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Scaling of Selected Elements of the Sensory Impressions of the Tactile Sense

Katarzyna Krawczyk[a]; Piotr Tomasik[a],*; Jacek Strojny[b]

[a]Cracow College of Health Promotion, Cracow, Poland.
[a]Department of Mathematical Statistics, University of Agriculture, Cracow, Poland.
*Corresponding author.

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Abstract
People from various regions of the world were questioned for their personal associations of three components of the sense of touch i.e. smoothness/coarseness, hardness/softness and warm/cold with peripheral colors of the rainbow e.g. either violet or red color. Links of violet color to smoothness, hardness and cold and red color to coarseness, softness and warm clearly dominated among collected 1433 replies. Thus, the dominating associations could be considered standard. These results will be helpful in attempted construction of standard sensory profiles of the human individuals.

Key words: Quantification of sensory impressions; Sense of touch; Sensual associations

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INTRODUCTION

In the common life, people used to be identified by means of ID documents, social security number and so on. Such documents are based on the owner personal data and physical appearance. In case of designation for a given field of education, employment and other areas of the ability and talents candidates are classified based on various tests arranged to derive their psychological profile.

Sensual impressions and their interpretation are common means of the contact with surrounding which controls the human reactions to the external signals (Laming, 1995; Geschreider, 1997). Therefore, construction of the sensory profile of the human individuals seems to be an interesting alternative for the estimation of the human personality. Such profiles might also provide an increased efficiency of multisensory information and increased sensitivity to the signals coming from the surrounding. It should be considered as a tool for evaluation of the human talents and various abilities for psychologists, psychiatrists, criminologists, sociologists and therapeutists. The approach might also attract attention of designers of various products as well as nutritional scientists, cosmetologists, and so on.

Tomasik-Krotki and Strojny (2008) have presented a step towards standardization of the human sensory impressions of sight, hearing, taste and smell together with a system of scaling these impressions. They checked human associations between 7 colors of rainbow and 7 sounds of the European music gamut, 5 basic tastes and 7 selected odors. Independently of the origin of the respondents, statistically significant majority of over 500 replies to the relevant questionnaires reported the same color—sound, color—taste and color—smell associations. It provided elaboration of some standards for the associations of the sensory impressions recorded by sight, hearing, tasting and smelling. That approach offered a generally valid translation of these sensory impressions into one another. The quantification of the deviations from the standards was possible involving proposed specific permutation system.

In that approach the sensory impressions collected by touch were omitted as the tactile sense has a complex nature and some of its elements cannot be expressed by units of any physical meaning (Schiffman, 1995; Robles-De-La-Torre & Hayward, 2006). Some organs, the receptors, collecting such impressions specific for

the tactile sense as warm and cold, pressure, softness, hardness, smoothness, coarseness and itching are located in the skin. They are classified as thermoreceptors, mechanoreceptors, and chemoreceptors. Feeling pain is registered by nocireceptors located not only in the skin but also deeply in muscles, bones, joints and some internal organs. The tactile sense includes also proprioception (the body position) and several other impressions which in this project are beyond the scope of interest. Recently, an additional receptor was found among people insensitive to pain. It surrounds vascular tracts (Bowsher, et al., 2009).

Because construction of the sensory profiles of human individuals is the future aim of this study, in this project attention was paid to these impressions which would be well understood by questioned people and could be experienced on request. Warm and cold, hardness and softness as well as smoothness and coarseness follow that condition and if it would be necessary, they could be measured and expressed in some physical units. In contrast to them feeling pain and body orientation do not obey such conditions. The selected elements of the tactile sense were linked to seven colors of rainbow in order to achieve compatibility of the approach with sensory associations formerly published by Tomasik-Krotki and Strojny (2008).

It should be underlined that the associations under investigation in this project should not be identified with synaesthesia (Baron-Cohen, Burt, Smith-Laittan, Harrison, & Bolton, 1996; Blakemore, Bristow, Bird, Frith, & Ward, 2005; Ramachandran & Hubbard, 2001; Simner, 2007; Ward, Li, Salih, & Sagiv, 2007). Synaesthesia is defined as result of unisensual impulse inducing automatic and non-anticipated impression in at least two sensual modalities, although sometimes synaesthesia can be restricted to a single modality as, for instance, think colored-graphemes (Simner et al., 2005).

Table 1
Associations of the Components of the Tactile Sense With Violet and Red Colors

Sensory impression	Women				Men				Total			
	Violet	%	Red	%	Violet	%	Red	%	Violet	%	Red	%
Smoothness	675	63.0	397	37.0	225	62.3	136	37.7	900	62.8	533	37.2
Hardness	608	56.7	464	43.3	180	50.0	181	50.0	788	55.0	645	45.0
Warm	63	5.9	1009	94.1	36	9.8	325	90.2	99	6.9	1334	93.1

Table 2
Log-Linear Model: Tests That K-Way Effects Are Zero

Effect's order	Likelihood ratio c^2-test	Probability	Pearson c^2-test	Probability	df
Main effect	1229.532	0.0000	1483.518	0.0000	4
Two-way interaction	1253.485	0.0000	1076.389	0.0000	5
Three-way interaction	11.124	0.0038	11.845	0.0027	2

Table 3
Log-Linear Model: Tests of Partial Associations

Effect name	Partial c^2-test	df	Probability
Color*sex	0.572	1	0.4495
Color*sensory impression	1253.057	2	0.0000
Sex*sensory impression	0.143	2	0.9310
Color	122.853	1	0.0000
Sex	1106.680	1	0.0000
Sensory impression	0.001	2	0.9996

Table 4
Log-Linear Model: Observed Frequencies, Expected Frequencies and Residuals

Code	Observed count	%	Expected count	%	Residual	Standardized residual
				Red color		
				Men		
Hardness	181	4.21	322.5	7.50	-141.5	-7.879
Smoothness	136	3.16	266.5	6.20	-130.5	-7.994

To be continued

Continued

Code	Observed count	%	Expected count	%	Residual	Standardized residual
Warm	325	7.56	667.0	15.52	-342.0	-13.242
				Women		
Hardness	464	10.79	322.5	7.50	141.5	7.879
Smoothness	397	9.23	266.5	6.20	130.5	7.994
Warm	1009	23.47	667.0	15.52	342.0	13.242
				Violet color		
				Men		
Hardness	180	4.19	394.0	9.16	-214.0	-10.781
Smoothness	225	5.23	450.0	10.47	-225.0	-10.607
Warm	36	0.84	49.5	1.15	-13.5	-1.919
				Women		
Hardness	608	14.14	394.0	9.16	214.0	10.781
Smoothness	675	15.70	450.0	10.47	225.0	10.607
Warm	63	1.47	49.5	1.15	13.5	1.919

1. RESULTS

Table 1 presents results of the respondents' survey. For the data grouped under Total heading the Pearson c^2-test value was 1091.099 with $df = 2$ and significance (two-sided) 0.000 (Table 2), which indicated that the color-touch terms associations are statistically significant.

Results of the application of the log-linear model are presented in tables 3 and 4.

2. DISCUSSION

The associations pattern was given by the hypotheses which was intended to be tested. One expected that sensory impression was associated with perceived color. This assumption suggested a linkage between those two variables and the counts distribution in the cross-tabulation (Table 3). The output of the final model (Table 4) includes observed and expected frequencies, residuals and standardized residuals. The model of independence—no associations between the three variables: sensory impression, color, sex—fit the observed data in the Table 4 imperfectly. One could infer that data configuration comprised some associations. This implicated a linkage between these two variables and the counts distribution within the cross-tabulation in the Table 1.

Although smoothness/coarseness, hardness/softness and warm/cold experienced by the sense of touch could be expressed by means of physical units one cold not establish any limits and borderlines for quantification of these impressions in frames of attempted sensory profile. In order to standardize these perceptions in the manner compatible with that formerly presented for scaling remaining senses (Tomasik-Krotki & Strojny, 2008) the borderlines for these perceptions were established allowing selecting between two peripheral colors of the rainbow. Association of smoothness with violet color immediately meant the association of red color with coarseness and, oppositely, the association of smoothness with red color would imply association of coarseness with violet color. Association of hardness with violet color pointed to the link of softness with the red color. Finally, association of red color with warm implied the violet color—cold association. In this manner the quantification of the elements of the tactile sense could be carried out within borderlines designed by the peripheral colors of the rainbow.

The scaling of these impressions could be carried out in the analogous manner as in case of their sensory impressions. The respondents, similarly as in case of senses of sight, hearing smelling and tasting, should be asked for associations of the components of the sense of touch with any of seven colors of rainbow. In order to standardize the procedure it was proposed that the numerical values of the units of smoothness and hardness, called "ohya" and "petr", respectively, varied from 7 for violet, 6 for blue, 5 for bluish green, 4 for green 3 for yellow, 2 for orange to 1 for red color. The values of 1 "ohya" and 1 "petr" would be equivalent to a peak both coarseness and softness, respectively. The unit of the warm called "uff" would take the values of 7 for red and 1 for the violet color. 1 "uff" would be equivalent to feeling extreme cold. These orders followed the sequence of the colors in rainbow. Then, the number of permutations required for bringing given association to the standards would be taken into account in the formation of the sensual profiles. If the total personal sensual profiles involving simultaneously the remaining senses would be required, the approach to the scaling based on the circle divided into seven fractions corresponding to seven colors of rainbow and distributed in that circle in the order of their appearance in the rainbow should be applied for the

normalizing permutations. This approach is described in the former paper by Tomasik-Krotki and Strojny (2008).

The effect of the sex and age upon the associations of the colors with investigated elements of the tactile sense has been also checked. Inspection of Table 1 shows that, to a certain extent, the genre determined the associations. The associations of the violet color with smoothness had almost 63% of the respondents and the differences in the number of these associations among women and men were not significant statistically. A vast majority of the respondents (93-94%) pointed to the link between red color and warm and, again, the differences in that perception between women and men groups were statistically insignificant. The links of hardness to either violet or red colors were not so univocal. Totally 55% respondents pointed to the violet color—hardness and 45% selected red color—hardness association. Because of the proportion of replies this association was sex dependent and the c^2 - test value = 0.000 at $df = 2$ and significance being 1.000 confirmed it. Men were less likely to associate the red color to warm and to link the violet color to hardness and smoothness that women did.

Statistic treatment of the results in total of the Table 1 by c^2- test revealed a relationship between sensory impression and a respondents' perceived color. The violet color could be associated with smoothness (cross-tabulation standardized residual 12.5), as well as with hardness (cross-tabulation standardized residual = 7.9) and red color could be linked to warm (cross-tabulation standardized residual 17.7).

3. METHOD

1433 people (1072 women and 361 men) aged 13 to 82, of average age 30.56, from Poland, USA, United Kingdom, Federal Republic of Germany, India, Republic of China, Taiwan, Sweden, Trinidad & Tobago, Nepal and Mongolia were questioned. The subjects in these countries were recruited based on the personal contacts of the authors of the research. The distribution of the questionnaire in reported countries was done by local associates.

The rule of the voluntary participation in the tests was followed and the subjects were informed about the idea and purpose of the action. Depending on the country, distributed questionnaires were available either in Polish or in English. The survey questions were based on the associations between the feeling of smoothness/coarseness, warm/cold and hardness/softness with either red or violet color. These two colors are the borderline colors of the rainbow. Respondents were informed that association of one of two colors with one of the impression in a given pair immediately associated the second impression in a given pair with the second color of possible choice. It means that, for example, association of smoothness with red color immediately linked coarseness to the violet color. Collected data were subjected to statistical examination by the c^2-test. Additionally, the log-linear model a flexible tool for modeling discrete data (Agresti, 2002) was applied to assess the statistical significance of the role of the respondents' sex.

4. END NOTES

Presented associations complement attempts of designation of certain standards of linking sensory impressions with 7 colors resulting from splitting white light with, for instance, Nicol prism or water droplets (rainbow) with 7 sounds of the European music gamut, 5 tastes, 7 odors and some elements of the tactile sense. Based on former (Tomasik-Krotki & Strojny, 2008) and present results the following associations should be considered standard, as they have been reported by a majority of questioned subjects. Sounds C, D, E, F, G, A, H (B) are associated with red, orange, yellow, green, greenish-blue, blue and violet colors, respectively. Associations of the same colors with five tastes provided the following standards: sweet—red, sour—yellow, salty—blue, bitter and umami—both violet. Associations with seven odors were as follows: floral—red, camphorous and ethereal—both blue, musky—violet, peppermint—green, pungent—yellow, and putrid—greenish-blue. Present study provided the following standard associations involving elements of the tactile sense: warm—red and cold—violet, smoothness—violet and coarseness—red, hardness—violet and softness—red.

Replies of questioned subjects compared to standards would provide a sensory profile of the respondents. Proposed units (mniams for taste, fuys for odors, wyes for sounds, uffs for warm/cold, ohyas for smoothsness/coarsnes and petrs for hardness/softness) offer quantification of possible discrepancies with the standards.

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