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OCCUPATIONAL RISKS: PERCEPTUAL MAP CONSTRUCTION USING PSYCHOMETRIC PARADIGM AND MULTIVARIATE METHODS

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ABSTRACT

Risk management focus main on technical and rational analysis about operational risks and by those imposed by occupational environment. In this work one looks to contribute to perception study of work safety professionals about a series of activities and environment agents. In this way it was used theory sustained by psychometric paradigm and multivariate analysis tools, mainly multidimensional scaling, generalized Procrustes analysis and facet theory, in order to construct the perceptual map of occupational risks. The results obtained showed that the essential characteristics of risks, which were initially split in 4 facets were detected and maintained in perceptual map. The construction of perceptual map also permitted to verify the formation of a new facet, not considered in the beginning. The facet theory which by hypothesis was used in this work showed adequate, providing the regional interpretation of the map. The inferential analysis realized showed fine results for the final configuration validation, indicating which risks and/or activities belongs to the same facet.

Keywords: Facet Theory; MDS; Occupational Risks; Perceptual Map; Procrustes.

1. INTRODUCTION

The perception of occupational risks is gaining prominence in Brazilian preventionist scenario, as recent work of Cabral et al. (2010), McGrath (2010), Johnsen et al. (2010) and Bjerkan (2010) in the oil and gas industry. In the same vein Soares et al. (2008) developed a study on risk perception in the port area.

The perception of risk is the subjective assessment of the likelihood of a specific type of accident occurs, and to what degree a person is worried about its consequences. The perception of risk however goes far beyond the individual and the result is a construct that reflects social and cultural values, symbols, history and ideology (WEINSTEIN, 1980).

Johnsen et al. (2010) advocate the use of an indicator of risk perception among the stakeholders involved in a remote operation. The authors suggest measuring the impact of risk perception on safety and resilience when a task is distributed between onshore and offshore.

Hussin and Wang (2010) compared safety perception among post-graduate students and discovered that oil and gas and aviation are considered safe industries and that nuclear and mining industries are considered unsafe. The students relate risk perception more linked with severity of accidents rather than probability of occurring.

Leiter et al. (2009) studied occupational risk perception in relation to safety training and injuries in a printing industry. Using structural equation analysis the authors confirmed a model of risk perception based on employee's evaluation of prevalence and lethalness of hazards as well as control over hazards the employees gain through training.

The study of risk perception has been developed since the initial work of Starr (1969) cited by Sjoberg et al. (2004). Two theories currently prevail, one represented by the psychometric paradigm, based on psychology and decision sciences and cultural theory developed by sociologists and anthropologists.

This paper aims to: i) obtain the perceptual map of the occupational risk, from the standpoint of psychometric paradigm in a group of safety engineering graduate students. The group was submitted to a list of hazards involving four facets represented by physical and chemical agents, activities with a predominance of

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ergonomic hazards and activities with various risks and admittedly dangerous, ii) testing the hypothesis of regional interpretation of the solution space of perceptual mapping, iii) to test statistical differences between the objects evaluated using multivariate statistical tools.

The expected contribution of the work is to produce a perceptual map using visualization techniques of multidimensional data, known as multidimensional scaling (MDS), aided by tools of shape statistics, the Procrustes. The methodological approach employed in this study was an exploratory research.

This paper is organized as follows: in the introduction section, dealt with the motivation and objectives for development of this work, Section 2 a brief review of the psychometric paradigm and studies of risk perception. Section 3 presents the method used in this study, the non-metric MDS and Procrustes analysis, Section 4 presents the analysis and results obtained using psychometric paradigm associated with visualization tools and multivariate statistics, and finally Section 5 with final remarks.

2. RISK PERCEPTION AND THE PSYCHOMETRIC PARADIGM

The ability to sense and avoid hazardous environmental conditions is necessary for the survival of Human beings. Survival is also assisted by the ability to encode and learn from past experiences. Humans also have an ability that allows them to change the environment and adapt it. This ability may both decrease and increase risks (SLOVIC, 2001).

The most common strategy for the study of risk perception employs the psychometric paradigm, which uses psychophysical scaling methods and multivariate analysis techniques to produce quantitative representations or also known as cognitive maps of attitudes and perceptions.

Within the psychometric paradigm people make quantitative judgments about the current and desired risk of various hazards and desired level of regulation of each of the risks. These judgments are then related to judgments about other properties, such as: willingness, fear, knowledge, control, benefits to society, the number of deaths in one year, number of deaths due to a disastrous year (SLOVIC, 1987, 2001).

Several authors have identified behavioral factors that affect risk perception, whether the risk is natural or anthropogenic, whether it is voluntary or not, whether it generates fear, whether it is familiar or new, whether it can produce chronic effects, (i.e.: the damage is small, but steady in contrast to the catastrophic effects many deaths instantly), whether the person has control over them or memorable situations, due to personal experiences, family situations or widely known in the media. (BAUMGARTEN; MCCRARY, 2004).

According Sojberg et al. (2004), the work of Fischhoff, Slovic, Lichtenstein, Read and Combs, 1978, reproduced in Slovic (2001) was a landmark of psychometric theory. The authors have compiled nine dimensions from the literature related to perception studies. The first refers to the risk exposure is being voluntary or involuntary, the second referring to the immediacy of the consequences or not, the third assesses the extent to which risk is known by the person who is exposed, the fourth refers to the potential chronic or catastrophic risk, (i.e. chronic risks are those that cause harm (deaths) in large time and catastrophic cause many damage (deaths) instantly).

The fifth dimension involves deciding whether the risk is common, (ie. A risk already assimilated by the people or causes a great fear). The sixth dimension relates to the severity of the consequences imposed by the risk, the seventh to the extent to which the risk is known by science, the eighth evaluates the level of control the person has upon risk and the last one if the risk is new to society or not.

Several surveys were conducted on a large number of activities (smoking, use of dyes in food, nuclear operations, vehicles, skiing, among others) described in nine dimensions. Data were analyzed with factor analysis and the authors identified two major factors that explain most of the data variance, which are: Fear and the Newness of Risk

McDaniels et al. (1995) cited by Sjoberg et al. (2004) defined the psychometric paradigm as an approach to identify the characteristics that influence the perception of risk. The approach assumes that risk is multidimensional, with many characteristics other than individual judgments of the likelihood of damage to health or life. The method application in studies of human health risk perception include: - develop a list of hazards based on events, technologies and practices that

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include a broad spectrum of potential hazards - developing a number of psychometric scales that reflect characteristics of the risks are important to map the human perception in response to the risks - to ask the respondents to evaluate each item on the list of hazards in each of the nine dimensions - using multivariate analysis to identify and interpret a set of latent factors that capture the variations the responses of individuals and the group.

Sjoberg, (2000, 2002) and Marris et al. (1998), mentioning that some analysis takes into account up to 18 dimensions, but typically 80% of the variance is explained by three dimensions by factor analysis and the factors that have been reported in studies of perception are New or Old, Feared or Common and Number of exposed persons. The author also presents some criticisms of the psychometric paradigm as regards the small number of dimensions evaluated from 9 to 18, and the fact of not including an important dimension which is related to the risk is natural or not, and finally that the analysis is based on average, not all data collected.

3. METHOD

Aiming to assess the perception of a population of safety engineers students to occupational risks a questionnaire was applied. The questionnaire listed 29 objects divided into four facets, 5 physical agents, 8 chemical agents, 11 activities that involve various hazards and 5 typical office activities, with emphasis on ergonomics. Table 1 shows the objects of research.

Table 1: Objects of Perception Survey of Occupational Risk divided into four Facets.

Physical agents	Noise Heat Vibration Humidity Non ionizing radiation	Chemical agents	Metal fumes Asbestos Silica Lead Gasoline Benzene Mercury Nanotechnology
Activities that involve various hazards	Hospital laundry Working under the sun Forest harvesting Electrical Maintenance Caisson Diving Confined space Working at height X-ray Operator Electroplating Electric Welding	Typical office activities, with emphasis on ergonomics	Labor office Telemarketing operator Bank Teller Posture Exertion

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Facet theory is a way of linking the geometric properties of an MDS configuration with attributes of the objects represented in it. This is a regional interpretation of the MDS space based on a theoretical framework (BORG; GROENEN, 2005).

In this study the facets are grouped according to 3 classes of occupational hazards: physical, chemical and ergonomic hazards and a different class, which involves various different hazards.

For each object the respondents were asked to assign scores on a Likert scale from 1 to 7 in nine dimensions, as Figure 1.

The forms provided to respondents contained objects arranged in a random way, aiming to eliminate any possibility of systematic error in data collection.

Dimensions	**Scale**
Willingness to risk. People "take" this risk voluntarily	**Voluntary Involuntary** **1 2 3 4 5 6 7**
Time to Effect. To what extent there is risk of immediate death or the risk of death is delayed.	**Immediate Late** **1 2 3 4 5 6 7**
Knowledge of Risk. – Exposed. To what degree the risk is known by people who are exposed to it.	**Known Not Known** **1 2 3 4 5 6 7**
Knowledge of Risk. - Science To what degree the risk is known to science.	**Known Not Known** **1 2 3 4 5 6 7**
Control of Risk. If you are exposed to risk, to what extent you can, because your skills, avoid death while engaged in activity.	**Incontrolable Controlable** **1 2 3 4 5 6 7**
Newness. This threat is new or old, familiar	**New Old** **1 2 3 4 5 6 7**
Chronic-Catastrophic. This risk kills one person at a time (chronic) or risk kills a large number of people at once (catastrophic)	**Chronic Catastrophic** **1 2 3 4 5 6 7**
Common-Feared. People have learned to live with this risk and may decide to quietly about the same, or is a risk that people have a great fear	**Common Feared** **1 2 3 4 5 6 7**
Severity of Consequences. What is the likelihood that the consequence of that risk is fatal	**Not Fatal Fatal** **1 2 3 4 5 6 7**

Figure 1: Dimensions of risk perception and their Likert scales.

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Respondents were only given instructions on how to fill, using the Likert scale, with no explanation of the meaning of each object. The respondent group comprised 13 students from a Safety Engineering course.

3.1. Multidimensional Scaling (MDS)

The method used to draw the perceptual map of risk was a non-metric Multidimensional Scaling (NMDS). The MDS also called classical metric was introduced by Torgerson (1952, 1958) and Gower (1966), as quoted by Wickelmaier, (2003), Borg and Groenen (2005). The classic MDS is also known as Torgerson Scaling or even Torgerson-Gower Scaling (BORG; GROENEN, 2005).

Classic MDS starts with a distance matrix D with elements dij, where i, j = 1 ,.... n, and the goal is to find a configuration of points in p-dimensional space from the distances between the points so that the coordinates of n points along the dimension p will produce a matrix whose elements are Euclidean distances as close as possible to the elements of distance matrix D. In this paper the distance matrix was obtained from the consensus configuration of generalized Procrustes analysis (GPA).

The GPA is a statistical tool shape. The term shape is defined by Brombin and Salmaso (2009) involving the geometric properties of a configuration of points that are invariant to changes in translation, rotation and scale. Direct analysis of a set of points is not appropriate due to the presence of systematic errors such as position, orientation and size, and usually to conduct a reliable statistical analysis GPA is used to eliminate factors not related to shape and to align the settings for a common coordinate system (BROMBIN; SALMASO, 2009).

The GPA, a multivariate statistical technique in which three empirical dimensions are involved: the objects of study, people who value the objects and attributes in which the objects are evaluated. In the case of this study p attributes, with (p = 1 ,..., 9), represented by the dimensions of risk perception, was measured on n objects, with (n = 1 ,..., 29), which in this case are represented by four facets, with (m = 1 ,..., 13), evaluators. The GPA is an ideal method to analyze data from different individuals (DIJKSTERHUIS; GOWER, 2010).

Suppose there are m (nxp) configurations X1, ... Xm and each ith row of Xj (j = 1, ... m) contain the coordinates Pi (j) in p-dimensional Euclidean space, eg scores of

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the attributes of a product i (i = 1, ... n) by evaluator j. Naturally it is considered that the m configurations contain information about the same n objects in the same attributes. The objective of the GPA is to determine to what extent the m configurations are consistent.

This problem can be described as the measure of similarity between the m configurations, or interrater reliability judge (RODRIGUE, 1999). The mathematical formulation of the GPA can be described as follows, Tj is an nxp matrix with all n rows equal to tj (1xp row vector), an orthogonal matrix Hj (pxp), and ρj a scalar (j = 1, ... m). The translation to the origin is given by adding the same row vector (1xp) tj to all line of Xj. The scaling, rotation and translation can therefore be expressed by the transformation given by Equation (1).

$$X_j \longmapsto \rho_j X_j H_j + T_j \qquad (1)$$

The GPA also allows to analyze the data set, to verify the similarity between judges, the influence of causal factors, using the Procrustes ANOVA, termed as PANOVA by Nestrud and Lawless (2008), and Dijksterhuis and Gower (2010); Gower (2004).

The NMDS ordinal is a special case of MDS, and possibly the most important in practice (COX; COX, 2000). It is normally used when, for example, we want to get the trial, placing the objects in ascending or descending order of importance from the perspective of an evaluator. The most common approach used to determine the elements dij and to get the coordinates of objects x1, x2, ..., xn is an iterative process, implemented in the Shepard-Kruskal algorithm, with the minimization of a function known as Stress as in Equation (2) (Kruskal, 1964). The NMDS is an iterative and its point of departure is the metric MDS.

$$Stress = \left(\frac{\sum_{i<j} \left(d_{ij} - \hat{d}_{ij} \right)^2}{\sum_{i<j} d_{ij}^{\ 2}} \right)^{\frac{1}{2}} \qquad (2)$$

The Stress function represents and evaluates the inadequacy (admissible transformation) of proximities and the corresponding distances. Stress is very similar to the correlation coefficient, except that it measures the misfit and not the adjust of a model. A comparison with the correlation coefficient is because the researchers know that a correlation may be artificially high by the presence of outliers, and also

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very low due to, for example, the linear model is not the most appropriate. What is done in these circumstances is to examine the scatter plot. The same practice is advocated in the NMDS, by means of a graph with the proximities in the abscissa axis against the corresponding distances in the y-axis. Typically a regression shows how the proximity and distance estimates are related. This chart is known as the Shepard diagram (BORG; GROENEN, 2005).

Another way is to determine the space dimensionality from which do not occur a significant reduction in the value of stress, ie solve the NMDS for several dimensions and plot the values of stress as the ordinate and dimension in the abscissa axis. This chart is known as "Scree Plot". The curve shape is generally monotonic downward, but at a very low rate as it increases the size (convex curve). What is sought is the "elbow", the point where a decrease in stress is less pronounced (BORG; GROENEN, 2005).

Finally, the trial dimension for use in the final configuration of points uses the criterion of interpretability, as cited by Kruskal (1964), i.e.: m dimensions provides a satisfactory interpretation, and m +1 in no way improves the interpretation, it makes perfect direction set in m-dimensions. That is the Stress obtained is only a technical measure and the NMDS. Evaluation of NMDS should be made knowing the theory that explains the behavior of the data.

In the specific case of this study it was defined a priori that two dimensions is a good representation, and relying on the Facets theory described by Borg and Groenen (2005) analyzed the differences between objects obtained in the final configuration of consensus.

The statistical differences between the objects of a facet were determined by Hotteling - T2 multinormal test, with 0.05 of significance, according to the hypothesis:

$$H_0: \mu^{j}_{faceta_i} - \mu^{k}_{faceta_i} = 0$$

where j and k are object of the same facet, e i=1,...,4.

To check the interrater reliability respondent used the RV coefficient, which is a multivariate statistical ranging between 0 and 1 (0 representing total disagreement, orthogonality and 1 a perfect agreement). According to Cartier et al. (2006); Nestrud and Lawless (2008) Rv values above 0.7 are accepted as a good level of agreement

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between the configurations. However, Josse, et al. (2008) argue that the RV coefficient between the two extremes (0 and 1) is not informative because their value depends on the number of individuals, the number of variables, and dimensionality (i.e. Structure covariance) of each data set, and hence a high value of Rv is not necessarily a significant relationship between the data sets.

One way to solve this problem is to perform a statistical test on the coefficient Rv. Josse, et al. (2008) proposed a permutation test to calculate the p-value. The hypothesis is:

H0: Rv=0 (no significant association between the data sets)

Thus it is calculated the Rv coefficient according to Equation (3) and using Permutation test calculates the significance of it according to H0 hypothesis.

$$Rv = \frac{tr(S_{XY}S_{YX})}{\sqrt{tr(S_{XX}^2)tr(S_{YY}^2)}} \tag{3}$$

where $S_{YY} = 1/(n-1)Y^TY$ and variance de Y, $S_{XX} = 1/(n-1)X^TX$ is X variance and $S_{XY} = 1/(n-1)X^TY$ is the covariance XY.

The NMDS solution was achieved using MASS package (VENABLES; RIPLEY, 2002). The GPA and the Rv coeficient were determined by FactoMineR package, (HUSSON, et al. 2009). Both implemented in R - CRAN Version 2.9.2 (R Development Team, 2009).

4. RESULTS AND DISCUSSION

The 13 sets of data for each of the respondents were submitted to GPA procedure, to obtain the aligned configurations. After the initial alignment each configuration was submitted to nonmetric multidimensional scaling to obtain representation in two dimensions. In this step the respondents A4, A6, A8 and A12, were eliminated from the process because one or more of the Euclidean distances between objects resulted in zero value, suggesting that the respondent gave the same scores for different objects.

With 9 other settings, we proceeded back to the alignment settings and obtaining consensus configuration.

The final consensus configuration is shown in Figure 2. The objects were grouped under the same initial Facets, where it was shown that the initial hypothesis

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was proved in the low dimension space, i.e. the original facets are mirrored in the configuration obtained. The only exception occurred with the humidity, because it remains located outside the facet of physical agents, as expected.

The first dimension divides the perceptual map in the inferior quadrant chemical risks, linking them with the greatest risk of death and physical risks, linking them with a lower risk of death.

The separation, however, is not perfect, since the facet of chemical risks tends to invade the field of physical risks facet, but this fact can be explained by the low level of knowledge about the risks posed by nanotechnology among the respondents. Although many already know the topic, unaware of the risks.

In relation to dimension 2, the map is divided between activities/operations and environmental agents.

In the first quadrant (left) activities related to office, bank teller, telemarketing operator, posture and physical effort to compose facet of activities with a predominance of ergonomic hazards and in the second quadrant (right) facet of activities with various risks are allocated. Again one cannot obtain a perfect facet, since working under the sun, forest harvesting and hospital laundry tend to be more distant from the group. The object humidity, as reported above, stands out in terms of dimension 2, being isolated at the top of the map.

The next step was to test the hypothesis that objects belonging to a particular facet cannot be separated statistically, which reinforces the initial hypothesis that the representations in four facets were demonstrated in the perceptual map. For that we use the test Hotteling T2, which is equivalent to "t" test of one-dimensional case.

To perform this test data initially arranged in an array (O, D, K) (O = 1,..., 29), (D = 1.2) and (K = 1,..., 9) were rearranged into an array (K, D, O).

A necessary condition for using the T2 test is that data is distributed as a multivariate normal, and in this case, the data were tested for multivariate normality with the Shapiro-Wilk (SHAPIRO; WILK, 1965).

The hypothesis H0 is that the data follow a multivariate normal distribution with a significance level of 0.05.

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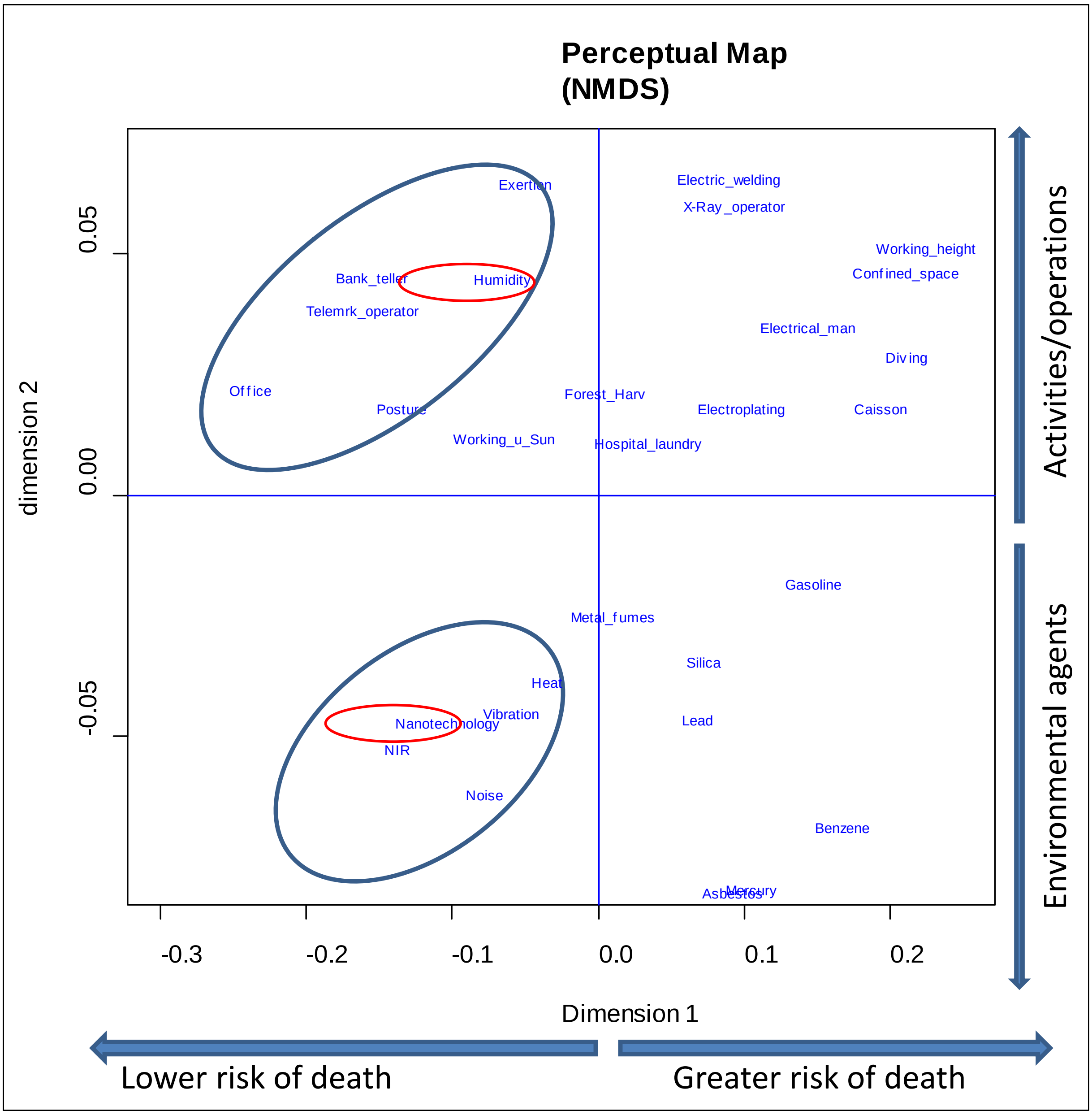

Figure 2: Configuration of consensus obtained for the NMDS.

The results of multivariate normality test for the data, showed that only the objects 5, 15, 22, 23 and 26 do not follow the multivariate normal distribution, and therefore the results obtained with the test T2 are unreliable for these objects.

In this paper it is assumed, although there are exceptions in some data, that Hotteling T2 can be used to test the hypothesis H0 of statistical equality of the objects within a single facet.

Table 2 shows the overall outcome of the activities of the facet comparisons with other risks.

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Table 2: P-values for the Hotteling T2 test of Facet Activities with several risks.

Object (N°)	10	12	13	15	17	22	23	24	25	27
Forest harvesting – 7	0,1741	0,8023	0,0853	**0,0017**	0,1782	0,288	**0,002**	**0,012**	**0,008**	0,3348
Electroplating – 10	-	0,3747	0,665	**0,019**	0,4908	0,468	**0,029**	0,132	0,097	**0,0021**
Hospital laundry – 12		-	0,1648	**0,004**	0,1881	0,163	**0,006**	**0,026**	**0,018**	0,125
Electrical mantenance – 13			-	0,2369	0,3512	0,421	0,305	0,560	0,4380	**0,0026**
Diving – 15				-	**0,0018**	**0,017**	0,822	0,685	0,886	**0,0000**
X-Ray Operator – 17					-	0,983	**0,006**	**0,022**	**0,008**	**0,0019**
Electric Welding – 22						-	0,052	0,066	**0,014**	**0,0289**
Working at height – 23							-	0,946	0,629	**0,0000**
Confined space – 24								-	0,467	**0,0002**
Caisson – 25									-	**0,0002**
Work under the Sun – 27										-

Bold values mean that the hypothesis H0 was rejected, ie there is significant difference between objects. It is for example the case of Forest Harvesting, which does not differ statistically from electroplating, hospital laundry, electrical maintenance, X-ray Operator, welding and work under the Sun, but differs statistically from Diving, Working at height, Confined Space and Caisson.

Likewise occur for other objects. These results lead us to conclusion that cannot be regarded as a single facet, that is, it can be subdivided, and the initial hypothesis is partially rejected. It should be noted also that the four objects mentioned above form a group where the risk of death is pronounced due to the characteristics of activities which may indicate the existence of a fifth facet, called activities with high potential for serious accidents.

In the case of Facet of Activities with a predominance of ergonomic hazards it appears that only the Bank Teller activity does not differ statistically from the other objects of the facet and that telemarketing operator differs statistically from Exertion, which is fairly consistent because we did not identify the presence of Exertion on office activities. Exertion does not seem to belong to this facet, as shown in Table 3.

Table 3: P-values obtained in Hotteling T2 in Facet Activities with a predominance of ergonomic hazards.

Object N°	4	8	18	26
Telemarketing operator – 2	0,9161	**0,0466**	0,2799	0,648
Bank teller – 4		0,1927	0,5461	0,489
Exertion – 8			0,2113	**0,007**
Posture – 18				**0,043**
Office – 26				-

The most consistency Facet was for physical agents, except for humidity, as shown in Table 4.

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Table 4: P-values for the T2 Test Hotteling Facet Physical Agents.

Object N°	19	20	29	28
Heat – 5	0,1825	0,443	0,7357	0,0697
RNI – 19		0,4758	0,4487	0,1465
Noise – 20			0,9225	0,0967
Vibration – 29			-	**0,022**
Humidity – 28				-

In this case an inconsistency is identified in Table 4, because the p-values revealed no statistical differences among the other objects, except for vibration, which does not arise in the positioning on the map. This inconsistency may be linked to the fact that the theoretical inadequacy of the humidity agent to other agents, or problems due to the strong assumption of multivariate normality test imposed by Hotteling.

And finally on the facet chemical agents, the objects metal fumes and Nanotechnology were those who differ from the others, except for lead and metal fume and metal fumes and nanotechnology that were not statistically different, as shown in Table 5.

Table 5: P-values for the Test Hotteling T2 in the Facet Chemical Agents.

Object N°	3	6	9	11	14	16	21
Asbestos – 1	0,2639	0,5581	**0,0154**	0,1843	0,9556	**0,0027**	0,188
Benzene – 3		0,1226	**0,0014**	0,4789	0,5413	**0,0003**	0,077
Lead – 6			0,1825	0,2010	0,6605	**0,0105**	0,877
Metal fumes – 9				0,0148	0,0728	0,1549	0,230
Gasoline – 11					0,2077	**0,0011**	0,348
Mercury - 14						**0,0068**	0,372
Nanotechnology - 16							**0,014**
Silica - 21							-

Intergroup comparison showed that only the evaluator A2 with A5, A7, A9, A10 and A11 the Rv coefficient did not differ from zero, ie only in those cases the evaluators disagree strongly. In other cases there is coincidence between the evaluations. This assessment points towards the evaluator A2 be an outlier within the group studied. The results of the RV coefficient and significance test obtained by Permutation are shown in Table 6. In the upper diagonal are the Rv values and the bottom diagonal are the p-values obtained by Permutation.

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TABLE 6: Coefficients Rv and significance test (p-value) inter evaluators.

	A1	A2	A3	A5	A7	A9	A10	A11	A13
A1	**1.0000**	0.1763	0.2460	0.3570	0.4823	0.4968	0.5253	0.4386	0.5254
A2	0.0289	**1.0000**	0.1612	0.1211	0.1007	0.0810	0.1329	0.0334	0.1596
A3	0.0049	0.0389	**1.0000**	0.1898	0.1924	0.3981	0.2241	0.2524	0.2725
A5	0.0002	**0.1176**	0.0211	**1.0000**	0.1710	0.2756	0.2765	0.1926	0.2797
A7	0.0000	**0.1436**	0.0181	0.0307	**1.0000**	0.2920	0.5056	0.3194	0.4264
A9	0.0000	**0.1983**	0.0001	0.0021	0.0028	**1.0000**	0.4389	0.4563	0.4067
A10	0.0000	**0.0692**	0.0085	0.0021	0.0000	0.0002	**1.0000**	0.3385	0.5664
A11	0.0000	**0.7138**	0.0033	0.0187	0.0009	0.0000	0.0006	**1.0000**	0.4453
A13	0.0000	0.0425	0.0025	0.0018	0.0001	0.0003	0.0000	0.0000	**1.0000**

5. CONCLUDING REMARKS

This study investigated the occupational hazards perception of a safety engineers group of students when subjected to a questionnaire administered according to the psychometric paradigm, considering the initial assumption of 29 objects divided into four facets. The result of the NMDS obtained through analysis of nine dimensions of the risk perception, created a perceptual map in two dimensions where the four facets were represented in low-dimensional space.

Statistical analysis between the objects of the facets showed that there are some objects that are not well represented, because they differ from the others, but generally speaking the facets generated are appropriate. The regional interpretation of the NMDS was positive due to the generation of the representation of the facets considered in the initial hypothesis.

A fifth facet can be determined from objects with high potential for serious accidents.

The introduction of the analysis of statistical inference can be regarded as an increment to the NMDS analysis, although the hypothesis of multivariate normality has been shown to be limiting. Future studies should be conducted using bootstrap or permutation test that are indifferent to the multivariate normality assumption and also to confirm the settings obtained in this work.

REFERENCES

BJERKAN, A. M. (2010) Health, environment, safety culture and climate - analysing the relationships to occupational accidents. **J. Risk Res.**, v. 13, p. 445–477.

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DOI: 10.14807/ijmp.v9i3.712

BORG, I.; GROENEN, P. J. (2005) **Modern Mutidimensional Scaling: Theory and Applications**. New York: Springer.

BROMBIN, C.; SALMASO, L. (2009) Multi-aspect permutation tests in shape analysis with small sample size. **Comput. Stat. Data An**.., v. 53, p. 3921-3931.

CABRAL, J. M.; PINHEIRO, F. M.; MARROZZI, W. F.; MARCHI, L. C. (2010) Red alert program in drilling rigs: A strong decision to show leadership and to involve work force towards zero serious or fatal incidents. **Society of Petroleum Engineers - SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production**, Rio de Janeiro, v. 3, p. 1648-1655.

CARTIER, R.; et al. (2006). Sorting procedure as an alternative to a product sensory map. **Food Qual. Prefer**., v. 17, p. 562-571.

COX, T. F.; COX, M. A. (2000) **Multidimensional Scaling**, 2º ed., London: Chapman & Hall/CRC.

DIJKSTERHUIS, G. B.; GOWER, J. G. (2010) **The interpretations of generalized Procrustes analysis and allied methods**, Urtecht: Oliemans Punter and Partners.

GOWER, J. G. (2004) **Procrustes Analysis**. In: SMELSER, N. J.; BALTES, P. B. International Encyclopedia of Social and Behavioral Sciences. Elsevier Science Ltd, Oxford,.p.12141-12143,

HUSSON, F. E.; JOSSE, J.; LE, S.; MAZET, J. (2009) **FactoMineR**: Factor Analysis and Data Mining with R. R package version 1.12. Source: <http://CRAN.R-project.org/package=FactoMineR>. Acess: Jan.15 2009.

HUSSIN, M. F.; WANG, B. (2010). Industrial safety perception among pos-graduate engineering students. **Knowledge Based Systems**, v. 23, p. 769-771.

JOHNSEN, S. O.; OKSTAD, E.; AAS, A. L.; SKRAMSTAD, T. (2010) Proactive indicators of risk in remote operations of oil and gas fields. **Society of Petroleum Engineers - SPE International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production**, Rio de Janeiro, v. 2, p. 804-825.

JOSSE, J.; PAGES, J.; HUSSON, F. (1998) Testing the significance of the Rv coefficient. **Comput.Stat.Data An**., v. 53, p. 82-91.

KRUSKAL, J. B. (1964) Nonmetric multidimensional scaling: a numerical method. **Psychometrika**, v. 29, n. 2, p. 115-129.

LEITER, M. P.; ZANALETTI, W.; ARGENTERO, P. (2009) Occupational risk perception, safety training, and injury prevention testing a model in the Italian printing industry. **J.Occup.Health Psychology**, v. 14, n. 1, p. 1-10.

MARRIS, C.; LANGFORD, I. H.; O´RIORDAN, T. (1998) A quantitative test of the cultural theory of risk perceptions: comparison with the psychometric paradigm. **Risk Analysis**, v. 18, n. 5, p. 635-647.

MCCRARY, F.; BAUMGARTEN, M. (2004) **The Young Epidemiology Scholars Program(YES)**. Available: http://www.collegeboard.com/prod_downloads/yes/risk_perception.pdf, Acess: Apr.16 2010, .

MCGRATH, T. (2010) Equipping hazard and risk awareness training course providers with web based virtual reality risk perception measurement simulation tests. **Society of Petroleum Engineers - SPE International Conference on**

Health, Safety and Environment in Oil and Gas Exploration and Production, Rio de Janeiro, v. 3, p. 1803-1808.

NESTRUD, M.; LAWLESS, H. T. (2008) Perceptual mapping of citrus juices using projective mapping and profiling data from culinary professionals and consumers. **Food Qual. Prefer**., v. 19, p. 431-438.

R DEVELOPMENT TEAM (2009) **R: A language and environment for statistical computing**. Vienna : R. Foundation for Statistical Computing.

RODRIGUE, N. (1999). **A Comparison of the Performance of Generalized Procrustes Analysis and the Intraclass Coefficient of Correlation to Estimate Interrater Reliability**. Montreal : McGill University, (1999). Master Dissertation, McGill University.

SHAPIRO, S. S.; WILK, M. B. (1965). An analysis of variance test for normality (complete samples) **Biometrika,** v**.** 52, n. 3-4, p. 591-611

SJOBERG, L. (2000) Factor in Risk Perception. **Risk Analysis**, v. 22, n. 4, p.1-11.

SJOBERG, L. (2002) Are received risk perception model alive and well? **Risk Analysis**, v. 20, n. 1, p. 665-669.

SJOBERG, L.; BJORG-ELIN, M.; RUNDMO, T. (2004) **Explaining risk perception An evaluation of the psychometric paradigm in risk perception research**. Trondheim, Norway: Rotunde..

SLOVIC, P. (1987) Perception of Risk**. Science** , p. 280-285.

SLOVIC, P., (2001) **Risk Perception**. London: Earthscan.

SOARES, J. F. S.; CEZAR-VAZ, M. R.; MENDOZA-SASSI, R. A.; ALMEIDA, T. L.; MUCCILLO-BAISCH, A. L.; SOARES, M. C. F.; COSTA,V. Z. (2008) Percepção dos trabalhadores avulsos sobre os riscos ocupacionais no porto do Rio Grande, Rio Grande do Sul, Brasil. **Cad. Saúde Pública**, v. 24, n. 6, p. 1251-1259.

VENABLES A. C. E.; RIPLEY B. D. (2002) **Modern Applied Statistics with S**, New York: Springer.

WEINSTEIN, N. D. (1980) Unrealistic optimism about future life events. **J. Pers. Soc.Psychol**., v. 39, n. 5, p. 806-820.

WICKELMAIER, F. (2003) **An Introduction to MDS**. Acessed: Feb.12.2009, Source http://perception.inrialpes.fr/~Arnaud/indexation/mds03.pdf.