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An Exploratory Study of the Multidimensional Health Locus of Control (MHLC) among Female Students in a French Context

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Authors' contributions

This work was carried out in collaboration between both authors. Author GS set up the initial study in psychology with the protocol, managed the literature searches and edited the manuscript. Authors GS and TT worked together on the coordination between the data and measures in an exploratory approach. Author TT developed the analyses between the subscales. Both authors read and approved the final manuscript.

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ABSTRACT

Background: The aim of this study is to test with an exploratory approach the relevance of the 3 MHLC sub-scales while examining the answers of a group of 61 female students in a French context. The Locus of control is acknowledged to be a personality variable which proves to be a good predictor of health problems according to its internal or external orientation.
Methods: In order to study the relationships between the different items of the 3 sub-scales and the way the students' answers are configured, we performed a multiple correspondence analysis

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(MCA) and we grouped the female students by using a hierarchical cluster analysis (HCA).
Results: Analysis with MCA clearly reveals the 3 subscales and within our sample 4 classes of female students are identified by means of HCA.
Conclusion: While confirming the relevance of the 3 MHLC subscales, this study shows that in this sample of French female students, 4 personality profiles appear with differentiated perceptions of control.

Keywords: Multidimensional health locus of control; female students; multiple correspondence analysis; hierarchical cluster analysis.

1. BACKGROUND

The notion of expectation of internal versus external control of reinforcements resulted from works carried out by Rotter on social learning which was applied to chronic disease [1]. The probability that, subsequent to a reinforcement, a type of behavior appears is dependent on the value of the reinforcement (reward or punishment). This concept was identified to be a personality variable for which it provides a measurement: when a person perceives a reinforcement as being linked to chance, fate or other uncontrollable powers, it is said to be "a belief in an external control". Conversely, if the person thinks that the event is linked to his or her own behaviour, it is said to be "a belief in an internal control" [2]. Rotter's famous scale called "Rotter I/E scale" distinguishes internal people from external people. The works of Overmier and Seligman [3] revealed the notion of "*learned helplessness".* They observed that animals exposed to uncontrollable electric shocks reacted with helplessness when confronted with the shocks; they thus manifested apathy as a result of a feeling of being unable to control events. Consequently this acquired resignation was connected to a human being's depressive attitudes. In 1962 a study by Seeman and Evans [4] established a link between the internal locus of control and disease. Following this an increase in the number of studies in the field of health was observed and continues today [5,6,7]. The concept of Health Locus of control was proposed by Wallston, Wallston, Kaplan and Maides [8]. If Rotter's initial conception was a one-dimensional conception of the LOC, the evolution of works led to the multidimensionality of the concept. This gave rise to the elaboration of specific scales such as the Multidimensional health locus of control (MHLC), which deals with the way one perceives control over one's health. In their article "Development of the multidimensional health locus of control (MHLC) scales", Wallston, Wallston and DeVellis [9] explained the development from the original health locus of control (HLC) scale as a "unidimensional measure" with "health-externals" on one dimension and "health-internals" on the other dimension to separation into 3 subscales: Internal Health Locus of Control (IHLC), Powerful others Health Locus of Control (PHLC) and Chance Health Locus of Control (CHLC). From these studies on the health locus of control it can be seen that individuals with an external LOC (i.e. believing that chance and fate determine their health) are much less committed to preventive health behaviour [10]. It has been indicated that MHLC constitutes a relevant construct to study diverse health behaviors among college students [11]. For example, Helmer, Krämer and Mikolajczyk [12], in a study with a sample of University students in Germany, showed that greater unhealthy behaviour was observed among students who thought that their health was determined by luck. Inversely, more healthy behaviour was apparent when students believed they had control over their own health. Gaymard and Tiplica [13] studied the links between leisure activities, risk perception in the practice of these leisure activities and the answers to the MHLC among a group of female students in human and social sciences. They showed that they were globally more internal than external but the power given to others could also play a positive role in the management of the state of health. Among the studies specifically concerned with MHLC scale measurement, studies can be found in the literature dealing with: –the comparison of answer scales; –measurement of validity and reliability of Multidimensional Health Locus of Control scales in a specific context [14] or –testing the factorial structure of the MHLC [15]. In this measurement, the question of cultural context is important [16]. Studies show variations in mean scores according to the country and the culture. For example Bonetti et al. [17] showed that Scottish or Irish patients had higher internality scores than Spanish patients.

The originality of this study lies in the exploratory questioning of the relevance of the 3 subscales

when analyzing the answers given by a sample of female students via MCA and HCA methods; it completes recent research on the theme of leisure activities and health among a population a female students in human and social sciences [13].

2. METHODS

2.1 Participants

Considering the differences identified in the past few years between men and women in the perception of the Locus of Control [18,19], our sample is solely composed of women. The sample includes 61 female students (average age= 20.56 years, SD= 1.35 years) following a course in human and social sciences. Previous studies have presented the characteristics of this student population [13]. In this sample, 75.41% have a driving licence (N=46), 42.62% work and study at the same time (N=26) and 70.49% receive a grant (N=43). It is also important to note that the sample was made up on a volunteer basis.

2.2 Tools

The tool concerns the Multidimensional Health Locus of Control (MHLC) Scale, form A [9] which is composed of 18 items that are divided into three subscales each with 6 items: internal (one's actions control one's health status, LOCs 1,6,8,12,13,17), chance (chance determines one's health, LOCs 2,4,9,11,15,16), and powerful others (health is something one has no control over, LOCs 3,5,7,10,14,18). Items are coded from strongly disagree = 1 to strongly agree = 6 (Likert scale).

For example in the Internal Health Locus of Control IHLC, LOC 6 was formulated as follows: "I am in control of my health"; in the CHLC LOC 9 is formulated as follows "Luck plays a big part in determining how soon I will recover from an illness"; in the PHLC LOC 10 is formulated as follows "Health professionals control my health" (those interested can see the original works [9]).

2.3 Statistical Methods Used in this Study

Multiple Correspondence Analysis (MCA) is a statistical technique for nominal categorical data, used to detect and represent underlying structures in a data set. It does this by representing data as points in a low-dimensional Euclidean space. The procedure thus appears to be the counterpart of principal component analysis for categorical data. MCA can also be viewed as an extension of simple correspondence analysis (CA) in that it is applicable to a large set of categorical variables [20,21,22].

Hierarchical cluster analysis (HCA) is a method of cluster analysis which seeks to build a hierarchy of clusters. The results of hierarchical clustering are usually presented in a dendrogram. In order to decide which clusters should be aggregated, a measure of dissimilarity between sets of observations is required. In most methods of hierarchical clustering, this is achieved by using an appropriate metric. A linkage criterion specifies the dissimilarity of sets as a function of the pairwise distances of observations in the sets. Generally, in psychology research, the most common distance measure is the Euclidean distance or the squared Euclidean distance. Thus in this paper we also used the Euclidean distance as the appropriate metric and Ward's criterion in order to aggregate clusters [23,24,25].

In this paper we used the R software and the FactoMiner[1] package in order to build MCA and HCA models.

3. RESULTS

3.1 Multiple Correspondence Analysis (MCA) and Hierarchical Cluster Analysis (HCA)

In order to identify the different student profiles we used the answers given by female students to the 18 locus of control (LOCs) questions and carried out a multiple correspondence analysis (MCA). Fig. 1 illustrates the projection of LOCs on the main plane of the MCA.

The variables that contribute most to the construction of the first axis of the MCA (see Table 1.1 in appendix 1 for more details) are in descending order: LOC_{16}, LOC_{15}, LOC_4, LOC_7 and LOC_{11}. Thus, this axis highlights an opposition between "chance" and "powerful others" profiles – it discriminates female students having a "chance" profile (on the right side in Fig. 1) from those having a "powerful others" profile (at least according to LOC_7) (on the left side in Fig. 1).

[1] *http://factominer.free.fr/*

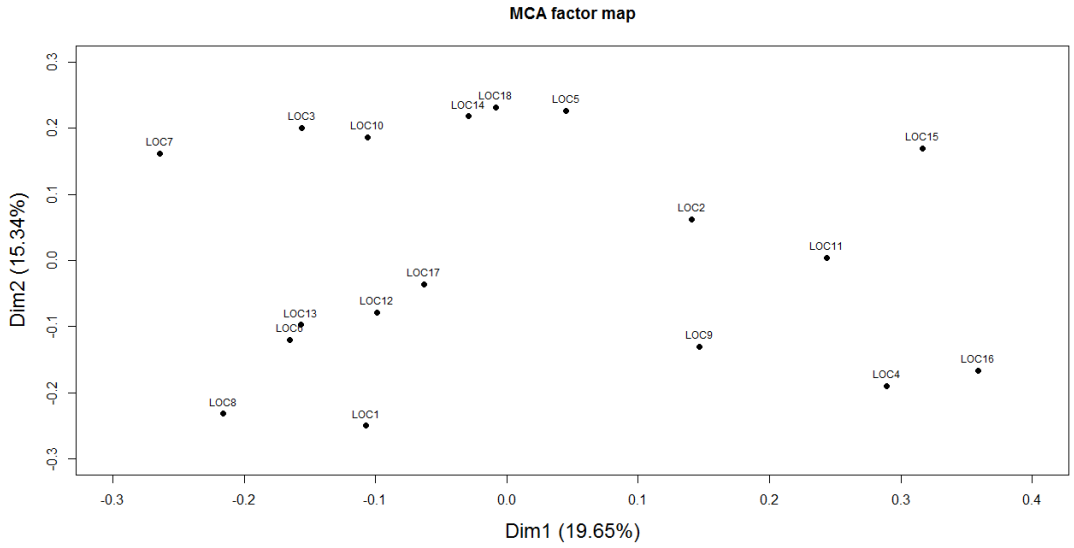


Fig. 1. Projection of LOCs on the main plane of the MCA (Internal: LOCs 1,6,8,12,13,17; Chance: LOCs 2,4,9,11,15,16; Powerful others: LOCs 3,5,7,10,14,18)

The variables that contribute most to the construction of the second axis of the MCA (see Table 1.2 in appendix 1 for more details) are in descending order: LOC_1, LOC_{18}, LOC_{14} and LOC_8. Thus, this axis highlights an opposition between "powerful others" and "internal" profiles – it discriminates female students who have a "powerful others" profile (on the upper side in Fig. 1) from those who have an "internal" profile (on the lower side in Fig. 1).

It is interesting to see that the different subscales of the MHLC ["powerful others", "internal" and "chance"] are well separated on the main projection plane.

We classified the female students by using a hierarchical ascendant classification method with the following settings: Euclidean distance as metric and Ward's criterion for the aggregation of individuals (see appendix 2 for more details). It came out that four classes (clusters) of female students are present (see Fig. 2).

A detailed characterization of these classes is presented in Table 2.1 in appendix 2. In the following we present the main results:

- The first class (cluster 1) composed of 20 female students is mainly characterized by high scores for LOC_7 and low scores for LOC_{11}, LOC_{15}, LOC_{16} and LOC_4. Thus, we can consider that this class of female students is more "powerful others" than "chance".
- The second class (cluster 2) composed of 9 female students is mainly characterized by high scores for LOC_8, LOC_1 and low scores for LOC_{15} and LOC_{18}. Thus, students belonging to this class are more "internal" than "powerful others" or "chance".
- The third class (cluster 3) composed of 20 female students is mainly characterized by high scores for LOC_{15} and low scores for LOC_1 and LOC_8. Thus, we can consider that this class of female students is more "chance" than "internal".
- The fourth class (cluster 4) composed of 12 female students is mainly characterized by high scores for LOC_4, LOC_{16}, and low scores for LOC_7 and LOC_{15}. Thus, we can consider these students as having more a "chance" than "powerful others" profile (according to LOC_7).

We compared the global scores of these students for the questions describing the three main profiles - "powerful others" coded "Pow" (LOCs: 3,5,7,10,14,18), "internal" coded "Int" (LOCs: 1,6,8,12,13,17) and "chance" coded "Chan" (LOCs: 2,4,9,11,15,16) (Fig. 3).

It can be noted that:

- The "internal" character prevails for female students belonging to classes 1, 2 and 4.

- Students belonging to class 1 are more "powerful others" than "chance" as already mentioned before when analyzing the results of the MCA.
- The "internal" character of female students belonging to class 2 is clearly the dominant characteristic. It could also be noted that female students belonging to this class have higher "chance" than "powerful others" scores.
- Female students belonging to the third class have globally mean scores for all profiles. They are not really "internal", nor "powerful others" or "chance".
- Female students from the fourth class show the more pronounced "chance" characteristics. It can also be noted that they are not "powerful others".

Thus, excepting female students from class 3, it can easily be observed that there are statistically significant differences between the global scores of these classes (see the Kruskal-Wallis p-values).

4. DISCUSSION

The psychometric qualities of the MHLC have often been verified in very different contexts [26,27,28]. If the aim of this study was not to propose a French validation of the MHLC, it can represent a preliminary study for the validation process (or thoughts on it). The originality of this study lies in the MCA and HCA approach among a population of female students registered in a Faculty of Arts and Humanities. Multiple correspondence analysis clearly distinguishes the 3 subscales of the MHLC that are separated on the main projection plane. A recent study among the same population with the aim of linking the question of leisure activities, risk perception and the possible relations with the MHLC has shown that this population is globally more internal than external [13].

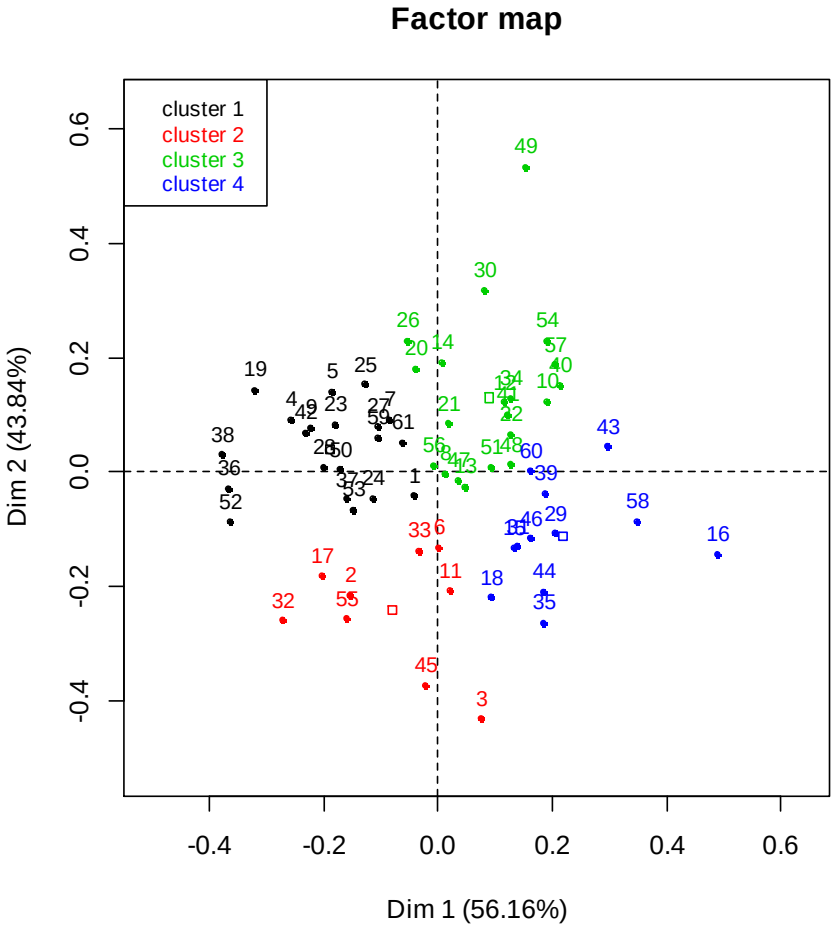
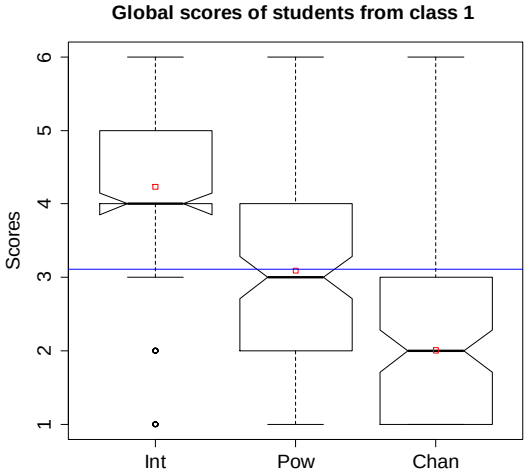
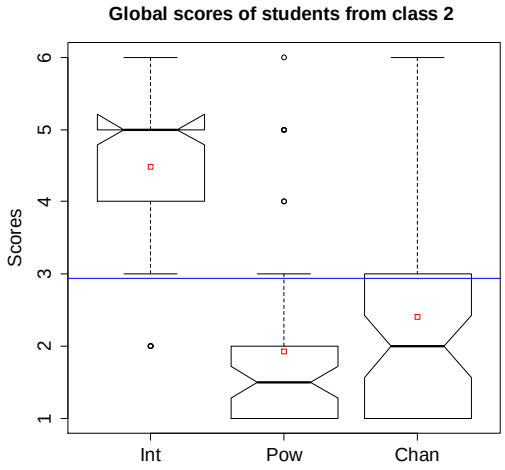


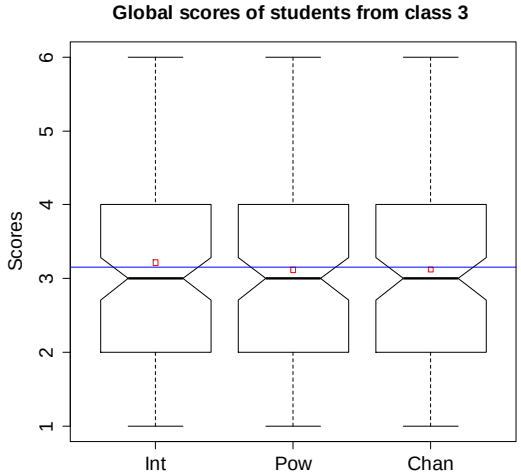
Fig. 2. Classes of female students on the main plane of the MCA



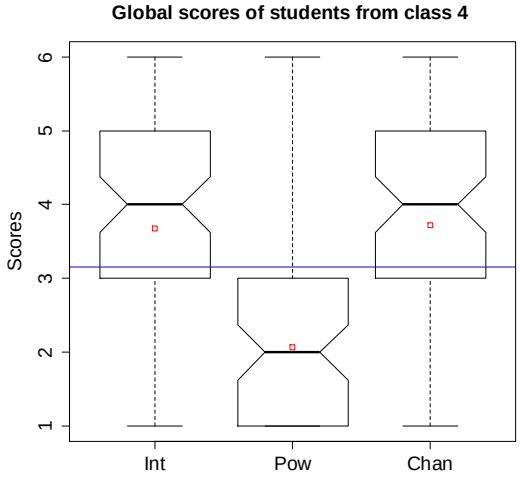
Kruskal-Wallis p-value < 2.2E-16
[Int vs. Pow.]: Man-Withney p-value = 5.627E-10
[Int vs. Chan.]: Man-Withney p-value < 2.2E-16
[Pow. vs. Chan.]: Man-Withney p-value = 3.267E-10



Kruskal-Wallis p-value = 1.959E-15
[Int vs. Pow.]: Man-Withney p-value = 6.631E-14
[Int vs. Chan.]: Man-Withney p-value = 4.721E-11
[Pow. vs. Chan.]: Man-Withney p-value = 0.01848



Kruskal-Wallis p-value = 0.8159
[Int vs. Pow]: Mann-Whitney p-value = 0.3044
[Int vs. Chan]: Mann-Whitney p-value = 0.2788
[Pow vs. Chan]: Mann-Whitney p-value = 0.48



Kruskal-Wallis p-value = 4.466E-12
[Int vs. Pow]: Mann-Whitney p-value = 1.189E-10
[Int vs. Chan]: Mann-Whitney p-value = 0.4121
[Pow vs. Chan]: Mann-Whitney p-value = 2.612E-10

Fig. 3. Global scores of students belonging to each class.[2]

Caption: the red squares are the mean scores for each modality and the blue line is the global mean score; the notches in the box plots represent the 95% confidence interval for medians

2 Int : Internal
Pow : Powerful others
Chan : Chance

The methodological approach proposed here provides other complementary information concerning the personality of sub-groups within this sample. Thus it can be said that female students in the first class have the particularity of giving power to the family by answering favorably to item 7: “My family has a lot to do with my becoming sick or staying healthy” but do not consider that their health is linked to chance. Female students in the second class have the particularity of considering that their state of health is primarily their concern by answering that when ill it is their own behaviour that determines the length of recovery or when ill it is their own fault; on the other hand they do not consider that whatever they do they are likely to fall ill or that following the doctor’s advice is the best way to stay healthy. The students in the third and fourth classes have the particularity of considering their state of health as being linked to chance by answering that they are likely to fall ill whatever they do (class 3); that their state of health is for a large part influenced by accidental events or that if they fall ill it is due to fate (class 4). It can be said that the internality scores are lower in these last two classes. Thus beyond the globally more internal character of this population [13], a closer look at the clusters and global scores of each class shows that if the scores of the internal subscales are never below the other subscales, they can also prove not be differentiated significantly as is the case of class 3 or as in the case of the subscales internality and chance in class 4. We have 4 personality profiles with differentiated perceptions of control. For further explanation, the students in class 2 dominantly internal should theoretically adopt healthy behaviour more. Students in classes 3 and 4 with the highest scores on the subscale “chance” should theoretically be more exposed and should thus be watched. Considering that one’s health is a matter of luck should effectively increase the likelihood of negative health behaviour [29]. As for the links between the subscale “powerful others” and health behavior that concerns class 1 more specifically, they remain ambiguous [12,13,30]. It is interesting to note here that it is also in this group that the score on the subscale “chance” is the lowest, which may reduce exposure to risks. In order to check these different links, information should be collected on these students’ practices, for example their eating habits, alcohol or tobacco consumption [30,31]. It also remains to go further into certain particularities of the sample that could explain these differences and that are not necessarily linked to the socio-demographic variables collected. Gaymard and Tiplica [13], for example had effectively hypothesized that female students who are more financially independent (studying while working) and so more responsible a priori, would also be more internal, which has not been verified when taking the whole of the subscale “powerful others” for example. Even if people with education theoretically know more about what health behaviour implies [12,32], a certain number of questions are pending, according to us, due to the great number of variables implicated in these measures.

5. CONCLUSION

The aim of this study was to check the relevance of the 3 MHLC subscales from a sample of female students from a Faculty of Arts and Humanities, using an exploratory approach. Our results reinforce the coherence and independence of the subscales that we have illustrated by means of Multiple Correspondence Analysis (MCA). The HCA method highlighted 4 classes of female students with different personality profiles. Several studies in the literature tend to show that internal students are in better health or have better health habits than those with external LOC [12,33]; other studies show that internals have higher scores in academic success than externals [34]. This approach thus proves to be important for understanding and contributing to the well-being of students, their health and their academic results.

CONSENT

Informed consent was obtained from all individuals taking part in this study.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rotter JB, Chance JE, Phares EJ. Applications of social learning theory of personality. New York: Holt, Rinehart & Winston; 1972.

2. Rotter JB. Generalized expectancies for internal versus external control of reinforcement. Psychol Monogr. 1966;80: 1-28.
3. Overmier JB, Seligman MEP. Effects of inescapable shock on subsequent escape and avoidance learning. J Comp Physiol Psychol. 1967;63:28-33.
4. Seeman M, Evans JW. Alienation and learning in a hospital setting. Am Sociol Rev. 1962;27:772-783.
5. Berglund E, Lytsy P, Westerling R. The influence of locus of control on self-rated health in context of chronic disease: A structural equation modeling approach in a cross sectional study. BMC Public Health. 2014;14:492
Available:http://www.biomedcentral.com/1471-2458/14/492
6. Buhagiar K, Parsonage L, Osborn DPJ. Physical health behaviours and health locus of control in people with schizophrenia-spectrum disorder and bipolar disorder: A cross-sectional comparative study with people with non-psychotic mental illness. BMC Psychiatry. 2011;11:104
Available:http://www.biomedcentral.com/1471-244X/11/104
7. De las Cuevas C, Peñate W, Sanz EJ. The relationship of psychological reactance, health locus of control and sense of self-efficacy with adherence to treatment in psychiatric outpatients with depression. BMC Psychiatry. 2014;14:324.
Available:http://www.biomedcentral.com/1471-244X/14/324
8. Wallston BS, Wallston KA, Kaplan GD, Maides SA. Development and validation of the health locus of control (HLC) scale. J Consult Clin Psychol. 1976;44:580-585.
9. Wallston KA, Wallston BS, DeVellis R. Development of the multidimensional health locus of control (MHLC) scales. Health Educ Behav. 1978;6:160-170.
10. Norman P, Bennett P, Smith C, Murphy S. Health locus of control and health behaviour. J Health Psychol. 1998;3:171-180.
11. Steptoe A, Wardle J. Locus of control and health behaviour revisited: A multivariate analysis of young adults from 18 countries. Br J Psychol. 2001;92:659–672.
12. Helmer SM, Krämer A, Mikolajczyk RT. Health-related locus of control and health behaviour among university students in North Rhine Westphalia, Germany. BMC Res Notes. 2012;5:703
Available:http://www.biomedcentral.com/1756-0500/5/703
13. Gaymard S, Tiplica, T. Leisure, risk awareness and personality factors among female students. J Public Health. 2016; DOI:10.1007/s10389-016-0752-5
14. Moshki M, Ghofranipour F, Hajizadeh E, Azadfallah P. Validity and reliability of the multidimensional health locus of control scale for college students. BMC Public Health. 2007;7:295
DOI:10.1186/1471-2458-7-295
15. O'Hea EL, Bodenlos JS, Moon S, Grothe KB, Brantley PJ. The multidimensional health locus of control scales: Testing the factorial structure in sample of African American Medical Patients. Ethn Dis. 2009; 19:192-198.
16. Luszczynska A, Schwarzer R. Multidimensional health locus of control: Comments on the construct and its measurement. J Health Psychol. 2005;10: 633–641.
17. Bonetti D, Johnston M, Rodriguez-Marin J, Pastor M, Martin-aragon M, Doherty E, Sheehan K. Dimensions of perceived control: A factor analysis of three measures and an examination of their relation to activity level and mood in a student and cross-cultural patient sample. Psychol Health. 2001;16:655–674.
18. Crowson TW, Rich EC, Harris IB. A comparison of locus of control between men and women in an internal medicine residency. J Med Educ. 1986;61(10):840-841.
19. Sherman AC, Higgs G, Williams RL. Gender differences in the locus of control construct. Psychol Health. 1997;12(2): 239-248.
20. Greenacre M. Correspondence analysis in practice (2nd ed). London: Chapman & Hall/CRC; 2007.
21. Abdi H, Valentin D. Multiple correspondence analysis. In: Salkind NJ, editor. Encyclopedia of measurement and statistics. Thousand Oaks, CA: Sage Publications. 2007;651-657.
22. Le Roux B, Rouanet H. Multiple correspondence analysis. Series: quantitative applications in the social sciences. Thousand Oaks, CA: Sage Publications. 2010;163.

23. Joe H, Ward J. Hierarchical grouping to optimize an objective function. J Am Stat Assoc. 1963;58:236–244.
24. Kaufman L, Roussew PJ. Finding Groups in Data - An introduction to cluster analysis. A Wiley-Science Publication John Wiley & Sons; 1990.
25. Rokach L, Maimon, O. Clustering methods, Data mining and knowledge discovery handbook. US: Springer. 2005;321-352.
26. Russell SF, Ludenia K. The psychometric properties of the multidimensional health locus of control scales in an alcoholic population. J Clin Psychol. 1983;39(3): 453-459.
27. Konkolÿ Thege B, Rafael B, Rohánszky M. Psychometric properties of the multidimensional health locus of control scale form C in a Non-western culture. Plos One. 2014;9(9):107-108.
28. Machado LAC, Telles RW, Costa-Silva L, Barreto SM. Psychometric properties of multidimensional health locus of control - A and general self-efficacy scale in civil servants: ELSA-Brasil musculoskeletal study (ELSA-Brasil MSK). Braz. J. Phys; 2016.
Available:http://dx.doi.org/10.1590/bjpt-rbf.2014.0177
29. Wallston KA. Hocus-pocus, the focus isn't strictly on locus: Rotter's social learning theory modified for health. Cogn Ther Res. 1992;16:183-199.
DOI: 10.1007/BF01173488
30. Bennett P, Norman P, Murphy S, Moore L, Tudor-Smith C. Beliefs about alcohol, health locus of control, value for health and reported consumption in a representative population sample. Health Educ Res. 1998;13:25-32.
DOI: 10.1093/her/13.1.25
31. Bennett P, Norman P, Moore L, Murphy S, Tudor-Smith C. Health locus of control and value for health in smokers and nonsmokers. Health
Psychol. 1997;16:179-182.
32. Patrick K, Grace TW, Lovato CY. Health issues for college students. Annu Rev Public Health. 1992;13:253-268.
DOI:10.1146/annurev.pu.13.050192.001345
33. Roddenberry A, Renk K. Locus of control and self-efficacy: Potential mediators of stress, illness, and utilization of health services in college students. Child Psychiatry Hum Dev. 2010;41:353. DOI:10.1007/s10578-010-0173-6
34. Findley MJ, Cooper HM. Locus of control and academic achievement: A literature review. J Pers Soc Psychol. 1983;44:419-427.

APPENDICES

Appendix 1- Results for the Multiple Correspondence Analysis (MCA)

Table 1.1. Eigen values and percentage of variance

Dimension	Eigenvalue	Percentage of variance	Cumulative percentage of variance
1	3.40E-02	19.65	19.65
2	2.66E-02	15.34	34.99
3	1.87E-02	10.81	45.80
4	1.44E-02	8.29	54.09
5	1.26E-02	7.30	61.39
6	1.16E-02	6.69	68.09
7	8.53E-03	4.93	73.02
8	8.05E-03	4.65	77.67
9	6.73E-03	3.89	81.56
10	6.06E-03	3.50	85.06
11	5.39E-03	3.12	88.18
12	4.99E-03	2.88	91.06
13	4.09E-03	2.36	93.42
14	3.62E-03	2.09	95.51
15	3.35E-03	1.94	97.45
16	2.81E-03	1.62	99.07
17	1.61E-03	0.93	100.00

Table 1.2. Coordinates, contributions and cos² of LOCs on the first two dimensions of the MCA

	Dim 1			Dim 2		
	Coordinate	Contribution	Cos²	Coordinate	Contribution	Cos²
LOC1	-0.11	2.03	0.07	-0.25	14.12	0.40
LOC2	0.14	2.77	0.14	0.06	0.69	0.03
LOC3	-0.16	2.04	0.10	0.20	4.29	0.16
LOC4	0.29	13.42	0.36	-0.19	7.39	0.15
LOC5	0.04	0.24	0.01	0.23	7.90	0.17
LOC6	-0.17	5.35	0.20	-0.12	3.59	0.10
LOC7	-0.26	10.46	0.29	0.16	5.02	0.11
LOC8	-0.22	5.95	0.18	-0.23	8.78	0.21
LOC9	0.15	2.26	0.08	-0.13	2.29	0.07
LOC10	-0.11	1.85	0.07	0.19	7.32	0.22
LOC11	0.24	9.20	0.24	0.00	0.00	0.00
LOC12	-0.10	2.48	0.18	-0.08	2.02	0.12
LOC13	-0.16	5.45	0.29	-0.10	2.69	0.11
LOC14	-0.03	0.15	0.01	0.22	10.22	0.40
LOC15	0.32	17.47	0.34	0.17	6.41	0.10
LOC16	0.36	17.96	0.47	-0.17	4.97	0.10
LOC17	-0.06	0.92	0.06	-0.04	0.39	0.02
LOC18	-0.01	0.01	0.00	0.23	11.91	0.42

Appendix 2- Results for the Ascending Hierarchical Classification (AHC)

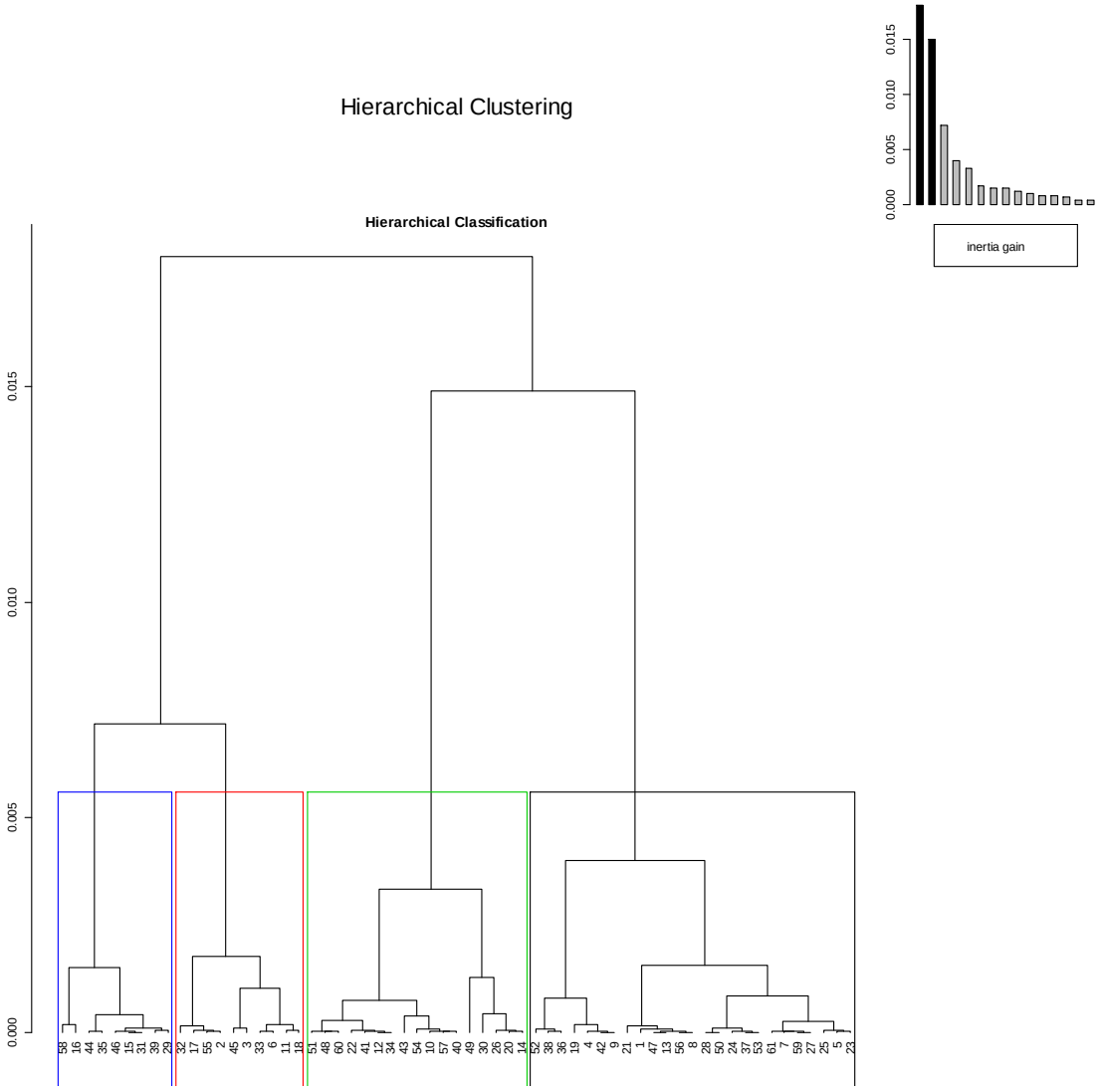

Figure. Dendrogram of the AHC (Euclidean metric and Ward' score for the aggregation of classes)

Table 2.1. Description of classes by the LOCs

	Internal (%)	Global (%)	Internal (freq)	Global (freq)	p. value	v. test
Class 1						
LOC7	6,79	5,10	76	174	0,0028	2,99
LOC15	4,46	5,92	50	202	0,0129	-2,49
LOC11	3,75	5,27	42	180	0,0057	-2,77
LOC16	2,95	4,75	33	162	0,0005	-3,49
LOC4	3,48	5,45	39	186	0,0003	-3,58
Class 2						
LOC8	6,51	4,34	31	148	0,0220	2,29
LOC1	8,40	6,01	40	205	0,0284	2,19
LOC18	3,78	5,89	18	201	0,0373	-2,08
LOC15	2,94	5,92	14	202	0,0021	-3,07
Class 3						
LOC15	7,31	5,92	83	202	0,0198	2,33
LOC8	3,08	4,34	35	148	0,0123	-2,50
LOC1	4,05	6,01	46	205	0,0007	-3,41
Class 4						
LOC4	8,21	5,45	56	186	0,0009	3,31
LOC16	6,89	4,75	47	162	0,0062	2,74
LOC15	8,06	5,92	55	202	0,0128	2,49
LOC7	2,49	5,10	17	174	0,0003	-3,60

Peer-review history:
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