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Comparison of multivariate pattering methods in group/cluster identification regarding the science of educational research: Implicative Statistical Analysis *vs*. L' Analysee Factorielle des Correspondances

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Abstract

Nowadays, there is a substantial improvement and utilisation of pattering methods in the science of educational research, a comparison of multivariate methods in group/cluster identification in the scientific domain of quantitative research has not been carried out. This study analyses two different statistical techniques: i.e., the principal components analysis (PCA) and the implicative statistical analysis (ASI). A survey was carried out using a structured questionnaire for a sample of 135 nurses which studied in the School of Pedagogical and Technological Education in order to be qualified in respect The study focuses on the presentation of the two main types of clustering methods, της ASI and L' Analysee Factorielle des Correspondances (AFC). AFC's results made it evident that *Emotionality, Self-control, Sociability, General items of EI constructs* are shaped attitudes and reveal the latent dimension of respondents psychological attributes related to EI conceptual constructs.

Keywords: L' Analysee Factorielle des Correspondances, principal components analysis, implicative statistical analysis, research.

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1. Theoretical framwork-statistical methodologies

This section is dedicated to the presentation of the three main types of clustering methods that is implicative statistical analysis (ASI), and Analysee Factorielle des Correspondances (AFC).

1.1. Implicative statistical analysis

ASI was initiated and developed by Regis Gras to be applied in the Didactic of Mathematics (Gras, 1979). Since the doctoral dissertation of Regis Gras, a great deal of research has been published concerning different paths of theory development (Gras & Couturier, 2013; Gras et al., 2004; Gras, Peter, Briand & Philippe, 1997; Gras, Suzuki**,** Guillet & Spagnolo, 2008; Gras, Regnier & Guillet, 2009; Gras, Regnier, Marinica & Guillet, 2013). Consequently, the method has been advanced noticeably and has been applied to a wide range of data, such as mathematics education; psychology; physics, medicine, etc. According to Coutourier (2008), the initial objective of this method is to define an approach that adequately confronts the question 'if an object has a property, does it also have another one'. This is seldom accurate although a tendency seems to emerge. ASI aims at highlighting such tendencies in a set of properties. According to Coutourier (2008), ASI can be regarded as a method used to generate association rules. Furthermore, it is considered to be a wide theoretical framework, a theory connected with causality due to the fact that it responds to the weakness regarding other multivariate methods, as well as highlighting formal tools and practical methods of data representation, evaluation and interpretation.

It is of a major importance to note that compared to other association rule methods; ASI distinguishes itself by providing a non-linear measure that satisfies some important criteria. In order for the implicative association rules to be extracted, the ASI assigns a numerical value between zero to *R* rules and one according to following form: If the variable *a* is observe then it is possible for the variable *b* to be observed. Consequently, if the variable *a* gets a specific value, then variable *b* possibly gets a higher value. The measure assigned is a probability, well known now as intensity of involvement. Consequently, causal and predictive relations are influenced by the intensity of involvement.

The principle of determining the intensity of involvement as a probability of a random event and it is defined as follows: if there was a non a priori asymmetric link between *a* and *b*, the number of counterexamples to the rule *R*, is under the unique effect of chance, usually higher than the number of counterexamples observed in the contingency. Thus, the method is based on the implication intensity that measures the degree of astonishment inherent in a rule. For example, the set of items B, then it is legitimate and intuitive to expect that the counter part is and the set of non-B items is strongly associated with the set of non A-items. According to Coutourier (2008), the implication intensity maybe reinforced by the degree of validity that is based on Shannon's entropy, in case that a researcher chooses this comparison approach. The implicative representation of the associations is presented in Figure 1 by a weighted graph without cycle where each edge corresponds to a rule. Specifically the implicative graph resulted by CHIC Software (Couturier, 2008).

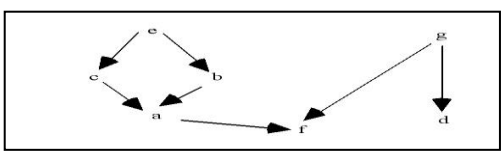

Figure 1. Implicative representation (Source: Wikipaideia).

1.2. Analysee Factorielle des Correspondances

AFC (Correspondence Factor Analysis) technique allows for the simultaneous statistical processing of categorized qualitative and quantitative variables (Anastasiadou, 2016; Benzecri, 1973; Karapistolis,

2015; Papadimitriou, 2007). The grouping of dominant observation groups is affected through this and, thus, attained is an almost universal description of the phenomenon which is expressed by the table analysed with the help of a smaller number of new complex variables-factors (Papadimitriou, 1994). These factors, independent per couple between them, are created from the synthesis of groups of the initial variables, fact that simplifies the process for probing the relations between the variables, thus offering a full and more complex image of the phenomenon under the examination. The factors can assume the form of axes and form the factorial levels in pairs, which will allow the graphic representation of the variables. The contribution and correlation indexes are the criteria for the selection of the variables for constructing and interpreting the axes and, consequently, the factorial levels.

2. Research methodology

2.1. Sample

Sample comprised of 135 female interviewees. With respect to the ages of participants, 12 (8.9%) of them were below 24, 39 (28.9%) of them were between 25 and 34, 53 (39.3%) of them were between 35 and 44, 20 (14.8%) of them were between 45 and 54 and, finally, 11 (8.1%) were between 55 and 64. With respect to their family status, 58 (43%) were single, while 67 (49.6%) were married and 10 (7.4%) were separated or divorced.

Regarding the education of interviewees, 81 (60%) stated that he has completed tertiary education, 42 (31.1%) hold a second degree and 12 (8.9%) hold a postgraduate diploma or doctorate. Regarding the years of experience 23 (17%) were unemployed, 42 (31.15) have between 0 and 10, 50 (37%) have between 11 and 20 and finally, 20 (14.8%) have between 21 and 30 years of experience. Twenty-three (17%) out of 135 respondents have not work before, 38 (28.1%) work in public hospital, 31 (23%) in private hospital and 23 had worked as nurses for a short period and now they work in secondary education.

2.2. Instrument

The research instrument is TEIQue-SF well known as Trait Emotional Intelligence Questionnaire" (Trait Emotional Intelligence Questionnaire-Short Form (TEIQue-SF)), (Stamatopoulou, Galanis & Prezerakos, 2016). This tool consists of 30 items referring to five different attitude sub-scales as follows: (1) Well-being (e.g., W_being1: I generally find life enjoyable), (2) Self-control (e.g., S_cont1: I usually find it difficult to regulate my emotions), (3) Emotionality (e.g., Emot1: Expressing my emotions with words is not a problem for me), (4) Sociability (e.g., Soci1: I can deal effectively with people), (5) General items of EI (e.g., G_Item1: On the whole, I'm a highly motivated person).

3. Results

3.1. Reliability test

A reliability test was carried out to ensure that the reserve instrument that evaluates the data collected is reliable. The coefficient Cronbach's α that is calculated to measure the reliability of the five dimensions, i.e., Well-being, Self-control, Emotionality, Sociability and General items of EI is 0.715, 0.812, 0.761, 0.821 and 0.944, respectively.

3.2. Analysee Factorielle des Correspondances results

The indexes employed to interpret the results of this particular correspondence factor analysis are the well-known indexes 'inertial' and 'contribution' (Benzecri, 1980; Papadimitriou, 2007). These indexes allow one to immediately distinguish the most important and determinative variables or

objects that contribute to the creation of factorial axes. The results of this factorial analysis were interpreted with the help of inertia, which is explained by each factorial axis, of correlation and of the contribution.

Based on the cumulative frequency, the first two factorial axes interpret 62.132% of the total data variance. This percentage is deemed satisfactory to interpret the data (Karapistolis, 2010). Moving on and from the table of the results of the factorial analysis of correspondences, pursuant to the aforementioned criteria that were chosen (inertia, correlation and contribution), the variables contributing to the shaping of the two first factorial axes were detected, using MAD software (Karapistolis, 2000). The aforementioned variables are deduced in compliance with two criteria, correlation ($Cor \geq 200$, criterion 2) and contribution ($(\text{Ctr} \geq \frac{1000}{87} \approx 11.4 \approx 12$, criterion 3) (Karapistolis, 2015).

The first factorial level e_1xe_2: The variables which are most significant for the first factorial level e_1xe_2 and pursuant to the criteria of inertia, contribution and correlation are analysed in what follows.

The first factorial level e_1xe_2 (Figure 2) interprets 62.132% of total inertia—information, a satisfactory percentage. The first factorial axis juxtaposes the extreme cases and the second those in-between of the extreme ones.

On the first factorial level and between the first quadrant (e_1+e_2+) and fourth quadrant (e_1+e_2 -) and the group of respondents may be distinguished vis-a-vis their positive attitude with respect to ***Emotionality, Self-control and General items of EI constructs***. To the right of the first factorial axis e_1, one finds those respondents who claimed that they often find it easy to show my affection to those close to them (Emot53) (Cor = 749, Ctr = 21), they can figure out what emotion they are feeling (Emot33) (Cor = 667, Ctr = 22), they are usually able to find ways to control their emotions when they want to (S_Cont43) (Cor = 783, Ctr = 22), they do not tend to get involved in things they later wish they could get out of (S_Cont53) (Cor = 612, Ctr = 16) and finally they normally find it easy to keep themselves motivated (G_Item33) (Cor = 598, Ctr = 24).

On the first factorial plane e_1xe_2 and between the first quadrant (e_1+,e_2+) and second quadrant (e_1-,e_2+), the group of respondents may be distinguished vis-a-vis negative attitude with respect to ***Sociability*** and ***Emotionality***. During the e_2+ axis, we then come across the respondents' views with respect to conceptual construct ***Sociability*** and ***Emotionality***. The respondents supported that they often find it difficult to stand up for their rights (Soci21) (Cor = 787, Ctr = 122), they are not usually able to influence the way other people feel (Soci31) (Cor = 787, Ctr = 122), they do not pause and think about their feelings (Emot71) (Cor = 868, Ctr = 152), they are not normally able to 'get into someone's shoes' and experience their emotions (Emot61) (Cor = 827, Ctr = 147), they find it difficult to bond well even with those close to them (Emot81) (Cor = 835, Ctr = 105) and finally they find it difficult to show my affection to those close to me (Emot51) (Cor = 636, Ctr = 83).

On the first factorial level e_1xe_2 and between the second quadrant (e_1-,e_2+) and third quadrant (e_1-,e_2-), a third group of respondents is appeared. Moving forward, to the left side of the second factorial axis *e2*, we come across the respondents who exhibited a neutral attitude with respect to ***Sociability, Self-control*** **and** ***Emotionality*** constructs. Their views were also unclear as to whether by they can deal effectively with people (Soci12) (Cor = 688, Ctr = 41), whether they find it difficult to stand up for their rights (Soci22) (Cor = 773, Ctr = 51), whether they are usually able to influence the way other people feel (Soci32) (Cor = 747, Ctr = 48) and whether they would describe themselves as a good negotiators (Soci42) (Cor = 703, Ctr = 36). In addition we also came across a neutral attitude finds those respondents who did not have a crystal clear view with respect as to whether they tend to change their mind frequently (S_Cont22) (Cor = 788, Ctr = 38), what are the chances to be able to find ways to control their emotions when they want to (S_Cont4) (Cor = 703, Ctr = 36) and whether on the whole whether they are able to deal with stress (S_Cont32) (Cor = 667, Ctr = 29). Moving forward, to the

centre of the second factorial axis *e2*, we came across a neutral attitude to part of conceptual construct ***Emotionality***. Respondents exhibited a neutral attitude with respect to whether the often pause and think about their feelings (Emot7) (Cor = 746, Ctr = 25), whether they find it difficult to bond well even with those close to them (Emot82) (Cor = 714, Ctr = 31) and whether they often find it difficult to show their affection to those close to them (Emot52) (Cor = 648, Ctr = 21).

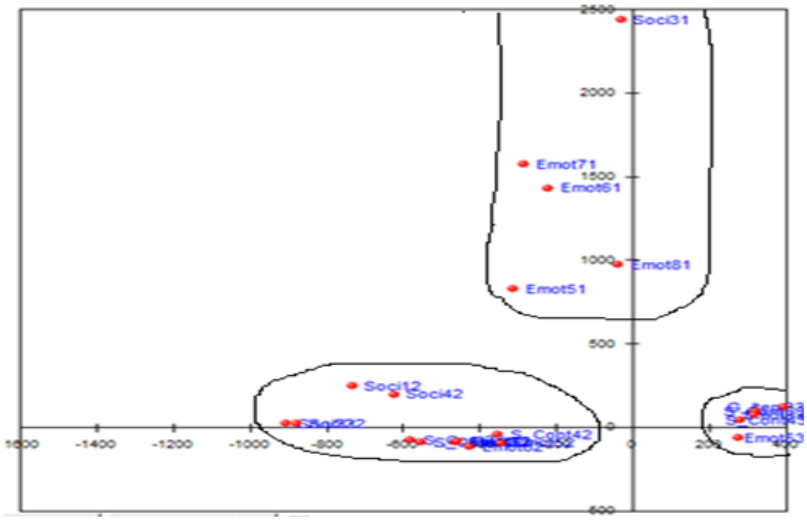

Figure 2. First factorial plane e_1xe_2

3.3. Implicative diagram

The implicative diagram shows the implicative relations between the variables (Figure 3). In more detail, a first part the first leg of the implicative chain, G_Item4- > G_Item3- > G_Item2- > G_Item1, S_Cont6, shows the belief that generally, they are able to adapt to new environments (G_Item4) leads the respondents to think that normally they do not find it difficult to keep myself motivated (G_Item3) and often they do not often find it difficult to adjust their life according to the circumstances (G_Item2) and on the whole, they are highly motivated persons (G_Item1) and thus others admire them for being relaxed (S_Cont6). The implicative chain, G_Item4- > G_Item3- > G_Item2- > G_Item1, represents the group named General items of EI which is been distinguished by the strongest intensity of involvement or by strongest implication intensity.

The second part of the unique leg of the implicative chain, G_Item1- > Emot4- > Emot2- > Emot3- > Emot5- > Emot8- > Emot6- > Emot7- > Emot1- > W_being6, shows the respondents belief that others admire them for being relaxed (G_Item1) leads the respondents to think that those close to then often claim that we treat them right (Emot4) because they often find it easy to see things from another person's viewpoint (Emot2), and many times, they figure out what emotion they are feeling (Emot3) and even more they often find it easy both to show their affection to those close to them (Emot5) and to bond well even with those close to them (Emot8) due to the fact that they are normally able to 'get into someone's shoes' and experience their emotions. (Emot6) as they often pause and think about their feelings (Emot7) and as expressing their emotions with words is not a problem for them (Emot1) and they generally believe that things will work out fine in their life (W_being6). The part Emot4- > Emot2- > Emot3- > Emot5- > Emot8- > Emot6- > Emot7- > Emot1 of the implicative chain represents the conceptual construct named Emotionality.

Another part of the implicative chain is W_being3- > W_being5- > W_being4- > W_being2- > W_being1 shows the respondents beliefs that on the whole they have a shining perspective on most things (W_being3), they are full of personal strengths (W_being5) and on the whole, they are pleased with my life (W_being4), they feel that they have a number of good qualities. (W_being2) and

generally they find life enjoyable **(**W_being1). This part of the implicative chain, W_being3- > W_being5- > W_being4- > W_being2- > W_being1, represents the conceptual construct named Well-being.

The implicative relation Emot6- > W_being2 shows respondents belief that they are normally able to 'get into someone's shoes' and experience their emotions (Emot6) imply the belief that they feel that they have a number of good qualities (W_being2).

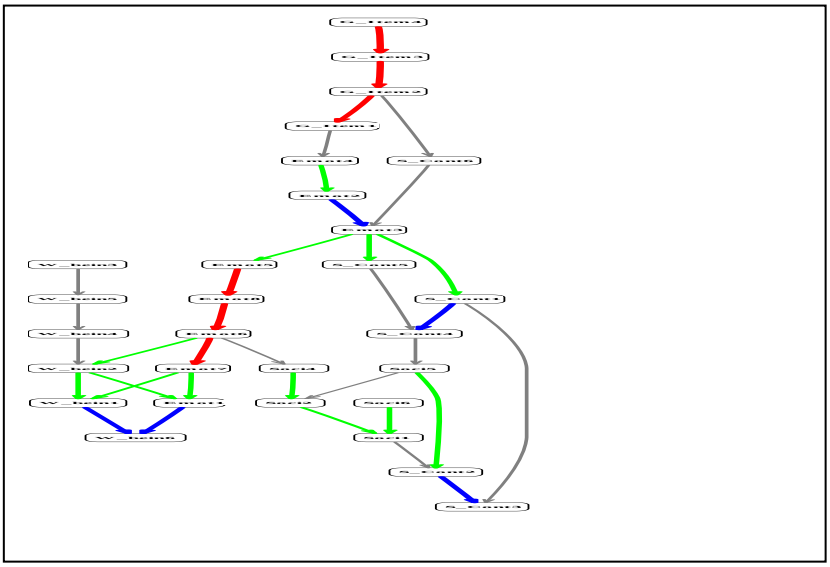

Figure 3. Implicative diagram

The implicative relation W_being2- > Emot1 shows respondents belief that they feel that they have a number of good qualities (W_being2) leads them to believe that expressing their emotions with words is not a problem for them (Emot1).

The implicative chains Soci4, Soci5- > Soci2 and Soci2, Soci6- > Soci1 reveal implicative relations between variables related to the same conceptual construct named Sociability.

The implicative chain Soci4, Soci5- > Soci2 exhibits implicative relations between the items Soci4, Soci5 and Soci2. In more detail, the implicative chain Soci4, Soci5- > Soci2 illustrates that the belief that they would describe themselves as good negotiators (Soci4) leads them to believe that they tend to 'back down' even if they know they are not right (Soci5) and often find it easy to stand up for their rights (Soci2).

The implicative relation Emot7- > W_being1 shows respondents belief that they often pause and think about their feelings (Emot7) leads them to believe that they generally find life enjoyable (W_being1).

The implicative relation Emot1- > W_being6 shows respondents belief that Expressing their emotions with words is not a problem for them (Emot1) leads them to believe that generally things will work out fine in my life (W_being6). The implicative chain Soci2, Soci6- > Soci1 demonstrates implicative relations between the variables Soci2, Soci6 and Soci1. In more detail, the implicative chain Soci2, Soci6- > Soci1 renders it clear that respondents' belief that they often find it easy to stand up for their rights (Soci2) leads that to consider that they don't seem to have any power at all over other people's feelings (Soci6) and they can deal effectively with people (Soci1).

There also a few more implicative relations: Emot3- > S_Cont5, S_Cont1- > S_Cont4, S_Cont3 and S_Cont4- > Soci5- > S_Cont2- > S_Cont3. The implicative chain Emot3- > S_Cont5, S_Cont1- > S_Cont4, S_Cont3 points up that the belief that the many times, they can figure out what emotion they are

feeling (Emot3) leads the respondents to think that they tend to get involved in things they later wish they could not get out of (S_Cont5) and they usually find it easy to regulate their emotions (S_Cont1) and they are able to find ways to control their emotions when they want to (S_Cont4), and thus accordingly on the whole, they are able to deal with stress (S_Cont3). The implicative chain, Emot3- > S_Cont5, S_Cont1- > S_Cont4, S_Cont3, establishes implicative relations only between one variable of a specific construct named Emotionality and three variables related to self-control.

The implicative chain, S_Cont4- > Soci5- > S_Cont2- > S_Cont3, illustrates that the respondents belief that the they are usually able to find ways to control my emotions when they want to (S_Cont4) leads to the belief that they tend to 'back down' when they know they are not right (Soci5), they do not tend to change their mind frequently (S_Cont2) and on the whole, they are able to deal with stress (S_Cont3). The implicative chain, S_Cont4- > Soci5- > S_Cont2- > S_Cont3, demonstrates implicative relations between three variables related to self-control and one variable related to fulfilment and one variable related to Sociability construct.

4. Conclusion and discussion

The current illustrates two different statistical techniques: i.e., the AFC and the ASI (Anastasiadou, 2018). The main objective is to compare the outcomes derived from AFC and ASI procedures with respect to educational research.

In addition, they showed that the two methods operate complementary, each one accentuating a different dimension for the interpretation of data, the interpretation of which would not have been determinative without the import educational research scientists. AFC application unveils factors, independent per couple between them, which are created from the synthesis of groups of the initial variables, simplifying the process for probing the relations between the variables, and thus offering a full and more complex image of the phenomenon under examination. The factors can assume the form of axes and form factorial levels in pairs, which will then allow for the graphic representation of the variables. AFC is a method where no a priori hypothesis is made.

ASI is related to Implication Intensity of Gras (1996) and Gras and Kuntz (2008). ASI measure is assigned as a probability, named Intensity of Involvement (Anastasiadou, 2018). The results from the application of the methods have pointed at their differences and similarities but also their complementarity. One can concisely cite that the application of AFC made it evident that ***Emotionality, Self-control, Sociability, General items of EI constructs*** are shaped attitudes and reveal the latent dimension of respondents psychological attributes related to EI conceptual constructs. The application of AFC based on the three criteria, inertia (criterion 1) correlation (Cor, criterion 2) and contribution ($Ctr2$, criterion 3) and the of ASI application resulted in implicative structures based on Intensity of Involvement.

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