Evaluating the psychometric properties of the MindMi™ Psychological Assessment System

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1. ABSTRACT

Research purpose: This study aims at testing the psychometric properties of the MindMi™ System and calibrating it for Romanian population. The system contains seven psychological reports based on psychophysiological measurements. The system associates SPL (skin potential levels) and SPR (skin potential responses) with a set of intermediate parameters. By advanced mathematical modeling, behavioral functions are established, leading to identification of a psychological profile.

Subjects and data collection methods: Testing a sample of 625 people from 4 counties in Romania allowed the investigation of results and the testing of psychometric properties in Romanian population. Stability over time was tested in a sub-sample of 178 subjects that were scanned with the MindMi™ System about two weeks apart. The data was collected with a device that scans the palm surface of the hands for 5 minutes.

Data analysis procedures: The statistical analysis was performed with PASW Statistics 18 and investigated descriptive data (distribution, means, standard deviations, percentiles, frequency in population), internal consistency (Cronbach's Alpha) and test-retest reliability (Pearson Correlation, paired samples t test, Cohen's Kappa coefficient).

Results: Cronbach's Alpha coefficient ranged between 0.93-0.99. The test-retest correlation *values* were significant for each measured concept, ranging from $r = 0.27$ to 0.58, $p < 0.001$. Paired samples *t* test didn't reveal significant differences between the testing times at any of the measured concepts. Cohen's Kappa coefficient revealed a significant overlap between the two tests, ranging from $K = 0.24$ to 0.35, $p < 0.001$.

2. INTRODUCTION

Human personality has been continuously investigated as a configuration of traits that reflect an individual's way of acting, feeling, thinking and adjusting to the environment. The continuous process of understanding human nature and nurture is vital for predicting an individual's way of acting in specific contexts and in different life areas such as work field, social interactions, family functioning or attitudes towards health (Grigore & Moldovan, 2015).

As we've shown in previous articles on this topic (Grigore & Moldovan, 2015), pychological research is making progress in linking personality traits with specific behaviors and actions (Eysenck, 1991; Gray, 1987, 1991; Watson & Clark, 1992) looking for individual differences in brain anatomy and physiology, in bodily functions and self-regulation processes, in sensation and perception, in information processing and thinking styles, in behavior and emotion regulation, interpersonal interaction and so on (Bandura, 2006, Block, 2002). Using biological and physiological data (Nebylitsyn & Gray, 1972; Fowles, 1980; Crider, 2008; Canli, 2006), the connection between human personality traits and behavior is now investigated through individual differences in brain functioning (Carver & White, 1994). A cybernetic model of global personality traits (Van Egeren, 2009; Wiener, 1948) is also examining how specific personality traits exert control over human behavior. These traits are seen as self-regulatory controls that underlie behavior patterns rather than manifest behavior itself (Van Egeren, 2009; Crider, 2008). It seems that human beings mentally incorporate propensities of action into personality traits (Robins, John, Caspi, Moffit & Stouthamer-Loebar, 1996; Schneirla, 1959; Carver, 2005). These traits encode all the actions and controls necessary for a person to achieve a goal.

Various psychological traits have been investigated with psychophysiological measures (Cacioppo & Tassinary, 1990), including electrodermal activity. Placing electrodes on the skin surface, especially in the palmar surface of the hand, is an ideal way to monitor the autonomic nervous system (Öhman, Hamm & Hugdahl, 2000) through the sweat glands, which are controlled by sympathetic nerve activity. The electrodermal response is seen as a peripheral manifestation of neural activation (Crider, 2008), entrained by demands on cognitive capacity (Murray & Kochanska, 2002). Although research in the field has made significant progress in explaining how personality and individual differences impact a person's behavior and adjustment to specific contexts, measuring these aspects of personality is far more complicated.

The inventor of MindMi™ System, Dumitru Grigore (Grigore, 1998, 2013; Grigore, Paraschiv, Ipate & Chivulescu, 2013), has experimentally demonstrated that all these psychological traits and indicators can be measured through a non-invasive hand scanning device, using the active principle of sweat gland activity as a peripheral manifestation of neural activation (Grigore, 2010; Grigore, Ipate, Craiovan & Mateescu, 2013; Grigore, Costache, Ştefan & Paraschiv, 2014). The MindMi™ System measures biopotentials from the skin surface (skin potential response and skin potential level) through a dual hand scanner with monopolar electrodes. Following a continuous process of modelling, developing and shaping the initial prototype, based on testing results (Talpoş, Sanislav & Grigore, 2015; Grigore & Petrescu, 2015; Grigore, 2013), the system gathers all the necessary data in 5 minutes.

After the scan, the system uses the collected data to acquire psychological information through an innovative algorithmic procedure. The algorithm combines multiple variables of key relevance for their corresponding personality traits (e.g. the amplitude, the lability of the electrodermal response, the level of cortical arousal, and others). This core set of variables goes through a cybernetic modelling process, resulting in a numerous set of psychological indicators that reflect cognitive, emotional and social abilities, but also specific aptitudes and tendencies. The psychological indicators obtained are further used to create extensive psychological reports that comprise information about an examinee's personality, cognitive intelligence, emotional intelligence, and interpersonal or group compatibility (Zaharia, Grigore & Moldovan, 2017). MindMi™ System provides scores for specific psychological indicators (e.g. creativity), the statistical interpretation based on five intervals (very low, low, moderate, high, very high) related to percentages found in the general population below or above certain scores (percentiles), and the conceptual explanation of these indicators (Grigore & Moldovan, 2015). The system contains seven psychological reports based on psychophysiological measurements.

MindMi™ reports do not treat or diagnose, and the information obtained with the system must be integrated with other sources (e.g. interview, other psychological tests, practical activities or assessment centers), and should be interpreted in the context of each specific assessment, depending on the assessment goal and domain of use. The system can be applied in individual or organizational settings, without specific stimuli or tasks during the assessment. The results are independent on the quality of communication between the examinee and the system user, and the only requirement is a correct positioning and maintainance of the hands in the recommended position on the scanner, until the scan is complete (~5mins). This method can be applied only after the examinee signs an informed consent form. More recommandations and precautions for use are described in the User's Manual and Technical Manual of the instrument.

3. RESEARCH PURPOSE

This study aims at testing the psychometric properties of the MindMi™ System and calibrating it for Romanian population. The system contains seven psychological reports based on psychophysiological measurements. The system associates SPL (skin potential levels) and SPR (skin potential responses) with a set of intermediate

parameters. By advanced mathematical modeling, behavioral functions are established, leading to identification of a psychological profile. The study investigated descriptive data, internal consistency and test-retest reliability of the results.

4. SAMPLE AND DATA COLLECTION METHODS

We collected a total of 1003 data sets (scans), from 625 people living in Romania. The sample (Table 1) included subjects from 4 counties in Romania (Cluj, Mureş, Iaşi, Bucureşti), aged between 6 and 73 years old (Figure 1). The participants' mean age was 34.7 years (SD = 13.6) and 56.2% of the sample was female.

Data was collected using a hand scanning device, with ~5 minutes/scan. Participants completed an informed consent form before the scan. Internal consistency, data distribution and percentiles for the quantitative variables were calculated on the total sample. The stability over time was investigated on a sub-sample (178 subjects), that were scanned twice, about two weeks apart.

Table 1. Sample data

	%	Mean age	SD	N' (data sets)	N (persons)
Total	100	34.65	13.63	1003	625
F	56.2	32.20	12.19	564	336
M	43.8	37.80	14.70	439	289

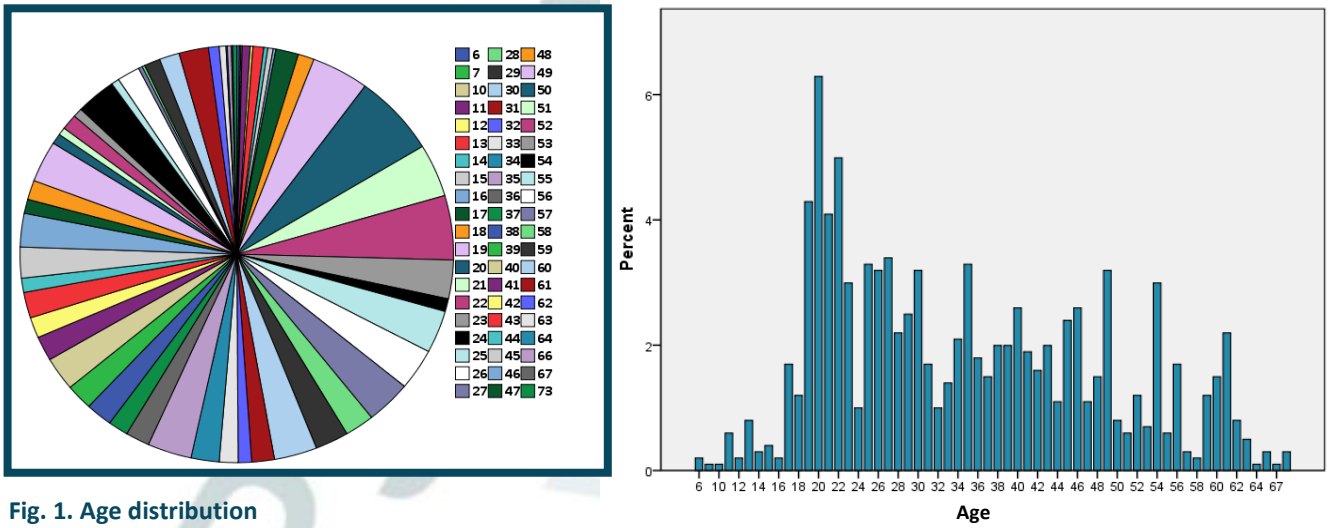

Fig. 1. Age distribution

5. DATA ANALYSIS PROCEDURES

The online platform can generate 7 types of reports based on one scan, that provide results for: 62 Psychological Indicators, Cognitive Intelligence Potential, Emotional Intelligence Potential, Talent, Personality, Group Compatibility and Interpersonal Compatibility. The results are in the form of quantitative variables (62 Psychological concepts measured in scores, 8 Cognitive Intelligence scores, 6 Emotional Intelligence scores, 11 Talent scores, percentage for four temperaments and two scores representing cerebral frequencies in the Personality Report) and categorical variables (assignation of the most active "personality type" at the time of testing, from 16 available, and ranking the other 15 types in a descending order; four categorical variables with two levels each - introvert-extravert, sensory-intuitive, reflexive-affective, perceptive-organized, expressly identified in the Interpersonal Compatibility, and hidden but accounted for in the Group Compatibility. There are also sections of descriptive text based on hidden quantitative data (back-end scores for the Understanding, Organization, Decision and Networking sections in the Interpersonal Compatibility, that 'decide' when and

what text description is appropriate for a specific pair). To facilitate the collection of all relevant data in one database format, a Macro Excel tool was used to export the final report results directly from the raw data strings (raw scan file), into an Excel file. The statistical analysis was performed with PASW Statistics 18 and investigated descriptive data (distribution, means, standard deviations, percentiles, frequency in population), internal consistency (Cronbach's Alpha) and test-retest reliability (Pearson Correlation, paired samples t test, Cohen's Kappa coefficient).

6. RESULTS

6.1. Normative data

In the case of reports with quantitative variables (Talent report, Potential of Cognitive and Emotional Intelligence, the 62 Psychological Indicators), the data obtained on the previously described sample led to interpreting data in five statistically calculated intervals (based on percentiles): very low, low, moderate, high and very high, depending on the percentages of the sample situated below or above a certain score. A percentile is a certain percentage of a set of data and is used to observe how many of a given set of data fall within a certain percentage range.

The MindMi™ system automatically fits scores in the corresponding statistical interval (very low, low, moderate, high or very high), visually representing the score on the scale and positioning it in one of the five intervals (Figure 2).

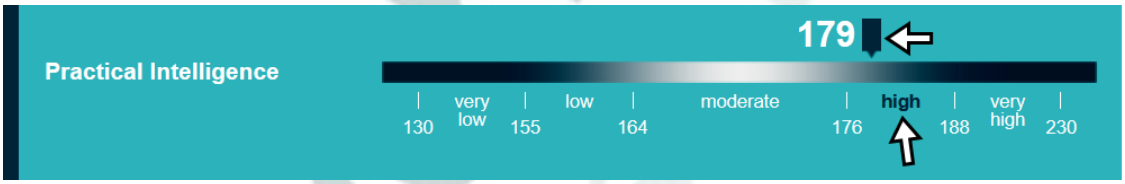

Fig. 2. Potential of Cognitive Intelligence: Practical Intelligence - Example of Interpretation

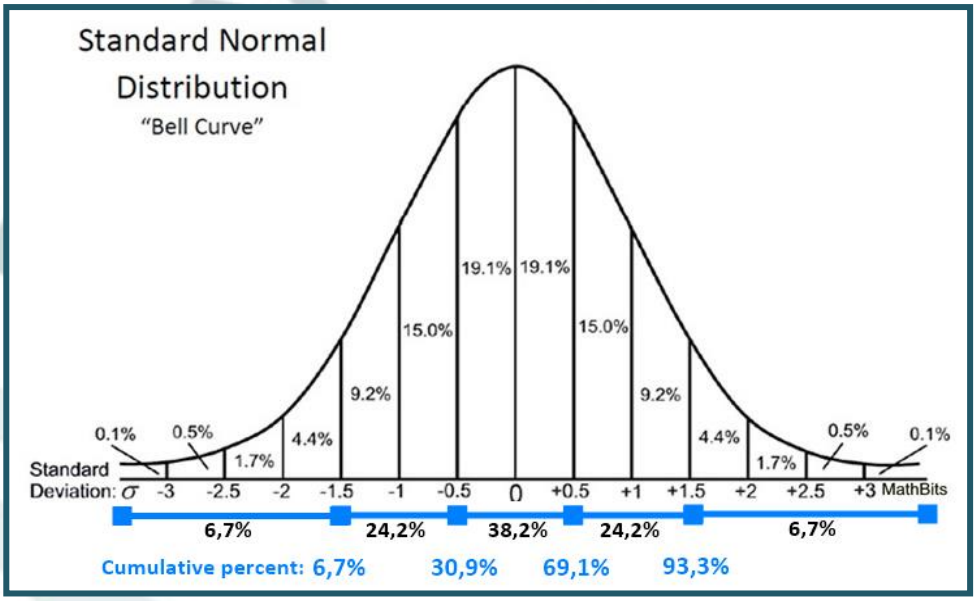

Fig. 3. Intervals and percentiles used to interpret MindMi™ scores *Adapted from mathbitsnotebook.com*

The percentile norms were built on five normalized intervals, with the following percentages: 6,7%, 24,2%, 38,2%, 24,2%, and 6,7% (Fig. 3,4). A score in the 'very low' interval is interpreted as lower than 6,7% of the population. A score in the 'low' interval is interpreted as higher than 6,7% of the population. A score in the

'moderate' interval is interpreted as higher than 30,9% of the population (cumulative percent). A score in the 'high' interval is interpreted as higher than 69,1% of the population. And a score in the 'very high' interval is interpreted as higher than 93,3% of the population. The scores and the intervals shown for each psychological indicator are based on the results obtained in the normative sample. A few examples are shown in Tables 2,3,4,5.

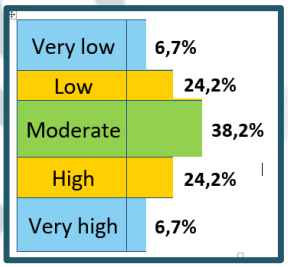

Fig. 4. Intervals and percentages in population

Table 2. Examples of Score interpretation: Talent

Intervals	Aptitudinal Potential	Ambition	Originality
Very low	≤ 81	≤ 80	≤ 79
Low	82-84	81-83	80-82
Moderate	85-86	84-85	83-84
High	87-88	86-87	85-86
Very high	≥ 89	≥ 88	≥ 87

Table 3. Examples of Score interpretation: Cognitive Intelligence Potential

Intervals	Total Cognitive Intelligence	Practical Intelligence	Mathematical Intelligence
Very low	≤ 162	≤ 155	≤ 163
Low	163-171	156-164	164-175
Moderate	172-186	165-176	176-192
High	187-198	177-188	193-205
Very high	≥ 199	≥ 189	≥ 206

Table 4. Examples of Score interpretation: Emotional Intelligence Potential

Intervals	Total Emotional Intelligence	Introspective Emotional Intelligence	Relational Emotional Intelligence
Very low	≤ 160	≤ 158	≤ 160
Low	161-171	159-170	161-172
Moderate	172-185	171-183	173-184
High	186-199	184-196	185-197
Very high	≥ 200	≥ 197	≥ 198

Table 5. Examples of Score interpretation: 62 Psychological Indicators

Intervals	Linguistic ability	Mathematical ability	Visual-spatial ability
Very low	≤ 83	≤ 84	≤ 85
Low	84-86	85-86	86-87
Moderate	87-91	87-88	88-89
High	92-94	89-90	90-91
Very high	≥ 95	≥91	≥ 92

Intervals	Adaptation to stress	Emotional comfort	Impulse control
Very low	≤ 81	≤ 80	≤ 79
Low	82-84	81-84	80-81
Moderate	85-87	85-87	82-84
High	88-89	88-90	85-88
Very high	≥ 90	≥ 91	≥ 89

Intervals	Assertiveness	Authority	Conformity
Very low	≤ 79	≤ 78	≤ 79
Low	80-83	79-82	80-82
Moderate	84-87	83-86	83-84
High	88-89	87-90	85-86
Very high	≥ 90	≥ 91	≥ 87

In case of descriptive or categorical results (Personality, Interpersonal Compatibility), the data obtained on the previously described sample led to the distributions presented in Tables 6,7,8,9.

	Frequency	Percent
EXTRAVERT	529	52.7
INTROVERT	474	47.3
Total	1003	100.0

Table 6. Personality: Extravert-Introvert distribution

	Frequency	Percent
CHOLERIC	384	38.3
PHLEGMATIC	375	37.4
MELANCHOLIC	99	9.9
SANGUINE	145	14.5
Total	1003	100.0

Table 7. Personality: Main temperament distribution

	Frequency	Percent
ANALYST	8	0.8
RESEARCHER	134	13.4
COLLABORATOR	110	11.0
COUNSELOR	61	6.1
DIPLOMAT	21	2.1
PERFORMER	121	12.1
EXPERT	41	4.1
EXPLORER	38	3.8
INSPECTOR	104	10.4
MANAGER	92	9.2
POLITICIAN	61	6.1
PRACTITIONER	76	7.6
TEACHER	6	0.6
PROMOTER	80	8.0
SPECIALIST	22	2.2
VISIONARY	28	2.8
TOTAL	1003	100.0

Table 8. Personality type distribution

	Frequency	Percent
EXTRAVERT	529	52.7
INTROVERT	474	47.3
Total	1003	100.0
	Frequency	Percent
INTUITIVE	244	24.3
SENSORY	759	75.7
Total	1003	100.0
	Frequency	Percent
AFFECTIVE	605	60.3
REFLEXIVE	398	39.7
Total	1003	100.0
	Frequency	Percent
ORGANIZED	508	50.6
PERCEPTIVE	495	49.4
Total	1003	100.0

Table 9. Interpersonal Compatibility: distribution of categorical variables

6.2. Reliability

6.2.1. Internal Consistency

We calculated Cronbach's Alpha coefficient for the Talent indicators (0.97), Cognitive Intelligence Potential (0.99) and Emotional Intelligence Potential (0.99), where the report contains a total score with sub-components. All Pearson correlations between sub-components and the total score were positive and significant ($p < 0.001$), with *r* values between 0.62 and 0.99. The means and standard deviations for each score, and the correlation of sub-scores with total scores are presented in Tables 10, 11, 12. For the 62 Psychological Indicators, the Cronbach's Alpha calculated for the sub-categories (cognitive, emotional, social and networking abilities, and other abilities and aptitudes) was between 0.93 and 0.99.

Table 10. Talent

	m	SD	r
Aptitudinal Potential (total score)	85	2.07	
Alert Attention	86	3.62	*0.93
Ambition	84	2.45	*0.91
Stress-Adapting Abilities	85	2.96	*0.94
Originality	83	2.53	*0.93
Curiosity and Interest	85	2.86	*0.89
Diligence	83	2.60	*0.69
Reasoning	86	2.81	*0.95
Self-confidence	85	3.54	*0.86
Uprightness	85	2.90	*0.62
Leadership	85	2.39	*0.92

r= Pearson Correlation between sub-indicators and total Aptitudinal Potential; *p<0.001

Table 11. Cognitive Intelligence Potential

	m	SD	r
Total Cognitive Intelligence	179	12.02	
General Intelligence	183	14.03	*0.97
Visual-Spatial Intelligence	174	12.98	*0.96
Practical Intelligence	171	10.68	*0.95
Verbal Intelligence	188	14.17	*0.97
Mathematical Intelligence	184	13.99	*0.96
Intuitive Intelligence	171	9.44	*0.98
Reasoning Clarity	181	12.71	*0.99

r= Pearson Correlation between sub-indicators and total Cognitive Intelligence; *p<0.001

Table 12. Emotional Intelligence Potential

	m	SD	r
Total Emotional Intelligence	179	12.73	
Introspective Emotional Intelligence	176	12.32	*0.97
Relational Emotional Intelligence	178	12.19	*0.97
Self-image; Inner Comfort	181	14.45	*0.99
Integrative Adaptability	177	12.74	*0.94
Stress resistance and impulsivity control	181	13.82	*0.99

r= Pearson Correlation between sub-indicators and total Emotional Intelligence; *p<0.001

In the case of Personality and Interpersonal Compatibility Reports, Pearson's correlations were calculated between the percentages of the four temperaments, between the percentages of temperaments and the extravert-introvert category, and between the cerebral frequencies displayed on both hemispheres, respectively.

Significant positive correlations were found between choleric and sanguine temperament, and phlegmatic and melancholic temperament (*r* ranging from 0.45 to 0.56, $p < 0.001$). Choleric and sanguine temperaments negatively and significantly correlated with phlegmatic and melancholic temperaments (*r* ranging from - 0.63 to -0.82, $p < 0.001$). Pearson's correlation coefficients are presented in Table 13.

Table 13. Pearson Correlation between temperaments

	Choleric	Sanguine	Phlegmatic	Melancholic
Choleric		0.56*	-0.76*	-0.79*
Sanguine			-0.82*	-0.63*
Phlegmatic				0.45*
Melancholic				

*p<0.001

The 'introvert' and 'extravert' labels of the categorical variable shown in the Personality Report correlated significantly with all four temperaments. Significant positive correlations were found between the "extravert" label and choleric and sanguine temperament, and also between the "introvert" label and phlegmatic and melancholic temperament.

Table 14. Pearson's Correlation between temperaments and extravert-introvert label

	Choleric	Sanguine	Phlegmatic	Melancholic
Extravert	0.88*	0.85*	-0.87*	-0.79*
Introvert	-0.88*	-0.85*	0.87*	0.79*

*p<0.001

Significant negative correlations were found between the "extravert" label and phlegmatic and melancholic temperament, and also between the "introvert" label and choleric and sanguine temperament. Pearson's correlation coefficients are presented in Table 14.

Numeric values of cerebral frequency in the left brain hemisphere significantly and positively correlated numeric values of cerebral frequency in the right brain hemisphere (r = 0.77, p <0.001).

6.2.2. Test-retest reliability

Stability over time was tested on a sub-sample of 178 subjects in Târgu Mureş, which were scanned with the MindMi™ System at about two weeks apart.

For quantitative variables (Talent indicators, Cognitive Intelligence Potential, Emotional Intelligence Potential, the 62 Psychological Indicators), we calculated Pearson correlations between T1 and T2. Mean differences between the two testing times (paired samples *t* test) were also calculated. There were no significant differences between the two testing times for any of the measured concepts. The test-retest correlations (Tables 15, 16) were positive and significant (p <0.001) for each measured concept and ranged between 0.29 and 0.58.

Table 15. Test-retest correlations

Talent	r
Aptitudinal Potential	*0.52
Alert Attention	*0.52
Ambition	*0.38
Stress-Adapting Abilities	*0.48
Originality	*0.38
Curiosity and Interest	*0.46
Diligence	*0.47
Reasoning	*0.50
Self-confidence	*0.44
Uprightness	*0.55
Leadership	*0.40

Cognitive Intelligence Potential	r
Total Cognitive Intelligence	*0.52
General Intelligence	*0.50
Visual-Spatial Intelligence	*0.48
Practical Intelligence	*0.42
Verbal Intelligence	*0.50
Mathematical Intelligence	*0.58
Intuitive Intelligence	*0.51
Reasoning Clarity	*0.52

Emotional Intelligence Potential	r
Total Emotional Intelligence	*0.56
Introspective Emotional Intelligence	*0.57
Relational Emotional Intelligence	*0.57
Self-image; Inner Comfort	*0.56
Integrative Adaptability	*0.48
Stress resistance; impulsivity control	*0.59

r= Pearson's Correlation between T1 and T2, N=178, *p<0.001

Table 16. Test-retest correlations, 62 Psychological Indicators

Cognitive abilities	r
Linguistic ability	*0.44
Visual-spatial ability	*0.44
Mathematical ability	*0.47
Mental agility	*0.50
Attention	*0.52
Concentration capacity	*0.49
Clarity of thought	*0.43
Decision-making	*0.49
Cognitive flexibility	*0.52
Lucidity	*0.52
Memory	*0.43

Emotional abilities	r
Adaptation to stress	*0.48
Emotional comfort	*0.54
Impulse control	*0.27
Emotionality	*0.51
Empathy	*0.40
Impulsivity	*0.32
Relaxation	*0.51
Emotional stability	*0.45

Social and networking abilities	r
Oratorical ability	*0.47
Assertiveness	*0.50
Authority	*0.53
Conformity	*0.29
Interpersonal trust	*0.42
Leadership	*0.40
Respect for others	*0.44
Sociability	*0.56
Sense of belonging to a group	*0.39
Tolerance to opposing views	*0.49

r=Pearson's Correlation between T1 and T2, N=178, *p<0.001

Other abilities and aptitudes	r
Adaptability	*0.46
Self-assertion	*0.35
Selflessness	*0.57
Ambition	*0.38
Righteous attitude	*0.57
Self-preservation	*0.44
Self-control	*0.50
Self-confidence	*0.44
Autonomy	*0.48
Mental calmness	*0.57
Creativity	*0.38

Other abilities and aptitudes	r
Thrift	*0.42
Courage	*0.46
Curiosity	*0.46
Dynamism	*0.39
Generosity	*0.56
Diligence	*0.47
Ego Indicator	*0.46
Intuition	*0.47
Inventiveness	*0.36
Objectivity	*0.42
Optimism	*0.52

Other abilities and aptitudes	r
Perseverance	*0.46
Trustworthiness	*0.55
Cautiousness	*0.42
Patience	*0.49
Realism	*0.42
Responsibility	*0.52
Honesty	*0.53
Force of character	*0.50
Vigilance	*0.50
Vitality	*0.34
Willpower	*0.42

r= Pearson's Correlation between T1 and T2, *p<0.001

For Personality and Interpersonal Compatibility Reports, Pearson correlations were calculated between T1 and T2 in the case of quantitative variables, the mean differences between the two tests (pair samples *t* test) were investigated and, Cohen's Kappa coefficient was calculated in the case of categorical variables.

Regarding the Personality Report (Table 17), the test-retest correlations were positive and significant for the 'Extravert' and 'Introvert' categories respectively (r = 0.35, p <0.001). The test-retest correlations for numerical scores corresponding to the extravert - introvert category were positive and significant (r = 0.38, p <0.001). Cohen's Kappa coefficient for the extravert-introvert category revealed a significant consensus between the two tests (K = 0.35, p <0.001).

Table 17. Test-retest correlations: Extravert-Introvert

Label	r
'Extravert'	*0.35
'Introvert'	*0.35

Numerical values	r
'Extravert'	*0.38
'Introvert'	*0.38

r= Pearson correlation between T1 and T2, N=178, *p<0.001

The test-retest correlations were positive and significant (Table 18) for the percentages of each temperament displayed in the temperamental configuration (r = 0.26 - 0.33, p <0.001). The paired samples *t* test found no significant differences between T1 and T2 for the Choleric, Sanguine, Phlegmatic and Melancholic temperaments (the resulting percentages). For the main temperament, Cohen's Kappa coefficient revealed a significant consensus between the two testing times (displaying the same temperament at T1 and T2 on the first position) (K = 0.28, p <0.001). For the secondary temperament (the second one displayed in the hierarchy), Cohen's Kappa coefficient revealed a significant consensus between the two testing times (K = 0.24, p <0.001).

Positive and significant test-retest correlations were also found (Table 19) for the brain frequencies (numerical values) on each hemisphere (r = 0.45-0.57, p <0.001).

Table 18. Test-retest correlations: Temperament

	r
Choleric	*0.33
Sanguine	*0.28
Phlegmatic	*0.26
Melancholic	*0.32

r= Pearson correlation between T1 and T2, N=178, *p<0.001

Table 19. Test-retest correlations: Cerebral frequencies

	r
Left cerebral frequency	*0.57
Right cerebral frequency	*0.45

r= Pearson correlation between T1 and T2, N=178, *p<0.001

Regarding the Interpersonal Compatibility Report, positive and significant test-retest correlations were found for the numerical values corresponding to the "Understanding", "Organization", "Decision" and "Networking" sections (r = 0.25-0.56, p <0.001). These numerical values are not actually displayed in the report but are computed in the algorithm, and based on them, text versions are displayed or hidden in the respective categories (Table 20).

Table 20. Test-retest correlations: Interpersonal Compatibility

Section	r
'Understanding'	*0.56
'Organization'	*0.52
'Decision'	*0.54
'Networking'	*0.25

r= Pearson correlation between T1 and T2, N=178, *p<0.001

Positive and significant test-retest correlations have been found for the numerical values corresponding to extravert-introvert, sensory-intuitive, reflexive-affective, and perceptive-organized categories (r ranging from 0.38 to 0.58, p <0.001).

These numeric values are not displayed in the report but are computed in the algorithm, and one label or another is displayed based on them. The Pearson correlation coefficients are shown in Table 21.

Table 21. Test-retest correlations: Interpersonal Compatibility

	r		r
EXTRAVERT	*0.38	AFFECTIVE	*0.57
INTROVERT	*0.38	REFLEXIVE	*0.52
	r		r
INTUITIVE	*0.58	ORGANIZED	*0.51
SENSORY	*0.56	PERCEPTIVE	*0.49

r= Pearson correlation between T1 and T2, N=178, *p<0.001

The Cohen's Kappa coefficient for categorical variables was also calculated to determine the consensus (overlap) between the two testing times on the extravert-introvert, sensory-intuitive, reflexive-affective, organized-perceptive bimodal categories. The consensus between T1 and T2 refers to displaying the same mode in both tests (eg displaying the 'Extravert' mode at T1 and T2, respectively displaying the 'Introverted' mode at T1 and T2). Cohen's Kappa coefficient revealed a significant consensus between the two testing times and ranged between K = 0.27 and K = 0.35, p <0.001.

6.3. Validity

In a pilot study based on 20 subjects, data collected with MindMi™ scanning was compared with data collected simultaneously with the EEG NeuroSky Headset. The raw data sets collected with the two instruments (electrodermal potential vs. EEG) were processed with the algorithm used by the MindMi™ system, to obtain the same set of final indicators. The results were calculated and exported to a database using an Excel macro file, and the results of the two methods were then statistically analyzed using PASW Statistics 18.

Pearson correlations between the MindMi™ system and NeuroSky Headset were calculated for quantitative variables, analyzing the results collected with the two different instruments, but processed with the same algorithm. Regarding the Talent report, positive and significant correlations between the two instruments were found for each indicator, with *r* values ranging from 0.57 to 0.96 (p <0.01). Regarding the Cognitive Intelligence Potential, positive and significant correlations were found for each indicator, with *r* values ranging from 0.73 to 0.88 (p <0.001). Regarding the Emotional Intelligence Potential, positive and significant correlations were found for each indicator, with *r* values ranging from 0.66 to 0.90 (p<0.01). Regarding the 62 Psychological indicators, positive and significant correlations were found for 60 indicators among the 62, with *r* values ranging from 0.45 to 0.97 (p<0.05). These preliminary data require replication on a representative sample.

6.4. Gender differences

After calculating the mean values of male and female gender scores (independent samples *t* test), significant gender differences were found in the 62 Psychological Indicators (44 out of 62 indicators, with mean difference ranging from 0.11 to 1.65), in the Talent indicators (6 out of 11 indicators, with mean difference ranging from 0.10 to 0.71), Cognitive Intelligence Potential (8 indicators, with mean difference ranging from 1.66 to 2.64), and Emotional Intelligence Potential (6 indicators, with mean difference ranging from 2.28 to 2.91).

7. SUMMARY AND CONCLUSIONS

This study aimed to test the psychometric properties of the MindMi™ System and to calibrate it on the Romanian population. The system contains seven psychological reports based on psychophysiological measurements.

The statistical analysis investigated descriptive data (distribution, means, standard deviations, percentiles, frequency in population), reliability measures such as internal consistency (Cronbach's Alpha) and test-retest reliability (Pearson correlation, paired samples *t* test, Cohen's Kappa).

In the case of quantitative variables (Talent indicators, Cognitive Intelligence Potential and Emotional Intelligence Potential, the 62 Psychological Indicators), the data obtained on our sample led to the interpretation of the scores based on five calculated intervals (based on percentiles): very low, low , moderate, high and very high, depending on the percentage of the population that is below or above a certain score. Percentiles were calculated on five normalized intervals, with the following percentages: 6.7%, 24.2%, 38.2%, 24.2% and 6.7%.

Reliability has been investigated, testing our instrument for internal consistency and test-retest reliability. Cronbach's Alpha coefficient ranged between 0.93-0.99. Positive and significant Pearson correlations were found between the two testing times (~two weeks apart) for each measured concept, ranging from $r = 0.27$ to $r = 0.58$, $p < 0.001$. The paired samples *t* test did not reveal any significant differences between the two testing times, for any of the measured concepts. Cohen's Kappa coefficient revealed a significant overlap between the two testing times and had values between $K = 0.24$ and $K = 0.35$, $p < 0.001$.

Considering these results, it is very important to interpret the scores and results based on data obtained in a large sample, that can be generalized to a larger scale in the general population. This way, we can understand the nature of the results offered by this system, how frequent or diverse some scores are and how this reflects on the results interpretation.

Future directions will continue investigating aspects of validity, comparing the system with other relevant instruments, and extending the simultaneous testing with NeuroSky EEG Headset, so we can have a relevant interpretation of results on a representative sample.

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