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TOWARD AN AFFECTIVE DESIGN OF PRODUCTS

Weihua Lu

LUNAM, Institut de Recherche en
Communications et Cybernétique de Nantes
(UMR CNRS 6597), Ecole Centrale de Nantes
1, Rue de la Noë - BP 92101
44321 Nantes Cedex 3, France
weihua.lu@ircryn.ec-nantes.fr

Jean-François Petiot

LUNAM, Institut de Recherche en
Communications et Cybernétique de Nantes
(UMR CNRS 6597), Ecole Centrale de Nantes
1, Rue de la Noë - BP 92101
44321 Nantes Cedex 3, France
Jean-Francois.Petiot@ircryn.ec-nantes.fr

KEYWORDS

Emotional Design, Non-verbal Assessment, Kansei Engineering, Sounds Perception, Glasses Frame.

ABSTRACT

The measurement and understanding of user emotions elicited by product appearance are critical elements of the product development process and have been interesting design challenges for many years. This paper proposes an original emotion measurement method, called Auditory Parameter Method. It is a non-verbal technique, which uses sounds and association tests for evaluating a set of products (given by their pictures). It provides an assessment of these products according to a series of emotional dimensions. We present a methodological framework to build the links between user's emotional responses and geometrical features of product, by using a glasses frame 3D model as application case. Analysis of Variance techniques are employed to examine how various shape factors influence users' emotional responses to 3D model. To demonstrate the effectiveness of our protocol, we compare the proposed method with the conventional Semantic Differential using Principal Component Analysis and Generalized Procrustes Analysis. The new protocol demonstrates interesting qualities to collect the intuitive emotions of user.

INTRODUCTION

In design practice, the designer has to balance between objective and subjective properties, between functional technology and emotional expressiveness, in an attempt to satisfy the demands and wishes that the prospective users may have. The success of a product in the marketplace is not only determined by technical and objective content, but also by aesthetic, emotional, and other experiential factors. It is crucial

for designers to get relevant inputs and to anticipate at best user's expectations. Emotions elicited by product appearance can enhance the pleasure of buying, owning and using it [1] [2]. Obviously, design for emotions plays a more and more important role in product design [3]. To be able to instill emotional values in product design, the understanding of user emotions and the measurement of emotions are interesting challenges. These issues have attracted the attention of many researchers.

Self-report measurement is an appropriate and efficient technique to reflect user's emotional desires. There have been lots of researches on emotions in design based on this approach, and we can benefit from many existing outcomes. A non-verbal pictorial assessment technique, the Self-Assessment Manikin [4], directly measures the pleasure, arousal, and dominance associated with a person's affective reactions to a wide variety of stimuli [5]. The Product Emotion Measure (PrEmo) [6] [7] is based on animations of a cartoon character. All emotions are regarded as stemming from a relatively small number of basic emotion categories. Another example, the Plutchik's wheel of emotions [8], argues that all emotions are mixtures of 'basic' emotions and therefore can be described according to a predefined list of terms.

Measurement of emotions is then an interesting input for product design. Kansei Engineering [9], the design approach developed in Japan, focuses on the behaviors of people when they perceive images or objects, and their links with the product parameters. Kansei is a Japanese word that is even used internationally, and which evokes senses, feelings, emotions and impressions [10] [11]. Several techniques have been developed to compose mapping and quantify Kansei qualities, the most common approach is the Semantic Differential [12]. It consists in listing relevant attributes of the product category to analyze, and to carry out user-tests in which the subject must

assess the products according to these attributes. The attributes are often defined by pairs of antonymous adjectives, which lie at either end of a seven point quantitative scale. A semantic space, Euclidean and multidimensional, is then postulated. Factor Analysis and Principal Components Analysis (PCA) may be used to reduce the dimensionality of the space and to find the underlying factors. They are used for the analysis of families of products or for the detailed analysis of a particular product.

Emotional reactions can be evoked by stimuli with different sensory modalities. Nevertheless, we noticed that the existing emotion measurement methods generally use verbal attributes or emotional visual pictures, and few are concerned with other sensory modalities. These other sensory modalities (e.g. hearing) may provide interesting qualities for the measurement of emotions. In this paper, we are interested in the auditory modality among all senses. Most people agree that auditory sensations (voices, sounds or music) can arouse profound and deep emotional reactions [13] [14] [15] [16]. In addition, the human's response to sounds is less sensitive than words on intercultural differences. In order to extend this exploratory domain, we set a methodology (called Auditory Parameter Method) based on auditory stimuli to elicit user emotions, and we develop an emotion measurement.

The objectives of this paper are to describe the new method and to illustrate it with a case study involving user-tests, and to build up computational models of the user's emotional responses to different shape factors of the product. To verify the effectiveness of our method, we also compare the results with the Semantic Differential Method.

The overall schema of the whole research process is shown in Figure 1. Two user-tests based on two different methods, Auditory Parameter Method (AP Test) and Semantic Differential Method (SD Test), were organized in parallel. The same subjects made assessments in both tests on the same samples of the product space. Then, Principal Components Analysis (PCA) was used for finding the underlying structure of the perceptual space. Based on these principal factors, Generalized Procrustes Analysis (GPA) was applied to verify the consensus between the two methods. In the end, Analysis of Variance (ANOVA) was employed to examine how various shape factors influence users' emotional responses on Factor 1 of the AP Test (F_{AP1}).

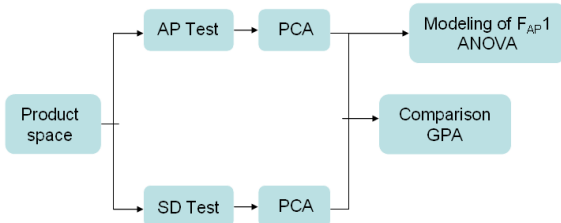


FIGURE 1 – OVERALL SCHEMA OF THE WHOLE RESEARCH PROCESS

In this paper, we describe the two user-tests we carried out, applied to the perception of glasses frame 3D digital models,

given by their pictures. In section 2, we present the description of materials and methods. Section 3 presents the analysis of the results. Conclusions and perspectives are drawn in section 4.

MATERIALS AND METHODS

Description of the application

Object selection

The objective of our research is to define a methodological framework to build the links between users' emotional responses and geometrical features of the product. To illustrate our approach, we propose to study glasses frames, which are very interesting products from a design perspective. A glasses frame is a complex product that not only integrates functionality, but also aesthetics, affectivity and individuality. It is representative of a mass customization product (limited production of very diversified products), and must transmit to the owner a controlled affective image [17] [18].

Model simplification

Although a glasses frame is a product with a limited number of parts, there are still a lot of geometrical details. In order to facilitate the CAD modeling, the digital model of the glasses frame has been simplified. We supposed that the bridge and the two rims are flat (in the same plane) instead of cambered in the space. There are various categories of glasses frames, such as full-frame, half-frame, no-frame ... We just concentrated on the common and ordinary full-frame samples.

Factor definition

A study on glasses frame is proposed in [19], where the authors present a method for form generation. We referred to these research findings, and considered that rim is the most fundamental and important part of a glasses frame. In order to control the design variables with a digital general model, four shape factors with different levels are defined as follows: *frame leg width* (Factor A), *rim profile* (Factor B), *rim aspect ratio* (Factor C), and *rim thickness* (Factor D).























The levels of the four shape factors are explicitly defined in Table 1. For three factors (*frame leg width*, *rim aspect ratio*, and *rim thickness*), we specified only two levels. The factor '*rim profile*' has 8 levels, depending on both the rim corner type (circular and square) and the rim corner symmetry (full symmetry, horizontal symmetry, vertical symmetry, and diagonal symmetry). Therefore, the combinations of the factors and levels yield a total of 64 possibilities ($2 \times 2 \times 8 \times 2$, full factorial design).

Experimental design

To limit the fatigue of the subjects during the test, we limited the number of designs around 24 products. We used a design of experiment software to generate a D-optimal experimental design. The model considered is a linear model, which integrated the effect of each factor and all the 2-level interactions for factor C. A 22 samples experimental design was

proposed. The products were next modeled with a CAD software.

TABLE 1 – DESIGN FACTORS WITH DIFFERENT LEVELS

Factors	Level Settings
A: frame leg width	A1: wide  A2: narrow 
B: rim profile	B1:   B2:   B3:   B4:   B5:   B6:   B7:   B8:  
C: rim aspect ratio (high to wide)	C1: 0.75  C2: 0.5 
D: rim thickness	D1: thick  D2: thin 

CAD Model generation

The 3D-parameterized shape profile of the glasses frame was defined by a CAD software (CATIA V5R19), using polylines and Bezier curves. The rim profile is modeled by eight adjacent cubic Bezier curves. Four curves contribute to the inner rim and four curves constitute the outer rim, as shown in Figure 2. To generate different rim profiles, the corner type can be changed by moving the two control points of each curve. Rim aspect ratio is controlled by changing the position of the starting point and the end point. The distance between the inner and outer curves is used to adjust the rim thickness. After the construction of the rim, a multi-sections solid operation is applied through the sections, to build up the frame leg. Since we are only interested in the width of the frame leg, the sections used for sweeping are defined with standard frame leg shapes. Twenty-two 3D digital models of the glasses frame were generated (Figure 3), and they were rendering without information of material, color and texture, in order to focus the subject's attention on shape only.

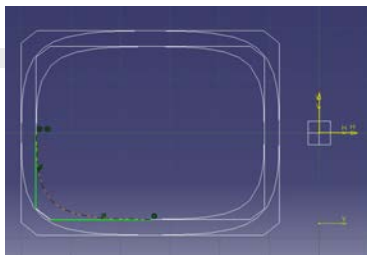


FIGURE 2 – PROFILE OF THE RIM

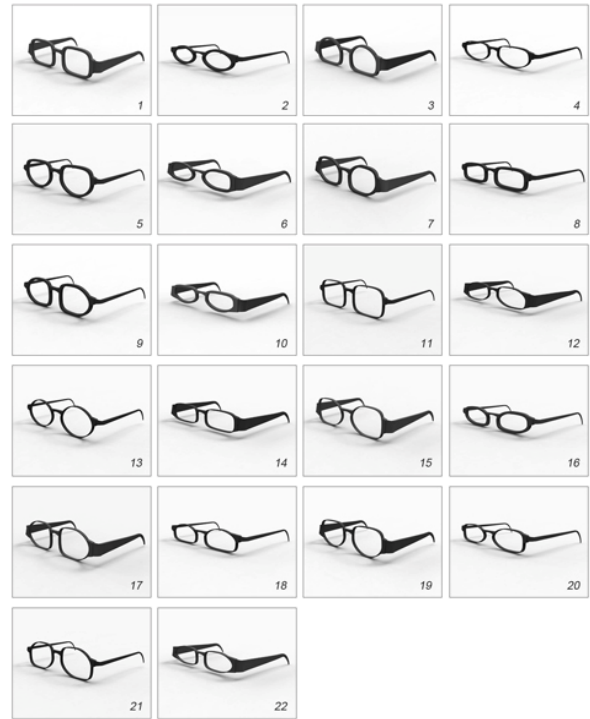


FIGURE 3 – THE PRODUCT SPACE: PICTURES OF THE 22 GLASSES FRAMES

The Auditory Parameter Method (AP)

Description

The Auditory Parameter Method (AP) is the new protocol that we propose for product assessment. It uses auditory stimuli to elicit user emotions and to develop an emotion measurement.

This method is inspired by the Kansei Parameter Method (KP) [20], developed by Prof. Kashiwazaki in Tokyo Denki University. The KP Method is a non-verbal technique for evaluating a set of stimuli (e.g. objects or perfumes), in order to obtain evaluations of these stimuli according to a set of variables. The principle of the method is based on an association test: given a stimulus, the subject is asked to select, among a set of proposed figures, the 'most representative figure of the stimulus'. The selections have to be in accordance with the emotions evoked by the stimuli. Originally, the KP method involves the vision sense. We adapt this method to hearing and to the use of auditory stimuli. Compared to vision, hearing possesses particular features that we must take into account (for example, sounds are embedded in time, not pictures). In order to make sure that the auditory stimuli are not over the subjects' cognitive load, we limit the number of proposed sounds to three for each selection phase of the test.

Given a set of auditory stimuli (a sounds bank – see below for the definition), and a set of objects of the product space, the experiment is based on the following stages:

1. Presentation to the subject of one object of the product space (picture),
2. Random selection by the algorithm of 3 sounds among the set of sounds,
3. After hearing the 3 sounds, the subject is asked to select the most 'representative' sound of the object.

The experimental protocol is actually based on several iterations of stages 2 and 3, and proposes all the objects of the product space to the evaluation. After running this test with s subjects, we count the number of times a given sound has been associated to a given product. This is described by matrix F :

$$F = \begin{pmatrix} f_{11} & \cdots & f_{1n} \\ \vdots & \ddots & \vdots \\ f_{m1} & \cdots & f_{mn} \end{pmatrix} \quad (1)$$

F : $m*n$ matrix, m refers to the number of objects of the product space, n is the number of sounds,

f_{ij} : frequency ratio of the association of object i to sound j (number of time the sound is selected / number of time the sound is presented).

The sounds are described by a set of variables (described below). The values of the variables are given by matrix P :

$$P = \begin{pmatrix} P_{11} & \cdots & P_{1k} \\ \vdots & \ddots & \vdots \\ P_{n1} & \cdots & P_{nk} \end{pmatrix} \quad (2)$$

P : $n*k$ matrix, n refers to the number of sounds, and k is the number of variables.

Finally, the objects of the product space are described by the matrix V_{AP} ($m*k$ matrix). V_{AP} is the product of the frequency matrix F with the variables of sounds (matrix P).

$$V_{AP} = F * P \quad (3)$$

The key point of the method is that if the associations of the sounds with the objects are consensual enough, and if the variables chosen to describe the sounds make sense for the emotions, then the matrix V_{AP} provides a relevant description of the objects.

First results of previous researches [21], using a selection of the International Affective Digitized Sounds (IDAS-2) as auditory stimuli, showed that this protocol has a good feedback from the participants and that it makes sense to ask to associate sounds to pictures. The agreement between subjects was sufficiently good to provide significant results (statistical test with the multinomial law). The AP Method can be considered

as a language-free alternative to the Semantic Differential Method, and these first results were encouraging for developing a new non-verbal protocol for measuring product emotions.

Selection of the music samples

The objective is to define a generic bank of auditory stimuli (like the bank of image words for Kansei Engineering) as an assessment scale, in an attempt to give a discriminant measurement of emotions. Emotion is one of the preeminent functions of music [22]. Genre and emotion provide complementary descriptions of music content and are often correlated [23]. For example, a rock song is often aggressive, and a rhythm and blues (R&B) song is more likely to be sentimental. As genre data are more stable and easier to collect, we use genre data to aid music selection. We selected a first set of 64 music samples (duration: 5 seconds) from different genres. We made then a second selection process.

This process is described in Figure 4. We consider that different products of the same category may have different semantic properties (such as 'cute', 'modern', 'luxurious' and etc), which can elicit various kinds of user emotions. Therefore, we selected a set of different samples of the same product category, to constitute a product bank. The category of product chosen was chairs, because a great variety of chairs is available on Internet. Next, we selected a set of 64 representative pieces of music from a huge library of exhaustive different genres. Then, we made a pilot test with a set of subjects: we asked them to associate three music samples of the 64 pieces to each product of the bank. The pieces of music have to be 'the most representatives of the product, from a connotative point of view'. We computed the frequency of the association product / sound sample.

Finally, we made a selection among the 64 samples. The samples which were under-chosen and over-chosen were discarded (under-chosen: they are not representative of the emotions elicited by the panel of chairs proposed; over-chosen: they are too general). Twenty-four pieces of music were finally selected, to constitute our sound bank for the AP Method. The duration of the piece of music is approximately 5 seconds.

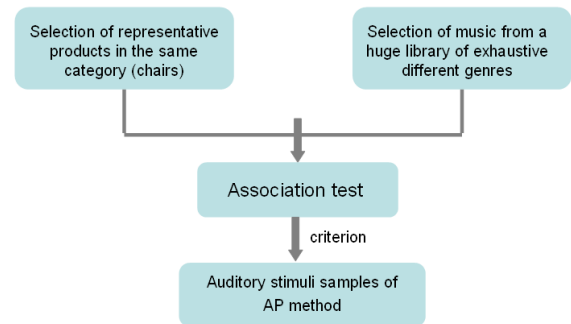


FIGURE 4 – THE PROCESS OF MUSIC SAMPLES SELECTION

Description of the sound samples (Matrix P)

To obtain perceptual variables of the 24 pieces of music, we made a Multidimensional Scaling (MDS) study [24], which uses dissimilarity assessments to create a geometrical representation of the perceptual space related to the family of objects. A pairwise comparison task of these 24 pieces of music was conducted with an expert, in order to obtain a dissimilarity matrix. A metric-MDS algorithm was used to process the dissimilarity matrix, and to define 5 perceptual dimensions. In order to interpret the 5 perceptual dimensions, 3 participants with design experience were asked to describe the 24 pieces of music with terms (free verbalization task). For each piece of music, the most occurring terms were selected, after a merging of the synonyms. An interpretation of each perceptual dimension was finally made, according to the position of the sounds on the dimensions and the most relevant terms. The five dimensions were labeled as ‘mellow – lively’, ‘noble – popular’, ‘sentimental – festive’, ‘technological – primitive’, and ‘odd – fashionable’.

Auditory Parameter Test

The Auditory Parameter Test (AP Test), based on the AP Method, was conducted with a panel of 22 participants. Subjects were asked to assess the 22 glasses frames 3D digital models (to associate music with glasses frame) with a user-friendly interface, shown in Figure 5. The image of the glasses frame is located at the upper-left, and the choice has to be made at the lower-right.

For each glasses frame, a 4-stage selection process was designed:

1. Random selection of 3 pieces of music by the algorithm, among the bank of 24 pieces of music. The subject had to select the most representative one,
2. Random selection of 3 pieces of music by the algorithm (different of those of stage 1). The subject had to select the most representative one,
3. Random selection of 3 pieces of music by the algorithm (different of those of stage 1 and stage 2). The subject had to select the most representative one,
4. Presentation of the pieces of music chosen at stage 1-2-3. The subject had to select the most representative one.

The subjects had to listen to the pieces of music patiently and carefully, and to select one of them according to the general image evoked by the glasses frame. There was of course no right or wrong answers. The subjects were advised to simply respond as honestly as they can.

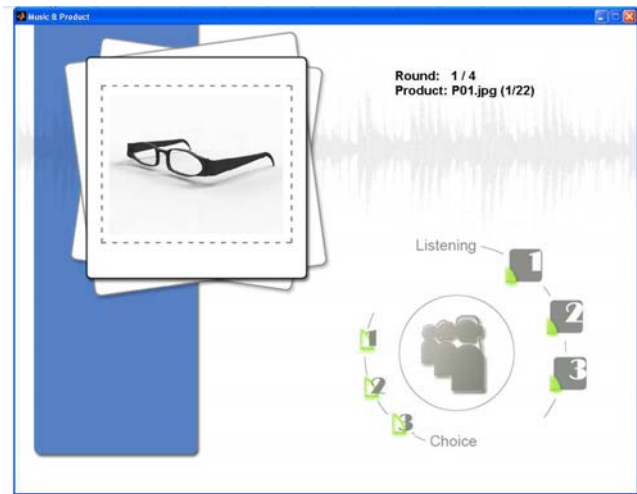


FIGURE 5 – INTERFACE OF THE AP TEST

The Semantic Differential Method (SD)

We ran a test based on SD Method with the same objects (22 glasses frames), and compared the result with the result of the AP Test, in an attempt to confirm the efficiency and the performance of the new protocol.

Selection of semantic attributes

The choice of the semantic attributes has been made by analyzing previous papers in Kansei Engineering, in particular on the perception of glasses frame [17] [19]. Eight pairs of French adjectives were selected, shown in Table 2 (the translation in English is given for information).

TABLE 2 – LIST OF THE SEMANTIC ATTRIBUTES

No.	Adjectives
1	féminine – masculine (feminine – masculine)
2	commune – particulière (common – special)
3	originale – banale (original – dull)
4	recherchée – basique (delicate – rough)
5	drôle – sérieuse (funny – serious)
6	sage – rebelle (obedient – rebellious)
7	moderne – rétro (modern – retro)
8	élégante – vulgaire (smart – ordinary)

Semantic Differential Test

The Semantic Differential Test (SD Test) was carried out according to the SD method. The interface is illustrated in Figure 6. The subjects were asked to rate each glasses frame according to the adjective pairs on an unstructured scale. The subjects were asked to express intuitively their assessments. The matrix V_{SD} of the average value of the assessment was

computed ($m \times p$ matrix, m refers to the number of products, p is the number of semantic attributes).



FIGURE 6 – INTERFACE OF THE SD TEST

Subjects and procedure

Twenty-two subjects (18 males, 4 females), students of Ecole Centrale de Nantes, participated in both tests. In order to balance the tests' order, they were divided into 2 equal groups of 11 participants (11 subjects started with the SD Test, 11 subjects started with the AP Test). In a short introduction, the subjects were informed about the purpose of the experiments and an explanation of the functioning of the interfaces was given. The presentation order of the glasses frames used Williams Latin Square in order to control the order and carry-over effects.

RESULTS AND DISCUSSIONS

After a verification of the validity of the data for each subject, the two matrices V_{AP} and V_{SD} , representative of the 22 glasses frames, were computed:

- V_{AP} ($m \times k$ matrix): rating of the m glasses frames, obtained by the AP Method (equation 3) ($k=5$ dimensions)
- V_{SD} ($m \times p$ matrix): average rating of the m glasses frames by the SD Method ($p=8$ pairs of semantic attributes)

These matrices were analysed by Principal Components Analysis (PCA), a classical data analysis method to uncover the underlined structure of data. To study the consensus between the two methods, we used Generalized Procrustes Analysis (GPA) [25]. This method is a 'rigid shape' analysis that uses isomorphic scaling, translation, and rotation to find the 'best' fit between two or more landmarked shapes. GPA is interesting to define the degree of agreement between two or more configurations, and to assess the similarity between families of terms used to describe products. Finally, Analysis of Variance (ANOVA) was employed to examine the effect of each design factor on the subjective assessments.

PCA results of the AP Test

The matrix V_{AP} was analyzed using standardized Principal Components Analysis. The two first factors of PCA represent 66.5% of variance. Three factors are necessary to represent 83.3% of variance. These 3 factors are considered as sufficient to represent the differences between the products. The coordinates of the products on these 3 factors are represented by the matrix X_{AP} , which will be used for the Generalized Procrustes Analysis (GPA).

The plane of the two first factors is given in Figure 7 for information. We interpreted the first factor F_{AP1} by examining the factor loadings of the variables on F_{AP1} , and by picking the typical products of this dimension, extreme on F_{AP1} . This factor can be interpreted as the *degree of dynamism* of the product (*mellow* (left) opposed to *lively* (right)).

PCA result of SD Test

The V_{SD} matrix was analyzed using a standardized Principal Components Analysis (PCA). Two principal components were extracted from PCA. The variability represented by the two first factors is 85.2%: only two factors are considered to represent the differences between the glasses frames. The factor loadings of the variables (see Figure 8) are useful for interpreting the meaning of the factors. Factor 1 is mainly created by the variables 'original – dull', 'funny – serious', 'delicate – rough', 'common – special', 'smart – ordinary' and 'obedient – rebellious'. The variables 'modern – retro' and 'feminine – masculine' contribute to Factor 2. The first factor can be represented by the degree of 'innovation' of the design (*innovative* (left) opposed to *classic* (right)). The second factor can be interpreted as the degree of 'sophistication' of the design (*sophisticated* (below) opposed to *simple* (top)).

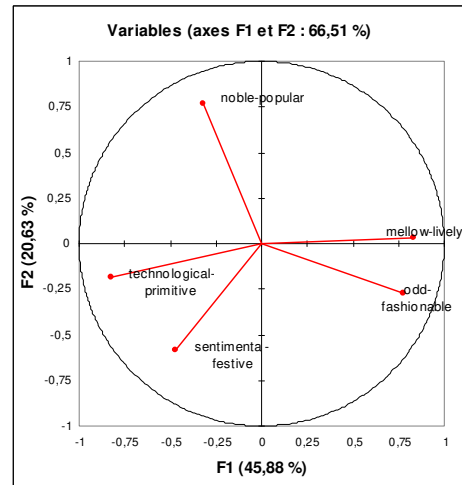


FIGURE 7 – PLANE OF THE VARIABLES OF PCA FOR THE AP TEST

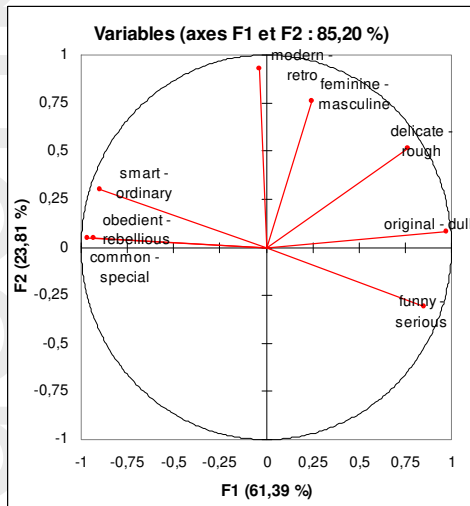


FIGURE 8 – PLANE OF THE VARIABLES OF PCA FOR THE SD TEST

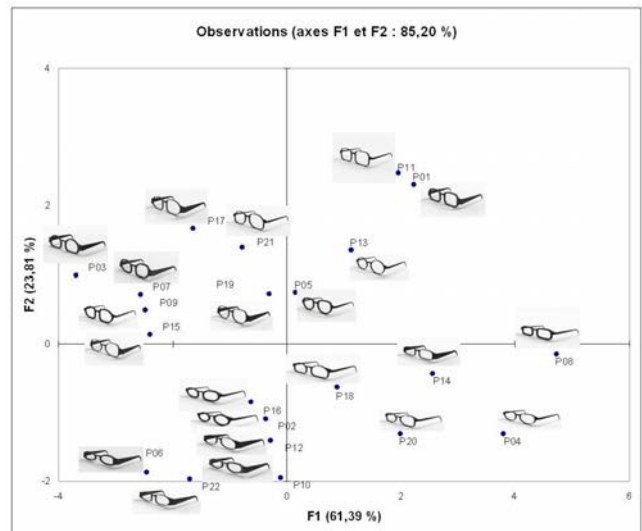


FIGURE 10 – POSITION OF GLASSES FRAMES OF THE SD TEST

We notice first that the AP and SD methods produced a priori different results: the location of the products on the factorial planes (Figure 9 and Figure 10) is not similar. The information we got from AP Test may be concentrated on the feeling and the experience of the subjects concerning the glasses frames, while the information we got from SD Test may be focused on the cognition of the subjects about glasses frames, which is more representative of the products themselves. However, assessing the similarity between the results of these two methods is not an easy task: the products are not described according to the same number of dimensions (3 principal components for AP Test – 2 principal components for SD Test). It could be interesting to define a posteriori the degree of agreement between the AP and the SD Tests.

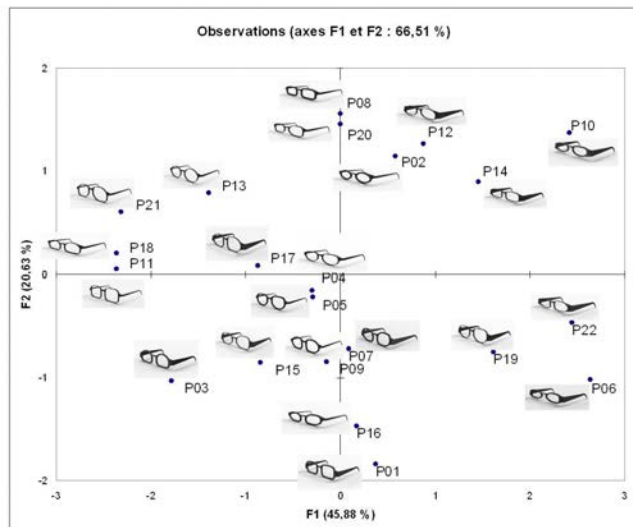


FIGURE 9 – POSITION OF GLASSES FRAMES OF THE AP TEST

The coordinates of the products on the first two factors of PCA are represented by the matrix X_{SD} (similarly as X_{AP}). In order to compare the consensus of the two methods, we used Generalized Procrustes Analysis (GPA) to study the agreement between the matrices X_{SD} and X_{AP} .

Agreement between the two tests with GPA

Generalized Procrustes Analysis (GPA) [25] is a multivariate technique commonly used in sensory analysis to produce a consensus representation from a set of different individual data matrices (called configurations), and to represent the consensus via PCA. The principle of GPA is to apply transformations to the configurations (translation, scaling, and rotations), so as to minimize a goodness of fit criterion (the distance between the transformed configuration and the consensus configuration).

The degree of consensus is assessed by studying the variance of the datasets. The total variance V_T can be partitioned as follows (equation 4):

$$V_T = V_C + V_W + V_R \quad (4)$$

Where V_C denotes the variance of the consensus, V_W denotes the within-product variance in the projection space, and V_R denotes the residual variance.

By dividing by V_T , and sharing the within variance V_W among the n products, the equation becomes (equation 5):

$$100\% = R_c + \sum_{j=1}^n r_{jW} + R_R \quad (5)$$

R_c corresponds to the consensus ratio: a large R_c indicates a good consensus.

The consensus between the results of AP Test and SD Test (matrices X_{AP} and X_{SD}) was analyzed using GPA. The consensus ratio R_c between the two tests is 74.3%. It signifies that after transformation of the data, more than 70% of the total variance is represented by the consensus configuration. The statistical

test (permutation test) on R_c indicates that the consensus is significant (confidence = 99.9%). We can conclude that the general agreement between the two tests is good. Figure 11 represents the values of the within variance r_{jw} of product j . The glasses frames P05, P11 and P22 are the most consensual, with a low within variance. The glasses frame P01 and P04 have the highest residuals, indicated that the disagreement between the two methods on these two product samples is important.

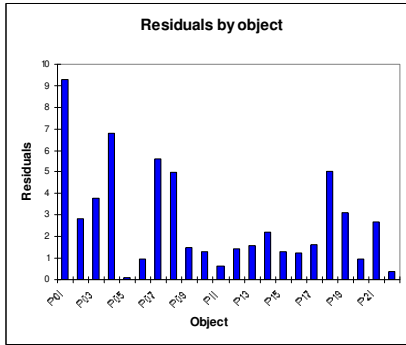

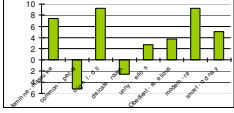
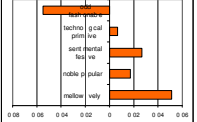

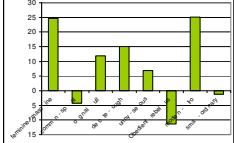
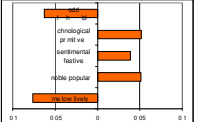

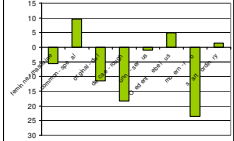
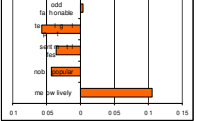


FIGURE 11 – WITHIN VARIANCE FOR EACH PRODUCT WITH GPA

In order to interpret the consensus between the two methods, we interested in the most three consensual glasses frames P05, P11 and P22. Table 3 presents the semantic profiles of these 3 products, for the SD (8 attributes) and the AP (5 dimensions) methods. P05 is a typical glasses frame, which is ‘average’ for both tests. It does not possess a noticeable character. P11 has important value on the attributes ‘masculine, retro, rough’ in SD Test, and this glasses frame is typical ‘mellow, odd’ in the result of AP Test. Though these semantic attributes are not synonyms, we can find obviously similarity between ‘retro, rough’ and ‘odd’. For sample P22, we can seek out similarity between the meanings of ‘delicate, modern’ and ‘lively’ depending on the typical profile of both methods. The two methods provide finally complementary point of view concerning the connotations of these glasses frames.

The agreement between the two methods can also be assessed by studying the position of the factors on the PCA plane of the variables after GPA (Figure 12). The first factor of AP Test F1 is nearly opposite to the second factor of SD Test FSD2. The second factor of AP Test F2 is close to the first factor of SD Test FSD1. If we come back to the initial interpretation of the factors with the initial variables, agreement (and also differences) in the interpretation of the assessments can be visualized. For example, ‘popular (F_{AP2}) – common (F_{SD1})’, and ‘festive (F_{AP2}) – funny (F_{SD1})’ are in agreement. On the other hand, ‘mellow (F_{AP1}) – masculine (F_{SD2})’ disagrees. This graph can be a very interesting vantage point to grasp the complexity of product semantics and to interpret users’ emotions.

TABLE 3 – AGREEMENT BETWEEN THE TWO METHODS ON THE SEMANTIC PROFILES (THE MOST CONSENSUAL SAMPLES)

Samples	SD Test	AP Test
P05 	 average, basic	 average, basic
P11 	 masculine, retro, rough	 mellow, odd
P22 	 delicate, modern	 lively

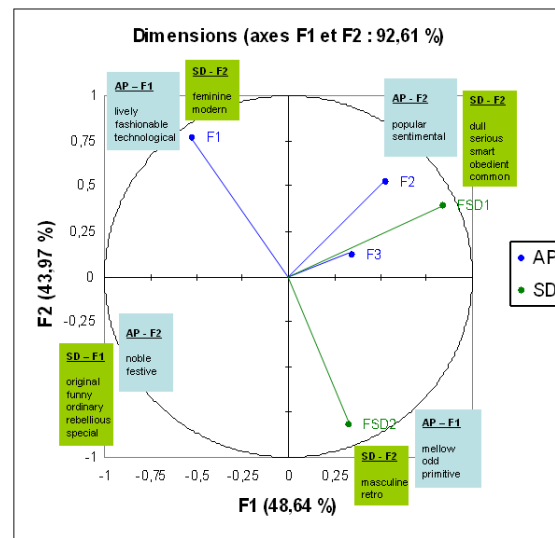


FIGURE 12 – AGREEMENT BETWEEN THE TWO METHODS ON THE INTERPRETATIONS OF THE FACTORS

Modeling the results of AP Test (F_{AP1}) with ANOVA

The next step of our methodology is to interpret the subjective dimensions of the products by design factors. The objective is to create a model for identifying the relative weighting of each design factor and factor level in the

perception of the glasses frames. The method used is Analysis of Variance (ANOVA – also named Quantification Theory Type I in Kansei Engineering, or Conjoint Analysis in marketing). The aim of ANOVA is to identify whether any of the shape factors has a statistically significant effect in changing the user’s affective responses to the glasses frames.

We analyzed the first factor of the AP Test (F_{AP1}) with Analysis of Variance. The coordinates of the products on factor F_{AP1} was considered as the response of the model, i.e. the dependent variable. The coefficient of determination R^2 of the model was $R^2 = 90\%$. So this linear model accounted for 90% of variance of the data. The goodness of fit of the model is important.

Figure 13 shows, for each factor, the part-worths of each level. The interpretation of the part-worths is as follows:

- Factor A: leg width. A wide frame leg (A1) increases the dynamism of the product w.r.t. a narrow (A2).
- Factor B: rim profile. The B5 profile reduces the dynamism of the product.
- Factor C: rim aspect ratio. A wide aspect ratio (C2) increases the dynamism w.r.t a high (C1).
- Factor D: rim thickness. A thick rim (D1) increases the dynamism w.r.t a thin (D2).

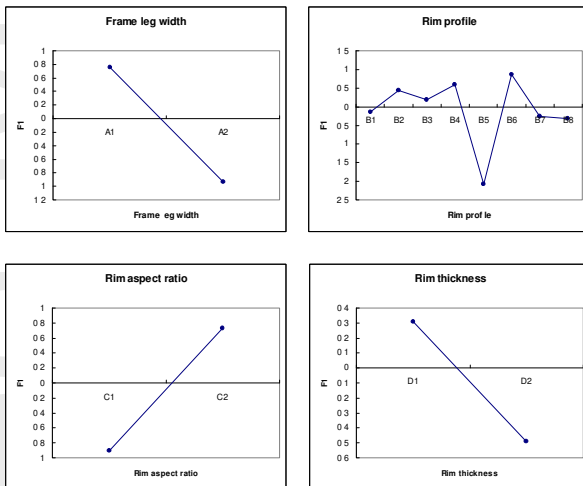


FIGURE 13 – MAIN EFFECTS OF THE DESIGN FACTORS FOR F_{AP1}

The part-worths and the importance of the factors are given in the following Table 4. Factor B is the most important factor in the dynamism of the glasses frame; the least important is factor D. This table characterizes the affective responses as a linear combination of the shape factors studied in our experiment. When a new glasses model is designed based on the combination of these factors, we can compute with the model the level of affective response that it may produce to the subject. For example, if the designer selects the same factor level settings to build up a new glasses frame, these values can be fed into the regression equation to obtain the affective

responses invoked by it. Another potential use of our experimental findings is the customization for emotional design. The end user (clients) can express their needs of a particular emotional feature of the desired glasses frame, and the model can be constructed accordingly.

TABLE 4 – RESULTS OF ANOVA (PART-WORTHS)

Factor	Level	Part-worths	Importance
A	A1	0,84	24%
	A2	-0,84	
B	B1	-0,04	42%
	B2	0,53	
	B3	0,27	
	B4	0,69	
	B5	-1,99	
	B6	0,95	
	B7	-0,18	
	B8	-0,23	
C	C1	-0,82	23%
	C2	0,82	
D	D1	0,4	11%
	D2	-0,4	

CONCLUSIONS

In this paper, we described an experimental protocol, called Auditory Parameter Method, for the measurement of emotions elicited by product appearance. The method uses music samples and association test to assess the emotions elicited by a set of glasses frame 3D models. The results showed that the method has a good feedback from the participants and that it makes sense to ask to associate music with pictures. The results of the Auditory Parameter Method were next compared with those of the Semantic Differential Method. We analyzed the results by PCA to establish the underlying information we got from these two tests. We provided an interpretation of the perceptual space obtained by the two methods. The similarities between the two methods were next evaluated using GPA. The relative high R_c showed that the consensus between the two methods is good. Our method is considered as efficient to measure stable dimensions and has the paramount advantage to be administered directly to people of any nationality, without difficult translation phase. Therefore, the AP Method can not only be a language-free alternative to the SD Method, but also a new extension to another sensorial modality of non-verbal experimental protocols.

We employed ANOVA to model the first factor obtained with the AP method: the degree of ‘*dynamism*’. The model allows an interpretation of how various shape factors influence user’s affective responses to product. The results indicated that the main shape factors are statistically significant in changing the responses. These findings can be design references to help designers to evaluate the emotional value of glasses frames. It may also benefit to the users, to position their anticipative desires associated with geometrical design attributes of the glasses frame.

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