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Title: The Euthymia Scale: A Clinimetric Analysis

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Fava and Bech [1] were the first who provided a comprehensive definition of euthymia since they conceptualized it as a condition characterized not only by the absence of affective disorders, as commonly conceived in psychiatry, but, most importantly, as characterized by the presence of psychological flexibility and resistance to stress. In this vein, they [1] developed a self-report rating scale, called Euthymia Scale (ES), which incorporates Jahoda's conceptualization of euthymia [2], that is the individual's balance among psychic forces leading to high levels of resilience and frustration tolerance, and the 5-item World Health Organization Well-Being Index (WHO-5) [3], a widely used measure for the assessment of psychological well-being. Indeed, 5 of the 10 items of the ES were derived from the WHO-5.

When Fava and Bech [1] developed the Euthymia Scale, they focused on the clinimetric approach [4, 5] which suggests scalability, incremental validity, and sensitivity as main clinimetric parameters for the validation of a scale. Scalability means that each item measures a specific symptom and that the symptoms assessed via the scale belong to an underlying clinical dimension. When the criteria for scalability are fulfilled, the total score of a scale is statistically sufficient for measuring the severity of the clinical condition under assessment [6]. Incremental validity refers to the evaluation of the unique contribution of a rating scale in the assessment and prediction of a specific clinical dimension [4]. Sensitivity is the ability of a scale to discriminate among different groups of subjects who are affected by the same disorder and to detect changes in symptoms following a treatment [4].

The aim of the present study was to test two main clinimetric properties of the Euthymia Scale: scalability and incremental validity. They were tested to verify whether ES is a statistically sufficient measure of euthymia and gives a unique contribution in the assessment of euthymia, beyond the WHO-5 score. Concurrent validity between the ES and the Psychological Well-Being Scales (PWB) [7] was also explored.

Two samples were enrolled: one consisted of type-2 diabetes outpatients consecutively recruited at the Diabetes Unit of the University Hospital of Chieti (Italy), the other consisted of a convenience sample of healthy subjects recruited from the general population of Florence (Italy).

Diabetes outpatients had to meet the following inclusion criteria: (1) a clinical diagnosis of type-2 diabetes according to the diagnostic criteria of the World Health Organization; (2) age 18-64 years. The inclusion criteria applied to the healthy subjects were: (1) being healthy; (2) age 18-64 years. Table S1 reports the exclusion criteria applied.

All participants had to provide and sign a written informed consent including a privacy protection disclaimer. The research study was approved by the Institutional Review Board of the University of Florence.

Table S2 reports the standard procedure followed to translate and pilot-test the ES.

The final version of the ES was administered in a paper-pencil format together with the WHO-5 [3], the PWB [7], and the NEO Personality Inventory-3 (NEO-PI-3) [8]. Table S3 reports a detailed description of the rating scales administered.

Scalability was examined via the Mokken analysis, a Loevinger's coefficient of homogeneity ≥ 0.30 is acceptable [6].

Incremental validity was tested via hierarchical linear regression analyses. The criterion variable was each PWB/NEO-PI-3 subscale. The entry order of predictors was: WHO-5 at Step 1; the ES at Step 2. The increase of the explained variance from Step 1 to Step 2 served as a measure of the incremental validity. Hierarchical regressions were adjusted for sex, age, education, history of psychiatric disorders since they correlated with criterion variables. Pearson correlation coefficients were run to examine concurrent validity.

Of the 124 diabetes outpatients who were invited to participate, 100 accepted (response rate: 80.6%). They had a mean age $\pm$ SD of 58.59 ± 6.06 years, 42% were females.

Of the 110 healthy subjects who were invited to participate, 100 accepted (response rate: 90.1%). They had a mean age $\pm$ SD of 32.64 ± 10.48 years, 73% were females.

When the Mokken analysis of the ES was run, the coefficient of homogeneity of the first 5 items of the Euthymia Scale, which assess psychological flexibility, was acceptable in diabetes outpatients. The coefficient of homogeneity of the last 5 items of the ES, which overlap with WHO-5 items, was acceptable in both samples (Table 1). However, when all 10 items were included in the analysis, the coefficient of homogeneity was below the level of acceptance (Table 1).

In the clinical sample, the Euthymia Scale significantly increased the percentage of the explained variance (from 5% to 15%) in all PWB subscales except PWB Personal Growth (Table S4). In the healthy sample, the ES significantly increased the percentage of the explained variance (from 4% to 9%) in three out of the six PWB subscales (Table S4). The unique contribution of the ES to explain additional variance in the NEO-PI-3 scores was statistically significant for five and four personality dimensions in the clinical and healthy samples, respectively, and ranged from 1% to 15% (Table S5).

The ES significantly positively correlated with PWB Environmental Mastery/Positive Relations with Others/Purpose in Life/Self-Acceptance in clinical subjects (Table S6), and with Environmental Mastery/Purpose in Life/Self-Acceptance in healthy subjects (Table S7).

The present clinimetric analysis disclosed a two-dimensional nature of the scale that reflects its development. The sum of the scores of the first 5 items for measuring psychological flexibility and the sum of the scores of the last 5 items for measuring a state of psychological well-being appear to be statistically significant. The results lend support to the use of two separate scores for the ES subscales (psychological flexibility and well-being), instead of using a total score. In brief, the ES is a valid measure of the level of psychological flexibility and of the level of psychological well-being.

The ES also provided satisfactory incremental contribution to the prediction of PWB dimensions and Neuroticism over and above the WHO-5 score. Thus, it seems to be more useful than the WHO-5 to predict most criteria considered in this study, particularly in the clinical sample.

Moderate concurrent validity with PWB dimensions confirms that the ES is a measure of a complex construct which overlaps only partially with the dimensions measured via the PWB. In psychometrics, a high correlation is often regarded as evidence that two scales measure the same factor. However, a high correlation does not indicate similar sensitivity [4]. Two scales may have common content which insures a high positive correlation, but the items they do not share may be important in determining sensitivity. Homogeneity of components, as measured by statistical tests such as Cronbach's alpha, is often seen as the most important requirement for a rating scale. However, the same properties that give a scale a high score for homogeneity may obscure its ability to detect change or pick up differences [4].

A relatively small sample and the cross-sectional design are the main limitations of this investigation.

In summary, the Euthymia Scale is a promising clinimetric tool in modern diabetes clinical and research settings [9]. In the framework of health promotion and research its clinical utility deserves further investigation [10].

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Disclosure statement

The authors have no conflicts of interest to declare.

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Table 1. Euthymia Scale. Mokken analysis

	Type 2 diabetes outpatients (n = 100)	Healthy subjects (n = 100)
10-ITEM EUTHYMIA SCALE	Loevinger's coefficient	Loevinger's coefficient
1. If I become sad, anxious or angry it is for a short time	0.21	0.27
2. I do not keep thinking about negative experiences	0.32	0.23
3. I am able to adapt to changing situations	0.32	0.32
4. I try to be consistent in my attitudes and behaviors	0.19	0.14
5. Most of the time I can handle stress	0.26	0.18
6. I generally feel cheerful and in good spirits	0.33	0.39
7. I generally feel calm and relaxed	0.23	0.26
8. I generally feel active and vigorous	0.29	0.27
9. My daily life is filled with things that interest me	0.22	0.19
10. I wake up feeling fresh and rested	0.38	0.22
Total score	0.28	0.25
FROM ITEM 1 TO 5 - EUTHYMIA SCALE		
1. If I become sad, anxious or angry it is for a short time	0.25	0.29
2. I do not keep thinking about negative experiences	0.55	0.29
3. I am able to adapt to changing situations	0.40	0.41
4. I try to be consistent in my attitudes and behaviors	0.22	0.29

5. Most of the time I can handle stress	0.27	0.16
Total score	0.33	0.28
FROM ITEM 6 TO 10 - EUTHYMIA SCALE		
6. I generally feel cheerful and in good spirits	0.35	0.44
7. I generally feel calm and relaxed	0.26	0.20
8. I generally feel active and vigorous	0.38	0.39
9. My daily life is filled with things that interest me	0.21	0.21
10. I wake up feeling fresh and rested	0.52	0.32
Total score	0.34	0.30

Table S1. Exclusion criteria applied to diabetes type-2 outpatients and healthy subjects

	EXCLUSION CRITERIA
Type 2 diabetes outpatients	1. a medical diagnosis of type-1 diabetes, current chronic illness other than type-2 diabetes 2. current psychiatric disorders as evaluated via the Mini International Neuropsychiatric Interview [S1] 3. cognitive deficits as assessed via the Mini Mental State Examination [S2] 4. mother tongue other than Italian
Healthy subjects	1. diagnosis of type-2, type-1 diabetes, or current chronic medical illness 2. current psychiatric disorders as evaluated via the Mini International Neuropsychiatric Interview [S1] 3. self-reported cognitive deficits

	4. mother tongue other than Italian
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Table S2. Standard procedure followed to translate and pilot-test the Euthymia Scale

Two independent Native Italian translators translated the Euthymia Scale from English into Italian; the two versions were then reviewed by a senior researcher to produce a single version; another bilingual expert back translated the scale and potential discrepancies were solved. A pilot-testing was run in 10 type-2 diabetes outpatients and in 10 healthy subjects

Table S3. Detailed description of the rating scales used

The Euthymia Scale is a 10-item self-administered scale which covers the following clinical dimensions: lack of mood disturbances or, in case of a prior history of affective disorders, the subject is in full remission; refreshing/restorative sleep; the subject is cheerful, calm, active, interested in things; the subject displays psychological flexibility, resistance to stress, frustration tolerance. Each item is scored dichotomously (true/false) [1]
The WHO-5 is a 5-item self-administered scale assessing a generic state of subjective well-being. The WHO-5 showed good measurement properties [3]
The PWB is an 84-item self-reported questionnaire assessing eudaimonic psychological well-being (i.e., autonomy, environmental mastery, personal growth, purpose in life, interpersonal relationships, self-acceptance). The questionnaire has excellent internal consistency, good test-retest reliability [7]
The NEO-PI-3 is a 240-item self-reported questionnaire assessing the five basic personality traits of neuroticism, extraversion, openness to experience, agreeableness, conscientiousness. Internal consistency is excellent [8]

Table S4. Hierarchical regression analyses examining the incremental validity of the Euthymia Scale on the PWB scales. Analyses were adjusted for sex, age, education, and past psychiatric illness

	Type-2 diabetes outpatients (n = 100)			Healthy subjects (n = 100)		
	ΔR^2	R^2	β	ΔR^2	R^2	β
Criterion variable: PWB	0.12***			0.02		
Autonomy						
Step 1: WHO-5		0.10	0.10***		0.03	-0.07
Step 2: Euthymia Scale		0.22	0.74***		0.05	0.33
Criterion variable: PWB	0.10***			0.04**		
Environmental Mastery						
Step 1: WHO-5		0.20	0.36***		0.07	0.22***
Step 2: Euthymia Scale		0.30	0.66***		0.11	0.49**
Criterion variable: PWB	0.00			0.04***		
Personal Growth						
Step 1: WHO-5		0.21	0.21**		0.10	-0.06***
Step 2: Euthymia Scale		0.21	0.16		0.14	0.41*
Criterion variable: PWB	0.13***			0.04		
Purpose in life						
Step 1: WHO-5		0.19	0.27***		0.08	0.22**
Step 2: Euthymia Scale		0.32	0.75***		0.12	0.38
Criterion variable: PWB	0.05***			0.00		
Positive relations with others						
Step 1: WHO-5		0.24	0.30***		0.06	0.16***
Step 2: Euthymia Scale		0.29	0.51		0.06	0.01

Criterion variable: PWB	0.15***		0.09***	
Self-Acceptance				
Step 1: WHO-5	0.15	0.25**	0.08	0.16***
Step 2: Euthymia Scale	0.30	0.84***	0.17	0.68**

PWB: Psychological Well-Being Scales; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S5. Hierarchical regression analyses examining the incremental validity of the Euthymia Scale on the NEO-PI-3 scales. Analyses were adjusted for sex, age, education, and past psychiatric illness

	Type-2 diabetes outpatients (<i>n</i> = 100)			Healthy subjects (<i>n</i> = 100)		
	ΔR^2	R^2	β	ΔR^2	R^2	β
Criterion variable: NEO-						
PI-3 Neuroticism	0.15***			0.13***		
Step 1: WHO-5		0.29	-0.43***		0.26	-0.25***
Step 2: Euthymia Scale		0.41	-0.74***		0.40	-0.83***
Criterion variable: NEO-						
PI-3 Extraversion	0.04***			0.01***		
Step 1: WHO-5		0.28	0.39***		0.15	0.26***
Step 2: Euthymia Scale		0.32	0.43***		0.16	0.16***
Criterion variable: NEO-						
PI-3 Openness to experience	0.00			0.01*		
Step 1: WHO-5		0.17	0.15		0.11	0.12
Step 2: Euthymia Scale		0.17	0.11		0.12	0.26
Criterion variable: NEO-						
PI-3 Agreeableness	0.01**			0.00		
Step 1: WHO-5		0.16	0.15		0.14	0.25*
Step 2: Euthymia Scale		0.17	0.19		0.14	0.01
Criterion variable: NEO-						
PI-3 Conscientiousness	0.02*			0.01		
Step 1: WHO-5		0.11	0.30**		0.02	0.07
Step 2: Euthymia Scale		0.13	0.34		0.03	0.23

NEO-PI 3: Neuroticism-Extraversion-Openness Personality Inventory 3; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table S6. Concurrent validity between the Euthymia Scale and Psychological Well-Being Scales. Type-2 diabetes outpatients ($n = 100$). Pearson correlations

	1	2	3	4	5	6	7
1. Euthymia Scale	-						
2. PWB Autonomy	0.20	-					
3. PWB Environmental Mastery	0.48**	0.54**	-				
4. PWB Personal Growth	0.24*	0.40**	0.56**	-			
5. PWB Positive Relations with Others	0.41**	0.34**	0.72**	0.61**	-		
6. PWB Purpose in Life	0.42**	0.47**	0.66**	0.58**	0.63**	-	
7. PWB Self-Acceptance	0.43**	0.48**	0.80**	0.63**	0.70**	0.74**	-

PWB: Psychological Well-Being Scales; * $p < 0.05$; ** $p \leq 0.01$

$r < 0.30$ weak correlation; r from 0.30 to 0.50 moderate correlation; $r > 0.50$ strong correlation [S3]

Table S7. Concurrent validity between the Euthymia Scale and Psychological Well-Being Scales. Healthy subjects ($n = 100$). Pearson correlations

	1	2	3	4	5	6	7
1. Euthymia Scale	-						
2. PWB Autonomy	0.04	-					
3. PWB Environmental Mastery	0.30**	0.41**	-				
4. PWB Personal Growth	0.02	0.44**	0.53**	-			
5. PWB Positive Relations with Others	0.09	0.10	0.42**	0.35**	-		
6. PWB Purpose in Life	0.30**	0.21*	0.70**	0.52**	0.43**	-	
7. PWB Self-Acceptance	0.32**	0.37**	0.74**	0.45**	0.37**	0.61**	-

PWB: Psychological Well-Being Scales; * $p < 0.05$; ** $p \leq 0.01$

$r < 0.30$ weak correlation; r from 0.30 to 0.50 moderate correlation; $r > 0.50$ strong correlation [S3]

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