material library, and through trial-and-error as recommended in the book "Rendering with Radiance"[10].

2) Interior model as design objective

Interior space is composed of many factors, and all factors influence the aesthetic evaluation of the space. But the design process is accomplished step-by-step, with the forms, materials, and furniture being adjusted gradually, and details added in sequence. IEC method cannot account for every factor of interior space in one process, just as the designer cannot decide everything at one time. Each design process employing IEC can only include a limited number of factors, and is thus considered as one step in a completed design process. Subsequent design steps can be carried out based upon these previous results.

The living room of a typical apartment in Beijing was selected as the design objective. The room model (Figure.2-1) is oriented in the south–north direction with a balcony at the



Interior space height: 2,600 mm, camera height: 1,550 mm
Figure 2-1 Living room model plan

south end. Because many apartment buildings in Beijing are of shearing-wall structure, two buttresses and a beam are placed between the living room and the balcony.

Because of the different lighting conditions during day and night, the atmosphere changes, and it is therefore necessary to adjust the factors under both conditions. Images of day and night were rendered for evaluation.

Sofas, standing lamps, plants, interior doors and ceiling lamps are part of the scenario. These are important features in the living room of a Chinese apartment, and greatly influence the resulting aesthetic feel. As the system is intended to be used by Chinese residents inexperienced in interior design, it is easier for them to make an aesthetic evaluation, without the necessity of imaging.

The factors involved in the design process using IEC (Table 2-1) are primarily color-and-texture-related. It is assumed that these are the main factors influencing the interior aesthetic feel. The light color of a ceiling lamp is also involved because it influences the interior space greatly during nighttime. The IEC searching results of these factors and the achieved images can be used as a basis of further interior designs for the residents.

Table 2-1 Factors optimized and material library construction

Factors	Category	Number
Material of ceiling	Paint	40 colors
Material of wall	Paint	40 colors
Material of floor	Carpet Wood Ceramic tile	32 textures 69 textures 94 textures (totally 195)
Material of door	Paint	64 colors
Material of sofa	Textile/leather	64 colors
Ceiling lamp light color		2 (white/warm)
*Material over picture rail		2 (ceiling/wall)

*This factor decides whether the area above picture rail uses the material of the ceiling or of the wall.

3) Material library

A material library was constructed for this study in the context of the actual Chinese interior works. The material categories in the material library were selected according to the typical choices of Chinese residents. Some of the materials' properties, such as the color of paint and textiles, were obtained from manufacturers' catalogs. Other material properties, including the texture of carpets, wood, and ceramic tiles, were the texture images used in CG simulation of interior designs in China; they are assumed to represent real materials available on Chinese market (Table 2-2).

Table 2-2 Examples of material records

No.	Category	Average RGB value (R G B)	Scale* (mm)	Aspect ratio*	File name
…	…	… … …	…	…	…
21	Wood	113 38 8	200	1	W010.jpg
22	Wood	81 44 35	300	0.6906	W005.jpg
23	Tile	56 53 54	350	1	T048.jpg
24	Carpet	58 57 54	300	1	C024.jpg
…	…	… … …	…	…	…

*The scale and aspect ratio are parameters used for texture mapping in Radiance.

4) IEC coding and process

In order to apply IEC in interior works design, materials in the material library had to be put in a coordinate system. In this research, RGB space was selected as the coordinate system. The paints and textiles were entered according to their color values. For each of carpet, wood, and ceramic tile, the texture images were reduced to 1×1 pixels using the Bicubic method in Photoshop to obtain average RGB values. These values were used as coordinates of the materials in RGB space.

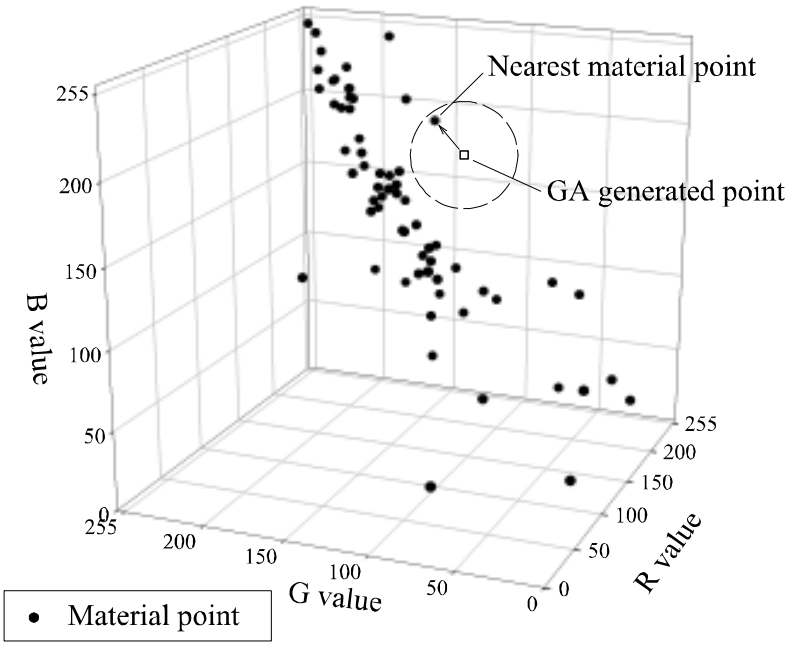


Figure 2-2 Material samples and gene relocation in RGB space.

The materials were identified as discrete points in RGB space. When the GA-generated coordinates did not have a corresponding material, the gene fraction was replaced by one of the coordinates of the nearest material point. This was based on the assumption that the nearer the RGB values, the more similar the subjective evaluation. Figure 2-2 shows the distribution of sofa colors in the material library in RGB space and a gene relocation process that occurred in that space.

The chromosome of the IEC IW design system has a length of 80 bits (Table 2-3). The gene bits corresponding to certain RGB values were shortened to make the GA search among sparse material points more effective.

Table 2-3 GA coding

Material above picture rail	Ceiling lamp color	Ceiling material			Wall material			Floor material			Door material			Sofa material		
		R	G	B	R	G	B	R	G	B	R	G	B	R	G	B
1 bits (2^1=2)	1 bits (2^1=2)	5 bits (2^5=32)	5 bits (2^5=32)	5 bits (2^5=32)	5 bits (2^5=32)	5 bits (2^5=32)	5 bits (2^5=32)	6 bits (2^6=64)	6 bits (2^6=64)	6 bits (2^6=64)	5 bits (2^5=32)	5 bits (2^5=32)	5 bits (2^5=32)	5 bits (2^5=32)	5 bits (2^5=32)	5 bits (2^5=32)

The first population of the design process using IEC was generated randomly. After the rendering process and evaluation by the user, the next population was generated by crossover and mutation as in the usual GA process. Afterwards, new individuals are compared by the program. If any two individuals are identical, mutation is applied. This process eliminates identical individuals and makes the GA search more effective.

5) Mutation-only evolution

After generations of evolution, the population of GA may converge around some local optimal solution, and it would be difficult to generate a better solution even if the evolution continued. This also occurs during the design process employing IEC. A previous study[5] showed that it is much more effective during early generations than in the latter ones.

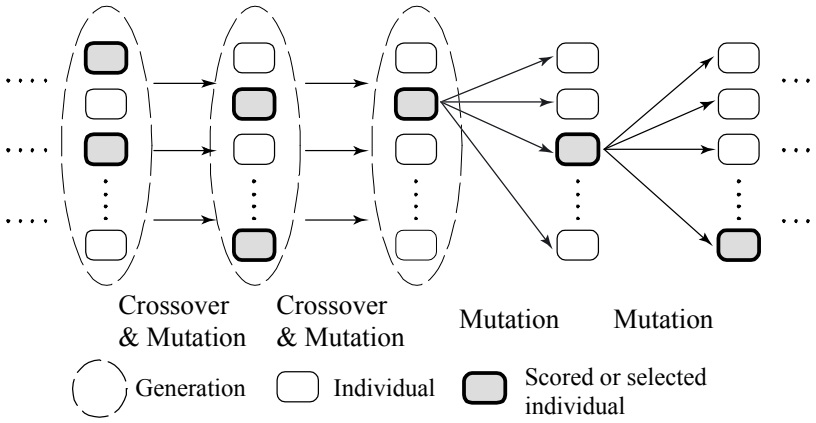


Figure 2-3 IEC Evolution using the mutation-only process

A mutation-only evolution method called "variation" was employed (Figure 2-3) to enhance the system in latter generations. In this method, the user can specify one individual he/she prefers in a certain generation as the parent. The next generation will be variations of the parent. The user can also specify factors manipulated in the mutation, and the mutation range: "small," "medium," and "large" (Fig. 2-4).

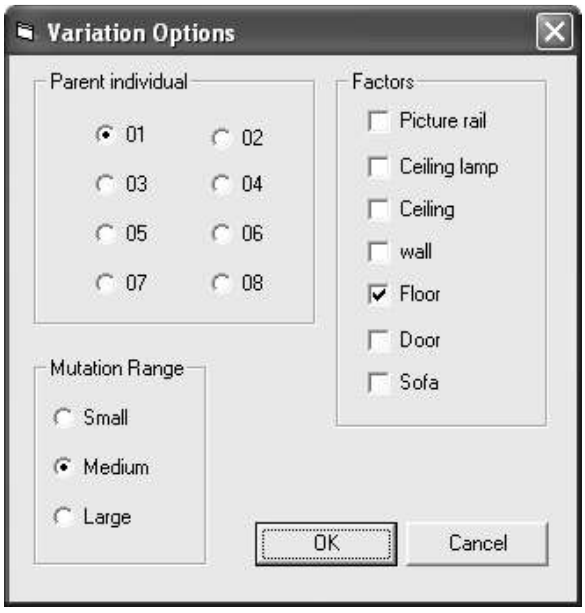


Figure 2-4 Dialog box of "variation"

6) Interface

The interface of the IEC program (Figure 2-5) was constructed with Visual BASIC. The interface is of the resolution of 1,024×768 pixels and displayed on a color computer monitor. Rendered images during day and night of eight individuals were displayed in pairs on the interface. The user can start the design process employing IEC by clicking "start," evaluate each individual by selecting scores from 0 to 7 in the ComboBox at the bottom right corner of the image, and produce the next generation of individuals by clicking on "next generation." The mutation-only process can be accessed by the button "variation."

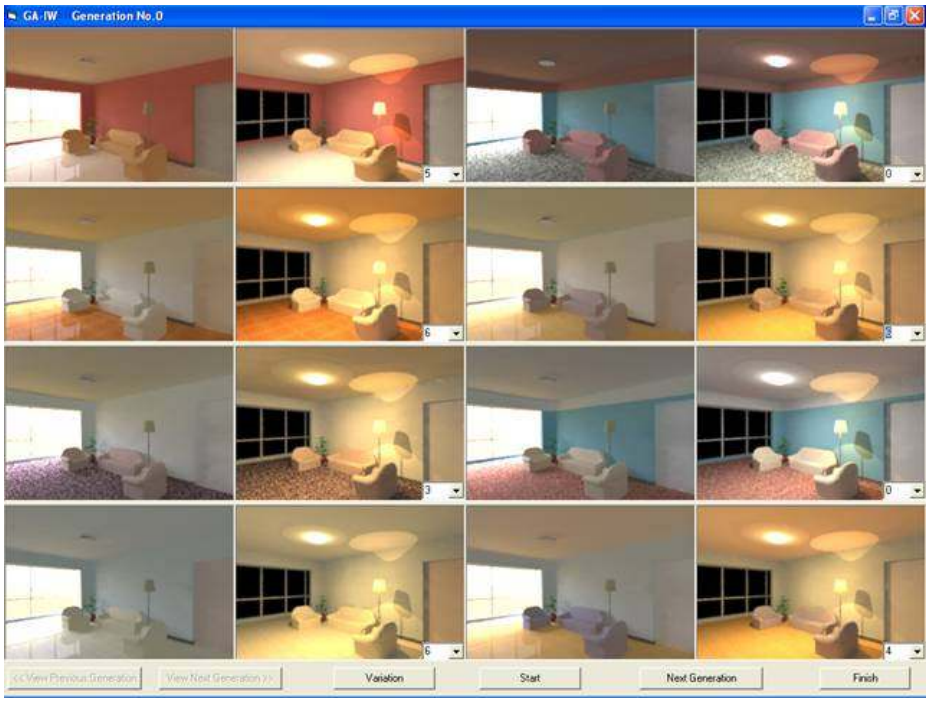


Figure 2-5 IEC program interface

2.5 Experiments on IEC IW design system

Three experiments were designed and carried out in this study. In experiment 1, a goal individual was set to test the searching efficiency of the IEC IW design system. In experiment 2, two users were asked to find an ideal interior design using the IEC IW design system, without any set goals. Based on the findings of experiment 2, the system was developed by increasing the population size, and a corresponding test was performed in experiment 3.

1) Searching efficiency

(experiment 1)

A Chinese student in Kyoto University was asked to use the IEC program to verify the searching effectiveness of the IEC IW design system.

Two images were rendered according to an individual in the search space of the IEC program. These two images (Figure 2-6) were set as the searching goal.

The experiment consisted of two parts: the traditional IEC search of the goal without the "variation" process (experiment1-1), and the IEC search of the goal including the "variation" process (experiment 1-2).

During the experiments, the student was asked to evaluate each individual displayed in the interface by comparing each with the goal images displayed on the same computer monitor. Both tests lasted for ten generations and resulted in two individuals as results, respectively (Figure 2-6, Table 2-4).

The optimization process of experiment 1-1 demonstrates the characteristics of the GA method. In

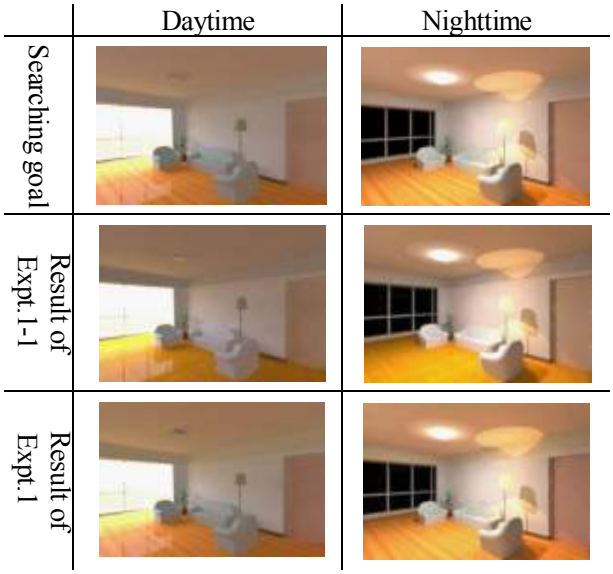
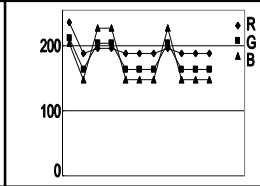
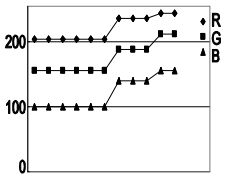
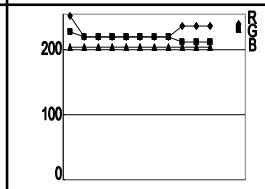
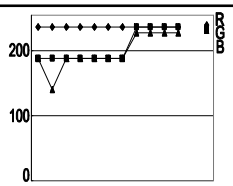
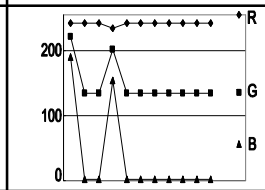
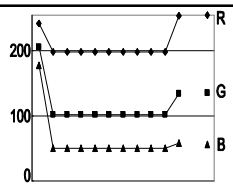
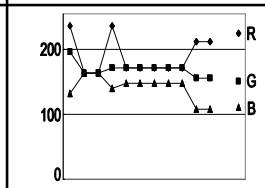
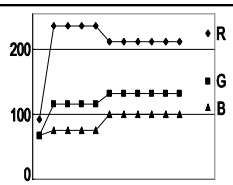
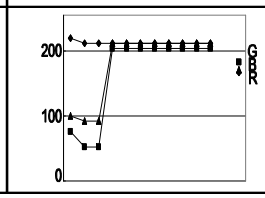
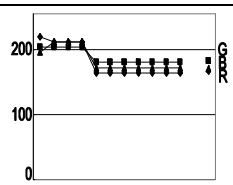


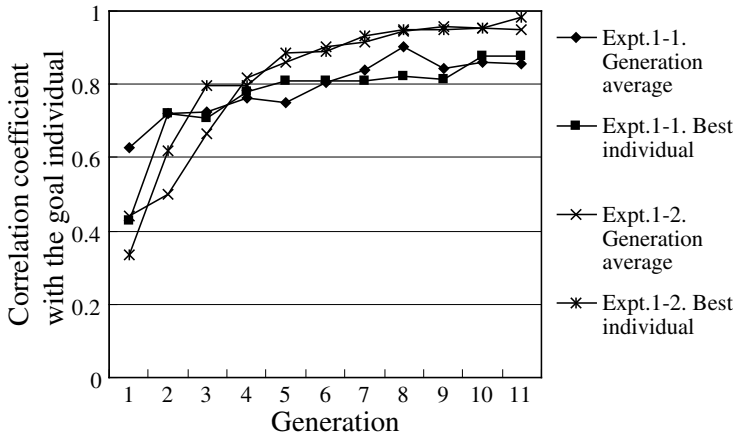
Figure 2-6 The goal and resulting images of experiment 1

Table 2-4 Evolutionary process of experiment 1

Factors	Expt.1-1	Expt. 1-2
Ceiling		
Wall		
Floor		
Door		
Sofa		

*Horizontal axis: Generation Vertical axis: RGB value
**The 3 points on the right end of each graph indicate the RGB value of the goal

early generations, the population evolved greatly, while in latter generations, it did not change very much.



*The correlation coefficient was calculated with CORREL function provided by Microsoft Excel

Figure 2-7 Evolution of correlation coefficient in experiment 1

In experiment 1-2, after two generations of crossover and mutation evolution, the user started to employ "variation" to generate successive generations. One or two factors were selected to participate in each mutation process. The best individual in each generation, which the user selected as the parent of the next generation, became incrementally closer to the final goal. The result of experiment 1-2 was found to be visually and numerically closer to the goal than that of experiment 1-1.

The correlation coefficient can be used to analyze the proximity of two data sets, and in this research, it was calculated to compare the goal individual with the best individuals and generation average values for each generation (Figure 2-7). The results indicated that experiment 1-2 evolved into individuals having a higher correlation coefficient with that of the goal individual. The IEC with "variation" was found to be more effective than the traditional IEC method in searching for a certain design goal, especially in the latter stages of the evolution.

2) Efficiency in design (experiment 2)

Although the searching ability was improved by the mutation-only process and verified in the above experiments, the real design process is different from searching for a designated goal individual. Further experiments were conducted to test the efficiency of the IEC IW design system for design problem solving.

Two Chinese students at Kyoto University, who were not architecture or design majors, were asked to participate in the experiment. The experiment consisted of three steps as follows. The interior model of a living room employed in this research was introduced to the user. After that, the user was asked to select materials for different factors of an ideal

interior space by directly viewing the material texture images and color samples displayed on the computer screen. This process was considered to be similar to the usual material searching and selecting activities conducted in material markets in China. Two images of daytime and nighttime interior space were rendered for the selected individual. In step 2, the user was asked to use the IEC program tentatively to search for an ideal interior space according to his/her subjective evaluation of the displayed images. In step 3, the user was asked to evaluate both individual results from steps 1 and 2 by viewing the rendered images of each. The user was also asked to evaluate the IEC IW design system.

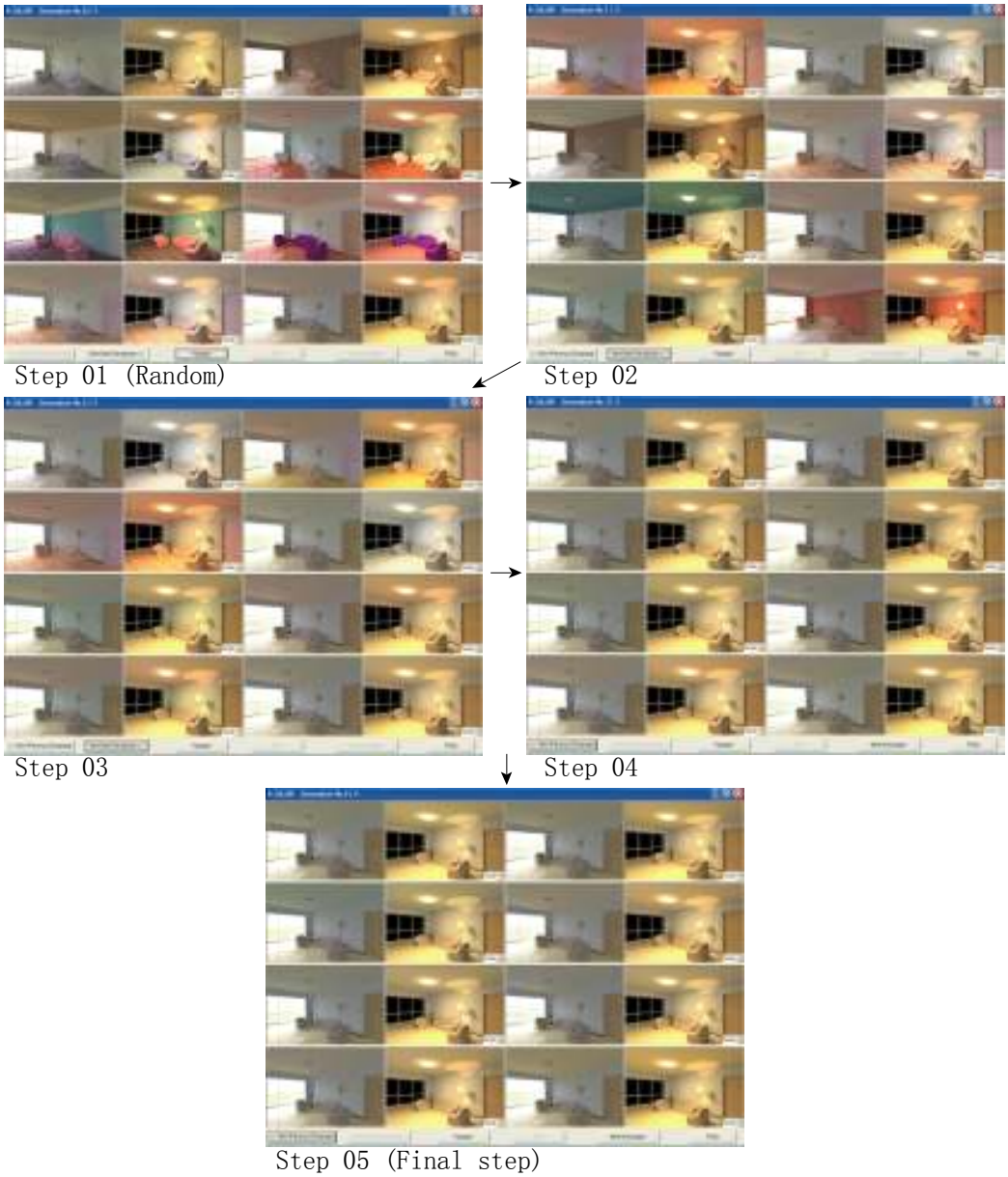


Figure 2-8 Results of experiment 3 (User A)

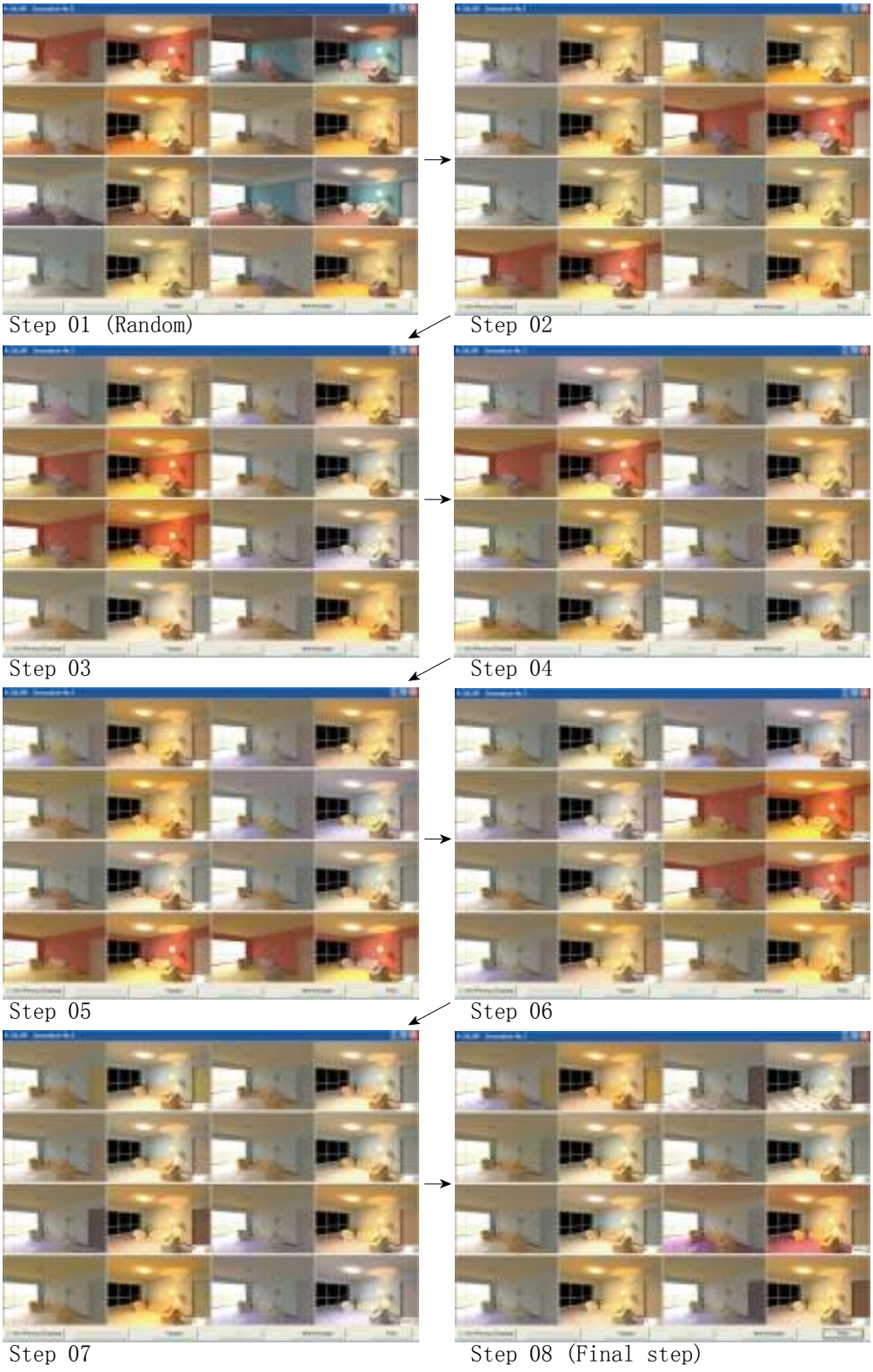


Figure 2-9 Results of experiment 3 (User B)

It took four and eight generations for user A and user B to obtain results using IEC, respectively. The design process using IEC were shown in figure 2-8 and 2-9, and the images generated from step 1 and step 2 for both users were compared in figure 2-10.

In step 1, user A selected materials based on her experience at home and some furniture shops, but she was not satisfied with the result. Comparing the results of step 1 and step 2, the user preferred the individuals in step 2 because "the materials in the room are more harmonious." But the user evaluated the results of step 2 as "not so good, moderate, like a hotel room." It may be observed that in step 2, the individuals became very similar after three generations, and the user stopped the process at generation 4. The user also mentioned that the form of the sofa had influenced her choices.

User B complained that it was hard to select materials in step 1 because "it was difficult to imagine the effect." The result of step 1 was evaluated as "ordinary, not special." She explained that "because it is hard to imagine the effect, I selected common materials, which are safe. And I was therefore restricted by conventional ideas." The design process employing IEC was evaluated as "heuristic, interesting" and the result was better. But the user was not very satisfied with the result from step 2. She said that "some of the ideas I was imagining were not shown during the process."

Figure 2-10 Comparison of individuals derived from direct selection and those derived by using IEC in experiment 2.

From the users' evaluations, it was suggested that the IEC IW design system can provide more possibilities to the user than the usual design process, and is "heuristic" in finding new ideas different from what the user was thinking. But the system still has the following problems. The evolution converges too quickly and the evolution cannot present sufficient choices to the user.

The users evaluated the direct selection of material as “difficult” and the IEC-searched design as “more harmonious,” which may have been because the users could view the rendered CG images and make an evaluation directly and easily.

3) Increasing population size (experiment 3)

The population size (number of individuals in a certain generation) is critical for the searching ability and efficiency of a GA optimization process. Increasing the population size will enhance the searching ability of the GA process, but increase the computation time.

The IEC population size was limited by the image number that could be displayed simultaneously on a computer screen; in this case, the image number was 16. Since daytime and nighttime images are both important for evaluation, they are displayed in pairs in the interface, which reduces the population size to 8.

From experiment 2, it was suggested that the IEC IW design system still had some problems: it converged too quickly and could not display sufficient choices, which can be explained by an insufficient population size. Based on this assumption, the system was developed by increasing the population size, and an experiment was performed.

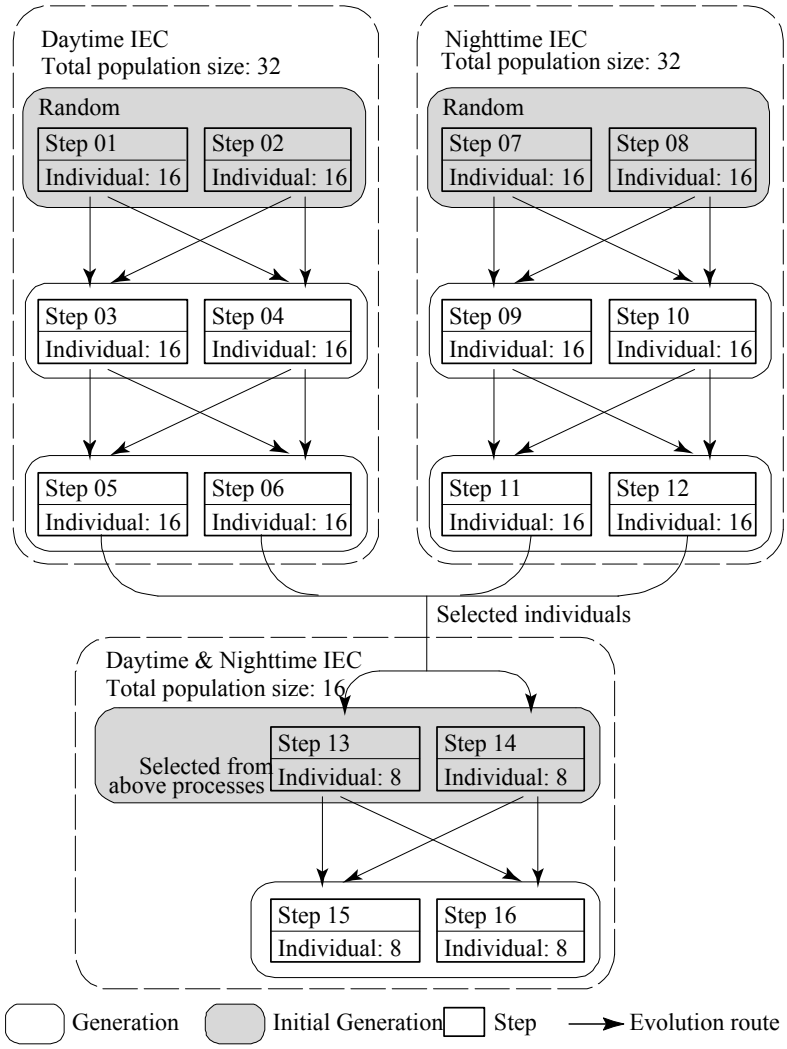


Figure 2-11 IEC searching flow in experiment 3

New developments were applied to the IEC flow to increase the population size (Figure 2-11). The IEC search process for daytime and nighttime was performed separately in the first step, with the resulting individuals from these two processes designated as first generation of a day and night (D&N) IEC, from which the final results were determined. This development was based on the assumption that people will give a similar evaluation of a day image and night image of a certain individual, so that day or night processes will evolve toward results that perform well in both day and night. In the D&N step, the day and night images were displayed simultaneously for precise evaluation and evolution.

Due to this development, 16 individuals could be displayed simultaneously in the day or the night processes, so the population size was double that of the original system. Also the population size increased since two groups of individuals evolved in the separated day and night IEC independently. (The latter D&N process obtained the results from both of the former processes and evolved into the final results.)

The population sizes of all three IEC were doubled again. The population size of daytime or nighttime process was increased to 32, and the D&N process to 16. The individuals of a certain generation were generated from all selected individuals of the parent generation, and were displayed on the computer screen in two successive steps.

Although individuals of a certain generation were not displayed at the same time, since they were generated from the same group of parent individuals, it was assumed that the user's evaluation of them was similar to his/her evaluation in the situation when all individuals could be viewed simultaneously.

Considering that the evaluation method of scoring individuals is not an easy task for non-design-professional users to use, a new "selection" method was employed in the experiment to reduce user fatigue. The user only needed to click on the individuals he/she prefers, and these individuals were marked and became parents of the same importance of the next generation. Although this "selection" method is not as precise as the scoring method, it is easier for non-design-professional users in evaluating a large number of individuals.

User B in experiment 2 was asked to tentatively use the newly developed system. The design process using IEC consisted of 16 steps (day: 6; night: 6; D&N: 4) (Figure 2-12 to 2-14) and the last generation of the D&N process was considered the design result.

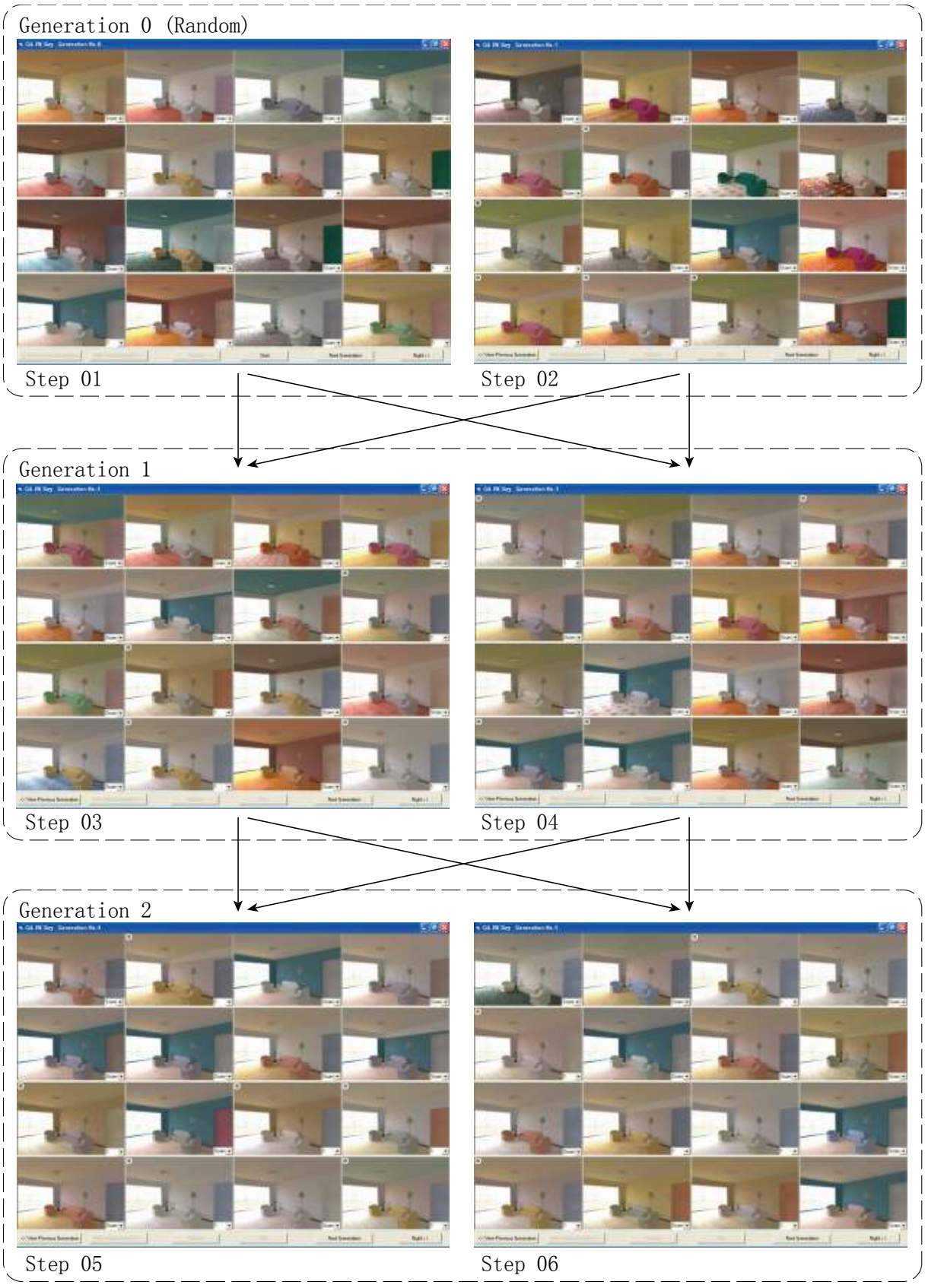


Figure 2-12 Process of experiment 3 (The daytime IEC)

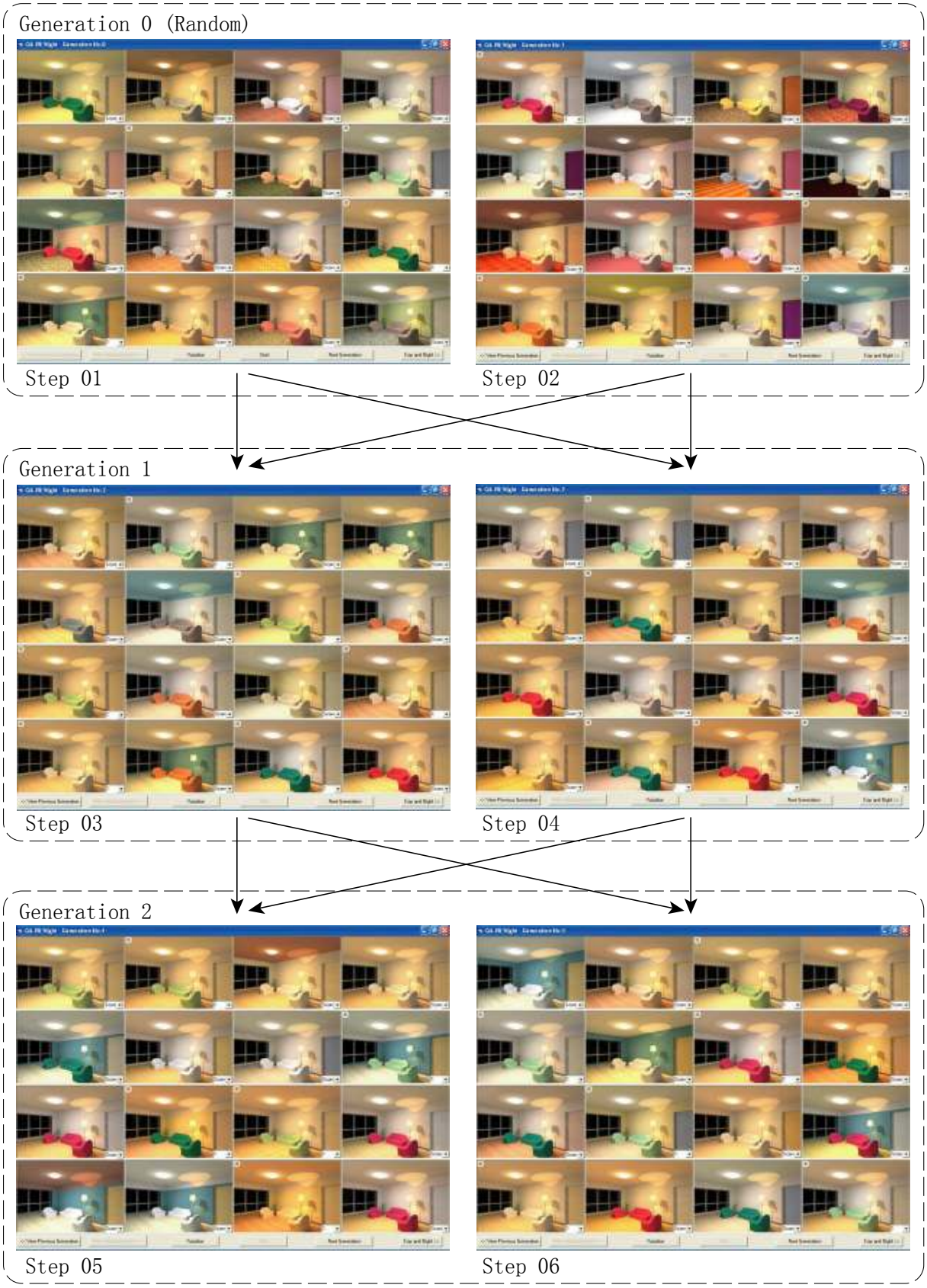


Figure 2-13 Process of experiment 3 (The nighttime IEC

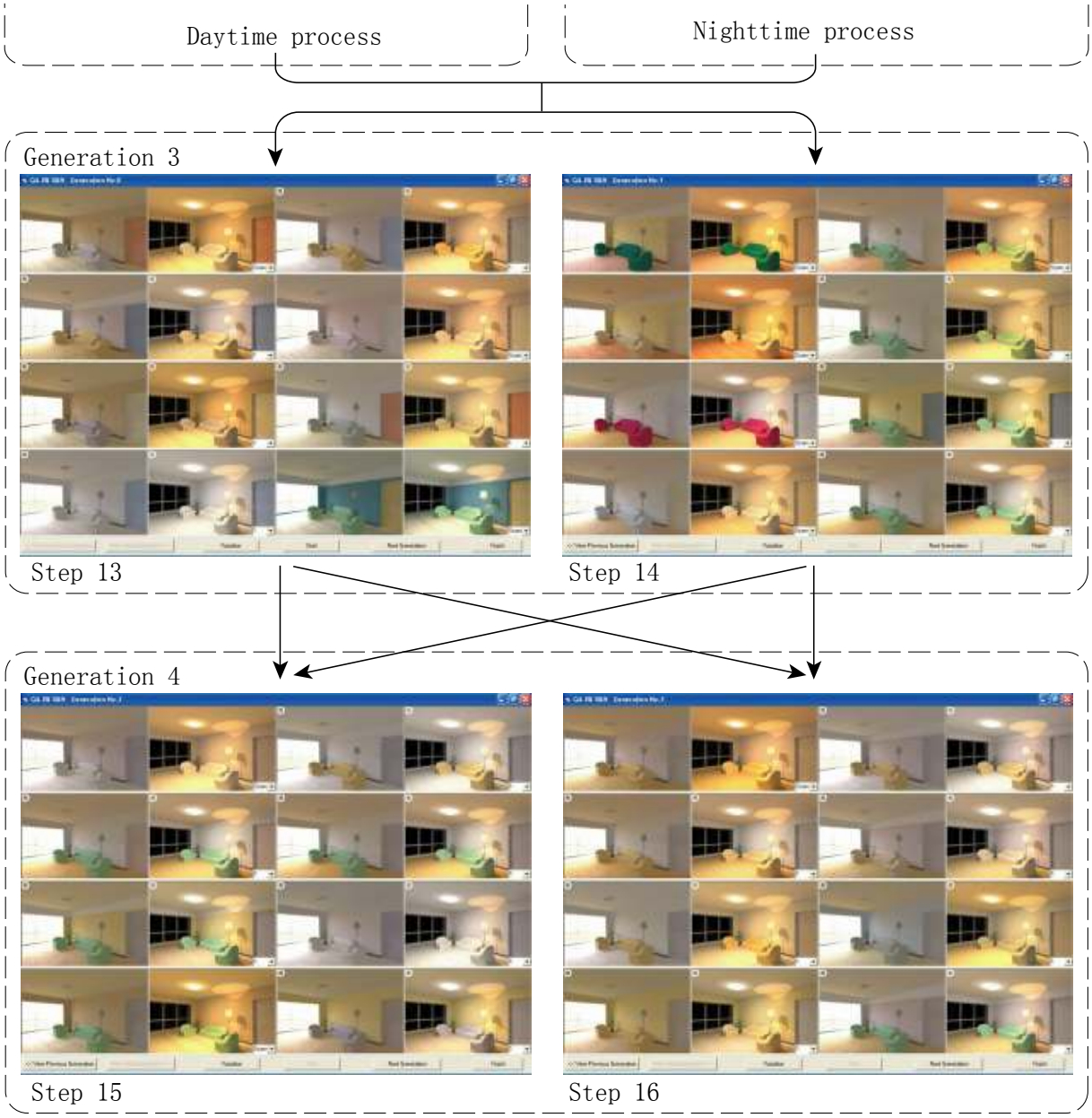


Figure 2-14 Process of experiment 3 (The D&N IEC)

When evaluating the results, the user felt "satisfied with the results," and she "liked many results" in the final generation. Compared to the former experiment, she stated that "this system was much more heuristic, and the results were better." She mentioned that "I have never imagined a green sofa before, and it seems to be a good idea," and "the results can be good reference in interior design." She also evaluated the "selection" evaluation method as "easier" to use than the scoring method.

For user B, two statistic values were calculated for experiment 2 and experiment 3. One was the amount of materials that appeared in each generation (sum of all factors;

Figure 2-15). The other was the average of AVEDEV (average of absolute deviation, function provided by Microsoft Excel) of materials' GB values of each generation (Figure 2-16). These two statistical values could be used to represent the material variation in a certain generation with respect to the aspects of amount and dispersion. It was found that both values of experiment 3 were generally much higher than that of experiment 2. Experiment 3 was found to be more effective in presenting more possibilities to the user.

It was concluded from this experiment that increasing population size improves the effectiveness of IEC method in searching for individuals that the user prefers.

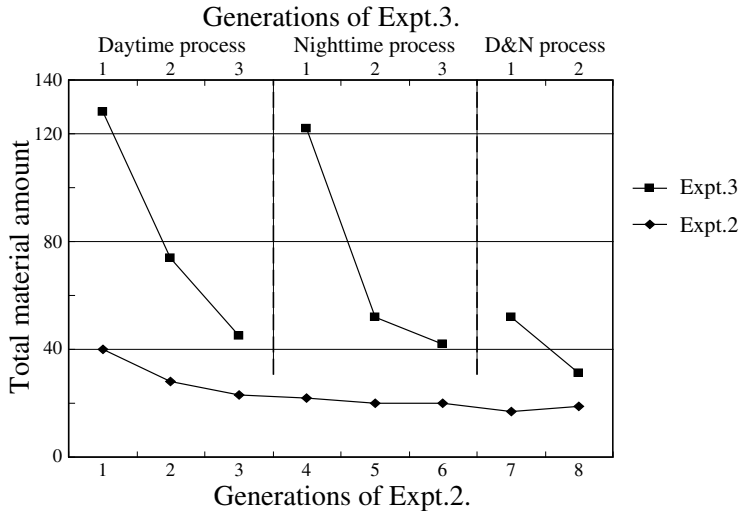


Figure 2-15 Evolution of material amount in each generation in experiments 2 and 3

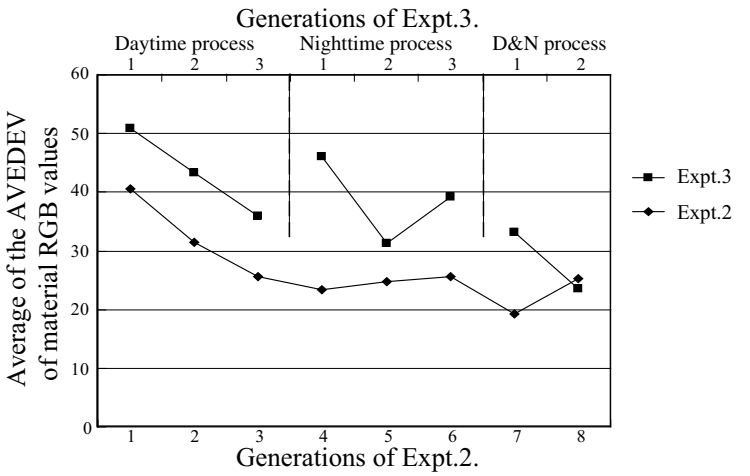


Figure 2-16 Evolution of the average for the AVEDEV of material RGB values in each generation

2.6 Summary of Chapter 2

In this study, IEC method was applied to Chinese interior works design areas. This system was intended to facilitate the interior design activities of non-design-professional residents. An IEC program and a graphic interface were developed, and a material library was constructed in the context of the actual situation of Chinese interior works. The rendering program Radiance was used to provide reliable simulations of interior space.

Three experiments were performed in this study. In experiment 1, the IEC IW design system was tested in searching for a designated goal, and a "variation" method was found effective in enhancing the IEC searching capabilities. Experiment 2 was intended to test the system for solving a problem for which no design goal had been set. The system was found useful for the two users who participated in the experiment, and some weak points of the system were exposed. Based on the findings of the second experiment, the system was further developed by increasing the population size, and the effect was tested in experiment 3. It was discovered that the development of the system might enhance the IEC search process by presenting more variations.

It was concluded from the experiments that the IEC IW design system helps non-design-professional residents in easily finding interior works design according to their own preferences, and thus improves the interior environments of their apartment living spaces.

In design process using IEC, a set of randomly generated individuals gradually evolve into a population, which the user evaluates. Behind the interface, on the gene level, the genes of the user's own preferences were approached by the program (supported by the fact that user B liked many individuals in the final generation of experiment 3).

Professional designers use architectural language, which can be interpreted as an integration of design rules, in their design practice. Non-design-professional residents, however, have difficulties in finding an ideal design because they have not mastered this language. The genes of the user's preference found by the system can be interpreted as the user's own architectural language. Since this language, which was difficult for the user to express and hard for professionals to understand, was revealed, the design ability of non-design-professional residents was greatly improved.

Finally, seven factors of the living room interior space were selected and used in the design problem. Although it was assumed that these factors were the primary ones that influence the aesthetic appearance of interior space, there may be other important factors in living room environments. For example, user A in experiment2 mentioned the influence of the form of the sofa on her evaluation. This indicates that the problem of IEC should be designed carefully to provide sufficient freedom to the user, and at the same time allow the IEC to evolve efficiently.

Notes

1. Radiance, developed by Lawrence Berkeley National Laboratory (http://radsite.lbl.gov/radiance/HOME.html)

Preferences

1) Zhou Xiaohong, Yoshida Tetsu and Mumemoto Junzo; Study on residents' apartment interior works effected by transformation of developers' completion standards and residents' apartment interior works management regulations. Journal of Architecture, Planning, and Environment Engineering, AIJ, No. 592, pp 1-8. 2005.6

2) Li Yaopei, Zhao Guanqian, Lin Jianping, Living Condition and Well Housing Design in China, Nanjing, China: Southeast University Press, 1999

3) Zhou Xiaohong, Yoshida Tetsu and Mumemoto Junzo: A study on the characteristic of interior works in units of apartment houses and customers' realizations and satisfaction. Journal of Architecture, Planning, and Environment Engineering, AIJ, No. 575, pp 1-6. 2004.

4) Zhou Xiaohong, Mumemoto Junzo and Yoshida Tetsu: Mining association rules between selections and their reasons of interior decoration in living room: Research on apartment interior works in Beijing (3), Journal of Architecture, Planning, and Environment Engineering, AIJ, No. 610, pp 9-16, 2006.12

5) Aoki Ken and Takagi Hideyuki: 3-D CG Lighting with an Interactive GA. In: vol.1 of the Proceeding of the 1st Int. Conf. on Conventional and Knowledge-based Intelligent Electronic System (KES'97), Adelaide, Australia, May 1997.

6) Matsushita Daisuke and Munemoto Junzo: A study of a search method of façade glass attributes by an aesthetic evaluation of CG images applying an interactive evolutionary computation, Journal of Architecture, Planning, and Environment Engineering, AIJ, No.584, pp 187-192, 2004

7) Targawa Kazumasa, Kawamura Hiroshi and Tani Akinori: Architectural interior design supporting system by interactive evolutionary computing. In: Proceedings of the 26th symposium on computer technology of information, systems and applications, AIJ, 2003, Japan.

8) Mahdavi, Ardeshir and Eissa, Hesham: Subjective evaluation of architectural lighting via computationally rendered images. Journal of the Illuminating Engineering Society, Summer 2002, pp 11-20, 2002

9) Mehlika N. Inanici: Application of the state-of-the-art computer simulation and visualization in architectural lighting research. In: Seventh International IBPSA Conference, 2001, Brazil.

10) Larson, Greg Ward and Shakespeare, Rob: Rendering with Radiance. California: Morgan Kaufman Publisher, 1998

Chapter 3

Evaluation of IEC IW Design System by Residents of Beijing

3.1 IEC IW design system and manual interior works design process

3.2 Purpose

3.3 Past studies

3.4 Trial Method

1) Trial site

2) The IEC IW design system

3) Questionnaire

3.5 Trial Procedure

3.6 Trial Results

1) Evaluation of the results and process

2) Selection of adjectives for describing results

3) Comments of the participants

3.7 Analysis of the Correlation Coefficients of Colors in the Evolutionary Process

3.8 Summary of Chapter 3

3.1 IEC IW design system and manual interior works design process

In the previous chapter, an IEC IW design system was developed to solve the interior works design problem of Chinese residents. The complex interior works design problem was simplified by involving only 7 material and color related factors. In the generate-and-test processes, the task of generating design alternatives was performed by the computer through GA, and the designers' work was simplified into only selecting several images within the interface based on their own ideas. In general, the IEC problem solving process could be considered as a model of interior works design process in reality, and there were differences and relations between them.

The design process employing IEC is closely related to the real design process in that both of them are repeated generate-and-test process for solving design problem, which was directed by designer's own idea. But the difference lies in that comparing to real interior works design process, IEC involved only limited design factor, and the users could not access all design possibilities as in reality. For example, they could not change the form of sofa, or hang paintings on the wall in the IEC IW design system. In addition, the users could not modify a certain design manually, but only select or not select it to participate in the evolution. On the other hand, since computer was employed to generate design alternative, the users could see many possibilities they did not think of, at the same time could not see some design ideas they were expecting. It could be say that the evolution of design ideas in IEC was both extended and limited by the generation algorithm, which was GA in this research.

The differences between IEC method and common design activity result in the fact that the interior works design process in IEC was restricted in some aspects, but also extended in some other aspects. Thus how users of the IEC IW design system evaluate its process and results is an important question of the validity of the system.

3.2 Purpose

As an interactive design system developed to assist the Chinese residents and inducing their design problem solving behavior, the IEC IW design system should be able to help them in achieving useful design results. In addition, both the advantage of computer and designer were expected to be efficiently employed in the system, which means the computer should provide design alternatives and evolve them effectively, and the designers

should be able to work in a way they can easily get used to and participate in the process actively. The validity of the IEC IW design system should be evaluated under the real circumstance of interior works by the Chinese residents themselves, and the status in which people participate in the design process employing IEC should also be examined.

Although in the previous chapter, the IEC IW design system was tentatively used by 2 Chinese students, and was evaluated as heuristic and helpful by them, since the interior works design related to a great variety of factors, and the users of the system may have different background, demand, and way of thinking, the efficiency and characters of the IEC IW design system was still not revealed clearly. This chapter presents an experiment with residents of Beijing, China, to evaluate validity of the IEC IW design system for actual design problems and identify any limitations. The study examined the following points:

1) Did the IEC IW design procedure effectively evolve residents' designs?

2) How did the residents evaluate the IEC IW design results, in terms of quality, heuristic level, and practicability?

3) How did the residents feel about the IEC IW design procedure?

4) Were any differences among groups of people evident in the evaluations of the procedure and of the design results?

3.3 Past studies

Among the many researches that applied IEC in a great variety of aesthetic design problems, there are some closely related to this research.

Aoki and Takagi (1997)[1)] applied interactive GA to 3-D CG lighting design, and tried to evaluate the efficiency of IEC method. Through comparison of IEC design results by professionals and non-professionals, it was found that the method effectively worked to assist amateur designers, especially those with limited experience or capabilities.

Newsham and Richardson (2005)[2)] applied an interactive GA to an investigation of peoples' preferences regarding surface luminance in office spaces. Forty participants viewed a series of grayscale images to find the ideal luminance combinations for six surfaces in a typical office space. The method effectively arrived at a participant's preferred luminance combination. The results were similar to the choices of people in actual office

spaces, and suggested that a person's subjective evaluation of office spaces can be predicted, in part, from the luminance of the six surfaces.

In order to evaluate the usability of software, Erik P. van Veenendaal (1998)[3] introduced a software usability measurement inventory (SUMI) testing technique as a possible solution. As a rigorously tested and validated method to measure software quality from user perspective, SUMI contains a 50-item questionnaire devised in accordance with psychometric practice, and each of the questions is answered with "agree", "undecided" or "disagree". Based on the answers given and statistical concepts the usability scores are being calculated. SUMI gives a global usability figure and other five subscales, such as efficiency, affect, helpfulness, control, and learnability.

Colombo and Guerra (2002)[4] proposed an evaluation method for software product from the point of view of the end user according to ISO/IEC 9126 and ISO/IEC 12119 in what concerns quality characteristics and software packages, respectively. All along the process, evaluators assign rates to the product according to the questions of the checklist, and write down comments on specific issues they consider relevant concerning the product. In the evaluation report, the major positive aspects of the evaluated product and suggestions for its improvement are required to be addressed.

There were also some other literatures on evaluating software and website from the view of end user. Wang, Tang and Tang (2001)[5] developed a 21 item comprehensive model and instrument for measuring customer information satisfaction (CIS) for websites that market digital products and services. Huang (2003)[6] used a 12-item questionnaire to examine a three stage model of user that incorporated effects of complexity, novelty and interactivity of website designs.

The difference between the present research and the above-mentioned studies is that we carried out an evaluation experiment, in which the IEC IW design system was evaluated in real design problems by a large amount of participants, intended to validate the efficiency of the system and identify its limitation. In addition, the research could also be considered as an investigation on Beijing residents' preference in interior works color combination, and their design process using IEC.

3.4 Trial Method

This trial was performed in Beijing, China. Study residents were asked to use the IEC IW design system, and then the evolutionary procedure and design results were evaluated with a questionnaire to examine the residents' evaluations of the system.

1) Trial site

The Lize shop, an Oriental Home Construction and Ornamental Material chain store and one of several interior works material markets in Beijing, was selected as the trial site. The shop has a floor area of 26,000 m². It provides a wide range of materials and is typical of where many people purchase their materials for interior works. We assumed that the majority of customers in the Lize shop had experience or an interest in interior works design and that some of them would be interested in the IEC IW design system and would participate in the trial (Figure 3-1).

Figure 3-1 The investigation environment

2) The IEC IW design system

The IEC IW design system developed in chapter 2 employed and revised in the following ways:

A. Design factors and material library

The factors involved in the IEC IW design system (Table 3-2) are primarily material and color-related as these are assumed to be the main factors in interior aesthetics. We reduced the number of factors to five. Images of materials were collected to construct a library of the materials available in the Chinese interior works market. In addition, little-used categories and materials incorporated in chapter 2 were replaced with new categories and materials to provide better options. (Please refer to Appendix A)

Table 3-1 Factors optimized and material library construction

Factors	Category	Number
Ceiling material	Paint	60 colors
Wall material	Paint	60 colors
	Wall paper	138 textures
Floor material	Wood	103 textures
	Ceramic tile	116 textures
	Carpet (monochromatic)	87 textures
	Carpet (patterned)	99 textures
Door material	Paint	64 colors
Sofa material	Textile	138 textures
	Leather	96 textures

B. IEC flow

It is difficult to arrive at a final solution using IEC because GA is not so effective in later generations and may converge into local solutions. This is a potential problem, as subjects may well become bored by repeatedly evaluating similar images. Consequently, the IEC IW design system is intended to be a heuristic approach to finding a user's aesthetic preferences rather than a means of identifying an exact design solution.

Increasing population size can generate more possibilities, and in chapter 2 the effect of increasing population size was verified. In this chapter, the IEC flow was adjusted to

increase population size of GA in addition (Figure 3-2). In the first stage, the initial steps of 16 designs of day and night settings were arranged by turns. Images of the first generation were generated randomly. Then images of the second generation (4 steps, totally 64 images) were generated by GA from the selected images of the first generation. The second stage was the simultaneous evaluation of day and night images in pairs, the same as in chapter 2 with a population size of 16. The IEC is intended to balance the trade-off between human fatigue and the quality of the results.

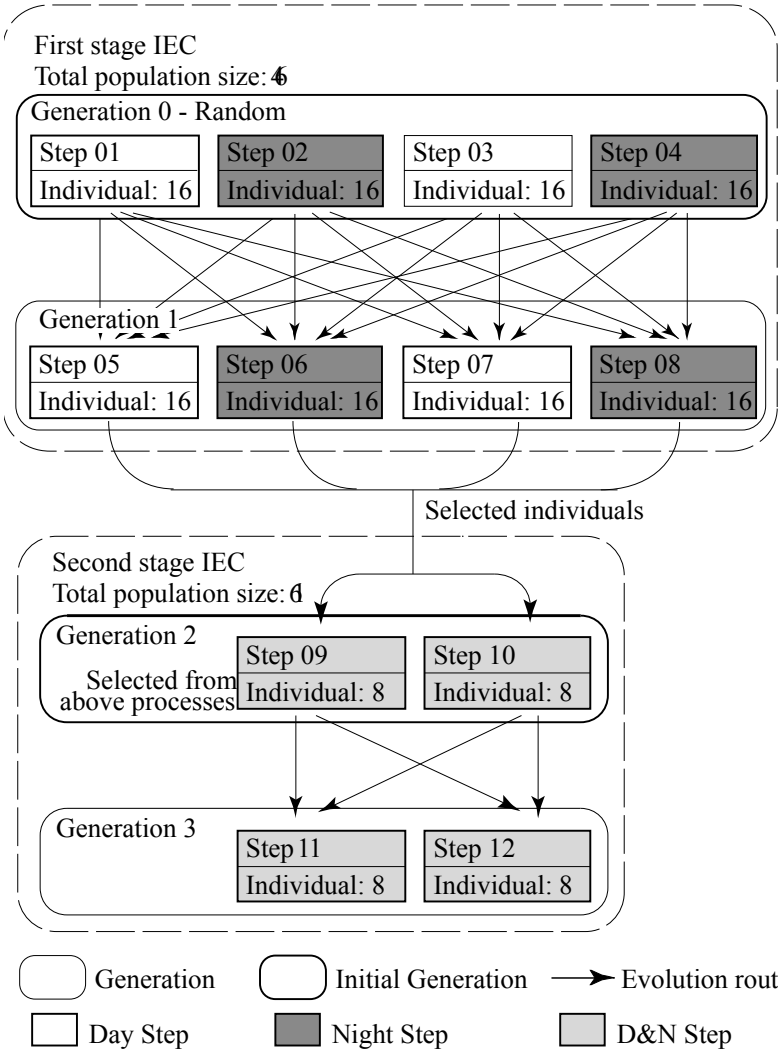


Figure 3-2 The IEC flow

C. Parallel rendering

Radiance[1, 7], a highly accurate ray-tracing software, was used to handle complex interior lighting simulation and to provide dependable rendered images of interiors. There is a trade-off between rendering accuracy and speed. In interior works design, inter-reflection between surfaces greatly influences interior lighting conditions and should be included in the image presented for evaluation. At the same time, rendering speed is critical because users cannot be expected to wait too long for the results. To balance these needs, we developed a parallel rendering method to accelerate rendering.

The method uses multiple PCs to perform rendering in parallel (Figure 3-3). The PCs are linked to form a local area network (LAN). One is the server; this generates and sends out the rendering parameters, performs one part of the rendering task, and displays the interface. The other PCs receive the parameter files, perform the remaining rendering tasks, and return the rendered images to the server. Eight PCs are used, each of which renders two images. Suitable adjustment of the parameters allows the PCs to finish rendering 16 images with acceptable accuracy in about 30 seconds.

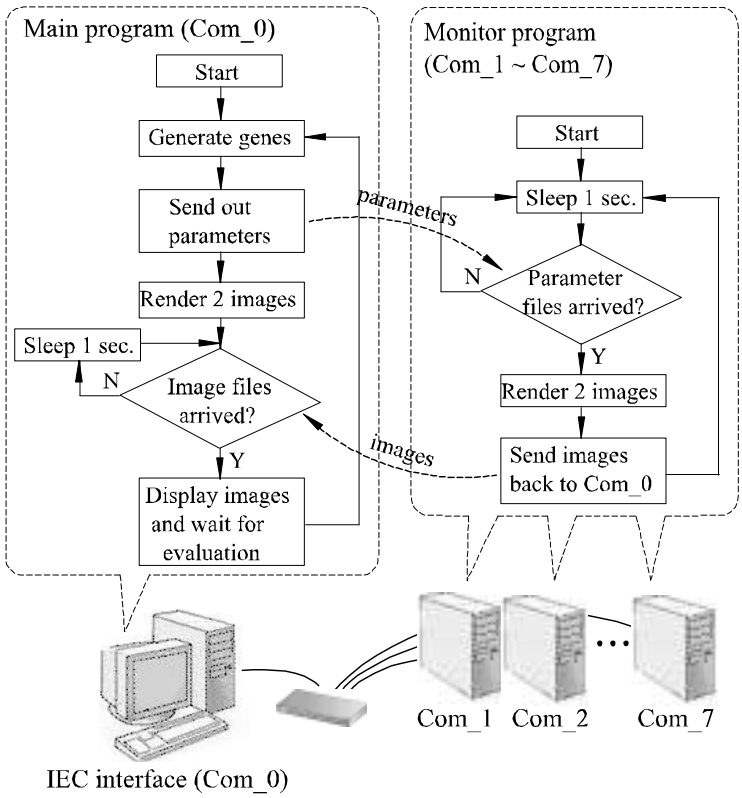


Figure 3-3 Rendering performed by multiple PCs in a LAN

3) Questionnaire

The questionnaire contained the following: basic information on the participants; seven questions related to evaluation of the design results; eight questions related to evaluation of the design process using IEC(a five-degree semantic differential scale was used for question answers); 30 adjectives that residents usually select to describe interior spaces when evaluating the design results; and comments made by the participants. (Please refer to Appendix B)

3.5 Trial Procedure

Customers of the Lize shop in Beijing were asked to participate in the trial. As most of the customers were either performing or preparing for interior works, either for new apartments or in the renovation of old apartments, they all had design goals. IEC was introduced to the participants as an evolutionary process that would gradually lead them to

their preferred design. The results might then serve as a reference for the interior works design of their apartments. Interested customers participated in the trial.

The trial consisted of the following steps:

1) 12 living room model choices were provide for the participants. Although the plans of apartments in Beijing vary, they can be divided into a few general types. Six models are shown in Figure 3-4, and the other six are their mirror images. These models have the same scale of room, but with different arrangements of the window opening, as window arrangement affects interior lighting conditions. Each participant was asked to choose one from twelve different living room types that was the most similar to the living room of his/her apartment. The provision of a choice of models makes the system more practical.

2) Each participant was asked to choose which materials he/she might use in his/her apartment from among the available categories. This step can reduce the searching space and makes the IEC more effective. Many participants did not choose carpeting, which is hard to keep clean in Beijing's climate.

3) The design process employing IEC began. The interface was displayed on an adjusted 19-inch cathode-ray tube color monitor at a resolution of 1024 x 768 pixels. To make IEC more effective, participants were asked to select three to five images in the first stage and two to three pairs of images for each step in the second stage. The process of each participant generally took twelve steps, eight in the first stage and four in the second, as shown in Figure 3-2, and took approximately 20–35 min. While the images were being rendered, general information about the participant was collected.

4) After completing the design process employing IEC, participants were asked to evaluate the results and the process by completing a questionnaire.

3.6 Trial Results

The trial took place from 23 February 2006 to 19 March 2006. During the 22 working days, 236 participants (an average of 10.7 participants per day) were interviewed, and the data from 231 participants (94 males and 137 females) were included in the study. Their ages ranged from 18 to 74 years (average = 35.6 years), and the majority had a high school or college-level education, or a bachelor's degree. Most had households consisting of two or three members and an income between 2,000 and 20,000 RMB per month (Figure 3-5).

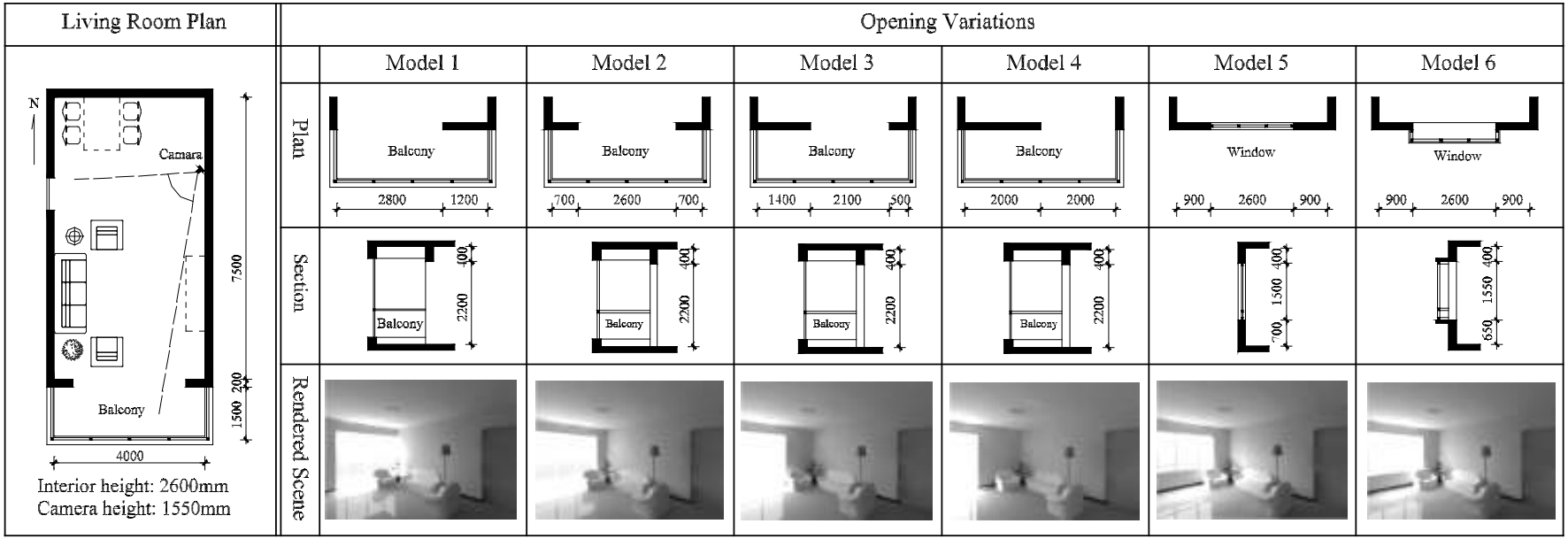


Figure 3-4 The living room plans and window-opening variations

In addition, among the participants, 15 of them were majored in design related specialty, and 7 of them were interested in do-it-yourself (DIY) interior works design or accomplished at painting or photography (10 males and 12 females). They were included as a group of experienced participants to provide a comparison in the analysis.

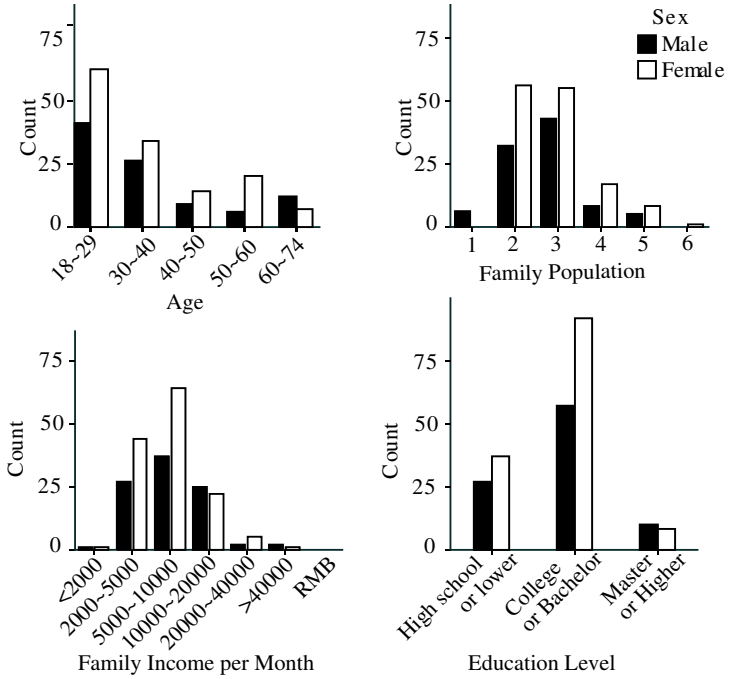


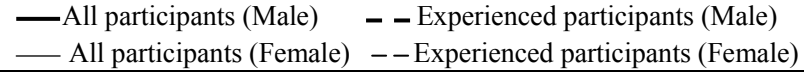
Figure 3-5 Distribution of participants

1) Evaluation of the results and process

Participants were asked to rate their responses to the questionnaire using a 5-degree semantic scale. The degree terms were “very,” “fairly,” “moderate,” “fairly,” and “very” (Tables 3-2 and 3-3). The semantic scale was explained to the participants as being an even subjective scale. To compare the answers to different questions by different groups of people, numerical values from -2 to 2 were assigned to the five degrees of the semantic differential scale, and average values were calculated. Although the semantic scale is an ordinal scale, average values were considered sufficient to determine general trends in participants’ answers.

The seven questions used to evaluate the design results and the statistical values generated by their answers are shown in Table 2. Questions R1 and R2 were a general evaluation of the results, R3 and R4 evaluated the creativity of the final designs, R5 examined the accuracy of the system in determining participants’ preferences, and R6 and R7 evaluated the feasibility of the design results.

Table 3-2 Design results questions and answers



Questions	Answers			Mean
R1. How do you feel about this method of design?	bad	very fairly neither fairly very	good	1.19
R2. Are you satisfied with the results?	unsatisfied		satisfied	1.23
R3. For you, the results are	old		new	1.01
R4. Have you ever imagined such interior color and material combinations?	negative		positive	0.31
R5. Do you think the results match your taste/preference?	negative		positive	1.17
R6. Are the results practical for you?	negative		positive	1.00
R7. Will you put them into practice?	negative	-2 -1 0 1 2	positive	0.74

Note: Adjectives in brackets show the two ends of the semantic differential scales.

Table 3-2 showed that the participants' evaluations were generally favorable, especially with regard to questions R1, R2, and R5. The IEC IW design system worked well in the trial. The lower mean score for R4 suggests that some of the participants found new interior works design ideas, while others did not. The participants gave fairly high evaluations in response to questions R6 and R7, but the scores for these questions were not as high as those for questions R1, R2, and R5. This suggests that the IEC design results were feasible, but not completely satisfactory to the participants.

The eight questions about the design process employing IEC concerned the operation, heuristics, human fatigue, and a general evaluation of the process (Table 3-3). The table shows that the participants were quite certain that the IEC IW design system was easy to operate (P3), the design process was fun (P6), and the improvement of the designs was significant (P5). They considered the process interesting (P1) and heuristic (P2), and verified that choosing among the images was generally easy (P4). The majority of participants wanted to use the system in their interior works design (P7). These results provide a good perspective on IEC method in interior works design. The last question (P8) was designed to determine whether the process had provided enough choices to the participants. The average score was low. Some participants complained that they had to make choices among similar images. This problem might be due to the disadvantages associated with later generations in the GA method, such as low efficiency and convergence on local answers.

Table 3-3 Questions on the design process employing IEC and participants' answers

—All participants (Male) – –Experienced participants (Male)
——All participants (Female) – –Experienced participants (Female)

Questions	Answers			Mean
P1. How did you feel about the process?	bored	very fairly neither fairly very	interesting	1.23
P2. Do you think the process was heuristic?	negative		positive	1.15
P3. Operation of the process was:	complex		simple	1.52
P4. How did you feel about making choices among images?	difficult		easy	1.06
P5. Were the final images greatly improved compared with the beginning?	negative		positive	1.38
P6. Did you feel tired during the process?	tired		easy	1.48
P7. Will you use the system when performing interior works?	negative		positive	1.05
P8. What is your opinion of the material and color choices provided?	meager	-2 -1 0 1 2	abundant	0.50

Note: Adjectives in brackets show the two ends of the semantic differential scales.

Aoki and Takagi (1997)[1)] found IEC method more effective for non-professional designers than for professionals. In the present trial, the mean values of answers of the group of experienced participants are shown in Tables 3-2 and 3-3. They generally gave lower scores to the process and the design results, in agreement with the findings of Aoki and Takagi (1997)[1)]; females in this group tended to give lower scores than did males.

Gender had little influence on the mean answers, as seen in Tables 3-2 and 3-3. In contrast, age, education level, and family income level did influence mean values (Figure 3-6). In general, older participants and those with lower education and family income levels

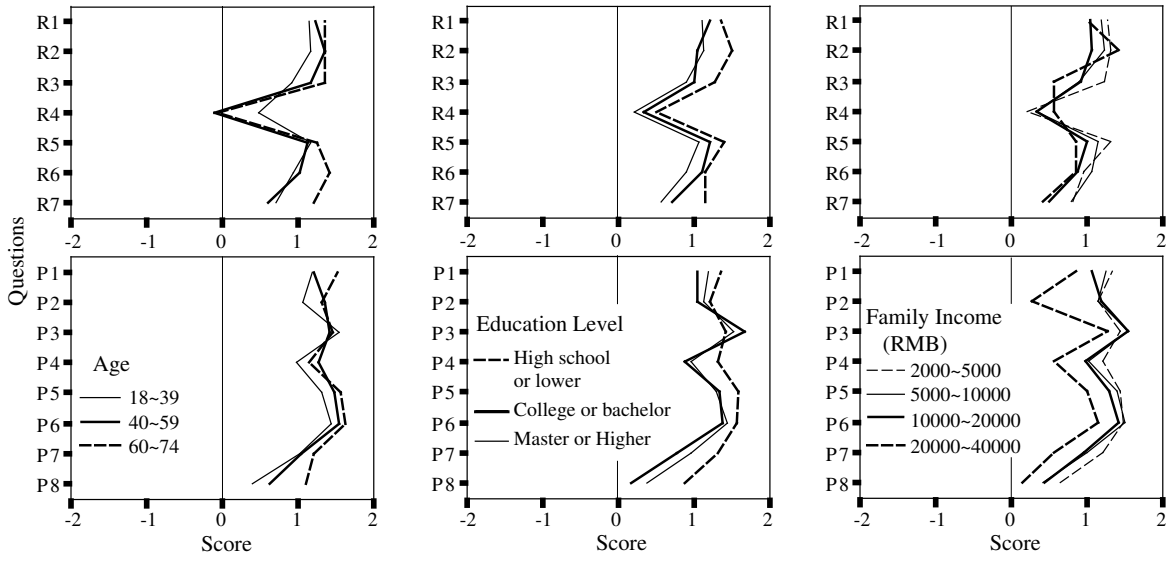


Figure 3-6 Comparison of answers by participants' age, education level, and family income level

gave the IEC IW design system better evaluations, which suggested that the system can greatly assist these groups.

2) Selection of adjectives for describing results

The participants' selection of the 30 adjectives is shown in Figure 3-7. Some adjectives were often chosen, such as "bright," "blend," "comfortable," "quietly elegant," and "clean." As these adjectives are often used by residents to describe their interior preferences, we concluded that the IEC design results had satisfied certain aspects of the participants' demand.

Some adjectives were rarely chosen, such as "passionate," "hard," and "impactive," which can be explained by the fact that the majority of people prefer a comfortable and relaxing home environment rather than one with a strong impact. The adjectives "occidental" and "national" were also rarely chosen. The scenes provided in the IEC IW design system are not complex, and the form of the sofa is fixed; therefore, it was hard for participants to find their style preferences. That few users selected "moderate" and "orthodox" might suggest that most residents want to express more personality in their interior works.

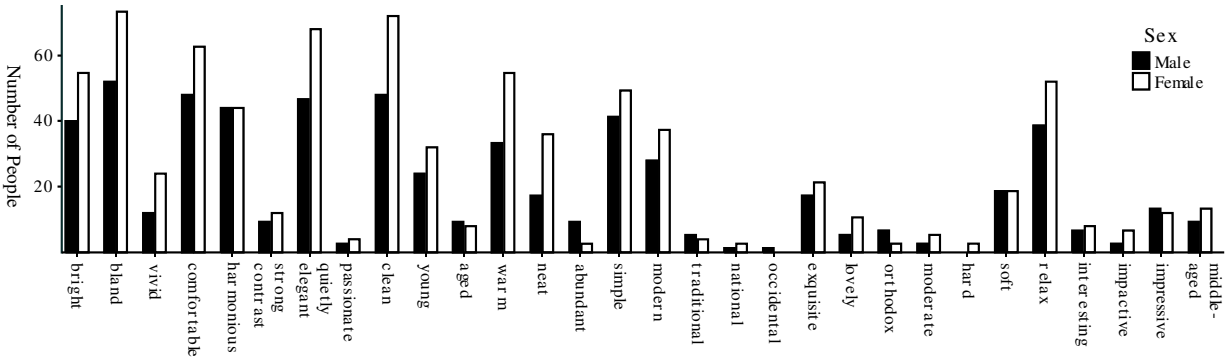


Figure 3-7 The selection of adjectives

3) Comments of the participants

Some of the participants made comments after they had used the IEC IW design system. Some considered the system quite useful, noting, for example, "The design system is very good, helpful." Other participants pointed out some of the system's limitations: "There should be more room types, more view angles," "I want to see more styles of sofa," and "Not enough interior factors, still different from reality." Some of them said "I wanted to change materials in the images by myself." It appears that users wanted to participate

more in the process. Some participants mentioned discomfort: “The images are similar, and it is not easy to make choices” and “Visual fatigue”.

Comments by the group of more experienced people were also collected. Some of them mentioned that “The design system is too restricted, and I cannot change materials by myself.” The system was not flexible enough for them, and they were subsequently restricted in the use of their design abilities. Some of them also mentioned the limitations of the system, such as “It did not involve many factors of interior design.” Some professionals realized that the system was “useful for unprofessional residents, and it could be a way of communication between customers and designers.” Possible applications of the method were suggested.

In the IEC flow, four steps were employed in a certain generation to increase the population size of GA. Consequently, images of the four consecutive steps were generated from the same parents, and were similar. Some participants commented they were evaluating similar images repeatedly, and the evolving effect was not significant. They complained that this kind of repeating was tiring.

3.7 Analysis of the Correlation Coefficients of Colors in the Evolutionary Process

Although the questionnaires revealed that the majority of participants considered the IEC IW design system useful, we note that this subjective evaluation may have been influenced by other factors, such as the participants’ expectations, their ability to evaluate aesthetic quality, and their mood at the time. Therefore, the trial data and the results were analyzed for additional evidence of the system’s validity.

A total of 231 participants selected 1307 designs (represented by image pairs of day and night settings) at the last generation. These designs were considered the final results. If the system worked effectively, the combination of materials and colors should be pleasing or harmonious. Although color harmony is a complex problem, certain numerical relationships should exist between color parameters at each location in the scene.

A correlation coefficient is a number from -1 to 1 that measures the degree to which two variables are linearly related; the larger the absolute value, the stronger the linear relation. Although the relationship expected between color parameters may not be linear, the correlation coefficient was employed in this study to reveal trends in color combinations.

The materials' color parameters (average red, green, and blue values of the texture image) were converted into hue saturation values[2] and the CIE 1976 L*, a*, b* color space[3]. These color systems were chosen because they are more closely related to human perception of colors, and they were expected to reveal tendencies in color combination. The participants' correlation coefficients[4] for the material color parameters (H, S, V, L, a, and b) for all of the 1307 final results were calculated, as shown in Figure 3-8 (the background color indicates the magnitude of the value).

Although there were no strong correlations (the maximum value was 0.13), the analysis revealed significant color correlations. Because the sample size was 1307, in a two-tailed test a correlation coefficient over 0.054 was significant at the 0.05 level, while a coefficient over 0.071 was significant at the 0.01 level. These results might be explained by the fact that color harmony is too complex to express as a simple linear correlation, although correlations in the color combinations at various locations in the scenes were found.

A correlation analysis of the color parameters (H, S, V, L, a, and b) was also performed for all designs and for the selected designs alternatives of all of the 231 participants in each generation (please refer to figure 3-2), and the results are shown in figure 3-9. Numbers are not shown because of space limitations. Instead, magnitude is indicated by the shading of the cells (same as in figure 3-8). The designs selected in the third generation were considered the final results, and the correlation coefficients were the same as in figure 3-8.

The correlation coefficients in figure 3-9 suggest a tendency toward greater correlation during the evolution process. There are no significant correlation coefficients for the designs in generation 0 because they were generated randomly. Once the participants have made their selection, weak correlations appear. These correlations are preserved through the crossover and mutation of the GA, and are transferred to the next generation. Then, when the participant selects again, the existing correlations are strengthened and new correlations appear. As the process continues, an evolutionary effect is clearly evident.

Since the pattern of correlation coefficients gradually strengthened from generation to generation, it can be concluded that, although the correlation coefficients were not strong, this result was not by chance, and the IEC IW design system was successful in revealing the correlations of colors.

		Wall						Floor						Door						Sofa					
		H	S	V	L	a	b	H	S	V	L	a	b	H	S	V	L	a	b	H	S	V	L	a	b
Ceiling	H	0.03	0.01	-0.03	-0.03	0.03	0.01	0.00	0.00	0.04	0.02	0.04	0.00	0.01	-0.03	-0.02	0.00	-0.04	-0.01	0.04	-0.02	0.03	0.02	0.05	0.01
	S	0.00	0.06	0.00	-0.02	-0.01	0.05	0.00	0.04	-0.09	-0.10	0.03	-0.01	0.07	-0.03	-0.01	0.00	0.00	-0.06	0.01	-0.02	-0.09	-0.05	-0.07	-0.03
	V	-0.02	-0.01	-0.01	-0.02	0.03	-0.04	0.00	-0.01	0.02	0.02	-0.01	0.02	-0.09	0.03	0.02	0.01	-0.02	0.05	-0.09	0.07	0.02	0.00	-0.02	0.05
	L	-0.01	-0.05	0.00	0.01	0.02	-0.05	0.00	-0.04	0.07	0.07	-0.04	0.01	-0.10	0.05	0.03	0.01	-0.01	0.08	-0.06	0.05	0.05	0.02	0.00	0.05
	a	-0.02	0.02	0.02	0.01	-0.01	0.01	0.03	0.07	-0.05	-0.07	0.06	0.01	0.03	-0.06	-0.01	0.02	-0.01	-0.06	-0.03	0.02	0.01	-0.01	0.04	-0.01
	b	-0.05	0.04	0.01	0.01	-0.05	0.02	0.00	0.02	-0.08	-0.07	-0.04	-0.01	0.03	0.01	0.01	0.00	0.00	-0.01	-0.03	0.01	-0.04	-0.02	-0.07	0.00
Wall	H							0.04	-0.01	-0.05	-0.05	0.04	-0.06	0.06	-0.04	-0.05	-0.03	0.00	-0.08	0.05	0.01	-0.09	-0.06	-0.05	-0.06
	S							-0.06	0.11	-0.04	-0.07	0.03	0.10	0.00	0.04	-0.01	-0.02	0.01	0.04	0.06	0.00	-0.06	-0.04	-0.01	-0.03
	V							-0.08	-0.02	0.13	0.12	0.04	0.06	-0.01	0.02	-0.02	-0.03	0.00	-0.01	0.03	-0.01	0.09	0.06	0.04	0.03
	L							-0.05	-0.08	0.13	0.13	0.01	0.01	-0.01	0.00	-0.01	-0.01	-0.01	-0.03	-0.02	-0.01	0.10	0.08	0.02	0.06
	a							-0.03	0.11	0.01	-0.03	0.04	0.09	0.00	0.06	0.01	-0.01	0.00	0.07	0.04	0.03	0.04	-0.01	0.09	-0.01
	b							-0.06	0.03	0.06	0.05	-0.02	0.08	-0.05	0.04	0.03	0.01	-0.01	0.07	-0.05	0.02	0.03	0.02	0.02	0.08
Floor	H													0.00	0.00	0.01	0.00	0.02	0.00	0.02	0.00	-0.06	-0.06	-0.01	-0.13
	S													-0.03	0.09	-0.04	-0.06	0.04	0.06	0.04	0.08	-0.02	-0.05	0.07	0.04
	V													-0.01	-0.03	-0.01	0.00	0.00	0.02	-0.08	0.06	0.02	-0.02	0.08	0.06
	L													0.00	-0.06	0.00	0.02	-0.01	-0.01	-0.09	0.01	0.02	0.01	0.03	0.05
	a													-0.03	0.06	-0.01	-0.02	0.00	0.06	0.06	0.04	0.01	-0.01	0.03	0.00
	b													-0.02	0.07	-0.05	-0.06	0.02	0.05	-0.04	0.04	0.02	0.00	0.07	0.12
Door	H																			-0.04	0.03	-0.07	-0.07	0.01	-0.01
	S																			0.05	-0.03	0.07	0.05	0.06	-0.01
	V																			-0.03	-0.01	0.03	0.01	0.05	-0.01
	L																			-0.02	-0.01	0.01	0.01	0.00	-0.01
	a																			-0.06	0.08	-0.03	-0.07	0.06	0.03
	b																			0.04	-0.06	0.09	0.08	0.02	0.02

0.11 Absolute value >0.10

0.08 Absolute value 0.07~0.10

0.05 Absolute value 0.04~0.07

=Figure 3-8 The correlation coefficients between color parameters of each location of the final results
(calculated by the person bivariation correlation of SPSS)

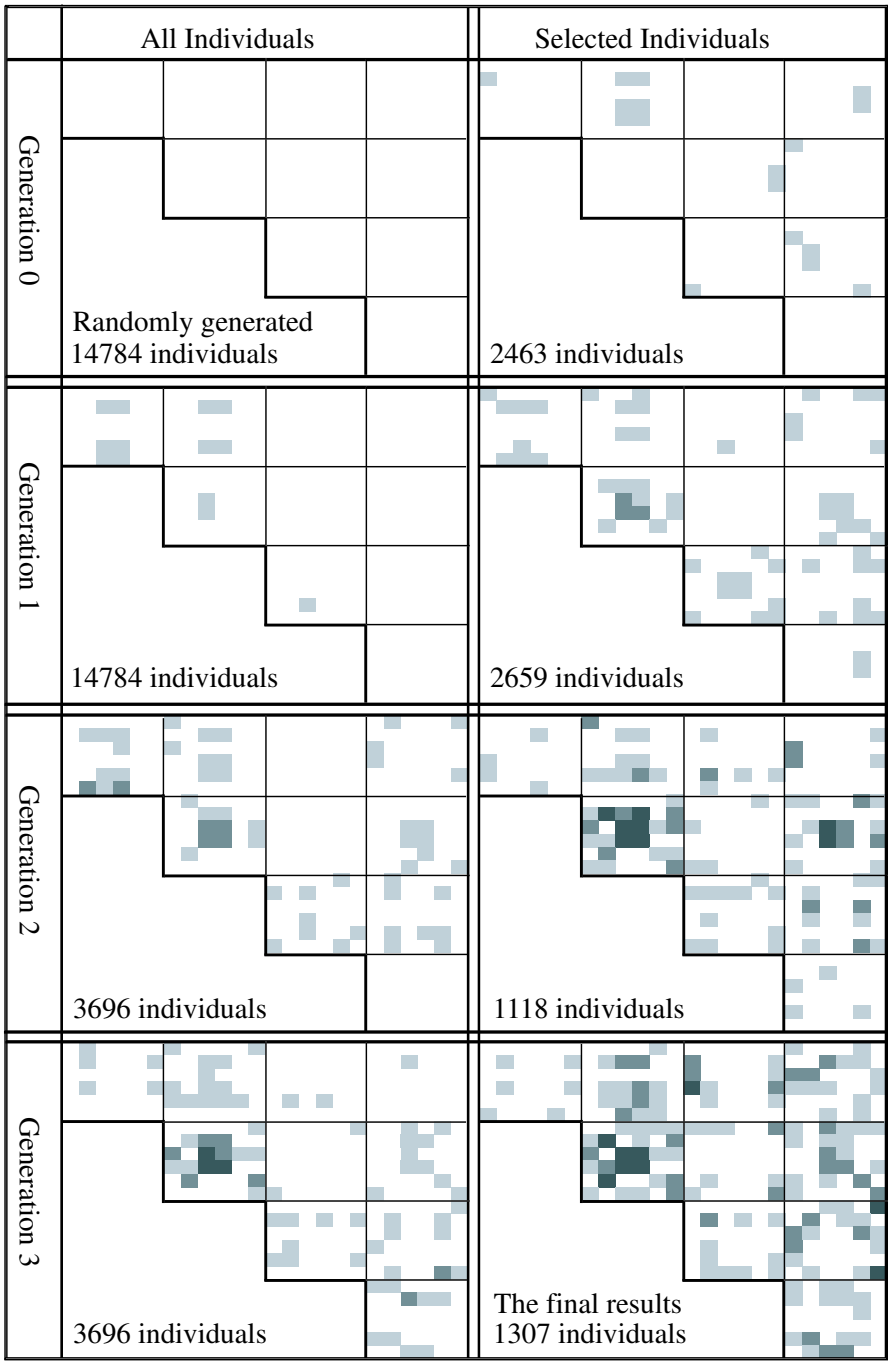


Figure 3-9 Correlation coefficient of all images and selected images in each generation (color parameters were arranged in the same order as Figure 3-8)

The evolution of the sums of the absolute values of the 36 correlation coefficients of the color values of a certain location vs. that of another location (see the six figures at the top right of figure 3-10), and the evolution of the summation of all these (bottom left in

figure 3-10), were plotted. These figures reveal a general increase in the correlations between colors during the evolutionary process. To remove small correlation coefficients caused by sampling error, only figures with an absolute value over 0.05 were summed; the evolution figures are shown in figure 3-11. They also reveal an increasing tendency. Figure 12 also shows that the sums of the correlation coefficients for the door vs. other locations increased in later generations, which might suggest that a door located near the edge of a rendered image is not considered by participants at the start of the evolutionary process.

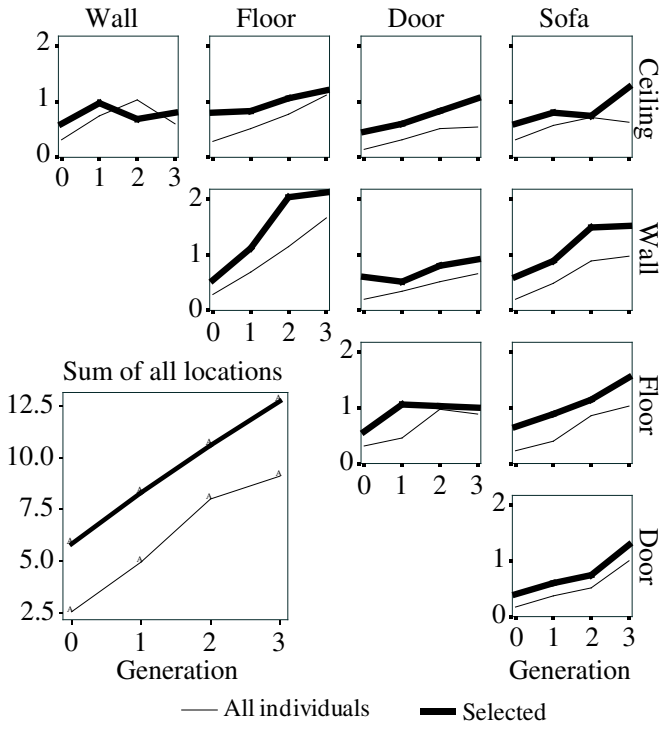


Figure 3-10 The evolution of the sum of all absolute values of correlation coefficients

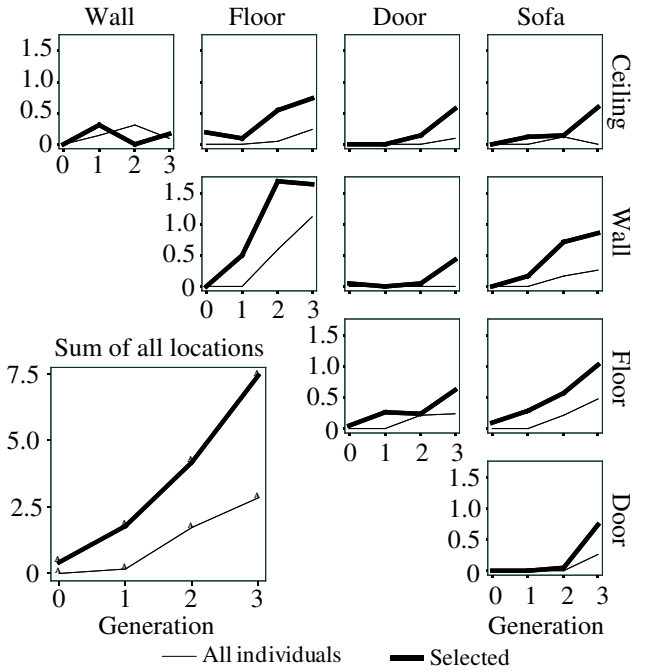


Figure 3-11 The evolution of the sum of absolute values of correlation coefficients greater than 0.05

3.8 Summary of Chapter 3

This trial of the IEC IW design system with Beijing residents showed that the system was generally rated favorably and worked well in helping residents who were not design professionals to conduct interior works design. Older participants, and those with lower education and family income levels, tended to rate the interior works design system more favorably. The trial also revealed that professional designers rated the system less favorably than did nonprofessional residents.

The trial also showed that the system has limitations, such as its inability to handle many interior works design factors, inefficient in later generations, repeating steps, limits to user participation, and visual fatigue. The identified limitation implied possible way of improving the IEC IW design system.

Some professionals have suggested that the system could be used as “a way of communication between customers and designers.” As the system may help non-design professionals to reveal their preferences, it could be a direct and effective way for them to express their ideas.

In a comparison of color-value correlation coefficients during the evolution process, a numerical correlation between color values at each location was gradually established and strengthened. Although the correlation coefficients were not strong and no in-depth research was carried out for each correlation, we concluded that certain numerical rules operate in preferred color combinations, and that the system is effective in revealing these rules.

Since the IEC design results were evaluated by majority of the participants as good and can reveal their tastes, and the design process employing IEC was evaluated as interesting, heuristic and easy, it could be concluded that the participants were actively involved in the design process using IEC, and in later part of the dissertation, certain design problem solving behaviors were expected to be explored through analysis of the design process employing IEC.

Notes

1. Radiance, developed by Lawrence Berkeley National Laboratory (http://radsite.lbl.gov/radiance/HOME.html)
2. The HSV (Hue, Saturation, Value) model was created in 1978 by Alvy Ray Smith, which is similar to the way humans tend to perceive color. The HSV color wheel is often used as a valuable tool for determining harmonious color schemes like complementary, split complementary, triadic, and analogous colors.
3. The CIELab color space developed by Commission Internationale d'Eclairage, which is the most complete color model that used conventionally to describe all the colors visible to the human eye. The CIELab system is also an attempt to linearize the perceptibility of color differences.

4. Pearson's correlation coefficient is a measure of the linear association between two variables that have been measured on interval or ratio scales.

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Chapter 4

Designer's Evaluation Process in Simulated Design Process of Interior works Using IEC

4.1 Exploring Design Problem Solving Behavior in Design Process Employing IEC
   1) Simulated design process by IEC IW design system
   2) Data of IEC evaluation operation for exploring participants' design problem solving behavior

4.2 IEC IW Design System
   1) Interface and evolutionary flow of IEC IW design system
   2) The operations of the IEC IW design system
   3) Parallel rendering

4.3 Experiment of IEC Design Process

4.4 Analysis
   1) Sequence of the evaluation in the first phase
   2) Time span for each operation
   3) The selection of the best image
   4) The spatial sequence of operation

4.5 Summary of Chapter 4

4.1 Exploring Design Problem Solving Behavior in Design Process Employing IEC

As the main research theme of this dissertation, the design problem solving behavior will be explored in two continuous researches of chapter 4 and the chapter 5. The IEC IW design system was employed in these two chapters to simulate the manual design process, and data of the participants' design problem solving behavior were analyzed.

1) Simulated design process by IEC IW design system

In the area of design methodology, the design activity was considered as a certain kind of problem solving behavior. Being an important research theme, the design problem solving behavior has been studied in many researches for decades. Peter Rowe[1)] tried to clarify the designers' activities by presenting case studies and various theoretical positions on how design is done. Takamatsu (1997)[2)] studied the whole design process of a practical architectural project through analysis of sketches and verbal reports of the designer. Donald Schön[3)] tried to show how professionals go about solving problems through discussion of examples of practice in different professions, and tried to show how "reflection on action" works. The past studies had tackled the analysis of complex manual design process, which was carried out by a great variety of subjects to deal with diverse conditions, and lasted for a long period of time. However, this research did not take the common design process as the research object, but employed a simulated and simplified design problem, which needed no professional design knowledge or experience to solve, and tried to analyze participants' design problem solving behavior based on their own aesthetic ideas.

In the IEC IW design system, the searching space was defined by the combination of the color and texture parameters of the wall, ceiling, floor and so on, and the design problem solving behavior was restricted as the provided operations in the system. Comparing to the manual design process of people, the design process employing IEC could be said confined and well structured, and allowed for analysis of different participants based on a comparable condition. In addition, the design process employing IEC could be finished within an hour, so it is possible to analyze the short term behavior of people in design process, which was not clearly revealed in other studies.

Through the experiment in chapter 3, it was understood the IEC IW design system was effective for residents in interior works design. The system was evaluated heuristic,

easy to understand, and not tiring. The results suggested the system was similar to the way people solving design problems, and they were actively involved in the process. The analysis also revealed that the design results were approached gradually, and different parts of the interior scene were evolved differently, which suggested the design process employing IEC was similar to the process where people solve design problems, and could induce design problem solving behavior of real design processes.

In this research, since the repeated process of generating design alternatives by computer through evolutionary algorithm and rendering algorithm, and evaluating them by designers based on their own aesthetic ideas was similar to the generate-and-test process[1)] in common design, and it has certain advantage to reveal design problem solving behavior, it was regarded as a simulated design process. This research intended to construct a simulated model of design activities by repeated generation and evaluation in the restricted problem space, and explore the design problem solving behavior through data analysis.

In addition, the design problem solving behavior in the design process employing IEC is also an important aspect in the interactive process of human and computer. Since it is possible to apply the interactive designing in practical design problems in the future, the design problem solving behavior revealed in this research may suggest possible ways of development in this kind of system.

2) Data of IEC evaluation operation for exploring participants' design problem solving behavior

During the design process using IEC, the task of the users was to evaluate the provided images according to their own ideas. The time sequence and spatial sequence of people evaluating the images one by one were considered the phenomenon of the behaviors of the participants, and the results of the problem solving processes that happened in their mind. In this chapter, the participants' mouse movement and operation were used as data of evaluation operation, and analyzed to explore the design problem solving behavior of the participants. The next chapter will try to analyze the verbal reports of participants, which can provide information on the thinking process in their mind by the method of protocol analysis.

4.2 IEC IW Design System

1) Interface and evolutionary flow of IEC IW design system

The IEC IW design system developed in chapter 2 and 3 was employed in this research. In order to make the experiment more effective, the design problem was simplified by providing daytime images only for evaluation. Six interior works factors were involved in the system, they were the material of the ceiling, wall, floor, sofa, interior door, and that above the picture rail. In addition, Choices of material category and interior model were not provided to unify the experimental condition for comparison of design problem solving behavior among participants.

From the experiment in chapter 3, some disadvantage of the IEC IW design system was identified, including the following problems.

1) Can not provide enough choices and variation, especially in later steps;

2) The images in the 4 steps of a certain generation were similar, and can not instantly reflect user's idea which was expressed through the evaluation.

3) Too much restricted, more ways of operation should be provided to the user.

Figure 4-1 Interface of the IEC IW design system

Aiming at above problems, the system was revised in the following ways to make it more effective in searching ideal designs and in inducing design problem solving behaviors of the users.

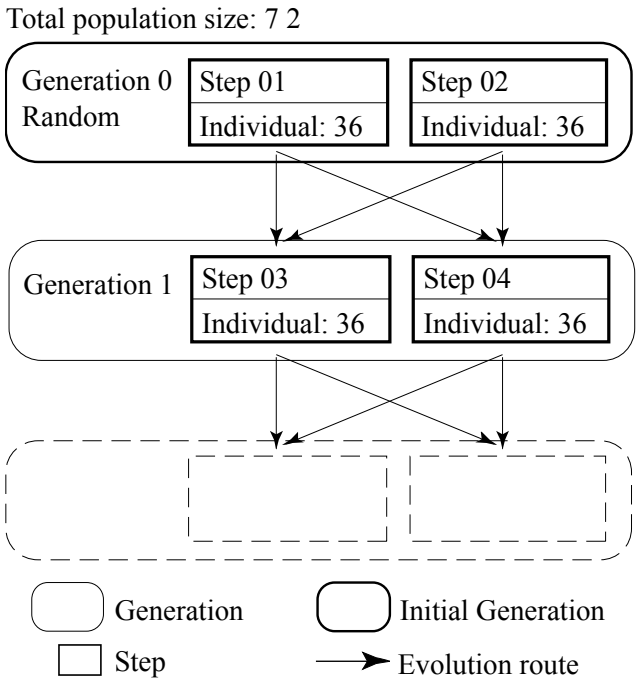


Figure 4-2 IEC flow diagram

1) A high resolution (1920x1200) wide screen LCD displayer was used in the experiment. The interface of the system was extended to display 36 images simultaneously (Figure 4-1). The interface can now provide more than twice the images then the original one, and allow users to see more possibilities simultaneously and compare more effectively.

2) As the image number in the interface increased, the step numbers in each generation was reduced to 2, and the process flow was reorganized as shown in figure 4-2. Because only 2 steps were used in each generation, the concept of "generation" and "step" did not differ greatly, especially for the research of participants' design problem solving behavior. In this research, they were not clearly distinguished from each other.

3) The selected images will be directly copied to the next generation, and randomly inserted among the new images. By this way, the users would not lose any selected image, only if they gave it up.

4) Because of 3), part of the images will be the same for the consecutive generations, so the mutation rate was increased to balance this similarity and produce more variations.

5) Evaluation operation of the system was extended as explained in the following part.

2) Operations of IEC IW design system

The operation of the IEC IW design system provided various possibilities of evaluating the images, and could influence the design problem solving behavior of the participants. In chapter 4, a "selection" method was employed to simplify the evaluation.

The user only needed to select images according to their aesthetic consideration, without giving specific scores to the images. In this experiment, since the image numbers was increased to 36, operation of the system was developed to make it easier.

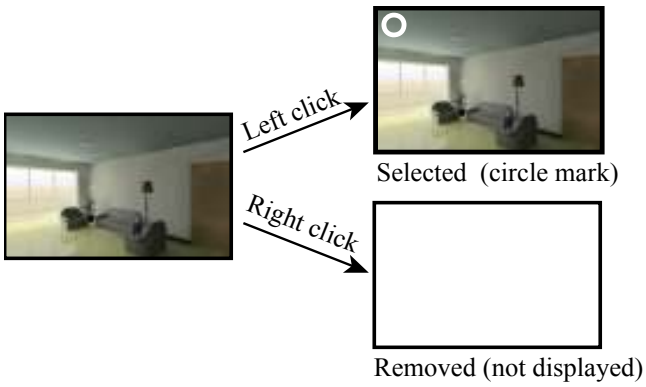


Figure 4-3 Operation of select and remove

In the system, the user could left click on the image to select it as before, and the image would be marked by a circle. In addition, if they did not like an image, it could be removed (not displayed) from the interface by a right click on it (Figure 4-3). By this operation the users could remove the images they did not like, and focused on the remained images. If they were not sure about removing the image, they could bring it back by another right click.

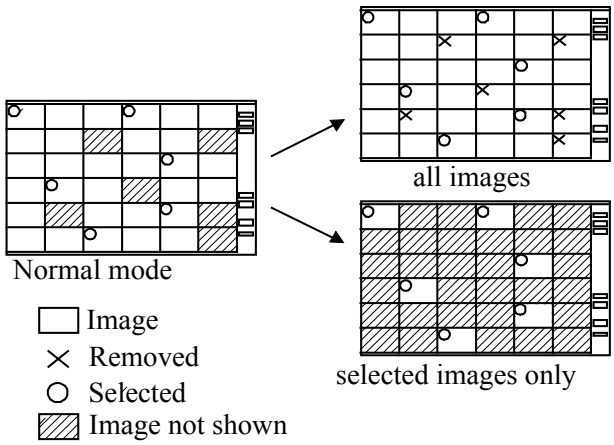


Figure 4-4 Three display mode of the interface

There were some display modes employed in the interface (Figure 4-4). In a normal mode, images except the removed ones were displayed. If the users wanted to see all the images they had removed, they could select a mode of "display all images", which shows all 36 images, with the removed ones marked by a cross. Since the participants were required to choose an image as the best one among the selected images in each step, they can use another display mode of "display selected images only", and concentrate on the selected images for further compare.

3) Parallel rendering

Same as chapter 3, the rendering of images should be performed by RADIANCE[4)1] in a short period of time with acceptable accuracy, because if the participants have to wait for a long period of time between generations for rendering of images, their design problem solving behavior could not be say continuous, and might be greatly influenced. Different

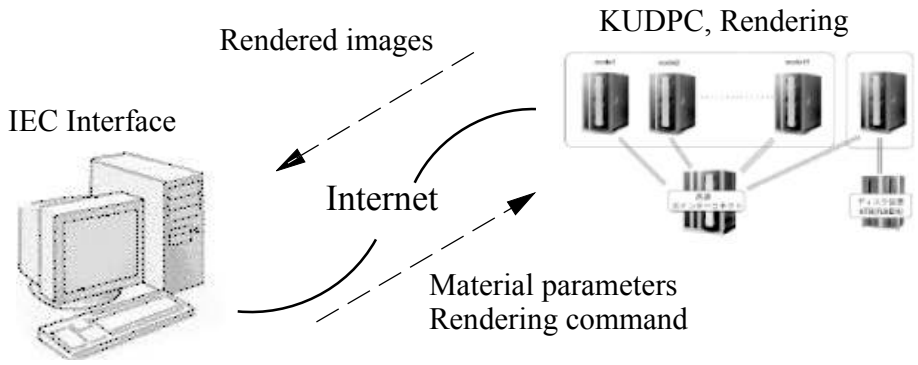


Figure 4-5 Rendering performed by remote KUDPC

from chapter 3, we employed a parallel rendering method which intended to perform parallel rendering on a remote super computer (Figure 4-5). The KUDPC (super computer of Academic Center for Computing and Media Studies, Kyoto University, Japan) was used. Rendering parameter, commands, and rendered images are transferred between the local interface and the remote super computer through the internet by SSH Secure Shell, and the 36 images of a certain step are rendered parallel by multi-CPUs on KUDPC. By adjusting rendering sequence and parameters, the rendering of 36 images was performed by KUDPC within 90 seconds, and no participants complained they had to wait for a long time.

4.3 Experiment of IEC Design Process

Although in chapter 2, the IEC IW design system was developed for non-professional Chinese residents, the investigation in chapter 3 showed some professionals also evaluated the system useful for them. It was expected their design problem solving behavior could also be induced in the simulated process. In this experiment, the participants were not required to be strictly non-professional.

Eleven Chinese speaking scholars and students had participated in this experiment. The experimental results of eight of them, including two architecture majored students, were selected for analysis (Table 4-1). The selection of participants was intended to represent common designer of interior works in China who were mainly non-professionals. Although the two architecture-majored students were trained in design, they were not majored in interior works design or interior design. They were involved to represent the more experienced designers among common people, and to provide more variations in the participants for revealing more findings of design problem solving behavior.

The experiment was carried out according to the following procedure:

Before the design process employing IEC, the general instruction was given to the participants. They were told to select several images (usually 4 to 10) they thought were comparatively better among the 36 images and one of them as the best image in each step. After several steps, the images were expected to get close to their target image. The process can continue for as many steps as they wanted. If they thought that the design problem had been solved, or the images were not improved greatly for steps, and there was no need to continue any more, the process could be ended. Then the operation of the system was introduced to the participants. The participants were told that these operations were provided for their convenience to select images as instructed, and they could choose to use or not use these operations.

Generally the processes of the 8 participants lasted for 9 to 11 steps, except two that lasted for 6 steps (08M, participant No. 08, male) and 15 steps (01M) (Table 4-1). The design process of each participant generally lasted for 30 minutes to 45 minutes. Mouse movement and operation were recorded for analysis.

Table 4-1 Basic information of the participants

Participant	Sex	Age	Major	Step number of process
01M	Male	31	Engineering	15
02M	Male	28	Engineering	9
03F	Female	28	Architecture	9
04F	Female	26	Engineering	11
05M	Male	30	Engineering	10
06M	Male	34	Engineering	11
07F	Female	33	Architecture	11
08M	Male	26	Engineering	6

4.4 Analysis

In 97.6% of the steps, the participants firstly selected several images they thought were better, then after comparing among the selected ones, decided the best image at the end of the step. So each step was generally considered constituted by two phases, the first one was selecting some images, and the second one was selecting the best images of the step (Figure 4-6).

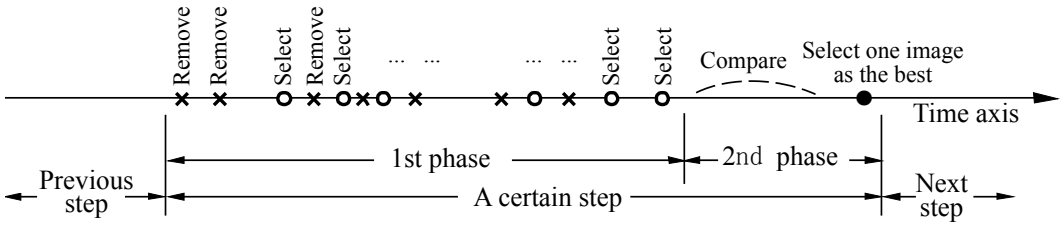
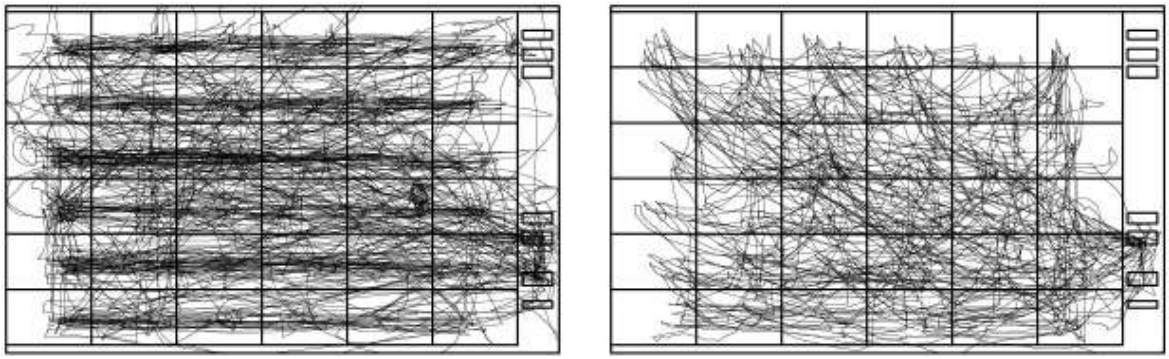


Figure 4-6 Two phases in a certain step

1) Sequence of the evaluation in the first phase

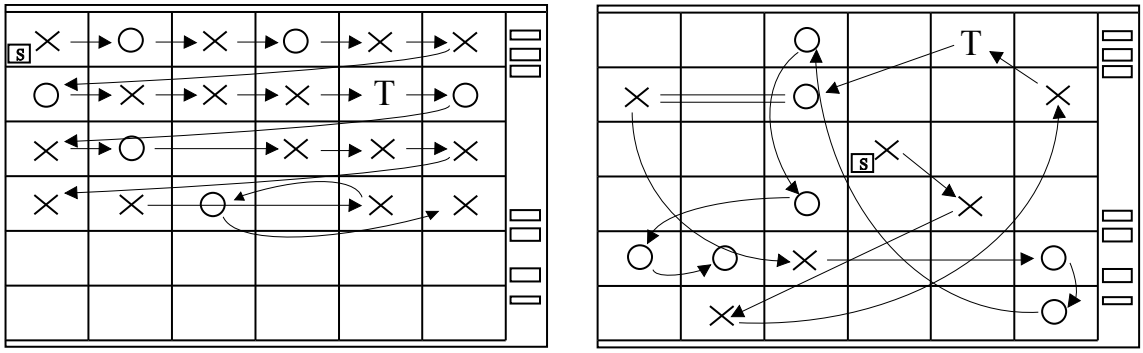
The 36 images of a certain step were placed randomly in the IEC interface, without being sorted by any properties of them. The mouse traces of the whole design process of 01M and 02M were shown in figure 4-6 as examples, which demonstrated that they had followed different spatial sequences when evaluating the images.

Examples of mouse trace were shown in figure 4-7. (For the rest participants, please refer to Appendix C) Generally, the 8 participants adopted two different types of spatial evaluation sequence. 01M and 08M generally checked the images one by one, from left to right and from top to bottom, although sometimes they would went back to evaluate an image which he had just passed. The other 6 participants did not follow such fixed sequence, but wandered around in the interface, and evaluated images in a dynamic sequence. (Figure 4-8) It was found that when tried to find the best image among the selected in the second phase, both 01M and 08M who checked images in the fixed sequence complained that the images are too far away from each other, and not easy to compare, while the other 6 participants did not.



Participant 01M Participant 02M

Figure 4-7 Examples of mouse trace



Participant 01M, 08M　　Participant 02M, 03F, 04F, 05M, 06M, 07F

S Start　Remove　Select　Route　Compare　T Think without operation

Figure 4-8 Two types of spatial evaluation sequence in the first phase records

The corresponding time sequences of operation of each participant in each step were shown in figure 4-9. The figure presented how the operation of "select" and "remove" were performed one by one along time sequence, without considering any spatial information. Some empty records were also inserted in the operation sequence which represented the situation the participant evaluated an image without operating on it. The resulted length of the sequence varied from 9 to 46.

From figure 4-9, it was found the majority of the participants evaluated almost all images (01M, 02M, 03F, 04F, 07F, and 08M), but for the disliked images, some of the them removed all images they did not select (03F, 04F and 07F), while others only removed part of the images not selected (01M, 02M), or removed no images (08M). For the rest two participants (05M and 06M), they were found only evaluated part of the images, and their process did not last long.

In each step, 02M, 03F, 04F and 07F usually removed some images at first, then selected and removed images alternatively. Figure 4-10 showed the comparison of the distribution of the two operations along time sequence of the 4 participants, and it was found the operation of "remove" happened generally earlier than that of "select". This kind of behavior suggested that they were using the difference-reduction method, and tried to remove images that were too far away from their idea firstly.

On the other hand, the processes of 05M and 06M were found usually started with "select", and contained mainly "select", with some "remove" inserted in. The sequences suggested that the "remove" operation was not so useful for them in the process. In fact, it was found 06M preferred strong colors and new ideas very much, so he could identify the images he wanted to select easily, and the other images might not be so disturbing for him.

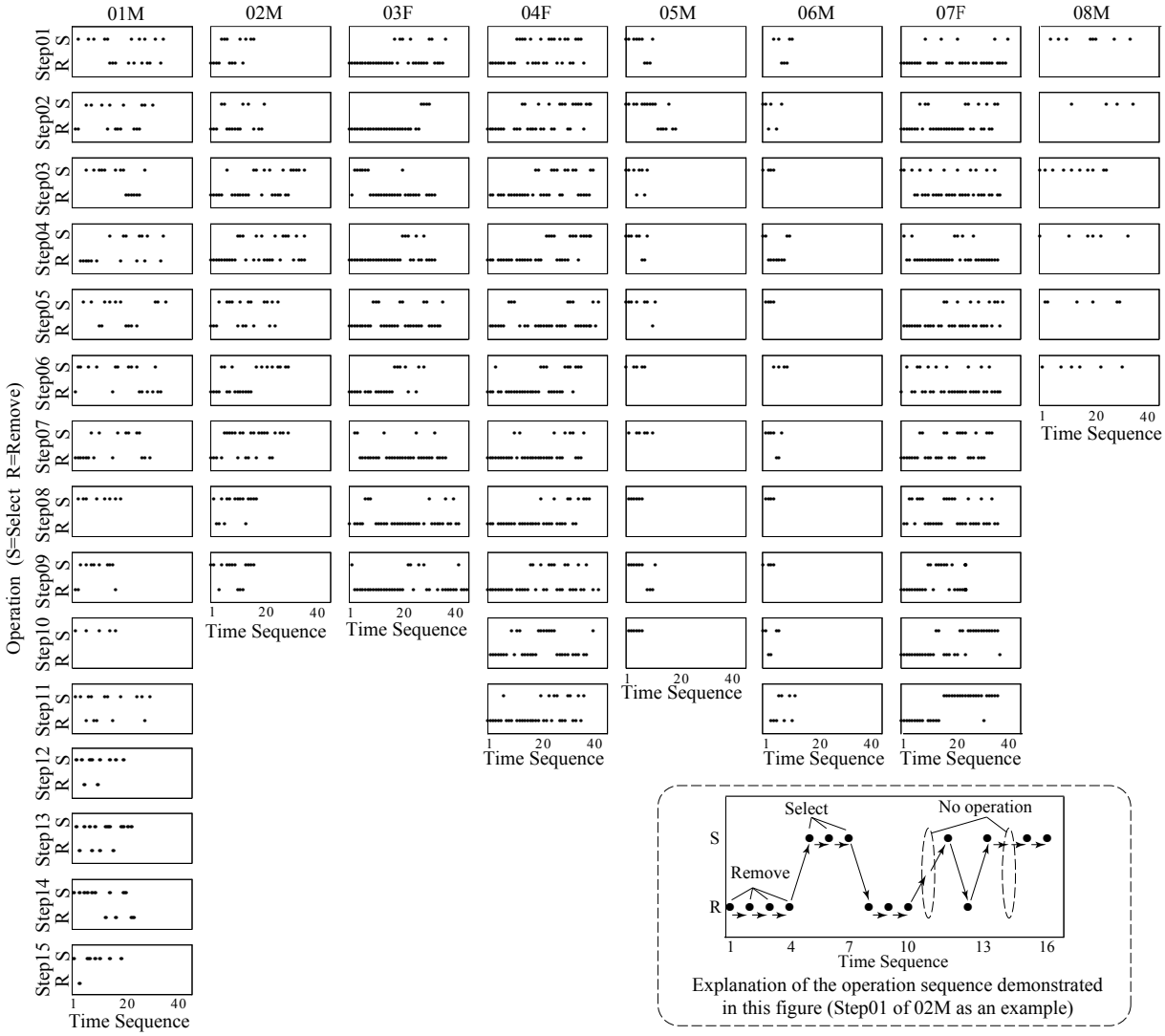


Figure 4-9 Operation sequence of each participant in the first phase

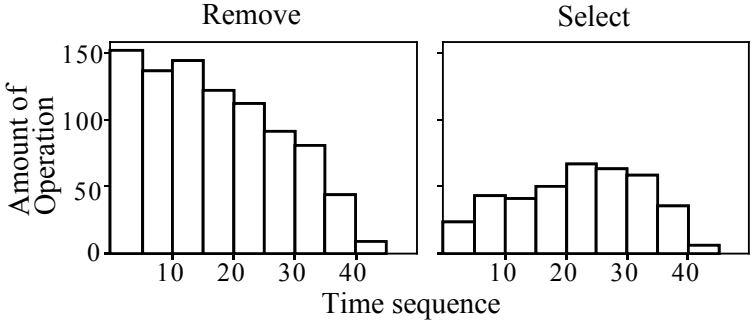


Figure 4-10 Frequency of “remove” and “select” along time sequence (02M, 03F, 04F, 07F)

For 01M and 08M who adopted the fixed spatial evaluation sequence, their operation sequences were decided by the position of images, not by themselves, and no significant rules were found in their operation sequence.

2) Time span for each operation

It could be assumed that the time span between two operations was mainly the time spent for making the decision of the next operation. The time span of each operation was obtained from the mouse operation record, except the first operation of each step, because it is hard to decide when the participants started to work on it. The time span for different operations of all participants along step was shown by Boxplot[2] provided by SPSS in figure 4-11.

It was found from the figure the operation of "select" took longer time than that of "remove", which suggested the decision of "select" is more difficult for the participants than that of "remove". In fact, the participant 02M mentioned that *"I was not sure about what I liked, but more certain about what I did not like."* He also said *"I made the decision of remove faster than that of select"*. In addition, no participant had ever used the display mode of "Display all images" in the experiment, which allowed the users to confirm again the images they had removed. The fact revealed that the participants were quite certain about the "remove" operation.

It was also found in figure 4-11 that there was a general decreasing tendency of the

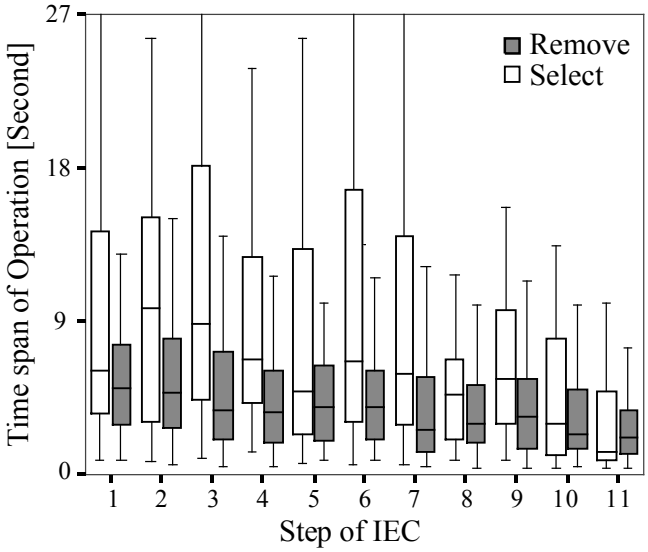


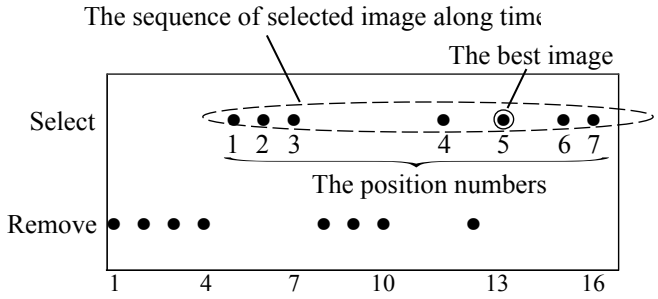
Figure 4-11 Comparison of the distribution of time span of operations of all participants along step

time spans of operation along step, especially for “select”. Since it was the first time for most participants to use the IEC IW design system, they might get used to the system gradually as the process went on, and could evaluate the images faster. Another reason could be that in later steps, the images were getting similar to each other, and similar to the images shown in former steps, so the participant were familiar with them, and could make their decisions faster.

3) The selection of the best image

In the second phase, the participants chose one best image among the selected images in each step as instructed. Most participants used the display mode of “Display selected images only” in this phase. Some participants operated on (selected or removed) every image, so they entered the “Display selected images only” mode automatically. Usually, the participant will compare among the selected images for a while, and decided the best one (Figure 4-6). Sometimes the participants could make the decision comparatively faster. From the participants’ comment, it was revealed that in this kind of situation, they still had memory of the best image, so they could make the decision quickly.

If we take a look at the sequence of selected image along time in each step (figure 4-12), it could be found that the best image



(Step01 of 02M as an example)

Figure 4-12 Definition of the images position number in the sequence of selected images

Table 4-2 The position of the resultant best image in the sequence of selected images along time

Step	Paticipant					
	02M	03F	04F	05M	06M	07F
1	5	1	1	1	1	1
2	3	3	1	2	1	3
3	1	7	2	4	1	2
4	1	4	3	3	1	1
5	2	4	2	5	1	1
6	2	4	1	1	3	2
7	3	1	3	1	1	11
8	7	2	1	3	1	5
9	2	3	8	2	3	6
10			1	4	4	1
11			6		3	3

1 The 1st selected
2 The 2nd selected
3 The 3rd selected
Sequence number over 3

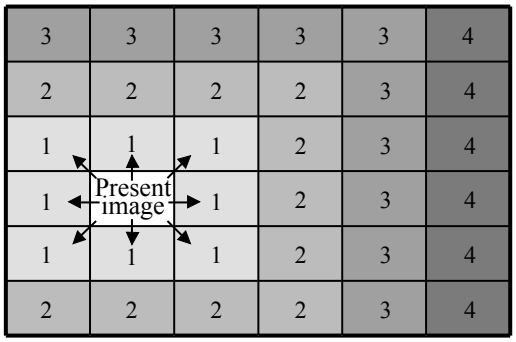
was often the first image being selected in the formal phase. Table 4-2 showed the position of the best image in the sequence of selected images along time. The participant 01M and 08M were not included in this analysis, because of the same reason in 4.4.1. Although the number of images selected by participants was 6.83 per step averagely, it was found that in 37.7% of all the steps, the best image was the first image selected, and in another 37.7% steps, it was the second or the third one selected.

The best image of a certain step was considered to be more appealing to the participant than the other selected images, the above phenomenon suggested that the participants tended to find out and select images which were more appealing to them earlier than the other selected images.

4) The spatial sequence of operation

It was known that 01M and 08M evaluate images in the fixed sequence, so the next image operated on was always the one on the right side of the present one. But for the rest participants who employed dynamic sequences, were there any rules in the spatial sequence of their operation?

The distance between two consecutive images in the operation sequence was defined according to the concept of Moore neighborhood[3], as shown in figure 4-13. The image positions were achieved from the mouse operation record, and then the corresponding distances from the previous operated image were calculated. The left figure in figure 4-14 showed the relative frequency distribution of the distances of the experimental result of all participants except 01M and 08M. It could be found that the frequency decreased



Numbers show the distance from the present image

Figure 4-13 Definition of the distance from present image to the next image operated

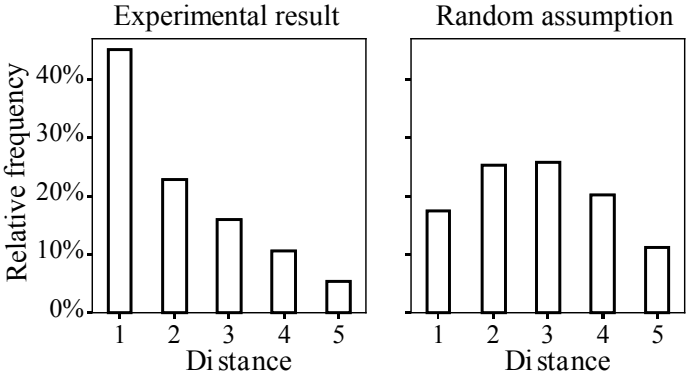


Figure 4-14 Relative frequency distribution of the distance from the present image to the next image operated

significantly along distance, which suggested that participants tended to choose an image which is nearer to the present one as the next one evaluated, and do not like to move his eyes to an image far away.

In order to provide a comparison, it was assumed that the sequence of images operated on was totally random. A computer program was used to generate a series of 20,000 random image positions (integers from 0 to 35), and the corresponding distances between two consecutive positions were calculated. The relative frequency distribution of the distance under the random assumption was shown in the right figure of figure 4-14. The peak of the distribution was at the distance of 3, which was significantly different from the experimental result. The comparison strongly supported the above findings.

4.5 Summary of Chapter 4

This chapter employed the IEC IW design system to simulate the common design process for exploring design problem solving behavior. The analysis was based on the time and spatial sequence of evaluation in the design process employed by the participants. This kind of information was not easy to achieve, and even harder to analyze based on numerical data in the previous researches that dealt with diverse and complex common design processes. The simulation model by IEC had extended the way for exploring design problem solving behavior.

It was found that the participants had adopted different design problem solving behaviors within each step, but there were still common design problem solving behaviors in their design process employing IEC.

Generally the participants were more certain about the decision of excluding disliked images (removing them from the interface) than that of selecting preferred ones, and many of them tended to remove disliked images first, and select preferred ones later. On the other hand, when selecting images, the best image which was considered more appealing to the participant was often selected earlier. These phenomena suggested that people tend to make the decisions which they are more certain about earlier, and try to figure out the harder decisions later. From the analysis it is understood when tried to identify several better images in each step, the participants employed the difference-reduction method, and it helped them to unfold the problem gradually.

The research also revealed that in the evaluation process, after evaluating a certain

image, the participants tended to choose an image in the interface which was neighboring to the present one as the next image evaluated. The design problem solving behavior suggested when making evaluation, people did not compare all images all the time. On the contrary, they often concentrate on evaluating adjacent images. Although this strategy might result in inaccurate evaluation, they were more convenient and effective for people, since they not have to move their eyes to places far away constantly.

Although the data of mouse movement and operation analyzed could not directly present the way of thinking in people's mind, but just phenomena of it, some design problem solving behaviors that closely related to the capability of human kind was revealed in this chapter. The participants have tendency to adopt these design problem solving behavior which were convenient for them when designing, and these design problem solving behaviors will resultantly influence the design results.

Notes

1. Radiance, developed by Lawrence Berkeley National Laboratory (http://radsite.lbl.gov/radiance/HOME.html)
2. Boxplot is a convenient way of graphically depicting the five-number summary, which consists of the smallest observation, lower quartile (Q1), median, upper quartile (Q3), and largest observation. The outliers were not shown in figures of this paper.
3. Moore neighborhood is used for the 8 cells surrounding a central cell on a two-dimensional square lattice in cellular automata.

References

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2) 高松伸: 建築設計における言語の役割に関する基礎的研究：設計者によるスケッチと発話を対象として, Doctoral dissertation, Kyoto university, Kyoto, Japan, 1997
3) Schön, Donald A.: The reflective practitioner: How professionals think in action. New York: Basic Books, 1983
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Chapter 5

Protocol Analysis on Designer's Verbal Report in Simulated Design Process of Interior Works Using IEC

5.1 Protocol analysis for exploring design problem solving behavior

5.2 Past studies

5.3 Method

1) Verbal report

2) The encoding and segmentation of utterance

5.4 Analysis of the evaluation criteria in utterance

1) The criteria of OBJECT and EVALUATION

2) The criterion of PROPERTY

3) The continuity in evaluation criteria

5.5 Analysis of whole design process employing IEC

1) Flow of image styles in the design process

2) The consistency of solution condition

3) The general problem solving stages in the design process

5.6 Summary of Chapter 5

5.1 Protocol analysis for exploring design problem solving behavior

This chapter presents the second part of the research on the design problem solving behavior revealed in a simulated design process by the IEC IW design system. Different from chapter 4, the method of protocol analysis was employed to explore people's thinking in the simulated process.

In chapter 4, analysis of evaluation process was carried out based on record of mouse movement and operation of the participants. This kind of behavior was the presentation or result of the thinking process in their mind. Although some phenomena in the time sequence and spatial sequence of evaluation operation were revealed, is still not clear how the process was carried out in the participants' mind, especially what kind of evaluation criteria they had used, and how they gradually formed the design ideas through the whole design process employing IEC.

In order to explore the design problem solving behavior in depth, analysis should be performed based on direct information of the thinking process in people's mind. In this chapter, the verbal reports of 8 participants achieved from a parallel experiment of chapter 4 were analyzed by the method of protocol analysis.

Protocol analysis is a methodology for eliciting verbal reports of problem solving sequences as a valid source of data on thinking. It has emerged as one of the principal methods for studying thinking in cognitive psychology, cognitive science, and behavior analysis. The central assumption of protocol analysis is that it is possible to instruct subjects to verbalize their thoughts in a manner that doesn't alter the sequence of thoughts mediating the completion of a task, and can therefore be accepted as valid data on thinking.[1)2)] It was expected that the method could clearly reveal the detail and general strategies of the process of people's thinking when interactively working with the computer during the design process using IEC.

5.2 Past studies

There are many researches that employ protocol analysis to reveal design problem solving behaviors in design tasks.

Peter Rowe (1987)[3)] tried to explore designer's action through case studies of three actual examples. The case studies involved lengthy periods of observation and

documentation, where designers described their activities in detail with the aid of sketches and other drawings. The aim of these interview sessions was to faithfully reconstruct the sequence of steps, moves and other logical procedures that were employed. The case studies provided material and variation to serve as an informative backdrop for further theoretical discussion.

Takamatsu (1997)[4] employed the method of protocol analysis in studying the design process of a real project, which lasted for three months. Through the analysis of the verbal report of the designer when explaining the sketches he had drawn, characters of different design phases were clarified. It was understood that it is possible to explore the evolving process of design object and theme through analyses of the utterance appeared in the verbal report and their inter-relationship.

Zhou, Munemoto and Yoshida (2006)[5] performed an interview on preference of interior works in China. The relation between the selection of living room interior decoration by Chinese people and the reason they reported was analyzed by the association rules. It was found the selection procedure of living room interior decoration was based on the coordination between plain and decorated, and the process led to the balance point between them.

Do and Gross (2001)[6] discussed the use of freehand diagrams in architectural design. They found that most empirical studies of design problem solving have been examinations of design protocols. They also found that many protocol analysis studies of design problem solving behavior collected both verbal and graphical data. The research was concluded with a discussion of the requirements of computational support of the diagram in design thinking.

Dillon and Sweeney (1988)[7] employed protocol analytic techniques to investigate the complex problem-solving nature of design and to demonstrate the crucial role of human factors in the development of interfaces which facilitated the designers in their task. 16 mechanical designers were separated into two groups to finish a design problem. Half of the tape-recorded verbal protocols were examined. A model of the cognition of design was proposed which indicated that the distinct nature of the engineering designer's task merits specific attention.

The above researches employed protocol analysis in revealing design problem solving behaviors in the manual design process of people, and that of people when using CAD tools. Differed from the past studies, the present research employed protocol analysis in a simulated design process by IEC, which was a simplified, controlled and well-structured

model of common design process, and easier for analysis and compare. It was supposed that the results of the analysis could be helpful in understanding of the manual design process of people.

5.3 Method

The experiment of this chapter is parallel with the one of chapter 4. As the experimental process of chapter 4 was going on, verbal reports of 8 participants were collected simultaneously, and analyzed in this chapter. So the analyzes of these two chapters were based on the same design processes employing IEC.

1) Verbal report

During the experiment, a general method of "think-aloud with retrospective reports" recommended by Ericsson and Simon (1993)[1)] was adopted. The think-aloud method was employed to collect utterance on the participants' thinking. The retrospective report was also employed, although it could be incomplete for long duration cognitive process, it could more clearly convey the general structure of the process.

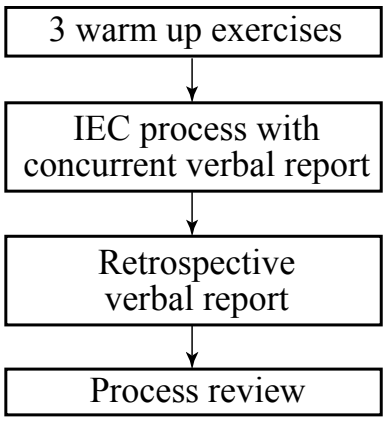

Figure 5-1 Flow of experiment with verbal report

Before the design process, a common warm-up procedure was employed. The participants were instructed to "think aloud" during the whole problem solving procedure. "Think aloud" means that they should speak out everything they are thinking continuously, just like they are alone in the room speaking to themselves. The participants were told that if they would be silent for any long period of time, they will be reminded to keep talking. After the instruction, the participants were asked to do three warm-up practices, and speak out everything they are thinking at the same time. After each practice, the participants were instructed to recall the process how they solved the problem, and report all about their memories of solving the problem in the sequence of occurrence. Through the warm up procedure, the participants would be comfortable in thinking aloud and provided reports of the same information in both utterance and retrospective reports.

During the design process using IEC, the participants were asked to select images as instructed, and "think aloud" at the same time. We took video of the interface during the process, together with the sound of the verbal report[1].

After the design process, the participants were asked to make retrospective report on the whole design process using IEC, and it was also recorded.

Finally the participants were asked to view all the steps of their own process, and comment on it.

Verbal reports of eight Chinese speaking scholars and students were analyzed. They were originally in Chinese, and translated into English by the author.

2) The encoding and segmentation of utterance

The utterance provided clues on the problem solving tactics of how the participants evaluate images one by one, and was analyzed in this research as a major source of information. The utterance of the 8 participants were listened to by the author sentence by sentence, and segmented and encoded for analysis[1)].

The participants' utterance and activities were identified into consecutive design problem solving behavior records according to following situations:

1) The participants made comment on an image. In this situation, they may or may not operate on the image. This situation took place most often.

2) The participants operated on an image without any comment.

3) The participants stopped at a certain image, thought for seconds without any comment or operation.

By this method, altogether 2307 design problem solving behavior records along the time sequence in the 8 participants' design process using IEC were identified. The record number in each step of the participants varied from 9 to 46.

In a certain record, usually the participants used a simple sentence to comment on the image, such as *"The sofa is too red"*, *"It is harmonious, good"* or "too cold" and so on. These sentences were the evaluation criteria, and were divided into the following three variables in the records:

OBJECT: such as “sofa”, “floor”, and “all” (the whole image). If the participants did not mentioned about which part they were talking about when commenting, the phrase “not mentioned” was be used.

PROPERTY: the participants used to describe the OBJECT, such as “red”, “dark”, “harmonious”. Phrases which have the same meaning were encoded as the same PROPERTY, for example, “a little dark” and “not bright enough” were both encoded as “dark”.

EVALUATION: the participants made of the OBJECT. It could be positive (+1) or negative (-1), sometimes it was not clearly mentioned.

If the participant commented more than one sentence on an image, variables like OBJECT2, PROPERTY2, EVALUATION2 and so on would be used.

Beside the evaluation criteria, the following parts were also included in the record.

BEHAVIOR: such as “think”, “compare”, “supposition” (e.g. the participant said the image could be better if certain adjustment be taken).

OPERATION: “remove” and “select” of the images.

COMMENT: include comments that could not be fixed in the above structure. Phenomena found by the author were also recorded in bracket.

Table 5-1 shows part of the design problem solving behavior records (For all the verbal report of all participants, please refer to Appendix D) It could be read from the table that in the 3rd step, the participant 03F (participant No. 03, female) commented at the beginning that *“This step is better”*. She commented on an image that *“the white sofa is good”* firstly, but she did not operate on it (time sequence No. 1), then she removed another image because *“This one is too blurry”* (time sequence No. 2), then she selected a different image since *“I like the light green tone”* (time sequence No. 3), and so on. Through the segmentation and encoding, the utterances were ready for further analysis.

It should be pointed out the BEHAVIOR, OPERATION were not analyzed in this research. They were included in this paper to show the complete information of design problem solving behavior records achieved.

Table 5-1 Part of design problem solving behavior records (03F, step 3)

Step	Time sequence	Evaluation Criteria						BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
		OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2			
3	1	sofa	white	1						this step is better
3	2	nm	blurry	-1					r	
3	3	nm	light green	1					s	
3	4								s	shown before
3	5								s	(same as above)
3	6	nm	light color	1					s	
3	7	nm	light color	1				cp	s	
3	8	nm	green	1					s	
3	9	sofa	khaki	-1					r	
3	10	sofa	red	-1					r	
3	11	nm	tone	-1					r	(red sofa)
3	12	nm	tone	-1					r	(red sofa)
3	13	sofa	brown	-1					r	
3	14	sofa	brown	-1					r	
…	…	…	…	…					…	…

nm=not mentioned cp=compare r=remove s=select

5.4 Analysis of the evaluation criteria in utterance

1) The criteria of OBJECT and EVALUATION

The OBJECT mentioned in the utterances of all participants (Figure 5-2) were two sorts, one was the “all” and “not mentioned”, which did not refer to certain factors in the scene; the other one included the “sofa”, “floor”, “wall”, “door”, and “ceiling” which referred to single factors. This result revealed that the participants evaluated images by both single factors and general appearance.

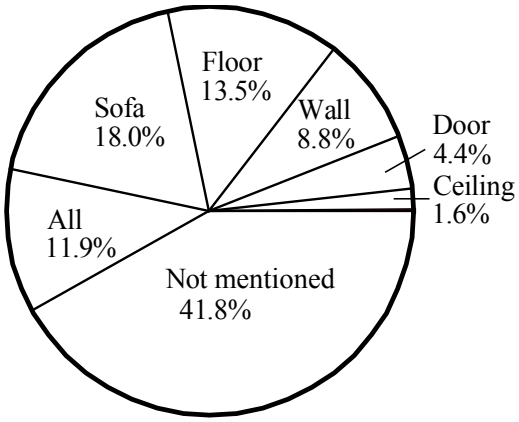

Figure 5-2 Relative frequency of OBJECT

For OBJECT referred to single factors, it was found the frequencies of “sofa”, “floor”,

and “wall” were significantly higher than that of “door” and “ceiling” (Figure 5-2), which suggested the sofa, floor and wall were more often considered by the participant when evaluating than the door and ceiling. In fact, 02M said he *“paid little attention on the door, and the door was always the last one considered”*. The other two participants who mentioned the door in retrospective report (01M and 08M) said *“If the door was too much ugly, I would remove the image”*.

This phenomenon could be tentatively explained by the location and property of each OBJECT. In the images, the floor, sofa, and wall located in the middle part, so they tended to be more often considered than the door that located near the edge. In addition, because the sofa could easily be identified as the central object, its frequency was higher than that of the floor and wall, which were more likely to be regarded as the background and sometimes not specified clearly by the participants.

Although the ceiling located in the upper-middle part of the image with a large area, it was illuminated by light reflected by the floor[8)] and usually darker than other parts. Furthermore, material samples of it in IEC are generally similar according to the situation of Chinese interior works market[1)]. These could be the reason why the ceiling was seldom mentioned by the participants.

If consider the OBJECT and the EVALUATION together (Figure 5-3), it is found for the OBJECT referring to single factors, the EVALUATION are mainly negative, but for “not mentioned” and “all”, there were much more positive EVALUATION. The result revealed that the participants tended to give negative evaluation to an image because of a disliked single factor, and were more likely to give positive evaluation considering the general performance. Participant 01M mentioned that there was a “veto by one vote” effect, which means a disliked factor will deny the whole image. A few participants mentioned in the retrospective report that the disliked single OBJECT were removed, and the rest survived, (Please refer to 4.3 in this paper) which could also support the present conclusion.

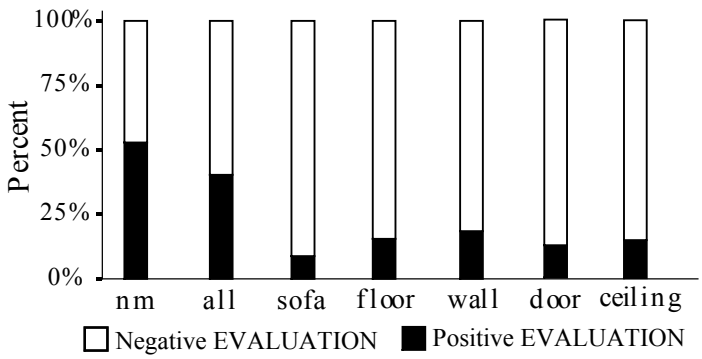

Figure 5-3 Relative frequency of EVALUATION of OBJECT

2) The criterion of PROPERTY

8 participants had employed 123 words or phrases for PROPERTY in the process. The frequency distribution of the words roughly answered to the Zipf's law[2] which states that only a few words are used very often, many or most are used rarely (Figure 5-4). The 10 most often used PROPERTY are shown in table 5-2. They are all color, brightness and harmony related adjectives.

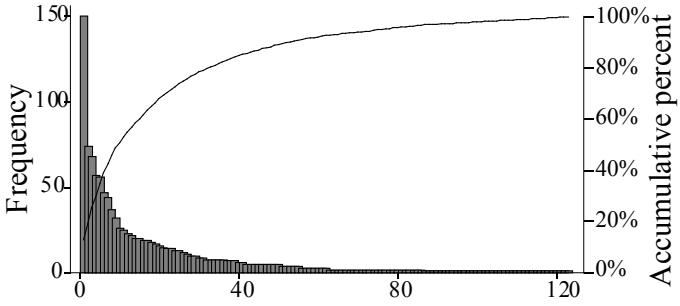

Figure 5-4 Frequency of words/phrases of PROPERTY along frequency rank

Table 5-2 The 10 most often used PROPERTY

Rank	PROPERTY	Frequency	Percent
1	dark	150	12.89
2	red	74	6.36
3	disharmony	68	5.84
4	ugly	57	4.90
5	green	56	4.81
6	harmony	47	4.04
7	showy	44	3.78
8	bright	37	3.18
9	pink	32	2.75
10	warm	26	2.23

The calculation of percent did not include records without any property mentioned.

The numbers of PROPERTY used by each participant were compared in figure 5-5. It is found generally the two architecture majored students used more PROPERTY to describe the images. Since they were trained in the aesthetic design area, they could describe the images more accurately. It could also be found 05M also used a lot of expressions for PROPERTY in his verbal report too. In fact 05M tried to evaluate images by their styles. He used criteria such as *"This one is good for me as an engineer"*, *"lovely, good for child"*, *"feels like live in Europe"*, *"middle class"*, *"commercial space"* and so on, which is quite different from other participants (Table 5-2). It was

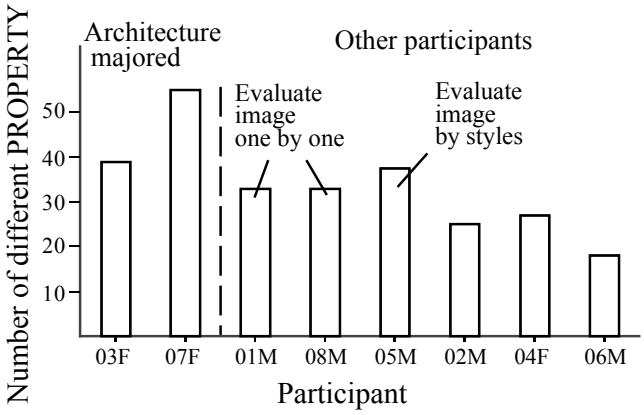

Figure 5-5 PROPERTY number used by each participant

supposed that since he was trying to find proper descriptions of the images, he used more expressions for PROPERTY than the others.

3) The continuity in evaluation criteria

It was found in the protocol records that the evaluation criteria and the OPERATION were often used continuous along time sequence. For example, the participant would continuously remove several images with disliked floors, or select a few images because they were bright. This kind of phenomenon can be revealed by the following analysis of continuity in OBJECT, PROPERTY and EVALUATION in the protocol records along time sequence.

Variables of continuity were calculated for OBJECT, PROPERTY and EVALUATION to evaluate frequency of the continuity of two consecutive records as shown in table 5-3. For example, in the consecutive records No. 2 and 3, the OBJECT were both "not mentioned", so the "Continuity of OBJECT" of record No. 3 was 1, which means that the OBJECT of record No. 3 was the same as the previous one. It could be found that the participants used the continuous evaluation criteria frequently. The relative frequencies of continuities of all participants were shown in figure 5-6, and labeled as "experiment".

Table 5-3 Part of the continuity calculation of the experimental data (Participant 03F, step 3)

Time sequence	OBJECT	Continuity of OBJECT	PROPERTY	Continuity of PROPERTY	EVALUATION	Continuity of EVALUATION
1	sofa	0	white	0	1	0
2	nm	0	blurry	0	-1	0
3	nm	1	Light green	0	1	0
4		0		0		0
5		0		0		0
6	nm	0	tinge	0	1	0
7	nm	1	tinge	1	1	1
8	nm	1	green	0	1	1
9	sofa	0	khaki	0	-1	0
10	sofa	1	red	0	-1	1
11	nm	0	tone	0	-1	1
12	nm	1	tone	1	-1	1
…	…	…	…	…	…	…

r=remove s=select nm=not mentioned

In order to demonstrate the significance of continuity in evaluation criteria, a comparison could be provided. If it was assumed that there was no such effect of continuity, and the values of these variables appeared in the same frequency as the experiment but in random sequence, the probability of continuity could be calculated by the following expression:

$$\text{Probability of continuity (radom assumption)} = \sum_{i=1}^{n} p_i^2 \quad (1)$$

Where p_i = relative frequency of each variables in experimental data, for example, the relative frequency of "floor" and "sofa" of OBJECT.
n = number of different values of the variable.

Considering that each participant might have different sets of expressions to describe the images, the probability of continuity of PROPERTY (random assumption) was firstly calculated for each participant, and then averaged by the weight of behavior record numbers of each participant. The probabilities of continuity under random assumption were also provided in figure 5-6 for comparison.

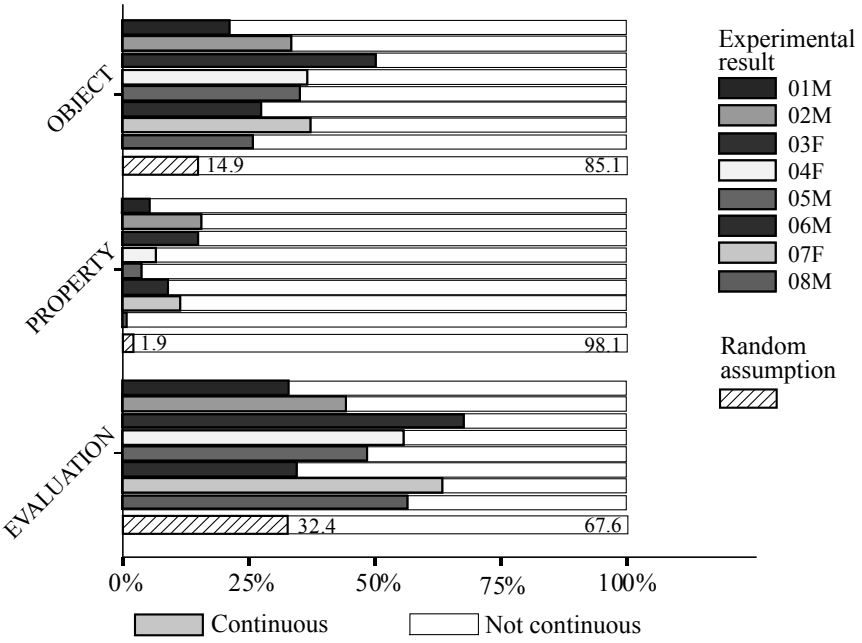

Figure 5-6 Relative frequency of continuity (Comparison between experimental result and random assumption)

It was found the relative frequencies of continuity of all participants were generally much higher than the continuity probabilities under random assumption, especially for OBJECT and PROPERTY. The result revealed the participant tended to use same evaluation criteria and do the same operation continuously during the evaluation process, or

they tended to group images with same properties to evaluate together. This kind of behavior could be considered as an effective method for people since they could use same criteria to evaluate several images, and did not have to change their mind constantly. The continuous evaluation criteria suggested that people often used the temporary criteria in their mind and the general image of all the design alternatives in their memory to make evaluation.

If we check the number of expressions used for PROPERTY in figure 7, it could be found that among the non-professionals, 01M and 08M used more expressions than other participant (except 05M, who used a different criteria system). Since these two participants evaluated images in the fixed sequence, they might be forced to change their mind according to the property of the next image constantly, so they used more expressions than the others.

5.5 Analysis of whole design process employing IEC

Besides the means of evaluation the participants adopted in each step explained above, it was also important to know how people solve the design problem gradually in the whole process. From the verbal reports, it was understood although the participants can not control the design process using IEC directly, they had adopted certain strategy passively corresponding to the design alternatives provided by computer from generation to generation. Different from those adopted within each step, this kind of design problem solving behaviors referred to the general problem solving strategies, and was always revealed in the retrospective report.

1) Flow of image styles in the design process

When recalling the whole process, some participants realized there were some styles of images appeared in the process, and reported the changes of styles along the process in their retrospective report. 03F said that *"...There was a good one with white wall at the beginning, I liked it, but it was not shown later. Then there were always two styles of images shown in each step, one was pink, the other was light green, gradually I was more inclined to the pink style, and the light green style did not survive..."* 05M reported that *"...I tended to select several styles, such as neutral, lovely, natural, and warm. Maybe because they were too different from each other, it was hard to find some good combination..."* 07F had reported a clear flow of image styles she had selected in her process, *"...At the beginning,*

generally, I selected images with blue floor and light sofa, and red sofa with light background. Gradually, the blue floor with light sofa survived. And some new idea of gray tone appeared. So generally the sofas were light. Sometimes I selected blue sofas, but it had to work with surroundings of the same tone, and it did not survive until the end. Then I almost just selected these two styles, the blue floor ones and gray ones for steps. At the end, a new idea appeared with brown sofa and gray back ground, and it was fairly good…"

The flow of image styles reported by 03F and 07F was shown in figure 5-7 and 5-8. From the figures, it could be found that different image styles competed with each other, some survived, evolved, and produced new variations, while others lost the competition, and did not survive until the end. It demonstrated how design ideas were generated, developed, survived through comparison, and transformed into new ideas.

It was also noticed the flow of image styles along the process was similar to the way design ideas were developed in common design processes. The phenomenon strongly supported the validity of the simulation of common design processes by the IEC IW design system employed in this dissertation.

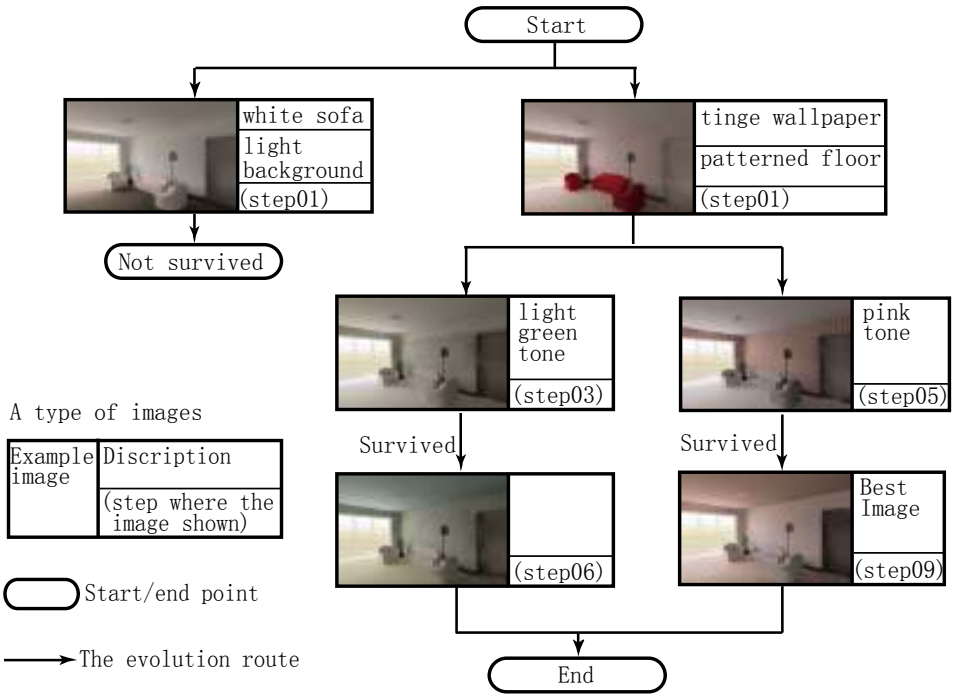

Figure 5-7 The process flow in the retrospective report of participant 03F

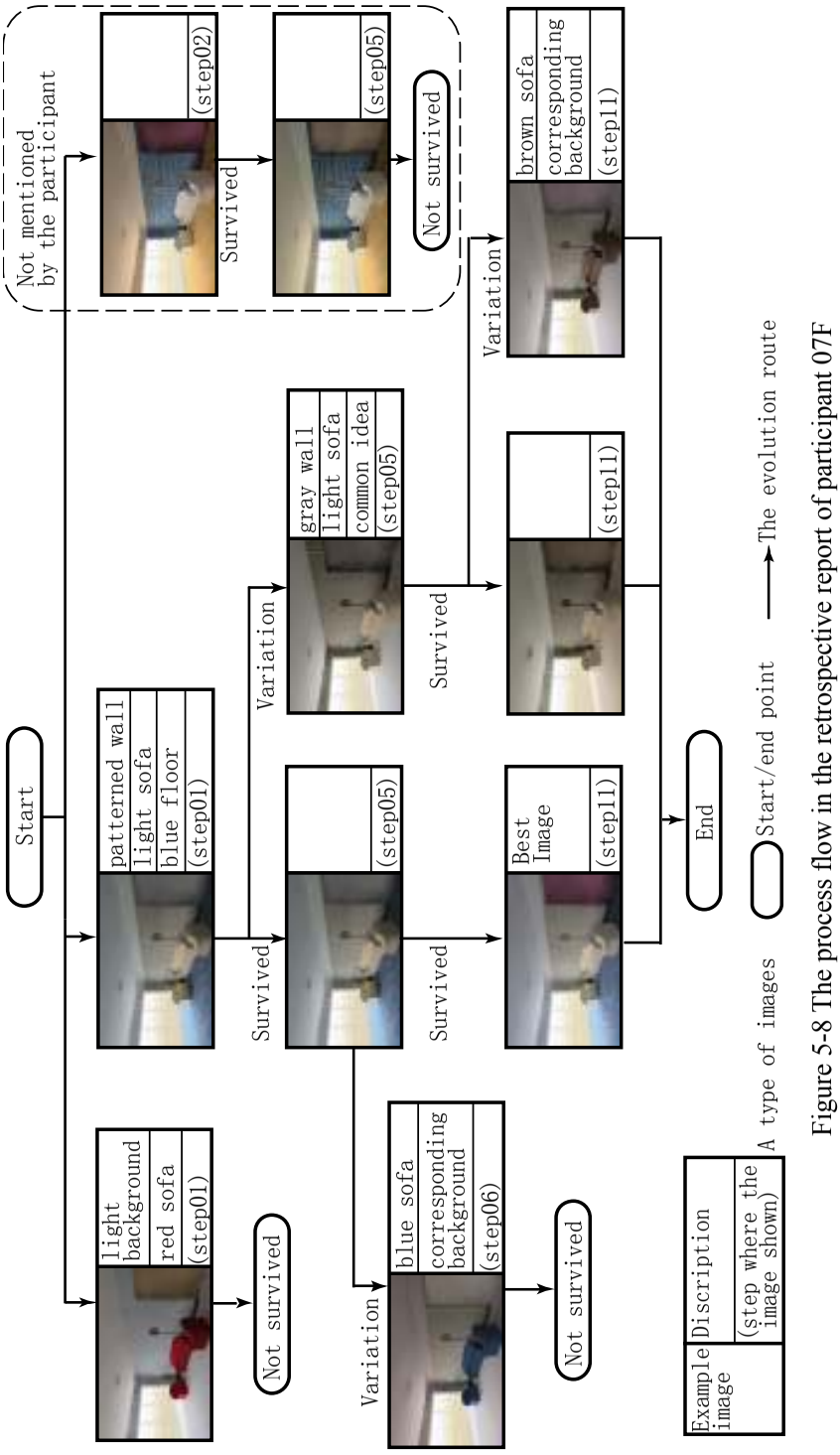

Figure 5-8 The process flow in the retrospective report of participant 07F

2) The consistency of solution condition

The solution condition refers to the aim of design, and it is the result of ideas lie in designers mind. Different from the temporary evaluation criteria, solution condition is comparatively constant and gradually clarified through the whole process.

After the design process, the participants were asked to review the whole process of their own, and comment on it. It was found most of the participants confirmed that the images were gradually getting better step by step, and they were generally satisfied with the design results. The result revealed there was general consistency of solution condition through the process, and most of the design process using IEC evolved successfully. On the other hand, some participants reported that they were not sure about their choice of the best image in some steps, which suggested the participants' idea had drifted to a certain extent.

It was also interesting to notice that when 02M reviewed the process of his own afterwards, he noticed that there were significant changes in the style of the best images during the process. He explained that *"I selected this kind image for steps, and got a little bored about it, so I needed some new ideas."* This phenomenon suggested that the common preference of people in new ideas could be a dynamic factor in the solution condition.

3) The general problem solving stages in the design process

In the design process employing IEC, the design alternatives evolved gradually from random combinations of interior works design factors to the final design results. Correspondingly, at the beginning of the process the participants commented *"The images varied greatly"*, *"There were many different combinations"*, and so on; as the process went on, they commented that *"the images are getting similar"*, and *"not easy to make decision"*, later in the few steps before the end, many participants asked the experimenter to confirm the end criteria, and mentioned "*The images do not change very much now"*, *"I hope to see the combination I want in the next step"*, and *"If no new ideas show, I would like to stop the process"*.

Correspondingly, the participants had adopted different ways of evaluation, which could be revealed by the general problem solving strategies summarized by them in the retrospective reports. Some examples of the retrospective reports were listed below.

02M: "…*Firstly I removed green floors which looks like swimming pool, the vertical wall texture was good, floor too red was generally removed, sofa too red was bad, ...I liked comparatively lighter colors, colors too much contrast were not so good..."*

03F: "…*I firstly removed the images too much showy and glaring, then I searched for preferred wall color and pattern, concentrate on the wall, there were several different combinations of other factors, and I chose one out of them..."*

04F: "…*I removed the showy ones at the beginning. In later steps, I started from the floor, and removed disliked floor, then removed the bad walls, and then sofa, so I removed the bad single factors, and then I evaluated by generally feeling…"*

05M: "…*There were many different choices at the beginning, so it was hard to make decision. Later they were getting similar, and the parts of the images were close to my preference, but the combinations still needed some development…"*

The retrospective report revealed the participants used different design problem solving behavior through the process (figure 5-9). For example, 03F concentrated on a certain OBJECT, and search for proper combinations, while 04F removed single OBJECT not good one after another, and the good ones remained. But it was found there were general stages in the participants' design problem solving behaviors. They usually removed the colors too strong or ugly firstly, and then considered the single OBJECT in the images,

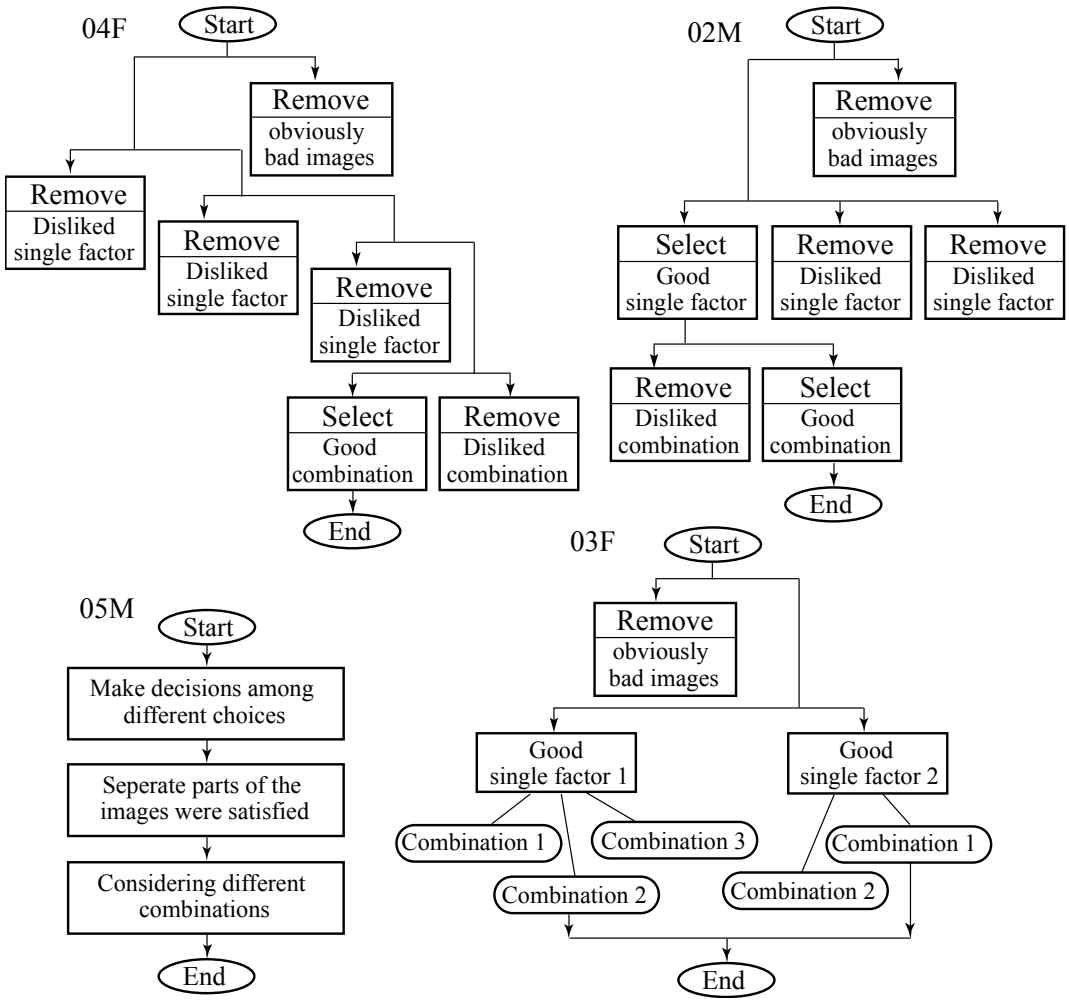

Figure 5-9 The general problem solving flows of 02M, 03M, 04F and 05M revealed in retrospective report

such as the wall, floor, and sofa, at last, they considered the general effect of the image, like color harmony and brightness.

It was noticed that some participants mentioned that their design problem solving behavior changed gradually as mentioned above from step to step (04F, 05M), while some of them reported the above stages as design problem solving behavior sequence within each steps. 02M said *"I used this kind of evaluation sequence in each step all the way."*

The phenomenon was understood when considering the mechanism of IEC method. At the beginning, since the combinations were generated randomly, many colors could be obviously unacceptable for the participants and were removed. In later steps, many acceptable colors were preserved by GA, the participants were able to consider the effect of the single factors more critically. As the process went on, new combinations of the preferred factors were generated by crossover of GA, and allowed the participants to evaluate the general effect of the images more specifically. So the participants' design problem solving behavior changed gradually as the general quality of the images improved from generation to generation.

On the other hand, within each step, there were always some new materials generated by the mutation of GA, and they were often not so good for the participants. So the participants might remove them firstly. After that, the rest images might still have different flaws comparing to each other, even the images or the single factors of them had survived from previous steps. So the participants still had to use certain procedure to make the evaluation.

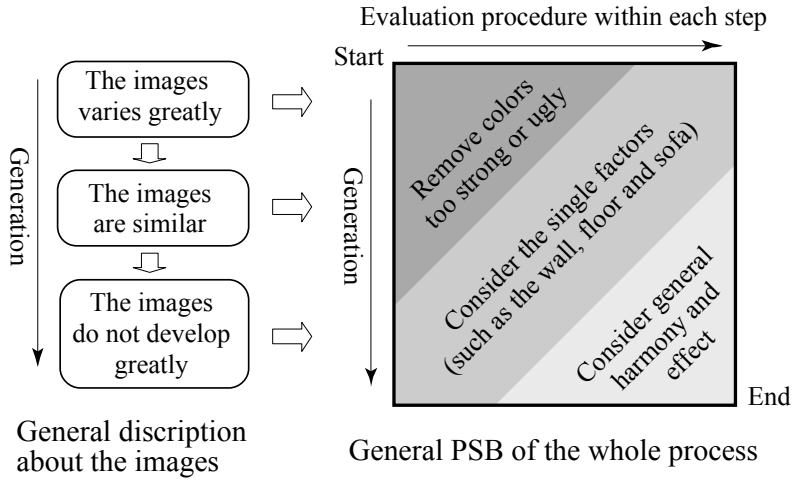

Figure 5-10 General stages of design problem solving behavior in whole design process employing IEC

Based on the above analysis, a general flow of stages of the design problem solving behavior was shown in figure 5-10. The figure illustrated that as the images evolved gradually along the process, the participants' design problem solving behavior also changed gradually and correspondingly. The figure also showed that there were no clear boundaries between the three stages, the participants switch between them gradually.

5.6 Summary of Chapter 5

This chapter continuously employed the IEC IW design system to simulate common design processes for exploring design problem solving behavior. Based on the verbal report achieved from a parallel experiment of the experiment in chapter 4, the protocol analysis revealed the way of participants' thinking in their mind when solving the interior works design problem. Two kinds of verbal report, the simultaneous utterance and the retrospective report, were analyzed, and they provided evidence both on the problem solving tactics which was employed within each step, and the general problem solving strategies which was employed through the whole process.

Through protocol analyses of the evaluation criteria in utterances, it was revealed different parts of the images had different influence on participants' evaluation, and the participants always gave negative evaluation to an image because of a single bad factor. It was also revealed when evaluating images one by one, people tend to use same evaluation criterion continuously for several images, then switch to another criterion. The use of continuous criteria is more convenient and effective for the participants, since they do not have to change their mind constantly.

Interior works design problem is an ill-defined problem, and people have to define and redefine the problem when designing to gradually approach the solution. Previous researches revealed the phenomena of "constancy of appreciation" and "selective inattention"[9] of professional designers, which mean at different moments in the design process, attention of designer is fixed exclusively on particular aspects of the problem that seem to warrant consideration, and other problems were temporarily ignored. These phenomena are consistent with the continuity in evaluation criteria found in this research that the participants evaluated certain aspect of several images continuously, and then switched to another criterion. In addition, since the non-professional participants in this research had not been trained in designing, and their design problem solving behavior remained in a natural status, it could be concluded the design problem solving behavior of

"constancy of appreciation" and "selective inattention" were not gained from professional training, but employed naturally in design processes by common people.

Different from the evaluation criteria switched dynamically, the design solution condition which directed the whole process was revealed general consistency by the retrospective report. At the beginning, the solution condition was not clear. The participants compared it with design alternatives provided by computer, and found the temporary evaluation criteria. As the process went on, quality of design alternatives were improved gradually, and the solution condition became clearer step by step. Being two kinds of ideas in people's mind, the temporary evaluation criteria were produced from the permanent existing solution condition, and helped the solution condition to be developed.

From the analysis of the retrospective reports, it was also revealed that the participants had employed different strategy to solve the interior works design problem, but generally there was a certain sequence of stages. The participants usually remove the colors obviously unacceptable for them firstly, and then focused on the single factors in the interior scene, after that, they would evaluate images by the general feeling of the whole image. This sequence was found used both within each step, and between generations. As the images provided by computer was getting better, it was possible for the participants to do more specific evaluation. This kind of refining strategy could be helpful for understanding the episodic procedures of common design processes, especially those in color and texture related design processes.

As a simulation of common design procedure, the research employed a controlled and well-structured model of design process, which needed no professional knowledge or experience to proceed. Benefit from this model, the authors could explore the design problem solving behavior of common people in a comparable condition, and find the commonness and difference among the participants. In addition, since the design process using IEC could be finished within an hour, it is possible to employ the utterance which can provide reliable data on the problem solving tactics, and explore how people solve design problems in detail. This research provided a different view angle on design problem solving behavior, and the findings could be complementary to those achieved from researches of common design processes.

Notes

1. Camtasia Studio, developed by TechSmith, was used in the experiment to record the video of the interface and audio of verbal report. (http://www.techsmith.com /camtasia.asp)

2. The Zipf's law stated that, in a corpus of natural language utterances, the frequency of any word is roughly inversely proportional to its rank in the frequency table.

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Chapter 6

Discussion and Conclusions

6.1 Findings of design problem solving behavior

1) Color-and-texture-related design problem solving behavior

2) Personal differences in design problem solving behavior

3) Design problem solving behavior common to participants

4) Conveniency and efficiency of problem solving

6.2 Discussion and Perspective

6.3 Future Research

As a research in design methodology, the main purpose of this dissertation was to approach the problem solving behavior in design process. Chinese residents' interior works design was selected as the design object. The intelligent method of IEC was used to simulate design process and induced the problem solving. Consequently, IEC method was applied to solve real design problem of interior works for Chinese residents.

Many previous researches had focused in the area of design problem solving behavior, and tired to clarify it through analysis of real design processes. But because of the varied conditions of different design problems, it is not easy to compare in the design problem solving behavior of different people correctly. The uniqueness of this dissertation lies in that the simulated design process by IEC provided the same design problem and condition to different participants, and allowed for analysis and comparison of their design problem solving behavior based on experimental results.

IEC is a method in which human and computer cooperate in subjective problems. It was employed in this dissertation as the core method. At the beginning of the dissertation, IEC method was regarded as the objective of research, and applied in interior works area to solve design problems, and then its efficiency was evaluated by Chinese residents. After that, the developed IEC IW design system was employed as a simulation method, and design problem solving behavior were explored for approaching the design problem solving behavior in manual design processes. As the researches proceeded one by one, an increasing emphasis on human in the interactive process can be seen clearly. As a research in architecture and urban planning area, the dissertation gradually approached the design problem solving behavior, which is one of the fundamental problems in the area of design methodology.

Analysis of the same design process employing IEC was performed based on different information, and by different method. At first, information of the participants' behavior, such as the time and spatial sequence of evaluation operation, was studied. Then verbal report of the participants, which was directly related to the thinking process of them, was collected, encoded, and analyzed by the method of protocol analysis. The observed evaluation behavior could be considered as the phenomenon of design problem solving behavior, and the verbal report reflected the inner processing in people's mind. These two kinds of information, behavioral and psychological, were both important in this dissertation, they provided complementary data to each other, and presented together a general view of the design problem solving behavior that happened in the design process employing IEC.

6.1 Findings of design problem solving behavior

Through analysis of design processes employing IEC of 8 participants, their design problem solving behavior had been explored, including both the general problem solving strategies and the problem solving tactics. These findings can be discussed in the following aspects.

1) Color-and-texture-related design problem solving behavior

The following design problem solving behavior found in the experiment was considered closely related to the characters of the interior works design which consisted of color-and-texture combination. These findings could be significant in the problem solving process of this kind of object.

Statistical analysis revealed that the participants evaluated images by both preferences on separated single factors and the total appearance of the scene. For the single factors, the frequency of sofa, floor and wall were significantly larger than that of door and ceiling. The result revealed that different parts of the image have different influence on participants' evaluation. When mentioning about a single factor, the evaluation of the image was mainly negative, which implied the participants tended to deny the whole image because of a disliked single factor.

The adjectives used to describe the mentioned factor or the whole image in evaluation criteria were usually color, brightness and harmony related, and their frequency distribution roughly answered to the Zipf's law. It was also indicated that the amounts of different adjectives used by each participants were different, the two architecture majored students employed more adjectives, which suggested that since they were trained in designing, they can describe the images more accurately.

2) Personal differences in design problem solving behavior

Diversities in problem solving behavior were revealed from the experiment. The participants adopted different design problem solving behaviors of their own in the design process employing IEC. For example, the participants employed two kinds of spatial evaluation sequences, some of them evaluated images in a fixed sequence one by one, from left to right and top to bottom, while the others evaluated in a dynamic sequence. In addition, for those who employed dynamic spatial sequence, some tended to remove disliked images

first, and select later, but others mainly focused on selecting images, and only remove images occasionally. On the other hand, differences were also found in their general problem solving strategies, such as those shown in figure 5-9.

Although these design problem solving patterns differed from person to person, they were found generally consistent in certain participant's process. These design problem solving behavior patterns could be said displayed differences in personal preference and way of thinking, and influenced the final design results.

3) Design problem solving behavior common to participants

Besides the diversities in design problem solving behavior, commonness was also revealed in the experiment of different participants. These findings are discussed in the following aspects.

A. general problem solving stages

It is known from past researches that the unfolding of the design process is usually performed in an episodic way with "to and fro" movement between areas of concern. Being an interactive process where people can not control the evolution of design alternatives directly, the "to and fro" movement can not be revealed in the simulation by IEC, but a staged strategy of problem solving was discovered in the experiment.

Analysis of participants' retrospective report showed that although the participants employed different behaviors to solve the design problem of interior works, their behaviors could be generalized into three consecutive stages: "Removing colors too strong or ugly", "Consider the single factors", and "Aim for general harmony and effect". These stages were found to take place both within each generation and from generation to generation with no clear boundaries between them. These stages suggested that as the design alternatives generated by computers gradually getting better along the process, it was possible for the participants to evaluate the images more specifically.

B. Difference reduction

The tasks of the participants in each step of design process employing IEC were to select several images. The participants tended to remove disliked images firstly, which they were more certain of, and select preferred images later. On the other hand, the best images

of each step, which were more appealing to the participants, were always selected earlier than other preferred images. These phenomena supported that the participants usually make decisions they were more certain of firstly, such as remove disliked images and select more appealing images, then focused on comparing the remaining images, and make the harder decisions later. These tactics allow them to gradually approach the goal of dividing all images into the groups of selected ones and not selected ones, and were consistent with the method of difference reduction.

When examined the general problem solving strategies, the 3 stages explained above could also be viewed as a process of difference reduction, in which the images too far away from the participants' idea was removed at first, and the design alternatives gradually getting close to the design goal.

C. Constancy of appreciation and selective inattention

"Constancy of appreciation" and "selective inattention" mean at different moments in the design process, attention of designer is fixed exclusively on particular aspects of the problem that seem to warrant consideration, and other problems were temporarily ignored. From experiment, it was found the participants often evaluated certain aspect of several images continuous in their design process employing IEC. The phenomenon of continuity in evaluation criteria is considered consistent with the "constancy of appreciation" and "selective inattention".

Past research explained the "constancy of appreciation" and "selective inattention" as the basis of "reflection on action", which is one of the professional problem solving ways. The non-professional participants in this research were not trained in designing, and their design problem solving behavior remained in a natural status, so it could be concluded the "constancy of appreciation" and "selective inattention" were employed naturally in selection processes by non-professionals.

4) Conveniency and efficiency of problem solving

When trying to solve ill-defined problems in the process of design, it is not possible for people to test all of the possibilities, since there could be numerous of them. Efficient way must be adopted to solve the design problem. In this dissertation, some design problem solving behaviors convenient for the participants found in the experiment were considered efficient, since design results could be achieved easier when adopting them, or they could

be said short cut of problem solving.

For example, the participants were found had tendency to evaluate adjacent images in the interface, and did not often pay attention to far away images. This was convenient for people because they did not have to move their eyes to far away place constantly. It was also found the participants often employed same evaluation criterion continuously for several images, than switch to another. This is convenient because people did not have to change their mind constantly. The 3 stages of general problem solving strategy revealed in retrospective report displayed a property of conveniency too, since ugly or too strong colors were easy to identify, and removing them is helpful for comparing the remaining images.

These design problem solving behaviors were often employed by the participants, even if they did not aware of the conveniency of them. The property of conveniency could be said a significant criterion when people choosing problem solving strategies in the design process employing IEC.

6.2 Discussion and Perspective

Benefit form the controlled and well-structured simulation of real design process using the developed IEC IW design system, the author could explore the problem solving behavior of common participants, non-professionals and more experienced ones, in a comparable condition. Through analysis, both commonness and diversity were revealed in participants' design problem solving behavior. Ill-defined problem usually can not be solved by fixed ways, and under the structure of generate and test, the diversity in design problem solving behavior leads to characteristics in design solutions, which is an important value of many high level works. At the same time, commonness or rules of design problem solving behavior are also of great importance. They display the commonness in people's way of thinking, which were proved efficient in people's practices and can be educated.

The design problem in this dissertation was an interior color-and-texture-related interior works design problem, and the findings can be considered meaningful in other color and texture related design processes. At the same time, since the design problem of interior works was an ill-defined problem, the simulation had properties general to many design processes. The findings of design problem solving behavior in this dissertation were also expected helpful in understanding the general way of design problem solving. Actually, the fact in design problem solving such as "difference reduction", "constancy of appreciation",

and “staged-process” revealed in previous researches were found consistent with findings in this dissertation strongly supported this perspective.

In general, the simulated design process provided a new way for approaching design problem solving behavior, and the findings in the process could be complementary for other researches dealing with real design processes.

IEC was an evolutionary computation (EC) based on human evaluation. Although theoretically EC will finally find the best solution, in interactive processes, the problem of human fatigue was one of the most crucial problems for IEC application, and the searching efficiency should be improved to reduce it. Two improvements were tentatively applied in IEC to improve its efficiency. Firstly, a mutation only process was introduced to allow advanced control of evolution. The user could fix part of the interior works design factors, and allow variation in other factors. The process was found more effective in later generations comparing to the pure GA process. Secondly, population size of IEC was tentatively improved by rearranging the evolutionary flow. It was found that the development might enhance the IEC searching process by presenting more variations.

Through validation of the system by a large amount of Chinese residents, it was understood that the IEC IW design system was generally helpful for them, The design process employing IEC was found heuristic and interesting, and easy to use. From comments of the residents, limitations of the IEC IW design system were identified, which raised problems for future researches. On the other hand, the participants also recommended ways of using the developed system, possible application of IEC in the future were suggested.

Since computer is expected to be more and more capable in assisting people in generating design ideas, and non-professionals could be more and more involved in design activities, this kind of interactive design process could be normal in the future. In another word, the interactive design process could not only be considered as simulation of real design process, but real design process itself. The findings of design problem solving behavior in this dissertation are considered significant in the future design practices.

6.3 Future Research

Although researches in this dissertation have achieved expected findings, some problems are not solved yet. Further researches could be carried out in the future. Some research proposals are presented as follow.

Development of the IEC IW design system could be continued to extend the capability of the system. Firstly, design factors involved should be extended from color and textures to the form of furniture and ornamentations, which are also important factors in interior works design. The spatial relationship of forms is considered the key problem in this kind of development. Secondly, since IEC could only evolve limited factors simultaneously, the design process by IEC could involve several stages to allow more design factors be included in gradually as the process going on, which is similar to usual design processes. It could be possible for users to solve the whole interior works design by IEC if method is developed to divide and connect the states. Thirdly, because the design of interior works is a spatial design problem which could not be totally conveyed only through 2D images, 3D navigation technique could be tentatively used in presenting design alternatives, and its efficiency should be examined through experiments of users.

It is also possible to do further exploration of design problem solving behavior in design process simulated by IEC. For example, because the simulated design process allows for comparison and data analysis, it is possible to achieve more findings through data of more participants. In addition, since the sight point and its movement of users can clearly reveal what the users are concentrating on, and what they are thinking of, the technology of eye tracking or eye camera may be employed to approach the problem solving tactics in depth.

Besides, analysis of color harmony could be performed based on the data of design results using the IEC IW design system achieved in experiment of chapter 3, in order to explore rules of preference in color combination of interior works of Beijing residents. Differs from the traditional research method of color harmony, analysis of IEC searching results could provide another view angle in the area of color harmony.

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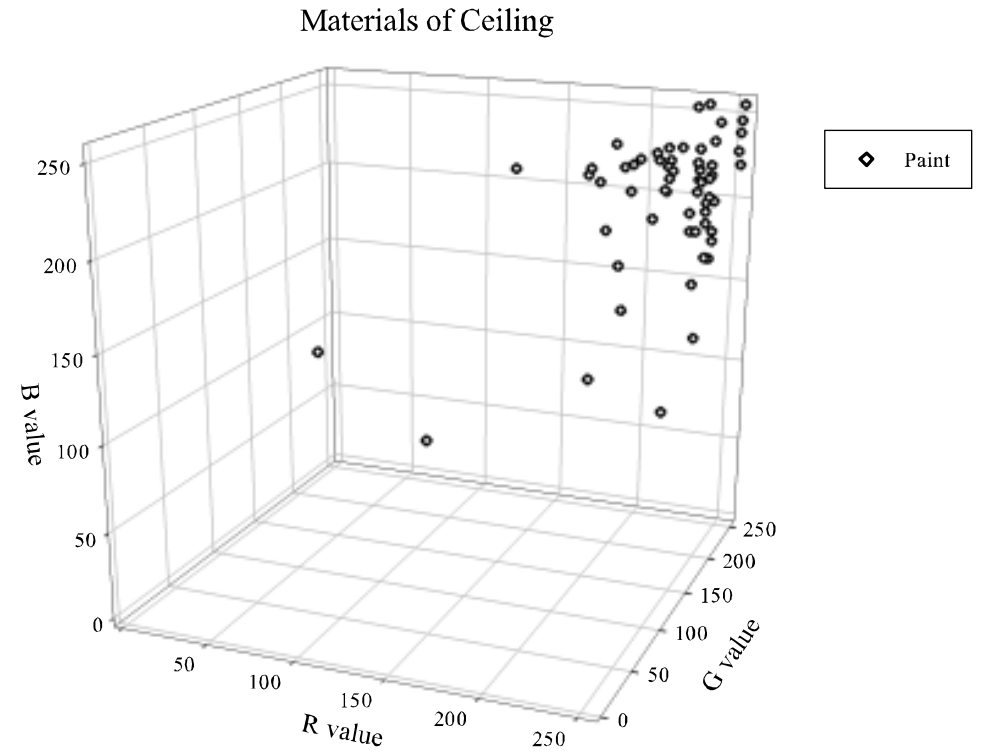
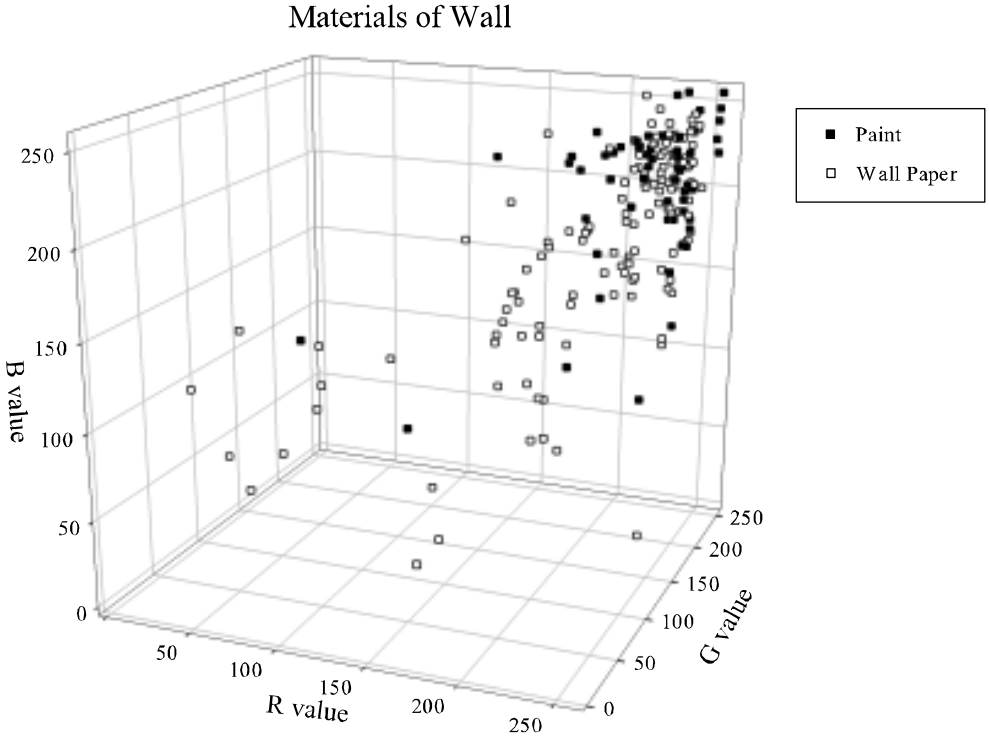
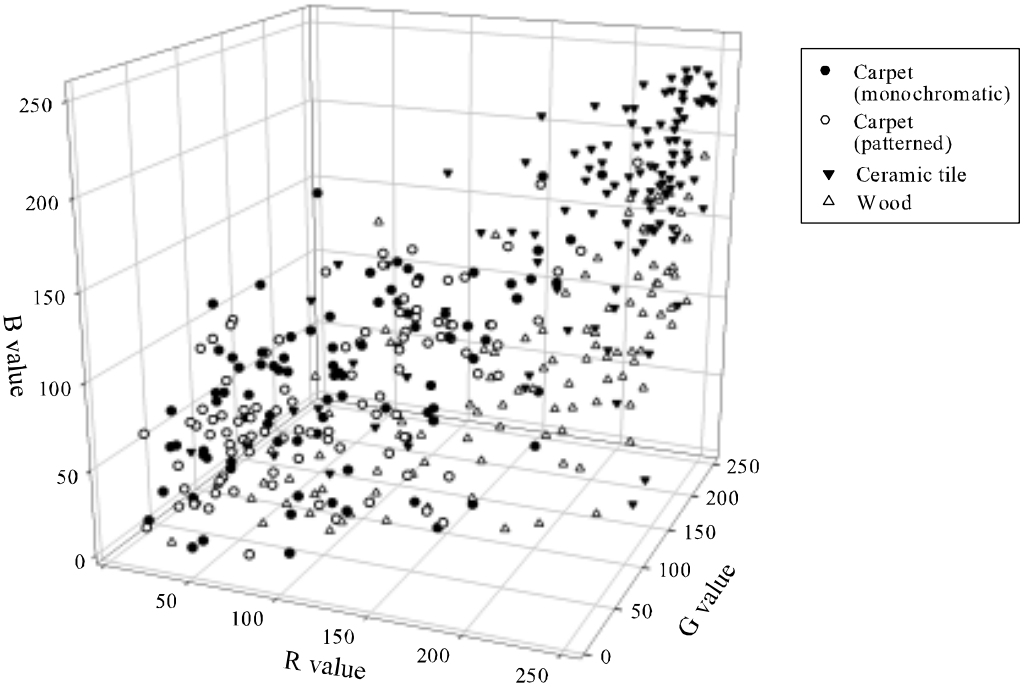
Appendix A: Material Sample Distribution in RGB Space

(Material library employed in Experiments of Chapter 3 to Chapter 5)

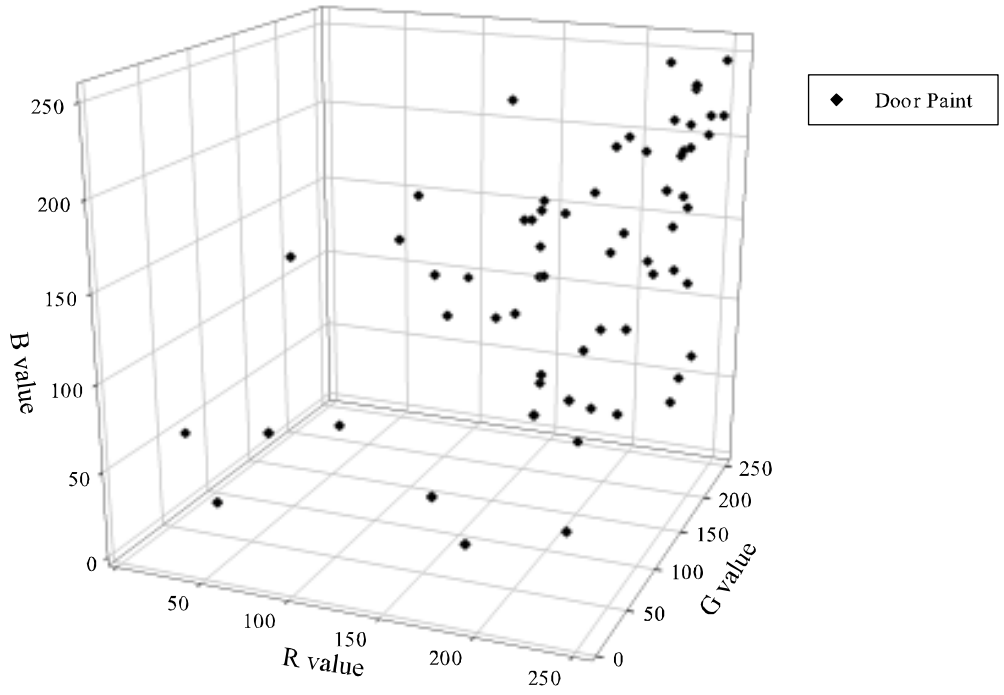


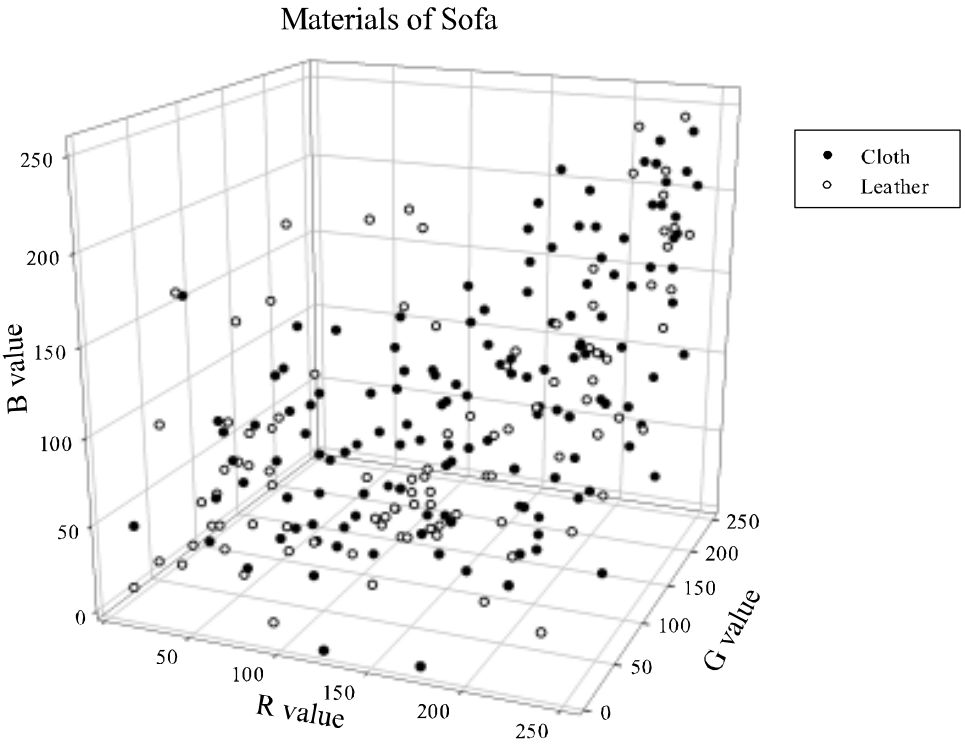


Materials of Floor



Materials of Door




Materials of Sofa
B value
250
200
150
100
50
0
R value
50
100
150
200
250
G value
250
200
150
100
50
0
Cloth
Leather

Appendix B: Questionnaire for Investigation on People's Evaluations of Design Process and Design Results Using IEC

Questionnaire

No.		Date		Time	: am / pm
Sex	M / F	Age		Education	1) Junior high school 2)Senior high school 3)Bachelor 4)Master 5)Doctor

Occupation	Family population	_____ (Aged : minor:)
0)Aesthetic related designer 1)Middle or high level manager of institutions 2)Staffer of institutions 3)Boss of enterprise 4)Middle or high level manager of enterprise 5)staffer of enterprise 6)Worker, handyman, salesperson, attendant 7)Research, education, art and literature, sports, sanitation professional 8)Professional 9) Self-employed 10)Soldiery 11)Student 12)Unemployed 13)Retired 14)Other _____	Family income (RMB/month)	1)<2000 2)2000~5000 3)5000~10000 4)10000~20000 5)20000~40000 6)40000~80000 7)>80000
	Apartment style	Bed room: Living room:
	Apartment area	M^2
	Unit price	RMB/M^2
	Living room area	M^2

Please evaluate the final results:

		very fairly neither fairly very	
R1. How do you feel about this method of design?	bad	**-2 — -1 —- 0 —- 1 —- 2**	good
R2. Are you satisfied with the results?	unsatisfied	**-2 — -1 —- 0 —- 1 —- 2**	satisfied
R3. For you, the results are	old	**-2 — -1 —- 0 —- 1 —- 2**	new
R4. Have you ever imagined such interior color and material combinations?	negative	**-2 — -1 —- 0 —- 1 —- 2**	positive
R5. Do you think the results match your taste/preference?	negative	**-2 — -1 —- 0 —- 1 —- 2**	positive
R6. Are the results practical for you?	negative	**-2 — -1 —- 0 —- 1 —- 2**	positive
R7. Will you put them into practice?	negative	**-2 — -1 —- 0 —- 1 —- 2**	positive

8. The results feel(multi-selection)	1)bright 2)bland 3)vivid 4)comfortable 5) harmonious 6)strong contrast 7)quietly elegant 8) passionate 9)clean 10)young 11)aged 12)warm 13)neat 14) abundant 15)simple 16)modern 17)traditional 18)national 19) occidental 20)exquisite 21)lovely 22)orthodox 23)moderate 24)hard 25)soft 26)relax 27)interesting 28) impactive 29)deep impression 30) middle-aged

Please evaluate the whole process:

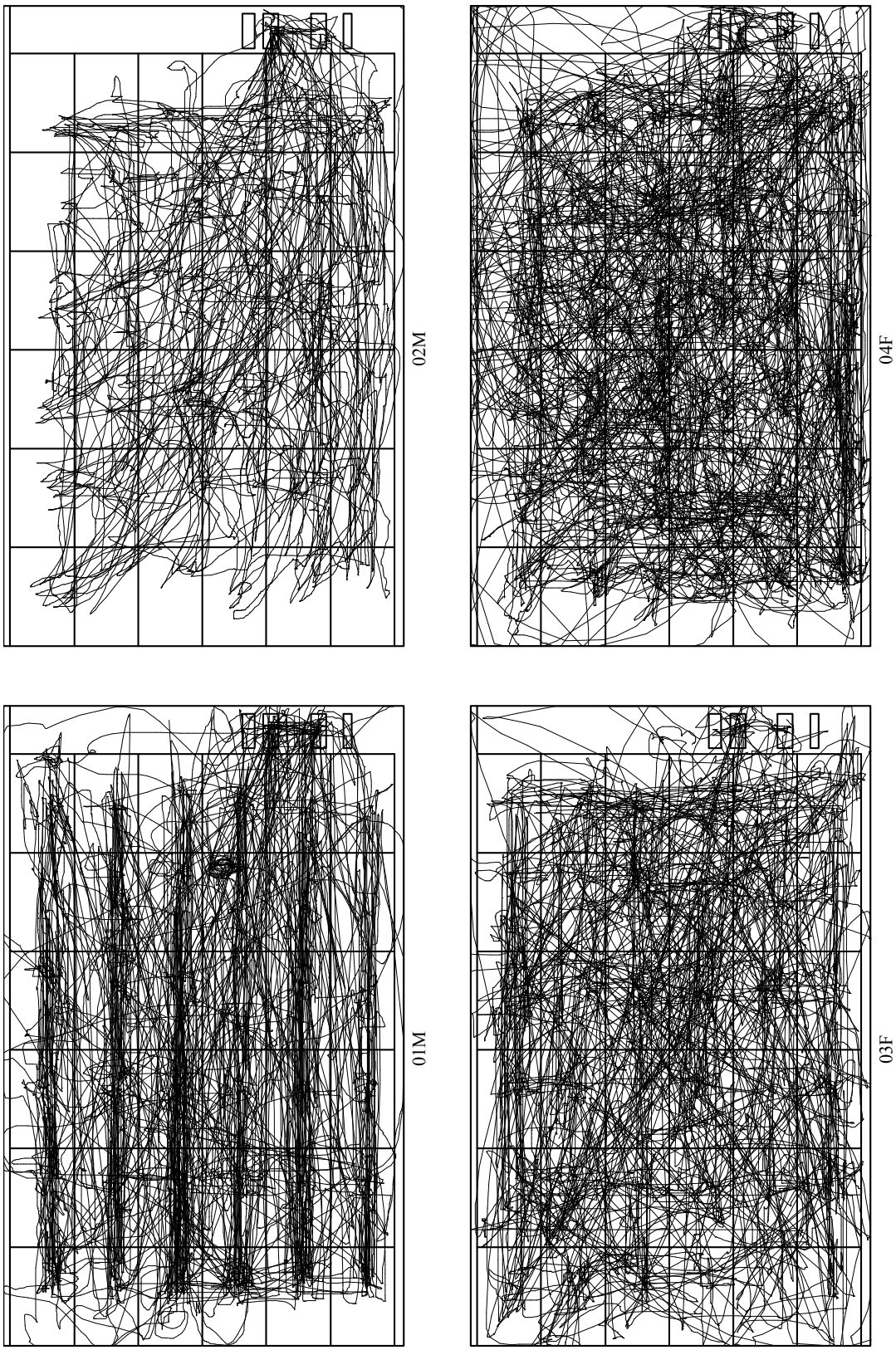
		very fairly neither fairly very	
P1. How did you feel about the process?	bored	**-2 — -1 —- 0 —- 1 —- 2**	interesting
P2. Do you think the process was heuristic?	negative	**-2 — -1 —- 0 —- 1 —- 2**	positive
P3. Operation of the process was:	complex	**-2 — -1 —- 0 —- 1 —- 2**	simple
P4. How did you feel about making choices among images?	difficult	**-2 — -1 —- 0 —- 1 —- 2**	easy
P5. Were the final images greatly improved compared with the beginning?	negative	**-2 — -1 —- 0 —- 1 —- 2**	positive
P6. Did you feel tired during the process?	tired	**-2 — -1 —- 0 —- 1 —- 2**	easy
P7. Would you use this interior design system when performing interior works?	negative	**-2 — -1 —- 0 —- 1 —- 2**	positive
P8. What is your opinion of the material and color choices provided?	meager	**-2 — -1 —- 0 —- 1 —- 2**	abundant

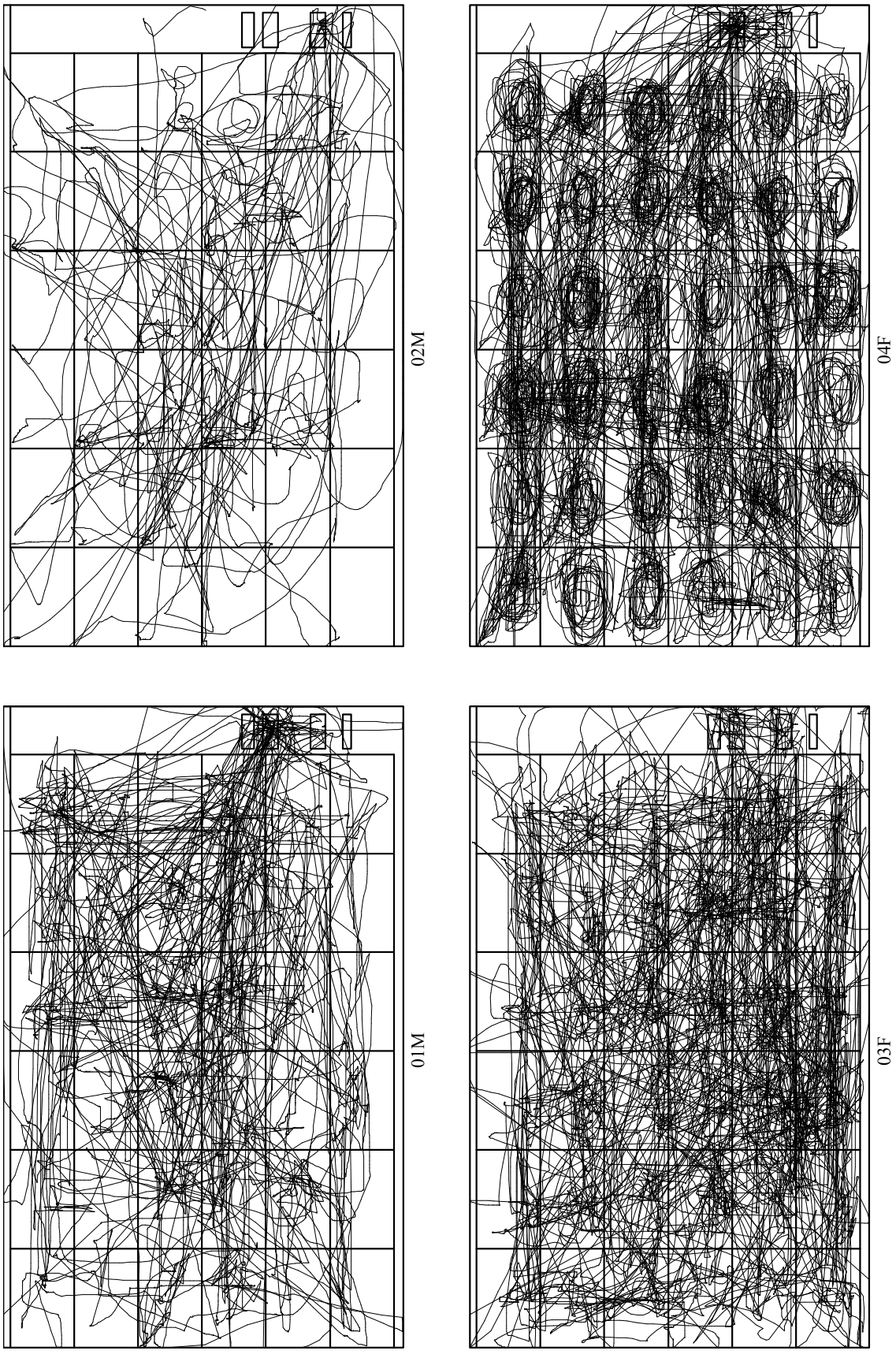
Comments:

Present selection: Small gift / Data CD

Investigator _____

Appendix C: Mouse Trace of IEC Process in PROBLEM SOLVING BEHAIVOR Analysis




02M
04F
01M
03F

Appendix D: Verbal Report of Participants Used in Protocol Analysis

nm = not mentioned -1 = negative evaluation 1 = positive evaluation
t = think h = hesitate p = quickly pass an image
cp = compare images if = supposition cs = compromise
sch = search s = select r = remove
ds = change selected into not b = select as the best image
cb = change selection of the best image

Record No. ≤100: the first phase, selection of several images in the step.
Record No. ＞100: the second phase, selection of the best image among the selected images.

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	1	1	nm	blurry	-1									
01M	1	2										t		
01M	1	3	nm		1								s	
01M	1	4	nm	dark	-1							t		
01M	1	5	sofa	color	-1									
01M	1	6	door	red	-1									
01M	1	7	nm	warm	1								s	
01M	1	8										p		
01M	1	9	floor	beautiful	1								s	
01M	1	10	nm	dark	-1									
01M	1	11	nm	hotel										
01M	1	12	door	red										
01M	1	13	nm		1								s	
01M	1	14	sofa		1								s	
01M	1	15	nm	dark	-1								r	
01M	1	16	nm	dark	-1								r	
01M	1	17	nm	dark	-1								r	
01M	1	18	nm		1									
01M	1	19										t		
01M	1	20										p		
01M	1	21										p		
01M	1	22	floor		-1								r	
01M	1	23	nm		1								s	
01M	1	24	all	light	-1								r	
01M	1	25										p		
01M	1	26	nm		1								s	
01M	1	27	floor		-1								r	
01M	1	28	nm		1								s	
01M	1	29	nm	red	-1								r	
01M	1	30	nm	dark	-1								r	
01M	1	31										t		
01M	1	32	nm		1								s	
01M	1	33										t		
01M	1	34	floor		-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	1	35	nm		1								s	
01M	1	36										p		
01M	1	101										t		
01M	1	102	nm	beautiful	1								b	
01M	2	1	nm	ugly	-1								r	
01M	2	2	nm	ugly	-1								r	
01M	2	3	sofa	green	-1								r	
01M	2	4	floor		-1									
01M	2	5	all	light	-1									
01M	2	6	nm		1								s	
01M	2	7	sofa		-1	floor		1						
01M	2	8	nm		1								s	
01M	2	9										p		
01M	2	10	nm	cool	1	nm	bright	-1						
01M	2	11										p		
01M	2	12											s	
01M	2	13										p		
01M	2	14	floor	green	-1								r	
01M	2	15	nm	color	1								s	
01M	2	16	nm	common	0									
01M	2	17			-1								r	
01M	2	18	door		-1							t	r	
01M	2	19	sofa		-1								r	
01M	2	20	nm		1								s	
01M	2	21										t		
01M	2	22	wall		1	sofa		-1						
01M	2	23										p		
01M	2	24											r	
01M	2	25											r	
01M	2	26	wall	ugly	-1								r	
01M	2	27			1								s	
01M	2	28			1								s	
01M	2	29										t		
01M	2	30										p		
01M	2	31			1								s	
01M	2	32										t		
01M	2	33										t		
01M	2	101		beautiful	1							t	b	
01M	3	1		My taste	1								s	
01M	3	2										p		
01M	3	3	wall		-1	floor		1	all	hotel	-1	t		
01M	3	4										p		
01M	3	5	floor	dark	-1									
01M	3	6	nm		1								s	
01M	3	7	wall		-1									
01M	3	8										p		
01M	3	9	nm		1								s	
01M	3	10										p		
01M	3	11	nm		1								s	
01M	3	12	nm	home	1								s	
01M	3	13			1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	3	14										p		
01M	3	15										p		
01M	3	16	sofa	rose-red	-1							p		
01M	3	17	nm	beautiful	1								s	
01M	3	18	sofa		-1									
01M	3	19	nm		1								s	
01M	3	20											s	
01M	3	21	floor	black	-1								r	
01M	3	22		black									r	
01M	3	23		black									r	
01M	3	24		black									r	
01M	3	25		black									r	
01M	3	26		black									r	
01M	3	27												
01M	3	28	wall		1								s	Same image as 18
01M	3	29												
01M	3	30	wall		1									
01M	3	31										p		
01M	3	32										t		
01M	3	101										t		
01M	3	102										h	b	
01M	4	1	nm		1								s	
01M	4	2										p		
01M	4	3										t		
01M	4	4	nm	red	-1								r	
01M	4	5	nm	red	-1								r	
01M	4	6	nm	red	-1								r	
01M	4	7	sofa	black	-1								r	
01M	4	8											r	
01M	4	9										t		
01M	4	10	floor	green	-1								r	
01M	4	11										p		
01M	4	12	nm	dark	-1									
01M	4	13	nm		1									
01M	4	14										t		
01M	4	15	nm		1								s	
01M	4	16										t		
01M	4	17										t		
01M	4	18										t		
01M	4	19	nm	dark	-1								r	
01M	4	20	nm		1								s	
01M	4	21	nm		1								s	
01M	4	22										p		
01M	4	23										t		
01M	4	24	corner	dark	-1									
01M	4	25											r	
01M	4	26	corner	bright	1								s	
01M	4	27	corner	bright	1								s	
01M	4	28	nm	green	-1								r	
01M	4	29											s	
01M	4	30										p		

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	4	31										p		
01M	4	32										t		
01M	4	33										p		
01M	4	34	nm		-1								r	
01M	4	35	sofa		1								s	
01M	4	101										t		
01M	4												b	
01M	4											t		
01M	5	1	nm	blurry	-1								r	
01M	5	2	corner	dark	-1									
01M	5	3										t		
01M	5	4		warm	1									
01M	5	5	nm	beautiful	1								s	
01M	5	6										t		
01M	5	7										p		
01M	5	8	nm	bright	1								s	
01M	5	9										p		
01M	5	10										t		
01M	5	11	wall	color	-1							t	r	
01M	5	12	nm	dark	-1								r	
01M	5	13	nm	home	1								s	
01M	5	14		luxury	0							t		
01M	5	15	nm		1								s	
01M	5	16	door		-1								ds	
01M	5	17		common	1								s	
01M	5	18										p		
01M	5	19	nm	warm	1								s	
01M	5	20										p		
01M	5	21	door		-1								r	
01M	5	22	sofa	disharmony	-1							t	r	
01M	5	23		dark	-1								r	
01M	5	24										p		
01M	5	25		bright	-1								r	
01M	5	26	nm		0							t		
01M	5	27										p		
01M	5	28	door		-1									
01M	5	29	nm	dark	-1									
01M	5	30										t		
01M	5	31										p		
01M	5	32	nm		1								s	
01M	5	33	nm		1								s	
01M	5	34										p		
01M	5	35	all	space small	-1							t		
01M	5	36											s	
01M	5	37										p		
01M	5	101	door	green	-1							t		
01M	5	102	nm		-1									
01M	5	103										cp		
01M	5	104											b	
01M	5	105	door		-1							if		
01M	6	1											r	images are blurry, not as good as the

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
														beginning
01M	6	2											r	
01M	6	3	door		1								s	
01M	6	4	nm		1								s	
01M	6	5										t		
01M	6	6	nm		0							t		
01M	6	7	nm	beautiful	1								s	
01M	6	8	ceiling	blurry	-1									
01M	6	9										p		
01M	6	10	nm		1								s	
01M	6	11										p		
01M	6	12	door	stain	-1									
01M	6	13										p		
01M	6	14										p		
01M	6	15										p		
01M	6	16	nm		-1								r	
01M	6	17											s	
01M	6	18											s	
01M	6	19										p		
01M	6	20										t		
01M	6	21										p		
01M	6	22	nm		1								s	
01M	6	23	nm		1								s	
01M	6	24										p		
01M	6	25	nm	beautiful	1								s	
01M	6	26	sofa	red	-1								r	
01M	6	27	floor	red	-1								r	
01M	6	28										p		
01M	6	29	floor	cleaning	-1								r	
01M	6	30										p		
01M	6	31	wall		-1								r	
01M	6	32	nm		1								s	same 30
01M	6	33	wall		-1								r	same 28
01M	6	34	wall		-1								r	
01M	6	101	nm	clean	1							t		selected should be moved together
01M	6	102										cp		
01M	6	103	nm		1								b	
01M	7	1	nm		-1								r	
01M	7	2	nm		-1								r	
01M	7	3	sofa	red	-1								r	
01M	7	4	sofa	red	-1								r	
01M	7	5	sofa	black	-1								r	
01M	7	6	sofa	black	-1								r	
01M	7	7	sofa	black	-1								r	
01M	7	8	nm		1								s	
01M	7	9	wall		-1								r	
01M	7	10	door		-1									
01M	7	11	sofa	pink	1								s	
01M	7	12										p		
01M	7	13										t		
01M	7	14										p		

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	7	15										t		
01M	7	16	nm		-1								r	
01M	7	17										t		
01M	7	18	floor		1								s	
01M	7	19										p		
01M	7	20										cp		
01M	7	21	nm	beautiful	1								s	
01M	7	22	nm		1								s	
01M	7	23	door	red	-1									
01M	7	24										p		
01M	7	25	nm		1								s	
01M	7	26	nm		1								s	
01M	7	27	floor	disharmony	-1								r	
01M	7	28	nm	dark	-1								r	
01M	7	29	nm	harmony	1	door	red	-1						
01M	7	30	door	red	-1								r	same 25
01M	7	31	nm	dark	-1									
01M	7	32										t		
01M	7	33	nm		1									
01M	7	34										p		
01M	7	101										cp		
01M	7	102	nm		1								b	
01M	8													
01M	8	1	all	light	-1									(fast selection in this generation)
01M	8	2										p		
01M	8	3	all	light	1								s	
01M	8	4										p		big light contrast not good
01M	8	5											s	
01M	8	6											s	
01M	8	7										p		
01M	8	8	door		-1							t		
01M	8	9										p		
01M	8	10											s	
01M	8	11	door	green	-1									
01M	8	12										p		
01M	8	13	nm		1								s	
01M	8	14										p		
01M	8	15	nm		1								s	
01M	8	16										p		
01M	8	17	nm		1								s	
01M	8	18										p		
01M	8	19	nm		1								s	
01M	8	20										p		wall texture like leaves increased
01M	8	101										t		I prefer bright and comfortable ones
01M	8	102										cp		
01M	8	103	floor		-1							h		
01M	8	104	all	dark	-1									
01M	8	105	nm	bright	1	nm	cold	-1						
01M	8	106	nm		1								b	
01M	9	1	wall	green	-1								r	do not like too strong colors
01M	9	2											r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	9	3											r	
01M	9	4	door		-1								s	
01M	9	5										p		
01M	9	6											s	
01M	9	7										p		
01M	9	8											s	
01M	9	9	nm		1								s	
01M	9	10	floor		1	door	red	-1				h		
01M	9	11											s	
01M	9	12										cp		why no other combination of door and floor
01M	9	13										sch		I want image with door not so red
01M	9	14											s	no other choices
01M	9	15											s	
01M	9	16											s	
01M	9	17											r	
01M	9	18										sch		
01M	9	101										cp		
01M	9	102	nm		1	floor		0						
01M	9	103	nm		-1									
01M	9	104	nm		-1									
01M	9	105	nm		1								b	should organize the selected together for compare
01M	10	1	nm		1									
01M	10	2	nm		1							cp	s	
01M	10	3										p		
01M	10	4	floor	beautiful	1	door		-1						
01M	10	5										sch		
01M	10	6	floor	beautiful	1								s	
01M	10	7										p		
01M	10	9	door	green	-1									
01M	10	10										p		
01M	10	11	sofa	beautiful	1								s	
01M	10	12	door	red	-1									
01M	10	13										t		
01M	10	14	door	black										
01M	10	15	nm	home	1								s	
01M	10	16										sch		
01M	10	17	nm		1								s	
01M	10	101										t		
01M	10	102	nm		0									
01M	10	103	nm		1	door		-1						
01M	10	104	corner	dark	-1									
01M	10	105	nm		1								b	
01M	10	106	door		1							cp	cb	same 102
01M	11	1										p		ask about end criterion evolution effect not so significant
01M	11	2	nm		1								s	
01M	11	3	nm		0							t		
01M	11	4											s	
01M	11	5	floor		-1							t		
01M	11	6	nm		-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	11	7	nm	quietly elegant	1								s	
01M	11	8	nm		1								s	
01M	11	9	door	red	-1								r	
01M	11	10	sofa	green	-1	sofa	contrast	-1					r	
01M	11	11		contrast	-1									
01M	11	12										t		
01M	11	13	nm		1								s	
01M	11	14	all	harmony	1								s	
01M	11	15										p		
01M	11	16	floor	white	-1								r	
01M	11	17	nm	dark	-1									
01M	11	18										p		
01M	11	19											s	
01M	11	20										t		
01M	11	21										p		
01M	11	22	sofa	red	-1	floor	red	-1						
01M	11	23	nm	common	0							t		
01M	11	24	nm	bright	1									
01M	11	25	nm	bright	1							cp	s	
01M	11	26										p		
01M	11	27	nm		1								s	
01M	11	28	door	red	-1								r	
01M	11	29										p		
01M	11	30	nm		1								s	
01M	11	31	nm	green	-1							t		
01M	11	32										p		
01M	11	101											b	
01M	11	102										h		
01M	11	103	nm	color	0	corner	dark	0				cp		
01M	11	104											cb	
01M	12	1	nm	blurry	-1									
01M	12	2	all	quietly elegant	1								s	
01M	12	3										p		
01M	12	4	nm		1								s	
01M	12	5	door	dark	-1								r	
01M	12	6	nm		0									
01M	12	7	door	bright	1								s	realized door color influence corner brightness
01M	12	8	door	bright	1								s	
01M	12	9										p		
01M	12	10											r	
01M	12	11	door	bright	1								s	
01M	12	12	sofa		1	door	red	-1				h		
01M	12	13										sch		I want beautiful sofa
01M	12	14										sch		search for sofa and floor harmony
01M	12	15	nm		1								s	
01M	12	16	door	black	-1									
01M	12	17	nm		1								s	
01M	12	18	door	green	-1									
01M	12	19	nm		-1									
01M	12	20	floor		1	door	red	-1				h	s	same 12

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	12	101										t		not easy to compare
01M	12	102	floor	bright	-1	door	red	-1				if		
01M	12	103	corner	dark	-1									
01M	12	104										cp		
01M	12	105	nm		1							cs	b	
01M	12	201												doubt about way of select
01M	13	1										t		if images organized for compare
01M	13	2	nm		1							cp	s	
01M	13	3	door	red	-1								r	
01M	13	4										p		
01M	13	5	nm		1								s	
01M	13	6										p		
01M	13	7	nm		1							t	s	
01M	13	8	floor	dark	-1								r	
01M	13	9	nm		1							t	s	
01M	13	10										p		
01M	13	11	nm	hotel	-1								r	
01M	13	12										p		
01M	13	13	nm		1								s	
01M	13	14	nm	beautiful	1								s	
01M	13	15	nm		1								s	
01M	13	16	corner	dark	-1								r	
01M	13	17										p		
01M	13	18	corner	dark	-1									
01M	13	19	all	islamic	1	door		-1					s	
01M	13	20											s	
01M	13	21										p		
01M	13	22	nm		1								s	
01M	13	23	nm		1								s	
01M	13	24										p		
01M	13	25										t		
01M	13	101										t		change show modes
01M	13	102	nm		1								b	
01M	13	201												evolve not so efficient
01M	13	202												there are evolving tendency
01M	14	1											s	red door often shown, I will not select red door this time
01M	14	2										p		
01M	14	3											s	
01M	14	4										p		
01M	14	5	nm		1							t	s	
01M	14	6	wall	beautiful	1								s	
01M	14	7										p		
01M	14	8	nm	home	1							t	s	
01M	14	9	nm		1								s	
01M	14	10										t		
01M	14	11	wall	beautiful	1	sofa		0				h		
01M	14	12										t		
01M	14	13	nm	red	-1								r	
01M	14	14										t		
01M	14	15	nm		1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
01M	14	16										p		
01M	14	17	nm		-1								r	
01M	14	18	door	red	-1									
01M	14	19										p		
01M	14	20	nm		1								s	
01M	14	21	all	light	1								s	
01M	14	22										p		
01M	14	23	nm	dark	-1								r	
01M	14	24	door	red	-1								r	
01M	14	25	nm		1	floor	green	-1						
01M	14	26	nm	beautiful	1	door	red	-1						
01M	14	101										t		
01M	14	102	wall	beautiful	1									
01M	14	103										t		
01M	14	104	nm	warm									b	
01M	14	201												similar for several generations
01M	14	202												Effect of "Veto by one vote"
01M	15	1	nm										s	
01M	15	2										p		
01M	15	3	door	dark	-1								r	
01M	15	4										p		
01M	15	5	nm	warm tone	1							t		
01M	15	6	nm	cool tone	1								s	
01M	15	7	nm	warm tone								t	s	
01M	15	8										p		
01M	15	9	sofa	pink	1	door	light	1					s	
01M	15	10										p		
01M	15	11	nm	harmony	1								s	
01M	15	12										p		
01M	15	13	nm	special	0									
01M	15	14	floor	texture	-1									
01M	15	15	wall	texture	1	floor	texture	1					s	
01M	15	16										p		
01M	15	17												
01M	15	18	nm	dark	-1									
01M	15	19	nm		1								s	
01M	15	101										t		
01M	15	102	sofa	pink	1	wall		-1		cheap		h		
01M	15	103	nm	warm tone	1								b	
01M	Retrospective report		firstly I select the bright and harmony ones I removed those showy and uncomfortable colors I selected bright and walls with vertical textures, then I selected floors with strips then I selected beautiful sofas, after that, I removed all the red doors											
02M	1	1	nm	color contrast	-1								r	
02M	1	2	sofa	red	-1								r	
02M	1	3	nm	color contrast	-1								r	
02M	1	4											r	
02M	1	5	nm		1								s	
02M	1	6	nm	color contrast	1								s	
02M	1	7	nm		1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
02M	1	8	nm		-1							t	r	
02M	1	9		swimming pool	-1								r	
02M	1	10											r	
02M	1	11	nm	warm tone	1	nm	color contrast	-1						
02M	1	12	nm	warm tone	1								s	
02M	1	13	floor	red	-1								r	
02M	1	14	nm		1	door		1					s	
02M	1	15										t		
02M	1	16	nm		1								s	
02M	1	17	nm	warm tone	1								s	too cold or too strong is not good for living room
02M	1	101										t		
02M	1	102	all	tinge	1							cp	b	good, wonder if there will be better ones
02M	2	1	wall	green	-1								r	
02M	2	2	nm	swimming pool	-1								r	
02M	2	3	ceiling	black	-1								r	
02M	2	4	nm		1	nm	white	-1						
02M	2	5	nm	comfortable	1								s	
02M	2	6	nm		1								s	
02M	2	7	wall	bright	-1								r	
02M	2	8	wall	cool tone	-1								r	
02M	2	9	nm	cool tone	-1								r	
02M	2	10	nm	cool tone	-1								r	
02M	2	11	sofa	red	-1								r	
02M	2	12	sofa	red	-1								r	
02M	2	13	nm		1								s	
02M	2	14	sofa	green	0							t		
02M	2	15	nm		1								s	
02M	2	16										cp		some do not differ greatly
02M	2	17	nm	red									r	
02M	2	18										t		
02M	2	19	nm	harmony	-1								r	
02M	2	20											r	
02M	2	21	nm		1								s	
02M	2	22	nm		1									not sure about self preference
02M	2	101										cp		different virtue
02M	2	102	wall	feature	1								b	wall vertical texture
02M	2		Comments: ask about design factors involved											
02M	3	1	nm	swimming pool	-1								r	
02M	3	2	sofa	similar	-1								r	the rest are not so bad
02M	3	3	wall	similar	-1								r	
02M	3	4	wall	green	-1								r	
02M	3	5	wall	green	0								r	
02M	3	6										t		
02M	3	7	wall	comfortable	1								s	realized: it was selected before
02M	3	8	wall	dark	-1									
02M	3	9	nm	bright	-1								r	(following 7 similar)
02M	3	10	nm	bright	-1								r	
02M	3	11	nm	bright	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
02M	3	12	nm	bright	-1								r	
02M	3	13	nm	bright	-1								r	
02M	3	14	nm	bright	-1								r	
02M	3	15	nm	bright	-1								r	
02M	3	16	sofa	dark	-1									
02M	3	17	nm		1							sch	s	(sofa is light)
02M	3	18	nm		1								s	(sofa is light, similar to above)
02M	3	19	nm	color contrast	1	floor	white	-1						
02M	3	20	floor	red	-1								r	(consider of floor)
02M	3	21	nm		1								s	
02M	3	22										t		
02M	3	23	nm		1							cp	s	
02M	3	24	floor	white	-1								r	
02M	3	25	nm		-1								r	(same white floor as 24)
02M	3	26	nm		-1								r	(same white floor as 25)
02M	3	27	nm		-1								r	(same white floor as 26)
02M	3	28	floor	warm tone	1								s	
02M	3	29	wall	cool tone	-1								r	(similar wall as 28)
02M	3	30											r	(similar wall as 29)
02M	3	31	nm		1	wall	complex	-1					s	
02M	3	32	nm		1								s	
02M	3	33	nm		1								s	
02M	3	34	nm		1	nm	red	-1					s	
02M	3	35	nm		1	ceiling		-1						
02M	3	36	nm		1	nm	harmony	-1					s	
02M	3	101										t		
02M	3	102	wall		1	floor	warm	-1					b	
02M	4	1	nm	swimming pool	-1								r	firstly remove swimming pool
02M	4	2	nm	swimming pool	-1								r	
02M	4	3	wall	green	-1								r	
02M	4	4	nm		-1								r	(similar cool tone as 3)
02M	4	5	wall	green	-1								r	
02M	4	6	sofa		-1								r	
02M	4	7	wall	red	-1								r	
02M	4	8	floor	red	-1								r	I seldom pay attention to door, door is small
02M	4	9	nm		-1								r	(light blue wall)
02M	4	10	ceiling		-1								r	
02M	4	11				floor	tinge	1					s	still like this one, floor lighter
02M	4	12	nm		1	sofa	color	-1				if	s	
02M	4	13											s	similar to the original one
02M	4	14	wall	red	-1								r	
02M	4	15										t		
02M	4	16	floor	red	-1									
02M	4	17	nm		-1								r	
02M	4	18	nm		1								s	
02M	4	19	wall	strong	-1								r	
02M	4	20	nm		1								s	
02M	4	21	floor	red	-1								r	
02M	4	22	floor	red	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
02M	4	23	all	similar	-1								r	
02M	4	24	door		-1								r	
02M	4	25	nm		1								s	
02M	4	26										t		
02M	4	27	ceiling	color	-1								r	
02M	4	28											s	mainly the remained
02M	4	29	nm		1								s	
02M	4	30	nm		1								s	
02M	4	31	nm		1									(with obvious ceiling color)
02M	4	32	ceiling		-1								r	
02M	4	33	nm		1								s	
02M	4	34	nm	red	-1								r	too red
02M	4	35	nm	red	-1								r	(similar to above)
02M	4	36	nm	tinge	1								s	tinge is better
02M	4	36	wall	tinge	-1								r	
02M	4	101	nm		1							cp	b	
02M	4	Comments: I am not sure about my preference Generally I prefer such wall (vertical line)												
02M	5	1	wall	red	-1								r	
02M	5	2	wall	complex	-1								r	
02M	5	3	sofa	abrupt	-1								r	
02M	5	4	nm	comfortable	1	door		-1				if	s	
02M	5	5	nm	bright	0									
02M	5	6	nm	blurry	-1									
02M	5	7	wall	prefer	1								s	
02M	5	8	all	harmony	1								s	
02M	5	9	nm		1								s	
02M	5	10	wall	prefer	1									do not want to select too many similar ones
02M	5	11	wall	strong	1	wall	color	-1					r	
02M	5	12	nm		1								s	
02M	5	13	wall	abrupt									r	
02M	5	14	nm	white	-1								r	
02M	5	15	nm		1								s	many are similar and good
02M	5	16	nm		1								s	
02M	5	17	ceiling	red	-1								r	
02M	5	18										cp		they are a serial of ideas
02M	5	19	sofa	red	-1									
02M	5	20	sofa	red	-1									
02M	5	21	floor	red	-1							if	s	
02M	5	22	floor	proper	1							cp	s	
02M	5	23											r	
02M	5	24	wall		1								s	
02M	5	25	nm		-1								r	
02M	5	26	nm		1								s	
02M	5	101	wall	prefer	1							sch		
02M	5	102	floor	proper	1							cp	b	
02M	5	Comments: I think I am near to the solution												
02M	6	1	nm	swimming pool	-1								r	
02M	6	2	nm	swimming pool	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
02M	6	3	nm	swimming pool	0								r	
02M	6	4	wall	red	-1								r	
02M	6	5	nm	shown before	1								s	
02M	6	6	nm	shown before	1								s	
02M	6	7	nm	contrast	-1								r	
02M	6	8	wall	complex	-1								r	
02M	6	9	floor	color	1							sch	s	
02M	6	10											r	
02M	6	11	floor	dark	-1								r	
02M	6	12	floor	dark	-1								r	
02M	6	13	nm	dark	-1								r	
02M	6	14	wall	red	-1								r	
02M	6	15	floor	dark	-1								r	
02M	6	16	floor	dark	-1								r	
02M	6	17	nm	dark	-1							t		
02M	6	18	nm	harmony	1								s	
02M	6	19	wall	white	-1									
02M	6	20	nm	harmony	1								s	
02M	6	21	nm	tinge	-1									
02M	6	22	nm		1								s	
02M	6	23	ceiling	dark	-1									
02M	6	24	wall		-1	nm	Just so-so	1					s	
02M	6	25										t		
02M	6	26	nm		1								s	
02M	6	27	nm		1								s	
02M	6	28	wall	green	-1									
02M	6	29	nm		1								s	
02M	6	30	wall	prefer	1	floor	red	-1					s	
02M	6	101	wall		1	sofa		-1				if		
02M	6	102	floor	tinge	-1									
02M	6	103										h		
02M	6	104	door		1							cp	b	
02M	7	1	wall	green	-1								r	
02M	7	2	wall	green	-1								r	
02M	7	3	nm	swimming pool	-1								r	
02M	7	4										sch		
02M	7	5	floor	similar	-1								r	
02M	7	6	nm	harmony	1								s	
02M	7	7	nm	harmony	1								s	
02M	7	8	nm	harmony	1								s	
02M	7	9	nm	shown before	1								s	
02M	7	10	nm		1								s	
02M	7	11	nm	green	-1								r	
02M	7	12	nm		1								s	
02M	7	13	nm		1								s	
02M	7	14	wall	color	-1								r	
02M	7	15	floor	similar	-1								r	
02M	7	16	door		1								s	
02M	7	17											s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
02M	7	18	wall	color	-1								r	
02M	7	19											s	
02M	7	20	nm	harmony	1								s	
02M	7	21											s	
02M	7	22											s	
02M	7	23	sofa	blue	-1								r	
02M	7	24	sofa	blue	-1								r	
02M	7	25	nm	harmony	1								s	
02M	7	26	floor	red	-1									
02M	7	27	nm	color	1								s	
02M	7	28	nm	color	1								s	
02M	7	29												do not like too red or too blue
02M	7	30	nm		1								s	
02M	7	101										cp		(walls with vertical texture)
02M	7	102												They are quit similar
02M	7	103	nm		1									
02M	7	104	nm		1									
02M	7	105	nm	contrast	1								b	
02M	7	Comments: I know what I do not like, but not sure what I prefer												
02M	8	1												no swimming pool, good
02M	8	2	nm	harmony	1								s	appeared just now
02M	8	3	sofa	strong	-1								r	
02M	8	4	nm	strong	-1								r	
02M	8	5											s	
02M	8	6	wall		-1								r	
02M	8	7											s	
02M	8	8	nm	harmony									s	
02M	8	9	floor	red	-1									
02M	8	10	floor	tinge	1								s	
02M	8	11	nm		1								s	
02M	8	12											s	
02M	8	13										cp	s	I do not pay much attention at door
02M	8	14	door	red	-1								r	
02M	8	15	nm	harmony	1								s	
02M	8	16	nm	harmony	1								s	
02M	8	17	nm	harmony	1								s	
02M	8	18	nm	harmony	1								s	
02M	8	19	floor	red	-1	nm	harmony	1				t		
02M	8	20	nm	tinge	-1									
02M	8	101										t		
02M	8	102											b	
02M	8	Comments: the evolution is almost enough for me												
02M	9	1	nm		1								s	generally good quality
02M	9	2											s	
02M	9	3	nm	similar	-1									
02M	9	4	wall	green	-1								r	
02M	9	5	nm		1								s	
02M	9	6	nm	tinge	-1									
02M	9	7											s	
02M	9	8											s	
02M	9	9	nm		1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
02M	9	10	nm		1								s	
02M	9	11	floor	red	-1								r	
02M	9	12	door	red	-1								r	
02M	9	13	door	red	-1								r	
02M	9	14	nm		1								s	same red door as above
02M	9	15											s	
02M	9	16											s	all acceptable, hard to compare
02M	9	17											s	all similar
02M	9	18										t		I like vertical texture on wall
02M	9	19												maybe not good to select all walls with vertical texture
02M	9	20											b	
02M	Retrospective report		I can not remember all details firstly I remove green floors which looks like swimming pool the vertical wall texture is good, but other textures are not so good floor too red were generally removed sofa too red were generally disliked I like comparatively lighter colors many combinations are similar, and acceptable I know clear what I do not like but not sure about what I prefer I decided what to remove quickly colors too much contrast are not so good I did not pay many attention to the door doors are usually the last one considered general mean: what dislike, but not what preferred												
03F	1	1	nm	ugly	-1								r	I'll firstly remove the disliked ones
03F	1	2	sofa	blue	-1								r	
03F	1	3	sofa	purple	-1								r	
03F	1	4	nm	pink	-1								r	
03F	1	5	floor	dislike	-1								r	
03F	1	6	door	color	-1								r	
03F	1	7	door	color	-1								r	
03F	1	8	nm	showy	-1								r	
03F	1	9	nm	dislike	-1								r	
03F	1	10	door		-1								r	
03F	1	11	nm	dislike	-1								r	
03F	1	12	nm	special	-1								r	
03F	1	13	nm	disharmony	-1								r	
03F	1	14	nm	dislike	-1								r	
03F	1	15	nm	dislike	-1								r	
03F	1	16	nm	dislike	-1								r	
03F	1	17	sofa	blue	-1								r	
03F	1	18	nm	like	1								s	I start to be uncertain
03F	1	19	all	dislike	-1								r	
03F	1	20	nm		1								s	
03F	1	21	nm		1								s	
03F	1	22	nm	like	1								b	(Same as 18)
03F	1	23	nm	dislike	-1								r	(No special idea of the rest)
03F	1	24	nm		1								s	
03F	1	25	nm	dislike	-1								r	
03F	1	26	nm	dislike	-1								r	
03F	1	27	nm	dislike	-1								r	
03F	1	28	nm	dislike	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
03F	1	29	nm	dislike	-1								r	
03F	1	30	sofa	dislike	-1								r	
03F	1	31	nm		1								s	
03F	1	32	nm	like	1								s	
03F	1	33	nm	common	-1								r	
03F	1	34	nm	common	-1								r	
03F	1	35	nm	warm	-1								r	
03F	1	36										cp	r	
03F	1	37	nm		1								s	
03F	2	1	nm	showy	-1								r	I will delete the too showy ones
03F	2	2	nm	showy	-1								r	
03F	2	3	sofa	showy	-1								r	
03F	2	4	sofa	ugly	-1								r	
03F	2	5	sofa	ugly	-1								r	
03F	2	6	nm	ugly	-1								r	no such image I like best in last step
03F	2	7	wall	showy	-1								r	
03F	2	8	door	showy	-1								r	
03F	2	9	door	dark	-1								r	
03F	2	10	sofa	dark	-1								r	
03F	2	11	sofa	dark	-1								r	
03F	2	12	sofa	brown	-1								r	
03F	2	13	sofa	khaki	-1								r	
03F	2	14	sofa	red	-1								r	
03F	2	15	nm	disharmony	-1								r	(red sofa)
03F	2	16	wall	dark	-1								r	(red sofa)
03F	2	17	nm	warm	-1								r	(red sofa)
03F	2	18	nm	orange	-1								r	
03F	2	19	nm	green	-1								r	
03F	2	20	nm	cool	-1								r	
03F	2	21	nm	lowery	-1								r	
03F	2	22	sofa	strange	-1								r	(sofa is dark blue)
03F	2	23	sofa	red	-1								r	(sofa is dark red)
03F	2	24	nm	bright	-1								r	
03F	2	25	nm		0							t		
03F	2	26	nm	brown	-1								r	
03F	2	27	nm	orange	-1							t	r	generally not so good
03F	2	28	nm		1								s	comparatively better ones
03F	2	29	nm		1								s	
03F	2	30	nm		1								s	
03F	2	31	ceiling	dark	-1							cs	s	
03F	2	32										cp	b	
03F	2	Comments: If I do not like them very much, will the results be misdirected?												
03F	3	1	sofa	white	1									this step is better
03F	3	2	nm	blurry	-1								r	
03F	3	3	nm	mint color	1								s	
03F	3	4	nm	shown before									s	
03F	3	5	nm	shown before									s	
03F	3	6	nm		1								s	
03F	3	7	nm	tinge	1							cp	s	
03F	3	8	nm	green	1								s	
03F	3	9	sofa	khaki	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
03F	3	10	sofa	red	-1								r	
03F	3	11	nm	tone	-1								r	(red sofa)
03F	3	12	nm	tone	-1								r	(red sofa)
03F	3	13	sofa	brown	-1								r	
03F	3	14	sofa	brown	-1								r	
03F	3	15	nm	disharmony	-1								r	
03F	3	16	nm	warm	-1								r	
03F	3	17	nm	warm	-1								r	
03F	3	18	ceiling	dark	-1								r	
03F	3	19	ceiling	dark	-1								r	
03F	3	20	nm	lowery	-1								r	
03F	3	21	nm	like	1								s	
03F	3	22	ceiling	dark	-1								r	
03F	3	23	nm	dislike	-1								r	(same dark ceiling)
03F	3	24	nm	dislike	-1								r	(same dark ceiling)
03F	3	25	nm	dark	-1								r	(same dark ceiling)
03F	3	26	nm	dark	-1								r	
03F	3	27	sofa	dark blue	-1								r	
03F	3	28										t		already selected (similar ones)
03F	3	29										cp		
03F	3	30	nm	tone	-1								r	
03F	3	31	nm	dislike	-1								r	
03F	3	32											r	
03F	3	33	floor	dislike									r	
03F	3	101										t		
03F	3	102										cp	b	
03F	3	103										t		
03F	3	Comments: This step is generally good Some one I selected in former steps shown in this step												
03F	4	1	nm	showy	-1								r	remove too much showy ones
03F	4	2	nm	showy	-1								r	
03F	4	3	nm	showy	-1								r	
03F	4	4	nm	showy	-1								r	
03F	4	5	nm	disharmony	-1								r	remove too much disharmony ones
03F	4	6	nm	disharmony	-1								r	
03F	4	7	sofa	showy	-1								r	
03F	4	8	nm	khaki	-1							sch	r	
03F	4	9	door	green	-1								r	
03F	4	10	floor	showy	-1								r	(green floor)
03F	4	11	nm	lowery	-1								r	
03F	4	12	nm	disharmony	-1								r	
03F	4	13	sofa	dark	-1								r	
03F	4	14	sofa	dislike	-1								r	
03F	4	15	sofa	dislike	-1								r	
03F	4	16	floor	dislike	-1								r	
03F	4	17	nm	yellow	-1								r	
03F	4	18	nm	brown	-1								r	
03F	4	19	door	disharmony	-1								r	
03F	4	20	nm	dislike	-1								r	
03F	4	21	nm		1							cp	s	
03F	4	22	nm		1							t	s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
03F	4	23	nm		1							cp	s	
03F	4	24	nm	lowery	-1								r	
03F	4	25	nm	lowery	-1								r	
03F	4	26	nm	like	1							cp	s	(21,23,26 similar)
03F	4	27	nm	cyan	-1								r	
03F	4	28	sofa	khaki	-1								r	
03F	4	29	nm	like	1								s	
03F	4	30	sofa	gray	-1								r	
03F	4	31	nm	dislike	-1								r	
03F	4	32	nm	lowery	-1								r	
03F	4	33	nm	dislike	-1								r	
03F	4	101										cp		oh, seems all pink
03F	4	102											b	
03F	5	1	sofa	peacock blue	-1								r	
03F	5	2	nm	disharmony	-1								r	
03F	5	3	sofa	dark	-1								r	
03F	5	4	sofa	brown	-1								r	
03F	5	5	nm	cyan	-1								r	
03F	5	6	nm	cool	-1								r	
03F	5	7	nm	green	-1								r	
03F	5	8	nm	khaki	-1								r	
03F	5	9	nm	orange	-1								r	
03F	5	10	nm	like	1							t	s	
03F	5	11	nm	like	1							cp	s	
03F	5	12	nm		1							t	s	(similar to above)
03F	5	13	floor	dislike	-1								r	
03F	5	14	floor	color	-1								r	(similar blue floor)
03F	5	15	floor	color	-1								r	(similar blue floor)
03F	5	16	floor	color	-1								r	(similar blue floor)
03F	5	17	floor	color	-1								r	(similar blue floor)
03F	5	18	sofa	dislike	-1								r	
03F	5	19	all	tone	-1								r	
03F	5	20	nm	like	1								s	
03F	5	21	nm	mint color	1								s	
03F	5	22	nm	dislike	-1								r	I don't like it any more (red floor)
03F	5	23	nm	dislike	-1								r	I don't like it any more (red sofa)
03F	5	24	floor	red	-1								r	I don't like too red ones
03F	5	25	sofa	red	-1								r	
03F	5	26	nm	brown	-1								r	
03F	5	27	nm	yellow	-1							cp	r	
03F	5	28	nm	dark	-1								r	
03F	5	29											s	
03F	5	30											s	
03F	5	31	floor	dislike	-1								r	
03F	5	32	nm	dark	-1								r	
03F	5	33	sofa	dislike	-1							cp	r	
03F	5	34	ceiling	dislike	-1								r	
03F	5	35	sofa	dark	-1	nm	yellow	-1				cp	r	
03F	5	36	nm		1								s	
03F	5	37										cp		(only selected left)
03F	5	38											b	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
03F	5	Comments: I sometimes select pink, sometimes select azury so it should be hard for computer to calculate												
03F	6	1	nm	showy	-1								r	oh, so showy, I'll first remove the showy ones
03F	6	2	sofa	blue	-1								r	
03F	6	3	sofa	blue	-1								r	
03F	6	4	sofa	green	-1								r	
03F	6	5	nm		-1								r	(blue wall, green sofa)
03F	6	6	sofa		-1	wall	like	1				h		
03F	6	7	floor	ugly	-1	sofa	ugly	-1					r	
03F	6	8	sofa	ugly	-1								r	
03F	6	9	floor	ugly	-1								r	
03F	6	10										t		(red floor)
03F	6	11	nm	common	-1								r	
03F	6	12	all	tone	-1								r	
03F	6	13	nm	warm	-1								r	
03F	6	14	nm	warm	-1								r	
03F	6	15	nm	disharmony	-1								r	(similar warm color as above)
03F	6	16	nm	slowy	-1								r	
03F	6	17	sofa	abrupt	-1								r	
03F	6	18	nm		1								s	
03F	6	19	nm		1								s	
03F	6	20	nm		1								s	
03F	6	21										cp		I like these walls, I'll select one from them
03F	6	22	nm	harmony	1							cp	s	to select between these two
03F	6	23	nm	common	-1								r	
03F	6	24	nm	like	1							cp		
03F	6	25										t		then, the rest… hard to select
03F	6	26	nm	dark	-1								r	hard to select
03F	6	27	nm		1								s	acceptable, I will keep it
03F	6	28	sofa	dark	-1								ds	(deselect the result of 22)
03F	6	29	nm		1							cp	s	(compare the similar ones again)
03F	6	101										cp		
03F	6	102	ceiling	dark	-1									
03F	6	103										h		
03F	6	104											b	
03F	6	Comments: I think there will be no great difference in later steps Keep on going to see if there will be progress. I hope to see this one but lighter ceiling, but I do not know if it will show What were the usual step numbers of the others?												
03F	7	1												see if there is the best one of last step
03F	7	2										sch		it do not generate the one I expected
03F	7	3	nm		1								s	But this is good, never shown before
03F	7	4	nm	bright	1							cp	s	
03F	7	5	nm	warm	-1								r	
03F	7	6	nm	disharmony	-1								r	
03F	7	7	nm	showy	-1								r	
03F	7	8	floor	dislike	-1								r	
03F	7	9	floor	strange	-1								r	
03F	7	10	sofa	showy	-1								r	
03F	7	11	sofa	strange	-1								r	

Participant	Step	Record No.	Evaluation Criteria										BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3				
03F	7	12	sofa	dark blue	-1									r	
03F	7	13	nm		1	sofa	color	-1					h		
03F	7	14	nm		1									s	
03F	7	15											cp	r	they are similar
03F	7	16												r	they are similar
03F	7	17	door	strange	-1									r	
03F	7	18	nm	disharmony	-1									r	
03F	7	19	nm	yellow	-1									r	
03F	7	20	nm	disharmony	-1									r	
03F	7	21	sofa	dislike	-1									r	
03F	7	22	nm	disharmony	-1									r	
03F	7	23	floor	strange	-1									r	(similar light and cool color)
03F	7	24	nm	dark	-1								t	r	
03F	7	25	sofa	dark	-1									r	
03F	7	26	nm		1									s	
03F	7	27	floor	green	-1									r	
03F	7	28	floor	green	-1									r	
03F	7	29	nm	slowy	-1									r	
03F	7	30	nm	dark	-1									r	
03F	7	31	nm	dark	-1									r	
03F	7	32	floor	ugly	-1									r	
03F	7	33	nm		1									s	
03F	7	34	floor	red	-1									r	
03F	7	35	floor	ugly	-1									r	
03F	7	36	nm	dark	-1									r	
03F	7	37	sofa	ugly	-1									r	
03F	7	101											cp		
03F	7	102	nm		1									b	I like the new one
03F	7	Comments: Generally not so good for me Sometimes generally good, sometimes generally not so good													
03F	8	1	nm	showy	-1									r	
03F	8	2	nm	pink	-1										
03F	8	3	nm	disharmony	-1									r	
03F	8	4	door	disharmony	-1									r	
03F	8	5	door	disharmony	-1									r	
03F	8	6	nm	orange	-1									r	
03F	8	7	nm		1									s	
03F	8	8	nm	beautiful	1									s	
03F	8	9	nm		1									s	
03F	8	10	ceiling	dark	-1										
03F	8	11	sofa	ugly	-1									r	
03F	8	12	sofa	ugly	-1									r	
03F	8	13	nm	pink	-1									r	
03F	8	14	nm	pink	-1									r	
03F	8	15	nm	green	-1									r	
03F	8	16	sofa	uncomfortable	-1										
03F	8	17	nm	disharmony	-1									r	
03F	8	18	nm	slowy	-1									r	
03F	8	19	nm	slowy	-1									r	
03F	8	20	nm	orange	-1									r	
03F	8	21	nm	dark	-1									r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
03F	8	22	nm	dark	-1								r	
03F	8	23	sofa	dislike	-1								r	
03F	8	24	nm	yellow	-1								r	
03F	8	25	nm	disharmony	1								r	
03F	8	26	sofa	ugly	-1								r	
03F	8	27	floor	dark	-1								r	
03F	8	28										t		
03F	8	29										cp	r	
03F	8	30	nm	dark	-1							cp	ds	
03F	8	31										cp	s	
03F	8	32	nm	tinge	-1							cp	r	
03F	8	33	nm	dark	-1								r	
03F	8	34	ceiling	dark	-1								r	
03F	8	35	ceiling	dark	-1								r	
03F	8	36	nm	dark	-1								r	
03F	8	37	wall	prefer	1								s	
03F	8	38	nm	dark	-1								r	
03F	8	39	nm	dark	-1								r	
03F	8	40	nm		1								s	
03F	8	41	nm	fade	-1								r	
03F	8	42	nm	disharmony	-1								r	
03F	8	43										cp		
03F	8	44										t	b	(same as 8)
03F	8	Comments: It is not what I really want but I think it will generate similar ones I will try the last step if I can make adjustment, it will be better												
03F	9	1												this is the new one (recognized)
03F	9	2	mirline		1							cp	s	among these with similar new wall paper, the best is…
03F	9	3											r	so I remove the rest similar ones
03F	9	4											r	
03F	9	5											r	
03F	9	6	nm	disharmony	-1								r	delete obviously disharmonious ones
03F	9	7	nm	disharmony	-1								r	
03F	9	8	nm	disharmony	-1								r	
03F	9	9	nm	disharmony	-1								r	
03F	9	10	nm	disharmony	-1								r	
03F	9	11	nm	dark	-1								r	
03F	9	12	nm	yellow	-1								r	(wall is yellow)
03F	9	13	nm	yellow	-1								r	(wall is yellow)
03F	9	14	nm	yellow	-1								r	(wall is yellow)
03F	9	15											r	
03F	9	16	sofa	dislike	-1								r	
03F	9	17	sofa	fade	-1								r	
03F	9	18	sofa	dislike	-1								r	
03F	9	19	nm	strange	-1								r	
03F	9	20	nm	dislike	-1								r	
03F	9	21	nm	slowy	-1								r	
03F	9	22										t		
03F	9	23	nm		1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
03F	9	24	nm		1							cp	s	really hard to choose
03F	9	25											r	(the similar one)
03F	9	26										cp		these are with the same wall paper
03F	9	27	nm	comfortable	1							h	s	
03F	9	28											ds	
03F	9	29											s	
03F	9	30	nm	green	-1								r	
03F	9	31	nm	red	1								r	(same as 27, 28)
03F	9	32										cp		chose one from these similar ones
03F	9	33										cp		they are with same floor
03F	9	34	ceiling	dark	-1								r	
03F	9	35	nm		1									This is the best(already selected)
03F	9	36											r	(the similar ones)
03F	9	37											r	(the similar ones)
03F	9	38	nm	common	-1								r	
03F	9	39	nm	common	-1								r	
03F	9	40	nm	fade	-1								r	
03F	9	41	nm	common	-1								r	
03F	9	42	nm	beautiful	1								s	
03F	9	43	nm	common	-1								r	
03F	9	44	nm	common	-1								r	
03F	9	45	nm	common	-1								r	
03F	9	45										cp	b	it is similar to the best of last step
03F	Retrospective report		In step 1, I like the best one, but it disappeared I remember that there is a white sofa inside later I am interested in walls with tinge pattern and floors with pattern I mainly select among images with wall pattern and floor pattern I firstly remove showy and glare ones then I search for preferred wall color and pattern concentrate on the wall, there are several different combinations of other factors, and I choose one out of them. or concentrate on another wall paper, and choose one. in every step, there will always 2 kinds of images one is in pink tone, one is in light green tone generally, I prefer pink tone At the beginning, there are pink tone and light green tone I was hesitating between these two tones. Then gradually, I tend to choose pink tone, and get quite sure about the pink tone.											
04F	1	1												Let me take a look
04F	1	2	sofa	yellow	-1								r	I do not like the sofa in yellow tone
04F	1	3	sofa	brown	-1								r	dark yellow
04F	1	4	sofa	yellow	-1								r	
04F	1	5	nm		-1								r	
04F	1	6	nm		-1								r	
04F	1	7	all	similar	-1	wall		-1					r	the colors are too much similar
04F	1	8										t		I like tinge ones
04F	1	9	sofa	red	-1								r	
04F	1	10	sofa	black	-1								r	
04F	1	11											r	(dark sofa)
04F	1	12	all	harmony	1	all	elegant	1					s	
04F	1	13	nm		1								s	
04F	1	14	nm		1								s	
04F	1	15	nm		1								s	
04F	1	16	nm	dark	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	1	17	nm		1								s	
04F	1	18	sofa	dark	-1								r	
04F	1	19	sofa	dark	-1								r	
04F	1	20	all		1	all	bar	-1					r	looks like a bar, not home
04F	1	21	nm		1							cp	s	These two yellow sofas…
04F	1	22	door	dark	-1								r	
04F	1	23	sofa	pink	-1								r	
04F	1	24	nm		1								s	
04F	1	25	nm		1								s	
04F	1	26											s	I generally do not like to showy ones
04F	1	27											r	
04F	1	28										cp	s	these three images
04F	1	29											r	they are generally good, but…
04F	1	30											s	
04F	1	31	nm		1								s	
04F	1	32	nm		-1								r	
04F	1	33	nm	dark	-1								r	
04F	1	34	nm		1								s	
04F	1	35	nm		1								s	
04F	1	36	nm		1							cp	s	
04F	1	37	all	disharmony	-1								r	
04F	1	38												among these images, I can select only one best…
04F	1	39											b	I prefer this one (first one selected)
04F	1	Comments: I selected so many, maybe to many I prefer these harmony ones The color contrast too much in some images, so they are not necessary for me to select												
04F	2	1	all	contrast	-1	nm	showy	-1					r	they are similar to the previous step
04F	2	2	sofa	similar	-1								r	(red carpet)
04F	2	3	nm	showy	-1								r	
04F	2	4	sofa	green	-1								r	I do not like this kind of green
04F	2	5	sofa	green	-1								r	
04F	2	6											r	
04F	2	7	wall		1	sofa	disharmony	-1					r	
04F	2	8										sch		the rest ones…
04F	2	9	nm		0									
04F	2	10	sofa		0									
04F	2	11	nm	dislike	-1								r	
04F	2	12	nm	dislike	-1								r	
04F	2	13											r	
04F	2	14	nm		1								s	
04F	2	15	nm		1								s	
04F	2	16	floor	dark	-1								r	
04F	2	17	sofa	similar	-1								r	(similar floor)
04F	2	18											r	
04F	2	19	nm	dark	-1								r	
04F	2	20	nm		1								s	
04F	2	21	all	cool	-1								r	
04F	2	22	door	red	-1								r	
04F	2	23	nm		1									
04F	2	24	nm		1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	2	25	wall	dark	-1								r	(same as 9)
04F	2	26	floor	white	-1								r	(same as 23)
04F	2	27												about the rest…
04F	2	28	nm		1								s	
04F	2	29											s	
04F	2	30											s	
04F	2	31	sofa	dark	-1								r	
04F	2	32	sofa	abrupt	-1								r	
04F	2	33	nm		1								s	
04F	2	34	nm		1								s	
04F	2	35											s	
04F	2	36											s	
04F	2	37	sofa	similar	-1								r	
04F	2	38	nm		1								s	
04F	2	39	nm		1								s	
04F	2	40	nm		1								s	
04F	2	41										cp	b	the best one is one of these two (the two selected at first)
04F	2	Comments: Some of them are good at first sight, but if you consider again, they are not so good If I consider the general feeling, it is good. But if I look at it carefully, I will find some details not good enough These two are fairly good (the two selected firstly)												
04F	3	1												This step is generally good, and more difficult to select
04F	3	2	floor	dark	-1								r	(blue floor)
04F	3	3	floor	dark	-1								r	(similar blue floor)
04F	3	4												dark is not so bad, but if dark contrast with light, it is strange
04F	3	5	floor	dark	-1								r	(red floor)
04F	3	6											r	(similar red floor)
04F	3	7											r	(similar red floor)
04F	3	8												I think in a home, if the sofa is abrupt, it is ok, but if the floor is dark, you can not see other things
04F	3	9											r	(similar red floor)
04F	3	10	nm	cool	-1								r	
04F	3	11											r	(similar image)
04F	3	12	sofa	disharmony	-1								r	If I take a look at sofa…
04F	3	13	sofa	similar	-1								r	
04F	3	14	sofa	dislike	-1								r	
04F	3	15	nm	dislike	-1								r	
04F	3	16	floor	dark	-1								r	
04F	3	17												Maybe I prefer the wooden floors
04F	3	18	all	blurry	-1								r	
04F	3	19	all		1								s	
04F	3	20	floor	wooden	1	sofa	red	-1					s	
04F	3	21	floor		-1								r	
04F	3	22	floor		-1								r	
04F	3	23	floor		-1								r	
04F	3	24	floor	texture	-1								r	
04F	3	25	nm		1								s	
04F	3	26	nm		1								s	
04F	3	27	floor	wooden	1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	3	28	sofa	contrast	-1								r	(similar wooden floor)
04F	3	29	all	harmony	1	all	blurry	-1					r	
04F	3	30	nm		1								s	
04F	3	31	nm		1								s	
04F	3	32										t		
04F	3	33	nm	bright	1								s	
04F	3	34	nm	bright	1								s	
04F	3	35	floor	texture	-1								r	
04F	3	36	all	blurry	-1								r	
04F	3	37	nm	dark	-1								r	(same as 32)
04F	3	38	floor	dark	-1								r	
04F	3	39	floor	texture	-1								r	
04F	3	40											s	
04F	3	41	nm		1								s	
04F	3	42												they seems not as good as last step
04F	3	43												I like the floor, but a little dark.
04F	3	44												It is hard to select the best one
04F	3	45											b	(the one selected firstly, same as 17)
04F	3	Comments: The textures in this step is better, but the colors are not so good In last step, I selected based on color, in this step I selected based on textures But they feel not so good as last step I think the floor should not be too dark, and it is better to be wooden												
04F	4	1	floor	dark	-1								r	I will first remove the floors too dark
04F	4	2	floor	dark	-1								r	
04F	4	3	floor	dark	-1								r	
04F	4	4	floor	green	1									
04F	4	5	floor	dark	-1								r	
04F	4	6	nm		-1								r	(dark floor)
04F	4	7	nm		-1								r	(dark floor)
04F	4	8	floor	texture	-1								r	(light floor)
04F	4	9	floor	dark	-1								r	
04F	4	10	floor	texture	-1								r	(light floor)
04F	4	11												firstly select floors
04F	4	12	floor	dark	-1								r	(same as 4)
04F	4	13	floor	dark	-1								r	
04F	4	14	floor	dark	-1								r	
04F	4	15	nm	dark	-1								r	
04F	4	16											r	(dark floor)
04F	4	17											r	(dark floor)
04F	4	18												I found that what I select is different from what I was thinking
04F	4	19	wall		-1								r	
04F	4	20	nm		-1								r	
04F	4	21	floor	dark	-1								r	
04F	4	22	floor		0									they are not as good as I saw before
04F	4	23	nm		1								s	
04F	4	24											s	
04F	4	25	nm		1								s	
04F	4	26	nm		1								s	
04F	4	27	floor	dark	-1								r	
04F	4	28	all	blurry	-1								r	
04F	4	29											r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	4	30	floor		-1								r	
04F	4	31	door	dark	-1								r	
04F	4	32	nm		1								s	
04F	4	33	nm		1								s	
04F	4	34	nm		1								s	
04F	4	35	nm	dark	-1								r	not bright enough
04F	4	36	nm		1								s	
04F	4	37	nm		1	floor		-1					s	
04F	4	38	nm		1								s	
04F	4	39											s	
04F	4	40										cp	s	not bright enough
04F	4	41										h		
04F	4	42	wall	dark	-1								ds	
04F	4	43	floor	dark	-1							cp	ds	
04F	4	44	nm	dark	-1								ds	
04F	4	45											ds	
04F	4	46	all	blurry	-1	all	dark	-1					ds	
04F	4	47										cp	b	(change once the selection of best one)
04F	4	48												
04F	4	49												
04F	4	50												
04F	4	201												ask about when to finish
04F	4	Comments: I feel that they are getting worse At the beginning, I am sure what I prefer But now I am not sure what I prefer, and they are not so good as the beginning												
04F	5	1												the floors are not so dark now
04F	5	2	floor	dark	-1								r	
04F	5	3	floor	pink	-1								r	
04F	5	4	floor	pink	-1								r	
04F	5	5	floor	pink	-1								r	
04F	5	6	floor	pink	-1								r	
04F	5	7	floor		-1								r	the rest floors are not so dark now
04F	5	8												so I start to select good floors
04F	5	9	floor	wooden	1								s	I like wooden floors
04F	5	10	floor	wooden	1								s	I will select the ones with wooden floors
04F	5	11	floor	wooden	1								s	
04F	5	12												the rest seems similar for me
04F	5	13	wall		-1								r	
04F	5	14	floor		-1									floor is not as good as wooden floor
04F	5	15	wall		-1								r	(wooden floor)
04F	5	16	nm	tinge	-1								r	
04F	5	17	ceiling	tinge	-1									
04F	5	18	sofa		-1								ds	
04F	5	19	sofa		-1								r	now select on sofa
04F	5	20	sofa	disharmony	-1								r	
04F	5	21	all	disharmony	-1								r	the rest are…
04F	5	22	nm		-1								r	
04F	5	23	wall	strange	-1								r	
04F	5	24	sofa	white	-1								r	
04F	5	25	floor	dark	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	5	26	all	bright	-1									
04F	5	27	floor		-1								r	
04F	5	28	floor		-1								r	
04F	5	29	sofa		-1								r	
04F	5	30	sofa		-1								r	
04F	5	31	nm		1								s	
04F	5	32	nm		1								s	
04F	5	33	nm		1								s	
04F	5	34	nm	dark	-1								r	
04F	5	35	sofa		-1								r	
04F	5	36	all	toilet	-1								r	(same as 26)
04F	5	37	sofa		-1								r	
04F	5	38	sofa		-1								r	
04F	5	39	all	strange	-1								r	
04F	5	40	all	strange	-1								r	
04F	5	41	nm		1								s	
04F	5	42	wall	dark	-1								r	
04F	5	43	nm		1								s	
04F	5	44											b	(the first one selected)
04F	5	45										h	cb	It is difficult to select
04F	5	Comments: I found that the difference is not so big now												
04F	6	1	sofa	bright	-1								r	(high saturation)
04F	6	2	nm		-1								r	
04F	6	3											r	
04F	6	4	nm		1								s	It is the one just now
04F	6	5	wall		-1								r	
04F	6	6	all	contrast	-1								r	
04F	6	7												this one feels…
04F	6	8	floor		-1								r	
04F	6	9	sofa		-1								r	
04F	6	10	sofa	disharmony	-1								r	
04F	6	11	wall		-1								r	
04F	6	12	wall		-1								r	(similar wall)
04F	6	13	sofa	dark	-1								r	(similar wall, same as 7)
04F	6	14	sofa	green	-1								r	
04F	6	15	floor		-1								r	
04F	6	16	floor		-1								r	
04F	6	17	sofa	not clear	-1								r	
04F	6	18	floor		-1								r	
04F	6	19											r	this step is not so good as last step
04F	6	20											r	
04F	6	21	nm		1								s	
04F	6	22	nm		1								s	
04F	6	23	nm		1								s	similar to last step
04F	6	24	wall		-1								r	
04F	6	25											r	
04F	6	26	floor		-1								r	
04F	6	27	floor		-1								r	
04F	6	28	all	blurry	-1								r	
04F	6	29	all	blurry	-1								r	
04F	6	30	nm		1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	6	31	nm		1								s	
04F	6	32	nm		1								s	
04F	6	33	floor		-1								r	
04F	6	34	all	bright	1								s	
04F	6	35	nm		1								s	
04F	6	36											s	
04F	6	37											b	(the first one selected)
04F	6	38	floor		-1								ds	
04F	6	39	all	blurry	-1								ds	
04F	6	Comments: They difference between steps are small But they are not yet what I want I want a room which you feel bright, and not too dark I think wooden floor is good This one is near what I want, but the color is still a little bit strange. Too warm												
04F	7	1	floor	dark	-1								r	I am looking for that one, but it is not here
04F	7	2	sofa		-1								r	
04F	7	3	sofa		-1								r	
04F	7	4	floor		-1								r	
04F	7	5	floor		-1								r	
04F	7	6	floor		-1								r	
04F	7	7	floor		-1								r	
04F	7	8	floor		-1								r	
04F	7	9	sofa	showy	-1								r	
04F	7	10	sofa	showy	-1								r	
04F	7	11	all	bright	1								s	
04F	7	12	sofa		-1								r	
04F	7	13	nm		1								s	
04F	7	14	floor	strange	-1							h	r	
04F	7	15	nm		-1								r	
04F	7	16	door		-1								r	
04F	7	17	sofa		-1								r	
04F	7	18	sofa		-1								r	
04F	7	19	sofa		-1								r	
04F	7	20	sofa		-1								r	
04F	7	21	sofa		-1								r	
04F	7	22	sofa		-1								r	
04F	7	23	sofa		-1								r	
04F	7	24	sofa		-1								r	
04F	7	25	sofa		-1								r	
04F	7	26	all	bright	1								s	
04F	7	27	floor		-1								r	
04F	7	28	wall		-1								r	
04F	7	29	sofa		-1								r	
04F	7	30											s	
04F	7	31	sofa		-1								ds	
04F	7	32											s	
04F	7	33	floor		1								s	
04F	7	34	floor		-1								r	
04F	7	35	floor		-1								r	
04F	7	36	nm		-1								r	
04F	7	37											s	This step is not so good as last one

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	7	38											b	
04F	7	Comments: I am now expecting that what I want will show in next step They are some how close to my preference, they are bright now, and colors not so showy Sofa is still close to the background, I want it to be more clear and bright												
04F	8	1	wall	dark	-1								r	(wall showy)
04F	8	2	floor		-1								r	
04F	8	3	wall		-1								r	
04F	8	4												this one is…
04F	8	5	floor		-1								r	
04F	8	6	sofa		-1								r	
04F	8	7	floor	showy	-1								r	
04F	8	8	sofa		-1								r	
04F	8	9	sofa		-1								r	
04F	8	10	sofa		-1								r	
04F	8	11	sofa		-1								r	
04F	8	12	sofa		-1							if		if the sofa color changes a little, it will be better
04F	8	13	sofa		-1								r	
04F	8	14	sofa	not clear	-1								r	
04F	8	15											r	
04F	8	16											r	
04F	8	17	nm		-1								r	
04F	8	18	floor		-1								r	
04F	8	19	nm		-1								r	
04F	8	20	sofa		-1								r	
04F	8	21											s	
04F	8	22	door	dark	-1								r	
04F	8	23	sofa		-1								r	
04F	8	24	sofa		-1								r	
04F	8	25	sofa	not clear	-1								r	
04F	8	26											s	
04F	8	27	sofa	dark	-1								r	
04F	8	28	sofa	not clear	-1								r	
04F	8	29	nm		-1								r	
04F	8	30	nm		-1								r	
04F	8	31	nm		1								s	
04F	8	32	all	bright	1								s	
04F	8	33	floor		-1								r	
04F	8	34	sofa	abrupt	-1								r	
04F	8	35										cp	s	this one is better
04F	8	36											ds	
04F	8	37	nm		1								s	
04F	8	38	nm		1								s	
04F	8	39	nm		1								s	
04F	8	40											b	(the first one selected)
04F	8	41	nm		-1							cp	ds	
04F	8	Comments: If it is still like this for two steps, I will give up I feel that the selected ones of each generation are quite similar I don't feel that they were developed greatly I select based on first feeling. If I think a lot, the two will become more similar												
04F	9	1	floor		-1								r	the floor is showy
04F	9	2	wall	dark	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	9	3	wall	dark	-1								r	
04F	9	4	floor	dark	-1								r	
04F	9	5	wall	dark	-1								r	
04F	9	6	wall	dark	-1								r	
04F	9	7	sofa	showy	-1								r	
04F	9	8	sofa	dislike	-1								r	(showy blue sofa)
04F	9	9	door	dark	-1								r	
04F	9	10	wall		-1								r	
04F	9	11												I selected this one before
04F	9	12	sofa		-1								r	
04F	9	13	floor		-1								r	
04F	9	14	wall	disharmony	-1								r	the rest…
04F	9	15	wall		-1								r	
04F	9	16	wall	tinge	-1								r	
04F	9	17	all	bright	1								s	
04F	9	18											s	
04F	9	19	all	dark	-1								r	
04F	9	20												now they are close to my idea, they are acceptable
04F	9	21											s	
04F	9	22	sofa	dislike	-1								r	
04F	9	23	sofa		-1								r	
04F	9	24	nm		1								s	the rest are similar
04F	9	25											s	
04F	9	26											s	
04F	9	27	floor	blurry	-1								r	
04F	9	28	floor	dark	-1								r	
04F	9	29	floor	patterned	-1								r	
04F	9	30	nm		1								s	
04F	9	31	nm		1							cp	s	
04F	9	32											r	(similar to above)
04F	9	33											r	(similar to above)
04F	9	34	sofa		-1								r	
04F	9	35	nm		1								s	
04F	9	36	sofa	bright	-1								r	(red sofa)
04F	9	37	sofa		-1								r	
04F	9	38											s	
04F	9	39												It is strange that they are getting close to my preference, but I am getting more and more uncertain about the best one
04F	9	40												I feel they are generally good
04F	9	41	nm	blurry	-1								r	Maybe too many, I will remove one
04F	9	42											b	
04F	9	43	sofa	dark	-1							cp	r	
04F	9	At the beginning, they differs greatly, so it is easy to select now they are similar to each other, and I get similar feeling about them ask about end criteria If next step is similar to this step…												
04F	10	1												They are not so good as last step
04F	10	2	wall	dark	-1								r	
04F	10	3	floor	dark	-1								r	
04F	10	4	floor		-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	10	5	nm		-1								r	
04F	10	6	floor	dark	-1								r	
04F	10	7	floor	dark	-1								r	
04F	10	8	floor	dark	-1								r	
04F	10	9												it is difficult to select now, they are similar to what I select in last step
04F	10	10	door		1							cp	s	comparing these two, this door is better
04F	10	11											r	so I remove this one
04F	10	12	nm		1								s	
04F	10	13	nm		1								s	
04F	10	14	sofa		-1								r	
04F	10	15	sofa		-1								r	
04F	10	16	floor		-1								r	
04F	10	17	all	cool	-1								r	
04F	10	18	sofa	dark	-1								r	(red sofa)
04F	10	19	nm		-1								r	
04F	10	20	nm		1								s	
04F	10	21	nm		1								s	
04F	10	22											s	
04F	10	23	all	clear									s	
04F	10	24											s	
04F	10	25											s	
04F	10	26										cp	s	
04F	10	27											r	
04F	10	28											r	
04F	10	29											r	
04F	10	30											r	
04F	10	31											r	
04F	10	32	sofa	dark	-1									
04F	10	33											r	
04F	10	34											r	
04F	10	35	sofa		-1								r	
04F	10	36										cp	ds	comparing these three…
04F	10	37											r	
04F	10	38	sofa	dark	-1								r	
04F	10	39	nm	blurry	-1								ds	
04F	10	40	all	clear	1								b	
04F	10	41	wall	like	1								s	
04F	10	42										cp	ds	compare these three, this one is the best, so the rest are removed
04F	10	43											ds	
04F	10	Comments: If the next step is not better than this one, it could be stopped I am a little bit tired												
04F	11	1	floor	dark	-1								r	I will remove the dark floors
04F	11	2	floor	dark	-1								r	
04F	11	3	wall		-1								r	
04F	11	4	sofa	dislike	-1								r	then the ugly sofas
04F	11	5	sofa	showy	-1								r	
04F	11	6	wall		-1								r	
04F	11	7	nm		1								s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
04F	11	8	sofa	not clear	-1								r	
04F	11	9	floor		-1								r	
04F	11	10	nm	dislike	-1								r	
04F	11	11	sofa	light	-1							if		if the sofa is darker, it is better
04F	11	12	nm	dark	-1								r	
04F	11	13	sofa		-1								r	
04F	11	14	all	disharmony	-1								r	
04F	11	15	all	dark	-1								r	
04F	11	16	nm	dislike	-1								r	
04F	11	17	sofa	light	-1								r	
04F	11	18										cp	r	
04F	11	19	all	disharmony	-1								r	
04F	11	20	all	disharmony	-1								r	
04F	11	21	nm		1								s	
04F	11	22	ceiling		-1								r	
04F	11	23											r	
04F	11	24											s	
04F	11	25	floor		-1								r	
04F	11	26											s	
04F	11	27										if	s	If these two can be combined, it may be what I want
04F	11	28											r	
04F	11	29	sofa		-1								r	
04F	11	30											r	
04F	11	31											s	
04F	11	32										cp	s	
04F	11	33	ceiling		-1								r	
04F	11	34											r	
04F	11	35										cp	s	
04F	11	36											r	
04F	11	37										cp	s	
04F	11	38											ds	
04F	11	39	sofa		-1								ds	
04F	11	40	nm	light	-1							cp	ds	
04F	11	41											b	I think I could end it now, it is not as good as just now
04F			At the beginning images differs greatly, so I select based on feeling, I removed the showy ones, and the harmony ones remained because the differs greatly, it is easy to make selection In later steps, I start from the floor, and remove floors not good then remove the bad walls, and then sofa so I removed the bad single factors and then I evaluate by generally feeling if it is generally showy, I will remove it Later, the differences are small. And I still remove the single bad factors firstly. then I try to see if they are bright, and select the bright ones. The blurry ones were removed firstly floor, then sofa, then wall, then general feeling, then brightness, after that, based on my feeling at last, I feel they are quite similar What I want is almost found, but still a little bit different from my hope not what I want very much, but acceptable The result are similar to what I was thinking about my home. I did not think what exactly the colors should be. Now I get some idea of them and I think I can design my home in that direction in the future. there are some heuristics After replay, I found the one with red sofa is fairly good, but it did not survive tile the end. maybe there are so many similar ones of other style, so it was diluted												

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
05M	1	1											s	I will select what I feel good
05M	1	2											s	It is good to have so many choices
05M	1	3	floor	green	1	door		-1					ds	
05M	1	4	door		1	floor		-1					s	
05M	1	5	ceiling	dark	-1	nm		1					s	
05M	1	6	nm		1								s	
05M	1	7	nm	warm	1								s	good for winter
05M	1	8	wall	dark	-1								r	
05M	1	9	wall	dark	-1								r	
05M	1	10	mirline		-1								r	
05M	1	11	nm	civilian	1	nm	warm	1		lovely			s	
05M	1	101											b	
05M	1	102	nm	rural										
05M	1	103	nm	middle class										
05M	1	104	nm	middle class										
05M	1	104	nm	child									cb	
05M	2	1	nm	lovely	1								s	generally warm feeling, red tone
05M	2	2	nm	engineer	1								s	
05M	2	3	nm		1	sofa	dark	-1						
05M	2	4	nm		1								s	
05M	2	5	nm	similar	1								s	
05M	2	6										cp	ds	
05M	2	7	nm		1								s	
05M	2	8	nm		1								s	
05M	2	9	nm	European	1								s	
05M	2	10	nm	similar	1		light difference	1					s	
05M	2	11	nm		1	door	dark	-1					s	
05M	2	12	sofa	dark	1								s	
05M	2	13	nm	showy	1								r	
05M	2	14	nm	dreamily	-1								r	
05M	2	15	sofa	showy	-1								r	
05M	2	16	wall	commercial									r	
05M	2	17	nm	lively	1								s	I have no idea of it at the beginning, but I feel good about it now
05M	2	18										t		
05M	2	19	door	low contrast	-1								r	door is tinge and seems disappeared
05M	2	20	door	low contrast	-1								r	
05M	2	101										cp		
05M	2	102	nm	home	1								b	
05M	3	1	ceiling	massive	1	floor	light green	1	sofa	red	1		s	I like quite a lot of them
05M	3	2	nm	comfortable	1	sofa	tinge	-1	door	red	1		s	
05M	3	3	sofa	lovely	1	nm	child	1						
05M	3	4	nm	my major	1	nm	simple	1	nm	comfortable	1		s	
05M	3	5	nm	green	1	nm	dirty	-1					r	
05M	3	6	nm		-1	door	earth color	1					s	
05M	3	7	floor	earth color	1								s	
05M	3	8	floor	sea	-1								r	
05M	3	9	nm		1	sofa	brown	-1					s	
05M	3	101										sch		
05M	3	102	sofa	red	-1							cp		
05M	3	103	nm	neutral	1								b	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
05M	4	1	floor	texture contrast	1	door	red	1					s	generally not so many good ones as last step
05M	4	2	wall	green	1	ceiling		-1	nm		1		s	
05M	4	3	sofa	similar	1								s	
05M	4	4	nm	like	1	ceiling	dark	-1						
05M	4	5	ceiling	existence	1	nm		1					s	I'll choose this one similar to above
05M	4	6	floor	relax	1								s	
05M	4	7	floor	texture strong	-1								r	
05M	4	8	floor	texture strong	-1								r	
05M	4	9	floor	holiday	1	floor	sea	-1					s	
05M	4	101	nm	simple	1	nm	colorful	1	nm	warm	1	cp	b	
05M	5	1											s	I selected this one before, and I select it again
05M	5	2	nm	brown	1	nm	dark	-1	nm	study	1		s	
05M	5	3										cp	s	It is better than previous one
05M	5	4											ds	
05M	5	5	nm	warm	1	door	red	1					s	
05M	5	6												
05M	5	7	nm	tinge	-1									I selected it before, but too tinge compare to present ones
05M	5	8	all	proper contrast	1	nm	red	1	nm	spiritual	1		s	
05M	5	9	wall	special	1								s	
05M	5	10										sch		
05M	5	11	wall	strong	-1	nm	ugly	-1					r	
05M	5	12											s	similar to 8, proper contrast
05M	5	101										cp		
05M	5	102	wall	special	1								b	
05M	6	1	floor	texture contrast	1	nm	lively	1	nm	child	1		s	
05M	6	2	nm			door	tinge	-1				h		
05M	6	3										sch		If I live myself, it seems no very good ones
05M	6	4	nm	engineer	1								s	
05M	6	5	nm		1								s	(neutral color)
05M	6	6	wall	like	1							h		I don't have strong feeling of the rest images
05M	6	7	nm	warm	1								s	
05M	6	8	nm	warm	1								s	
05M	6	101											b	the one I saw at first sight
05M	7	1												I feel they are generally good
05M	7	2	nm		1								s	I'll choose the one I saw at first sight
05M	7	3												It seems there are always good image at this position
05M	7	4	nm		1							cp		
05M	7	5	floor		1	wall	bright	1				cp	s	compare with the first one, same red sofa…
05M	7	6	nm	lively		door	red	1					s	maybe I really like red door
05M	7	7												the rest are not so good
05M	7	8	ceiling	special	1								s	
05M	7	9	floor	color contrast	1	sofa	warm	1					s	
05M	7	10	nm	warm	1	wall	dark	-1				h		
05M	7	11	nm	neutral	1								s	
05M	7	101										cp	b	the one I saw at first sight

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
05M	8	1												there are fewer images that I like at first sight
05M	8	2											s	but there are still some ones I prefer to live in.
05M	8	3											s	
05M	8	4											s	
05M	8	5											s	
05M	8	6											s	The colors of separate parts are close to what I prefer, but some combination are not good
05M	8	7											s	
05M	8	101	nm	bright	1	floor	lively	1				cp	b	
05M	9	1												They are generally my style
05M	9	2											s	instinctively I like…
05M	9	3											s	
05M	9	4											s	it is hard to say which is best
05M	9	5	wall	similar	1	sofa	lively	1					s	ceiling, wall and door are similar tone, sofa is red and lively, so it feels bright
05M	9	6	wall	dark	-1	all	harmony	1				if	s	if the color of sofa and wall can exchange, it will be better
05M	9	7	all	proper contrast	1	sofa	conspicuous	1					s	
05M	9	8										cp	ds	(same as 14)
05M	9	9	nm	dark	-1	nm	similar	-1					r	
05M	9	10	nm	similar	-1	nm	green/gray	-1					r	
05M	9	11	door	strange	-1								r	
05M	9	12	wall	harmony	1	ceiling	dark	-1					s	
05M	9	101										cp		
05M	9	102										h		
05M	9	103	floor	green	1	nm	warm	1	nm	harmony	1		b	
05M	10	1												I like many of them
05M	10	2											s	floor with texture, sofa and others are simple
05M	10	3											s	
05M	10	4											s	what I prefer at first sight may be a little warmer ones, but not too chaos
05M	10	5	nm	warm	1								s	
05M	10	6	all	sea	1								s	this is not what I often choose, but the combination makes me feel like living near sea
05M	10	7											s	
05M	10	101												I'll choose warm and good combination
05M	20	1												I firstly choose ones that attract me at first sight
05M	20	2												I studies engineering, so I want my home be simple and neutral
05M	20	3												with vivid color in certain part, but generally neutral
05M	20	4												so my home would not be dull
05M	20	5												I prefer my home to be bright and warm
05M	20	6												I am planning to have child, so it is better to be lively
05M	20	7												the conbination should not be to ugly
05M	20	8												I did not consider the cost factor

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
05M	20	9												
05M	20	10												There are many different choices, so it is hard to make decision
05M	20	11												later they are getting similar, and the parts of the images are close to my preference.
05M	20	12												but the combination need development
05M	20	13												there are several different final results, I want to have some difference in my home
05M	20	14												All parts of the final results are close to what I want
05M	20	15												but still not very good
05M	20	16												maybe because I choose several different feeling like neutral, natural, lovely
05M	20	17												so it is not easy to make decision
05M	20	18												
05M	20	19												it feels like play with toy blocks, and interesting
05M	20	20												in later generations, fewer choices maybe better because they are similar
06M	1	1												I firstly select images with clear color contrast
06M	1	2												So I will firstly check all red sofas
06M	1	3												but I feel that the color combination of sofa and floor are not comfortable
06M	1	4												so I turn to pay attention to the floor
06M	1	5	floor	blue	1								s	other floors give me no special feeling
06M	1	6												so I start to look at the wall
06M	1	7	wall	special									s	
06M	1	8	wall	discomfortable	-1								r	
06M	1	9	nm	discomfortable	-1								r	
06M	1	10	nm	discomfortable	-1								r	
06M	1	11	all		1								s	now I tried to look at all factors
06M	1	12											s	If I have to choose one more image…
06M	1	13	floor	comfortable	1								b	The one I saw at first sight
06M	1	Comments: The floor is the first thing you see in a room, so if it is lively, you will have a good mood.												
06M	2	1	wall	special	1								s	I saw it at first sight, the wall is special
06M	2	2	wall	contrast	1								s	
06M	2	3	wall	red	-1								r	the wall is too red
06M	2	4	nm	bland	1								s	
06M	2	5										cp		about the rest…
06M	2	6	wall	ugly	-1							cp	r	
06M	2	7											b	The one I saw at first sight
06M	2	8	sofa	comfortable	1								s	If I have to select one more…
06M	2	Comments: May I review and choose from what I selected at the end of this process?												
06M	3	1	floor	blue	1								s	I like the blue floor
06M	3	2	floor	blue	1							cp		No great difference of these two, so I do not choose this one
06M	3	3	sofa	contrast	1	sofa	red	-1					s	
06M	3	4	sofa	harmony									s	the green sofa works well with the

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
														wall
06M	3	5										cs	s	the rest are common, but I have to choose more
06M	3	6											b	I still like what I selected firstly
06M	4	1	sofa	bright	1	all	harmony	1					s	
06M	4	2	floor	bland	1								s	(the floor is red)
06M	4	3	nm	ugly	-1								r	these are ugly
06M	4	4	nm		-1								r	
06M	4	5	nm		-1								r	
06M	4	6	nm		-1								r	
06M	4	7	nm		-1								r	
06M	4	8	nm		-1								r	
06M	4	9	nm		-1								r	
06M	4	10	all	harmony	1								s	
06M	4	11	nm	natrual	1	nm	home	1					s	(neutral color)
06M	4	12											b	The best one is what I selected firstly
06M	4	Comments: The simulation is quite different from the real feeling of the space												
06M	5	1												I see many blue sofas, but I think I should not select all of them
06M	5	2	nm	harmony	1								s	so considering the combination
06M	5	3	nm	harmony	1								s	(two images with blue sofa)
06M	5	4	all	warm	1								s	About the red sofa and red floor combination
06M	5	5	nm	bright	1								s	Considering that the home should be bright, so I choose this one
06M	5	6										cp		Considering all the blue sofas…
06M	5	7	door	dark	-1							h		
06M	5	8											b	(the first selected one)
06M	6	1												When I start to do it, I felt the blue sofa was very bright
06M	6	2												After several steps, I lost the exciting feeling of the blue sofa
06M	6	3												Now I'll focus on the combination and harmony of the images
06M	6	4												combination of wall, floor and sofa
06M	6	5	nm	warm	1								s	
06M	6	6												I don't find any one I like very much, but I have to choose
06M	6	7	all	harmony	1								s	the green floor is harmony with the wall and sofa, but I do not compare it with other green floors carefully
06M	6	8												based on feeling, I see, I choose
06M	6	9	floor	bright	1								s	
06M	6	10	all	harmony									s	the pink wall works well with red floor and sofa
06M	6	11	nm	new	1								b	This one gives me new feeling, so I select it
06M	7	1												I will pay more attention to the yellow floor, as the last step
06M	7	2	floor	harmony	1								s	the yellow floor works well with pink sofa
06M	7	3	sofa		1								s	Among the blue sofas…
06M	7	4	all	contrast	1								s	all colors in this image are different, and it is good
06M	7	5	all	warm	1								s	
06M	7	6	ceiling	dark	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
06M	7	7	door	dark	-1								r	
06M	7	8	all	elegance	1								s	
06M	7	9											b	(the first one selected)
06M	7	Comments: It is not easy to speak out every thing People select based on instinct, so some times it is not easy to explain instinct												
06M	8	1												oh, so many blue sofa
06M	8	2	wall	special	1								s	(with blue sofa)
06M	8	3	door	red	1								s	I remember that the red door has never shown, so I select it
06M	8	4	nm	comfortable	1								s	
06M	8	5	sofa	warm	1								s	
06M	8	6											b	the first one I selected, with different wall
06M	8	Comments: The sofa in my home is blue												
06M	9	1	nm	warm	1	nm	dark	-1					s	
06M	9	2										t		Many blue sofa, but combinations of wall and floor are not good
06M	9	3	nm		1								s	
06M	9	4	sofa	pink	1								s	through last step, I feel better of the pink sofa
06M	9	5	nm	common	1								s	the rest are not so good, so I select a common one
06M	9	Comments: Ask about the step numbers It seems there will be no new ideas to stimulate me												
06M	10	1	sofa	green	1								s	the green sofa has not been selected, it is good to be a scene
06M	10	2	sofa	bright	1								s	
06M	10	3	nm	dislike	-1								r	
06M	10	4	nm	dislike	-1								r	
06M	10	5	nm	contrast	-1									take a look at the red sofas…
06M	10	6	nm	natural	1								s	(red sofa)
06M	10	7	nm		1								s	(red sofa)
06M	10	Comments: I want to see if there will be more of the green sofa												
06M	11	1												there are two green sofas
06M	11	2	floor	green	1	floor	green	-1						(green sofa)
06M	11	3	floor	green	1	floor	green	-1						(green sofa)
06M	11	4	nm	ugly	-1								r	there are many pink sofas
06M	11	5	nm	ugly	-1								r	(pink sofa)
06M	11	6	nm	ugly	-1								r	(pink sofa)
06M	11	7	nm	contrast									s	(pink sofa)
06M	11	8	nm		1								s	(blue sofa)
06M	11	9	nm	dark	-1								r	(blue sofa)
06M	11	10	all	green	0									
06M	11	11	floor	green	1	nm	harmony	1					s	the green floor works well with the wall and sofa
06M	11	12	nm	pink	0	nm	dark	-1					r	
06M	11	13	nm	common	1								s	
06M	11	14											b	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
06M	Retrospective report	At the beginning, there are some floor colors that are usually used, so I am interested in floor colors I did not see before Then I am interested in sofa colors generally, no matter floor or sofa, I want the room bright Later, beside bright, I add warm as criteria Then I saw the blue sofa, and be interested in the blue sofa all along for several steps, I pay attention to the blue sofa and some bright and pleasant walls generally, in each step, there are something passed down from previous steps for example, I focus on wall for several steps, the sofa for several steps finally, I think I have considered every thing, sofa, wall, floor, brightness, contrast, warm so I think that the process could be ended At the beginning, I focus on single factors in the middle, I paid attention on harmony, brightness, warm, and so on Then I went back to single factors again At the end, it is hard to say it's general feeling, or single factors. at the end, I focused on ideas I have never seen. I think the variations of factors are just like that, and no need to continue. So I end it up												
07F	1	1	nm	dull	-1								r	
07F	1	2	sofa	ugly	-1								r	
07F	1	3	wall	ugly	-1								r	nothing I like at first sight
07F	1	4	floor	contrast	-1								r	
07F	1	5	nm	dull	-1								r	
07F	1	6	nm	dull	-1								r	
07F	1	7	nm	disharmony	-1								r	
07F	1	8	sofa	ugly	-1								r	
07F	1	9										t		
07F	1	10	nm	mytast	1	floor	color	-1	nm	harmony	1		s	this is near what I like, but the floor… the floor is good here
07F	1	11	nm	ugly	-1								r	
07F	1	12	floor	ugly	-1								r	
07F	1	13	floor	ugly	-1								r	
07F	1	14	nm	gloomy	-1								r	
07F	1	15										t		
07F	1	16	sofa	dark red	1	floor		-1					s	Sofa is good, but floor not so good
07F	1	17										t		I like this kind of feeling(10), and I like the sofa (16)
07F	1	18	wall	pink	-1								r	
07F	1	19	all	contrast	-1								r	
07F	1	20	nm	ugly	-1								r	
07F	1	21	sofa	disharmony	-1									
07F	1	22	nm		1	floor	dislike	-1				h	s	
07F	1	23	sofa	ugly	-1								r	(ask about how many to select)
07F	1	24	sofa	abrupt	-1	sofa	green	-1					r	
07F	1	25	sofa	ugly	-1								r	
07F	1	26	sofa	abrupt	-1								r	
07F	1	27										t		
07F	1	28	all	red	-1								r	
07F	1	29	sofa	disharmony									r	
07F	1	30										t		
07F	1	31	all	harmony	1	sofa	ugly	-1					r	
07F	1	32	all	disharmony	-1								r	
07F	1	33	nm	contrified	-1								r	
07F	1	34	all	warm tone	1	wall	contrified	-1					r	
07F	1	35	all	tone	1	all	dislike	-1					r	
07F	1	36	wall	dark	-1	nm		1				if	s	it will be better if the door is lighter

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
07F	1	37	nm	ugly	-1								r	
07F	1	38	nm	exanimate	-1								r	
07F	1	39	nm		1	door	ugly	-1					r	
07F	1	40	door	ugly	-1								r	
07F	1	41	all	tone	1								s	
07F	1	42											b	(check again the removed)
07F	2	Comments: What is the rendering quality of these images?												
07F	2	1	sofa	ugly	-1								r	it feels similar to the previous step
07F	2	2	floor	dazzling	-1								r	
07F	2	3	sofa	gloomy	-1	nm	disharmony	-1					r	
07F	2	4	nm	contrast	-1								r	
07F	2	5	wall	black strip	-1								r	
07F	2	6	wall	contrast	-1								r	
07F	2	7	all	similar	-1								r	
07F	2	8	wall		1	floor	light	-1				if	s	wall is good, but if the floor can be darker, it will be better
07F	2	9	sofa	ugly	-1								r	
07F	2	10	nm	common	1	nm	warm	1				t	s	
07F	2	11	all	harmony	1	floor	lively	-1				if	s	if the floor can be a little steady, it will be better
07F	2	12	nm	pink	-1								r	
07F	2	13	nm	dull	-1								r	
07F	2	14	nm	dull	-1								r	
07F	2	15	nm	hotel	-1	nm	clean	1					r	
07F	2	16	sofa	ugly	-1								r	
07F	2	17	sofa	disharmony	-1								r	
07F	2	18	all	bath room	-1								r	
07F	2	19	sofa	contrast	-1								r	
07F	2	20	sofa	contrast	-1								r	
07F	2	21	sofa	contrast	-1								r	
07F	2	22	sofa	ugly	-1								r	
07F	2	23	nm	dull	-1								r	
07F	2	24	sofa	dislike	-1								r	
07F	2	25	all	harmony	1	wall	dark	0					s	I did not expect that dark wall can work well here
07F	2	26	all	harmony	1								s	
07F	2	27	sofa	ugly	-1								r	
07F	2	28	floor	ugly	-1								r	
07F	2	29										t		
07F	2	30	nm	hotel	-1	nm	clean	1					s	
07F	2	31	nm	reception hall	-1								r	
07F	2	32	nm	no meaning	-1								r	
07F	2	33	sofa	like	1	floor	texture	-1					s	
07F	2	34	wall		1	sofa		-1					r	
07F	2	35	nm	dislike	-1							t	r	
07F	2	36	nm	emotional	1								s	not very good, maybe in later step.
07F	2	37	sofa		1	wall	barren	-1					s	
07F	2	38										t		
07F	2	39										cp	b	the best may be this or that one…
07F	2	Comments: I select some of them because I am expecting some good part shown in new combinations												
07F	3	1											s	quite similar to one I selected before
07F	3	2										cp	s	this one is similar, but better

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
07F	3	3										t		
07F	3	4	floor	ugly	-1							sch		when red sofa appears in this room
07F	3	5	nm		1							cp	s	(compare with another image with red sofa)
07F	3	6	wall	heavy	-1	floor	light	-1					r	wall too heavy and floor too light
07F	3	7	all	simple	-1	nm	not home	-1					r	
07F	3	8	wall	like	1	wall		-1				if	s	wall and sofa are good, but I expect new walls
07F	3	9	floor	showy	-1								r	
07F	3	10	floor	showy	-1								r	
07F	3	11	floor	showy	-1								r	
07F	3	12	floor	showy	-1	all	harmony	1					s	
07F	3	13	floor	strong	-1								r	
07F	3	14	all	cool	-1								r	
07F	3	15	floor	pink	-1								r	
07F	3	16	all	not home	-1								r	
07F	3	17	all	harmony	1	sofa		-1					s	
07F	3	18	all	common	-1								r	
07F	3	19	all	common	-1								r	
07F	3	20	sofa	dark	-1								r	
07F	3	21	sofa	disharmony	-1								r	
07F	3	22	nm		1	floor	pink	-1					s	
07F	3	23	sofa	disharmony	-1	floor	ugly	-1					r	
07F	3	24	nm	dull	-1								r	
07F	3	25	nm	dull	-1								r	
07F	3	26	sofa	dislike	-1								r	
07F	3	27	nm		1	nm	bedroom	-1				if	s	this combination is better for bedroom
07F	3	28	nm	pink	-1								r	
07F	3	29	sofa		1	floor		-1					s	floor bad, sofa good
07F	3	30	wall	disharmony	-1								r	red door and green wall is too ugly
07F	3	31	nm	green	-1								r	
07F	3	32	ceiling	dislike	-1								r	
07F	3	33	all		1	all	not home	-1					s	
07F	3	34	nm	pink	-1								r	
07F	3	35	sofa	dislike	-1								r	
07F	3	36	nm		1	floor	light	-1				if	s	if the floor could be darker, it will be better
07F	3	37	wall	no meaning	-1								r	
07F	3	38	nm		-1								r	
07F	3	39												which one is the best?
07F	3	40											b	the second one chosen, but better than the first one in this step
07F	4	1												generally, there are nothing I like at the first sight
07F	4	2	all		1	door	ugly	-1					s	
07F	4	3	all		1	all	not my tast	-1					r	
07F	4	4	nm	warm	-1								r	
07F	4	5	nm		1	floor	warm	-1					s	
07F	4	6	floor	ugly	-1								r	
07F	4	7	floor	pink	-1								r	
07F	4	8	floor	dislike	-1								r	
07F	4	9	wall	heavy	-1	floor	light	-1					r	wall heavy, floor light

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
07F	4	10	all	disharmony	-1	all	same tone	1					r	
07F	4	11	all	dull	-1								r	
07F	4	12	nm	cool	-1								r	
07F	4	13	all	disharmony	-1								r	orange wall and floor with such sofa is ugly
07F	4	14	all	orange	-1								r	
07F	4	15	wall	strange	-1	sofa	strange	-1					r	
07F	4	16	wall	cool	-1							if	r	the wall should be warmer
07F	4	17	all	ugly	-1								r	
07F	4	18	all	contrast	-1								r	
07F	4	19	all	pink	-1								r	
07F	4	20	floor		-1								r	I prefer dark and cool color on the floor
07F	4	21	sofa	dark red	1	floor	disharmony	-1				h	s	it is hard to select, should I preserve the sofa, or remove it because the whole image
07F	4	22	nm		1	floor	orange	-1					s	I will let it to evolve
07F	4	23	ceiling	yellow	-1								r	
07F	4	24	door		-1	nm		1				if	s	The door and wall should be improved
07F	4	25	sofa	ugly	-1								r	
07F	4	26	sofa	ugly	-1								r	
07F	4	27	floor	orange	-1	sofa		1					r	
07F	4	28	nm		1	sofa		-1				if	s	
07F	4	29	floor	dislike	-1								r	
07F	4	30	floor		-1								r	
07F	4	31	all	disharmony	-1								r	
07F	4	32	nm	cool	-1								r	
07F	4	33	nm	cool	-1								r	
07F	4	34	nm	cool	-1								r	
07F	4	35	nm	cool	-1								r	
07F	4	36	nm	dislike	-1								r	
07F	4	37	floor	meeting room	-1								r	
07F	4	38											b	(the first one selected)
07F	5	1												the walls in this generation are colorful
07F	5	2	floor	purple	-1								r	I will firstly remove the purple floor
07F	5	3	nm	contrast	-1								r	remove the ones I do not like at first sight
07F	5	4											r	
07F	5	5	sofa	green	-1								r	
07F	5	6	sofa	purple	-1								r	
07F	5	7	wall	contrast	-1								r	
07F	5	8	wall	contrast	-1								r	
07F	5	9												it appears again (dark red sofa)
07F	5	10	sofa	red	-1								r	
07F	5	11	sofa	red	-1								r	I want dark red sofa
07F	5	12	sofa	dark red	1	nm	green	-1					r	but the dark red sofa is in a green room
07F	5	13	nm	gloomy	-1								r	
07F	5	14										t		so the ugly ones at the first sight have been removed
07F	5	15	nm	toilet	-1								r	
07F	5	16	sofa	dark red	-1	floor		-1					r	I'll give it up, the ceramic tile is not

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
														good
07F	5	17	nm		1								s	this one has not changed
07F	5	18	nm		1								s	this one is similar
07F	5	19	wall	patterned	-1								r	
07F	5	20	floor	patterned	-1								r	
07F	5	21	floor	patterned	-1								r	
07F	5	22	wall	steady	1	sofa		1	floor	light	-1		s	
07F	5	23	nm	no meaning									r	
07F	5	24	nm	ugly	-1								r	(same patterned floor)
07F	5	25	nm	ugly	-1								r	(same patterned floor)
07F	5	26	nm	ugly	-1								r	(same patterned floor)
07F	5	27	nm	interesting	1								s	
07F	5	28	floor	red	-1								r	
07F	5	29	floor	disharmony	-1	sofa	dark red	1					r	the floor is too red for a red sofa
07F	5	30	floor	pink	-1	sofa	dark red	1					s	
07F	5	31	nm	ugly	-1								r	(dark red sofa)
07F	5	32	wall	ugly	-1								r	(dark red sofa)
07F	5	33	floor	disharmony	-1	wall		1					r	the green floor is not harmony with the patterned blue wall
07F	5	34	nm		1								s	(same patterned blue wall)
07F	5	35	all	contrast	-1								r	
07F	5	36	nm		1								s	
07F	5	37	nm		1	nm	toilet	-1					s	
07F	5	38	nm	harmony	1	floor	yellow	-1					r	
07F	5	39	nm	clean									s	
07F	5	40										cp		
07F	5	41										cp	b	these two are similar with different doors, but the doors are both ugly
07F	5	Comments: Here are many images, if there are not images I like very much, it is hard to select I am confused if I should evaluate by whole image or by separate factors, so the criterion is changing I sometimes expect that the program will change certain part for me, so I select it, sometimes I give it up												
07F	6	1	nm	ugly	-1								r	Obviously ugly ones
07F	6	2	floor	dazzling	-1									
07F	6	3											s	I will firstly select this one, it has not changed
07F	6	4												It is difficult now, the ugly ones at first sight are fewer.
07F	6	5	floor	patterned	-1								r	
07F	6	6	floor	patterned	-1								r	
07F	6	7	all	harmony	1	door	ugly	-1					s	
07F	6	8										cp	s	they are quite similar
07F	6	9	sofa	green	-1								r	
07F	6	10	all	dull	-1								r	
07F	6	11	sofa		-1	all	harmony	1					s	
07F	6	12	floor	ceramic tile	-1								r	
07F	6	13	all	warm	-1								r	
07F	6	14	nm		1								s	
07F	6	15										t		
07F	6	16	sofa	strange	-1								r	
07F	6	17	wall	orange	-1								r	
07F	6	18	all	cool	-1	all	harmony	1					s	
07F	6	19	all	harmony	1	nm	not my tast	-1					r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
07F	6	20	all	orange	-1								r	
07F	6	21	sofa	disharmony	-1								r	
07F	6	22	all	pink	-1								r	
07F	6	23	all	harmony	1	all	exanimate	-1					r	
07F	6	24	all	exanimate	-1								r	
07F	6	25	nm	orange	-1								r	
07F	6	26	nm		1	floor		-1				if	s	
07F	6	27	all		1	all	not my taste	-1					r	
07F	6	28	all	contrast	-1								r	
07F	6	29	floor	patterned	-1								r	
07F	6	30	nm	gloomy	-1								r	
07F	6	31	nm		1								s	
07F	6	32	sofa		-1								r	
07F	6	33	sofa		-1								r	(similar to above)
07F	6	34										cp	s	They are quite similar
07F	6	35	floor	orange	-1								r	
07F	6	36	floor	orange	-1								r	
07F	6	37	floor	orange	-1								r	
07F	6	38	all	disharmony	-1							t	r	
07F	6	39											b	still this one (the first one selected)
07F	6	Comments: I wonder if I select blue wall, it will provide me blue sofa												
07F	7	1	floor	showy	-1								r	firstly remove the showy floor
07F	7	2	floor	showy	-1								r	
07F	7	3	sofa	disharmony	-1							h	r	remove the showy sofa… but it seems acceptable
07F	7	4	sofa	ugly	-1								r	
07F	7	5	sofa	ugly	-1								r	
07F	7	6	all	harmony	1	sofa	dislike	-1					r	
07F	7	7	wall	gloomy	-1								r	
07F	7	8	all		1								s	
07F	7	9	sofa	acceptable	1								s	
07F	7	10	sofa	dislike	-1								r	
07F	7	11	all	dislike	-1								r	
07F	7	12	all	no works	-1								r	
07F	7	13	all	acceptable	1									
07F	7	14	sofa	showy	-1								r	
07F	7	15	sofa	showy	-1								r	
07F	7	16	floor	showy	-1								r	
07F	7	17	nm		1								s	
07F	7	18	nm		1								s	
07F	7	19	sofa	disharmony	-1								r	
07F	7	20	sofa	disharmony	-1								r	
07F	7	21	sofa	disharmony	-1								r	
07F	7	22	nm		1								s	
07F	7	23	nm		1	door	red	1					s	the red door here is not bad
07F	7	24	sofa	dark blue	1	door	red	-1					s	
07F	7	25	all	harmony	1	door	red	-1					s	
07F	7	26	nm	dislike									r	
07F	7	27	nm	dislike									r	
07F	7	28	all	harmony	1	all	not my tast	-1					r	
07F	7	29	nm	acceptable	1	all	gloomy	-1					s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
07F	7	30	all	dislike	-1								r	
07F	7	31	sofa	yellow	-1								r	
07F	7	32	sofa	yellow	-1								r	
07F	7	33	nm		1								s	
07F	7	34	nm		1								s	
07F	7	35	nm		1	sofa	dark blue	-1					s	
07F	7	36										cp	b	they are quite similar
07F	7	Comments: I selected a lot, because they are similar, and I have no reason to select this one, but remove that one												
07F	8	1												There are more ugly ones in this step
07F	8	2	floor	ugly	-1								r	
07F	8	3	sofa	showy	-1								r	
07F	8	4	nm		1								s	this is a new one, it is good
07F	8	5	all	clean									s	
07F	8	6	floor	pink	-1								r	
07F	8	7	nm		1								s	
07F	8	8	nm		1								s	(similar to above)
07F	8	9	all	harmony	1								s	
07F	8	10	all	no works	-1								r	
07F	8	11	nm	reception room	-1								r	
07F	8	12	sofa	showy	-1							if	r	the sofa should be more purple
07F	8	13	floor	orange	-1								r	
07F	8	14	all	chaos	-1								r	
07F	8	15	floor		-1								r	
07F	8	16	nm	cool	-1								r	
07F	8	17	all	harmony	1								s	Although its floor is green, not blue
07F	8	18											s	similar to what I selected before
07F	8	19											s	similar to what I selected before
07F	8	20	sofa	dark blue	1								s	
07F	8	21	all	gloomy	-1	all	acceptable	1					s	
07F	8	22	sofa	disharmony	-1								r	
07F	8	23	door	dark	-1								r	
07F	8	24	wall	black strip	-1								r	
07F	8	25	wall	dull	-1								r	
07F	8	26	nm		1								s	
07F	8	27	sofa	dislike	-1								r	
07F	8	28	wall	dislike	-1								r	
07F	8	29	nm	tone	-1								r	(similar tone)
07F	8	30	nm	tone	-1								r	(similar tone)
07F	8	31	all	harmony	1								s	
07F	8	32	sofa	purple	-1								r	
07F	8	33	floor	pink	-1							cs	r	floor too pink, I give it up
07F	8	34	all	ugly	-1								r	
07F	8	35											s	
07F	8	36	floor	ugly	-1								r	
07F	8	37	nm	gloomy	-1								r	
07F	8	38										cp	b	
07F	8	Comments: There are some new ideas which I also prefer but I can only select one best image I wonder if I select several different styles, what will be the result of evolution The red sofa did not survive												
07F	9	1	wall	yellow	-1								r	
07F	9	2	wall	patterned	-1								r	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
07F	9	3	sofa	green	-1								r	
07F	9	4	door	red	-1								r	
07F	9	5	all	dull	-1								r	
07F	9	6	all	dull	-1	all	cool	-1					r	
07F	9	7	all	disharmony	-1								r	
07F	9	8	all	disharmony	-1								r	
07F	9	9	all	disharmony	-1								r	
07F	9	10	all	no	-1								r	
07F	9	11	nm		1								s	
07F	9	12	nm		1								s	same as before
07F	9	13	all	disharmony	-1								r	
07F	9	14	all	acceptable	1	ceiling	green	-1					s	
07F	9	15	nm		1								s	
07F	9	16	sofa	red	1	door	cool	-1				if	s	
07F	9	17											s	
07F	9	18	nm		1	nm	cool	-1					s	same as before
07F	9	19	wall	disharmony	-1								r	
07F	9	20	all	harmony	1								s	
07F	9	21	door	red	-1								r	
07F	9	22	door	red	-1								r	
07F	9	23	sofa	dislike	-1								r	
07F	9	24	door	red	-1								r	
07F	9	25	nm	harmony									s	the red door is harmony here
07F	9	25	sofa	dislike	-1								r	
07F	9	25	all	disharmony	-1								r	
07F	9	25	wall	dislike	-1								r	
07F	9	25	wall	dislike	-1								r	
07F	9	25	nm		1								s	
07F	9	25	nm		1								s	
07F	9	25	floor	dislike	-1								r	
07F	9	25											r	
07F	9	25	all	gloomy	-1								r	
07F	9	25	all	gloomy	-1								r	
07F	9	25	nm		1								s	
07F	9	25											b	
07F	9	Comments: I can accept this one (the best) and this one. I tend to use some lively color This one is like common ideas in magazines												
07F	10	1	nm	showy	-1								r	remove the showy colors
07F	10	2	nm	showy	-1								r	
07F	10	3	nm	showy	-1								r	
07F	10	4	nm	showy	-1								r	
07F	10	5	all	dislike	-1								r	
07F	10	6	all	dull	-1								r	
07F	10	7	sofa	ugly	-1								r	
07F	10	8	floor	pink	-1								r	
07F	10	9	all	gray	-1								r	
07F	10	10	all	gray	-1								r	
07F	10	11	floor	pink	-1								r	
07F	10	12	sofa	abrupt	-1								r	
07F	10	13	door	red	-1								r	
07F	10	14											s	(same red door as above)

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
07F	10	15											s	(same red door as above)
07F	10	16												Now I start to select, they are generally acceptable
07F	10	17	sofa	ugly	-1								r	
07F	10	18	all		-1								r	I give up this kind of image
07F	10	19	wall	no meaning	-1								r	
07F	10	20	door	green	1									
07F	10	21	wall	no meaning	-1								r	
07F	10	22	door	blue	-1								r	
07F	10	23											s	nothing special remains
07F	10	24											s	
07F	10	25	all	common	-1								r	
07F	10	26											s	the rest are selectable
07F	10	27											s	
07F	10	28											s	
07F	10	29											s	
07F	10	30											s	
07F	10	31											s	
07F	10	32											s	
07F	10	33											s	
07F	10	34											s	
07F	10	35											s	
07F	10	36											s	
07F	10	37											s	
07F	10	38											r	
07F	10	39	door	red	0								b	the evolution seems already done
07F	10	Comments: I found that if I want different styles, it is not possible. I have to give up some ideas, otherwise it will disturb the rest (through crossover) If I want to explore the possibility of red sofa, I have to do it again, and it will be tiring												
07F	11	1	nm	showy	-1								r	I'll remove the showy ones
07F	11	2	nm	showy	-1								r	
07F	11	3	nm	showy	-1								r	
07F	11	4	nm	showy	-1								r	
07F	11	5	nm	showy	-1								r	
07F	11	6											r	and the ugly colors
07F	11	7											r	
07F	11	8											r	and the too strong contrast colors
07F	11	9											r	
07F	11	10												the rest are alike and acceptable
07F	11	11	wall		-1								r	then I remove the ones looks like no works, or no wall paper
07F	11	12	wall		-1								r	
07F	11	13	wall		-1								r	
07F	11	14	wall		-1								r	
07F	11	15	wall	ugly	-1								r	this wall paper is ugly
07F	11	16												More than half of them remain
07F	11	17	all	new	1	all	same tone	1	sofa	dark	1		s	This one is new, compare to the other one, which is common
07F	11	18											s	the rest are selectable
07F	11	19											s	
07F	11	20											s	
07F	11	21											s	
07F	11	22											s	

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
07F	11	23											s	
07F	11	24											s	
07F	11	25											s	
07F	11	26											s	
07F	11	27											s	
07F	11	28											s	
07F	11	29											s	
07F	11	30											s	
07F	11	31											s	
07F	11	32	door	green	-1							h	r	
07F	11	33											s	so actually there are two different types in my selection
07F	11	34											s	
07F	11	35											s	and I inclined to select this kind of images.
07F	11	36											s	this two styles are not conflict, some crossovers are acceptable
07F	11	37											s	
07F	11	38	floor	wooden	-1								r	
07F	11	39	floor	wooden	-1								r	
07F	11	40	floor	pink	-1								r	
07F	11	41	wall	tinge	-1								r	
07F	11	42												So there are two kinds of images
07F	11	43												one is this kind, common ideas
07F	11	44												one is these ones, with some lovely colors
07F	11	45	sofa	warm	1	door	red	1				cp	b	
07F	Retrospective report		Before I do this experiment, I have some ideas of interior works, harmony, simple, not too much patterned but when the process started, there are some patterned wall papers and some colored carpet in fact, they felt fairly good. so I kept them until the end. The program gave me the idea At the beginning, I also selected one with red sofa and tinge background, and hope it to be developed generally, I selected images of blue floor with tinge sofa, and red sofa with tinge background gradually, the blue floor with tinge sofa survived. And some new idea of gray tone appeared So generally the sofas are tinge Sometimes I selected blue sofas, but it should work with surroundings with same tone at last, the blue sofa did not survive Then I almost just select these two styles (blue floor ones and gray ones) for steps at the end, a new idea appeared with brown sofa and gray back ground, and it is good although the floor should be darker but generally I prefer the blue floor with light yellow sofa I think I am getting more an more satisfied with this one The best one of each step changed very little, except the one of second step. in that step I am not quit sure, so…											
08M	1	1	nm	like	1	all	cool	-1						I will systematically check each image. I will check them from top to down, and from left to right
08M	1	2	nm	dislike	-1									
08M	1	3	nm	dislike	-1									
08M	1	4	nm	dislike	-1									
08M	1	5	all	comfortable	1							cp	s	compare this one with the first one, it is comfortable
08M	1	6	nm	dislike	-1									
08M	1	7	nm	dislike	-1									
08M	1	8	nm	dislike	-1	nm	new	1					s	
08M	1	9	nm	dislike	-1									
08M	1	10	sofa	similar	-1									

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
08M	1	11	all	like	1								s	this may be the most favorite one until now
08M	1	12	nm	dislike	-1									
08M	1	13	floor	dislike	-1									
08M	1	14	sofa	dislike	-1									
08M	1	15	wall	blurry	-1									
08M	1	16	nm	dislike	-1									
08M	1	17	door	dislike	-1									
08M	1	18	all	dislike	-1									
08M	1	19	sofa	dislike	-1									
08M	1	20	nm		1								s	
08M	1	21	nm		1								s	
08M	1	22	all	like	1								s	
08M	1	23	wall	dislike	-1									
08M	1	24	sofa	dislike	-1									
08M	1	25	floor	dislike	-1									
08M	1	26	all	dislike	-1									
08M	1	27	sofa	dislike	-1									
08M	1	28	wall	disharmony	-1									
08M	1	29	nm		1								s	
08M	1	30	all	red	-1									
08M	1	31	nm		1									
08M	1	32	nm	dislike	-1									
08M	1	33	nm	dislike	-1									
08M	1	34	sofa	dislike	-1									
08M	1	35	ceiling	like	1								s	
08M	1	36	nm	dislike	-1									
08M	1	37												(count the selected images)
08M	1	38												I want to confirm if they are all good
08M	1	39												in order to make it clear, I will use the mode of "display selected", and it is much easy to see now
08M	1	101	nm	dislike	-1	wall	new	1					ds	
08M	1	102	wall	similar	-1								ds	
08M	1	103											ds	these are the answers of me among these 36 images
08M	1	104										cp	b	
08M	1	Comments: From what I selected, I found that my preference are too simplex, maybe I should prefer different things												
08M	2	1	all	not new	-1									I still use the up down, left right procedure
08M	2	2	all	dislike	-1									
08M	2	3	floor	dislike	-1									
08M	2	4	all	swimming pool	-1									
08M	2	5	wall	dislike	-1									
08M	2	6	door	dislike	-1									
08M	2	7	all	vitreous	-1									it looks like a glass ball, good for game, but not good for home
08M	2	8	sofa	dislike	-1									
08M	2	9	all	dislike	-1									
08M	2	10	all	dislike	-1									
08M	2	11	door	dislike	-1									
08M	2	12	floor	dislike	-1									

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
08M	2	13	nm		1								s	It is just so-so, it is possible that I will remove it later
08M	2	14	wall	dislike	-1									
08M	2	15	all	dislike	-1									
08M	2	16	nm		1									
08M	2	17	sofa	dislike	-1									
08M	2	18	sofa	dislike	-1									
08M	2	19	sofa	dislike	-1									
08M	2	20	wall	disharmony	-1									
08M	2	21	floor	dislike	-1									
08M	2	22	sofa	dislike	-1									
08M	2	23	wall	dislike	-1									
08M	2	24	nm		1									
08M	2	25	sofa	green	-1									
08M	2	26	nm		1	sofa	yellow	-1					s	
08M	2	27	sofa	dislike	-1									
08M	2	28	sofa	dislike	-1									
08M	2	29	wall	dislike	-1									(the wall and floor are blue)
08M	2	30	nm		1								s	
08M	2	31	all	red	-1									
08M	2	32	sofa	blue	-1									
08M	2	33	sofa	blue	-1	wall	purple	-1						
08M	2	34	sofa	red	-1	wall	green	-1						
08M	2	35	all	swimming pool	-1									
08M	2	36	nm		1								s	
08M	2	101	sofa	dislike	-1								ds	
08M	2	102	sofa	smoky gray	1								b	
08M	2	Comments: I don't know what will be the final result It is my custom to confirm my selection again												
08M	3	1	nm	like	1								s	the images are generally more comfortable in this step
08M	3	2	all	yellow	-1									
08M	3	3	all	comfortable	1								s	
08M	3	4	sofa	pink	-1									
08M	3	5	sofa	dislike	-1									
08M	3	6	all	like	-1								s	
08M	3	7	sofa	dislike	-1									
08M	3	8	sofa	dislike	-1									
08M	3	9	sofa	green	-1									
08M	3	10	all	like	1							cp	s	similar to what I selected, but I like the tone
08M	3	11	sofa	brown	-1									
08M	3	12	nm	dislike	-1									
08M	3	13	all	like	1								s	
08M	3	14	sofa	disharmony	-1									
08M	3	15	sofa	tinge	-1									
08M	3	16	all	proper	1								s	
08M	3	17	all	yellow	-1									
08M	3	18	sofa	contrast	0	wall	dislike	-1						
08M	3	19	all	comfortable	1								s	
08M	3	20	wall	dislike	-1									

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
08M	3	21	nm		1								s	
08M	3	22	sofa	dislike	-1									
08M	3	23	sofa	yellow	-1									
08M	3	24	sofa	pink	-1									
08M	3	25	nm		1								s	
08M	3	26	all		1								s	
08M	3	27	sofa	green	-1									
08M	3	28	all	dislike	-1									
08M	3	29	sofa	cyan	-1									
08M	3	30	all	pink	-1									
08M	3	31	all	clean	1									
08M	3	32	sofa	yellow	-1									
08M	3	33	all	green	-1									
08M	3	34	floor	smoky gray	1									
08M	3	35	floor	dislike	-1									
08M	3	36	sofa	dislike	-1									
08M	3	101												(count the images selected)
08M	3	102												Maybe I have selected too many
08M	3	103	wall	green	-1								ds	
08M	3	104	sofa		1							cp		compare these three with yellow floor, this one has a better sofa, so I will remove the other two
08M	3	105											ds	
08M	3	106											ds	
08M	3	107										cp		I have to move my line of sight from here to there, so it is a little difficult
08M	3	108	floor	dislike	-1									
08M	3	109	all	acceptable	1									
08M	3	110	all	similar	-1									so I wlll not select these two
08M	3	111	door	dislike	-1									so I will not select these three
08M	3	112	sofa	dislike	-1									
08M	3	113	floor	dislike	-1									
08M	3	114	floor	dislike	-1									
08M	3	115	all	acceptable	1									
08M	3	116	all	acceptable	1									So I will select among these three
08M	3	117	all	tone	-1									the interior color is similar to the outdoor, so not good enough
08M	3	118												so between these two, they both have good points and drawback
08M	3	119	all	clean	1								b	
08M	3	Comments: It is difficult to select now, they are quite similar The software is interesting												
08M	4	1	nm		1								s	Generally there are fairly a lot I do not prefer.
08M	4	2	all	dislike	-1									
08M	4	3	sofa	dislike	-1									
08M	4	4	sofa	dislike	-1									
08M	4	5	wall	dislike	-1									
08M	4	6	sofa	disharmony	-1									
08M	4	7	all	cool	-1									
08M	4	8	sofa	dislike	-1									
08M	4	9	sofa	dislike	-1									
08M	4	10	all	dislike	-1	sofa		1						

Participant	Step	Record No.	Evaluation Criteria										BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3				
08M	4	11	sofa	dislike	-1										
08M	4	12	all		1									s	
08M	4	13	wall	dislike	-1										
08M	4	14	sofa	dislike	-1										
08M	4	15	all	disharmony	-1										
08M	4	16	all		1	sofa	dislike	-1							
08M	4	17	sofa	dislike	-1										
08M	4	18	sofa	dark	-1										
08M	4	19	nm		1									s	
08M	4	20	wall	dislike	-1										
08M	4	21	all		1									s	
08M	4	22	sofa	dislike	-1										
08M	4	23	wall	dislike	-1										
08M	4	24	all		1									s	similar to one I saw before
08M	4	25	floor	dislike	-1										
08M	4	26	all	dislike	-1										
08M	4	27	wall	dislike	-1										
08M	4	28	floor	dislike	-1										
08M	4	29	all	dislike	-1	door		1							
08M	4	30	sofa	dislike	-1										
08M	4	31	wall	dislike	-1										
08M	4	32	all		1	sofa	dislike	-1							
08M	4	33	all	disharmony	-1										
08M	4	34	all		1									s	
08M	4	35	sofa	dislike	-1	all	dislike	-1							
08M	4	36	floor	dislike	-1										
08M	4	101	wall	dislike	-1	all	dislike	-1						ds	
08M	4	102	all		1										
08M	4	103	all		1										
08M	4	104	all		1										
08M	4	105	all		1										
08M	4	106	all	cool	-1	floor	wooden	-1							
08M	4	107											cp	b	this one is the best, no drawback
08M	4	Comments: My selection becoming fewer now I am interested in it, so I will continue to do it. But I feel somehow it is not very meaningful to continue, because in step 3 there are many similar ones, but in step 4, it provide many different ones maybe it can not provide better options now													
08M	5	1	floor	dislike	-1										Generally there are images I don't like, but I will check one by one
08M	5	2	sofa	dislike	-1										
08M	5	3	all		1									s	
08M	5	4	all	new	1									s	
08M	5	5	sofa	dislike	-1										
08M	5	6	all	disharmony	-1										
08M	5	7	wall	dislike	-1										
08M	5	8	sofa	dislike	-1										
08M	5	9	door	abrupt	-1										
08M	5	10	floor	wooden	-1										
08M	5	11	sofa	dislike	-1										
08M	5	12	sofa	hard	-1										
08M	5	13	all	cool	-1										
08M	5	14	all	warm	-1										

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
08M	5	15	nm		1								s	
08M	5	16	sofa	dislike	-1									
08M	5	17	all	cool	-1									
08M	5	18	all	yellow	-1									
08M	5	19	sofa	dislike	-1									
08M	5	20	all	similar	-1									
08M	5	21	all	comfortable	1								s	
08M	5	22	all	exciting	-1									
08M	5	23	all	green	-1	ceiling	dislike	-1						
08M	5	24	sofa	dislike	-1									
08M	5	25	sofa	dislike	-1									
08M	5	26	all		1									
08M	5	27	all		1									
08M	5	28	sofa	dislike	-1									
08M	5	29	sofa	dislike	-1									
08M	5	30	all		1								s	
08M	5	31	all		1								s	
08M	5	32	wall	dislike	-1									
08M	5	33	all	dislike	-1									
08M	5	34	sofa	dislike	-1									
08M	5	35	door	dislike	-1									
08M	5	36	door	dislike	-1									
08M	5	101	all	dislike	-1								ds	I selected it because it was new to me, but it is not so good for me now
08M	5	102	all	tinge	-1							cp	ds	difference of interior and out door
08M	5	103	all	tinge	-1								ds	the difference of interior and out door
08M	5	104	all	dark	-1							cp	ds	
08M	5	105												the rest 4 images are good
08M	5	106	all	harmony	1								b	
08M	5	Comments: If no new ideas that attract me in the new step, and the process can be ended I feel tired now, because they are of the same scene I feel that the selected are similar to previous step, so I think maybe there will be not many other options If they are similar, I will end it up												
08M	6	1	all	similar	-1									there are some new ones appeared
08M	6	2	all		1								s	
08M	6	3	sofa	dislike	-1									
08M	6	4	floor	dislike	-1									
08M	6	5	sofa	dislike	-1									
08M	6	6	sofa	dislike	-1									
08M	6	7	floor	dislike	-1									
08M	6	8	sofa	dislike	-1									
08M	6	9	floor	flocky	1								s	
08M	6	10	wall	dislike	-1									
08M	6	11	all	dislike	-1									
08M	6	12	wall	dislike	-1									
08M	6	13	all		1								s	
08M	6	14	floor	dislike	-1									
08M	6	15	sofa	dislike	-1									
08M	6	16	all		1								s	
08M	6	17	sofa	dislike	-1									
08M	6	18	floor	dislike	-1									

Participant	Step	Record No.	Evaluation Criteria									BEHAVIOR	OPERATION	COMMENT or note (shown in bracket)
			OBJECT	PROPERTY	EVALUATION	OBJECT2	PROPERTY2	EVALUATION2	OBJECT3	PROPERTY3	EVALUATION3			
08M	6	19	floor	dislike	-1									
08M	6	20	floor	cool	-1									
08M	6	21	floor	dislike	-1									
08M	6	22	floor	dislike	-1									
08M	6	23	sofa	dislike	-1									
08M	6	24	all	comfortable	1								s	
08M	6	25	ceiling	dark	-1									
08M	6	26	floor	dislike	-1									
08M	6	27	floor	dull	-1									
08M	6	28	sofa	dislike	-1									
08M	6	29	sofa	tinge	-1									
08M	6	30	wall	dislike	-1									
08M	6	31	all	pink	-1									
08M	6	32	all		1								s	
08M	6	33	all	yellow	-1									
08M	6	34	sofa	tinge	-1									
08M	6	35	sofa	dislike	-1									
08M	6	36	sofa	dislike	-1									
08M	6	101												I will confirm if any selected one could be removed.
08M	6	102												they are all good
08M	6	103												for the best one, I think the floor should be darker, so among these three
08M	6	104										cp		I like this one, so I will check the rest two firstly. I feel they are the same. ah, the wall is different
08M	6	105	wall	dark	0	floor	warm	1				cp	b	
08M			I saw many images, and firstly I pass the ones with green colors Because it is winter now, I also passed the blue ones then I found the door has big influence on total effect, so if the door is too abrupt, it was passed then the sofa. If consider only the sofa, I prefer lighter sofa but if consider sofa and floor, I think the sofa should be darker, and it will feel natrual so I passed the ones where sofa and floor are too similar For the general tone, I prefer gray and colors between gray and yellow, but not too yellow The the floor, I prefer smoky gray carpet, so I select maily the smoky gray carpet At last I check the difference of interior and outdoor, if the are similar, I pass them My score of the selected images may be influenced by the amount of selected images I feel the process interesting I want to know about other people's choices, I wonder if my selection are too strange I think that the process should be up going, but I do not feel such tendency strongly I feel that step 3 is fairly good, and a suddenly good step so if consider the process without step 3, it is an up going tendency												

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Huang Weixin, Matsushita Daisuke and Munemoto Junzo: Designer's Evaluation Process in Simulated Design Process for Interior Works Using Interactive Evolutionary Computation, Submitted to Journal of Architecture, Planning, and Environment Engineering, AIJ.

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