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An Indicator of environmental enrichment to measure physical, social and cognitive activities in human daily life

Mónica Flores-Ramos¹ , María Yoldi-Negrete² , Rodrigo Guiza-Zayas¹, Gerardo-Bernabé Ramírez-Rodríguez³ , Adolfo Montes-Castrejón¹ and Ana Fresán^{2*} 

Abstract

Background: The concept of environmental enrichment (EE) encompasses complex physical, social, cognitive, motor, and somatosensory stimuli to which individuals are differentially exposed. An indicator of EE comprising these elements would facilitate the study of the impact of EE in diverse clinical settings by allowing an easy and comparable measurement. This study aimed to create and test such an EE indicator based on the Florida Cognitive Activities Scale (FCAS), the Multidimensional Social Integration in Later Life Scale (SILLS), and the International Physical Activity Questionnaire (IPAQ).

Methods: Participants with major depression and control subjects were recruited in this cross-sectional comparative study. Depressive symptom severity was assessed with the Hamilton Depression Rating Scale (HAM-D). The EE indicator was used to evaluate cognitive, social, and physical activity. We divided the sample into three levels of cognitive and social activities to construct an EE indicator and compared the obtained scores between participants with major depression and control subjects.

Results: 40 patients suffering from major depression and 50 control subjects were included. Higher HAM-D scores were associated with lower EE levels. Cognitive and social items exhibited adequate reliability. Control subjects reported higher scores in all three activities evaluated, except for some items of physical activities. This indicator of EE clearly differentiated between participants with major depression from control subjects.

Conclusions: FCAS, SILLS, and IPAQ used together are valid to evaluate EE. This EE indicator may be a useful tool during clinical practice. The cross-sectional design and the small sample size are limitations of the present study.

Keywords: Environmental enrichment, Depression, Cognition, Physical activity, Social activity

Background

Environmental enrichment (EE) is a model that combines complex physical, social, cognitive, motor, and somatosensory stimuli that have been proven to have multiple

benefits in animals [1]. Metabolism, cognitive function, immunity, anxiety, and depression are improved by EE [2]. Their cognitive and behavioral effects seem to be mediated by several factors including growth factors, neurotransmitters, and neurotrophins such as the increased level of brain-derived neurotrophic factor (BDNF) in the hippocampus [1, 3, 4]; BDNF induction could also promote diverse biological changes in the metabolism, immunity, and suppression of cancer growth [2].

*Correspondence: a_fresan@yahoo.com.mx; fresan@imp.edu.mx

² Laboratorio de Epidemiología Clínica, Subdirección de Investigaciones Clínicas, Instituto Nacional de Psiquiatría "Ramón de la Fuente Muñiz", Calzada México-Xochimilco 101, Col. San Lorenzo Huipulco, Tlalpan, C.P. 14370 Ciudad de México, Mexico

Full list of author information is available at the end of the article



The benefits of the exposure to environmental stimuli and the consequences for brain function seen in animal models are likely to exist in humans, with many examples of the correlation between the presence of the components of poorly environmental enrichment and negative clinical consequences, i.e., the presence and impact on psychiatric disorders of poor social integration, lack of cognitive activity and diminished physical activity [5–11]. As such, depressed patients could be poorly interested in certain activities because of their symptoms [9–11], and they can serve as an example of low EE where an approximation for measuring EE could be tested.

Furthermore, the manipulation of environmental factors, alluding to the environmental enrichment provided in animal studies, seems to demonstrate similar benefic effects in clinical populations. Indeed, the exposure of humans to some of the elements of the EE have proven positive effects in psychiatric conditions, such as physical activity in depressed patients [12, 13], cognitive activities to reduce the risk of dementia [5, 14, 15] and social interaction for bipolar disorder [16]. Also, studies using a type of environmental enrichment for the rehabilitation after stroke are promising [17, 18], and some authors developed clinical EE adaptation to be also applied as a treatment for autism [19, 20] or as an adjuvant treatment for several disorders including schizophrenia, antisocial behavior, attention-deficit and hyperactivity [21].

However, the measurement of EE in humans is still controversial and the difficulties to translate this model to human life have been analyzed in some studies [22]. One of the difficulties is having a “standardized model” about EE, considering that housing conditions in animals among laboratories show differences in the complexity of EE, duration of the exposure to EE, the continuous or restricted exposure, thus making difficult its replication in rodents and its establishment for the human behavior [22–25]. In addition, it is yet not clear which components of the EE are the most important elements that benefit animals, although some reports have provided evidence of the benefits of cognitive, social, and physical activities [26–28].

An approximation to creating an instrument for measuring EE in humans could be to combine measures of the frequency of certain daily life activities related to the parameters of EE—such as social integration, cognitive activities, and physical activity—to create an integrated indicator of EE for clinical settings, which would, theoretically, adequately distinguish populations with different degrees of EE.

The aim of the present study was to validate an integrated indicator of EE obtained by combining the scores the Florida Cognitive Activities Scale (FCAS), the Multidimensional Social Integration in Later Life Scale

(SILLS), and the International Physical Activity Questionnaire (IPAQ) (all adequate and useful instruments for the assessment of cognitive activities, social integration, and physical activity, respectively). For this purpose, we determined the validity and reliability of these three instruments, and secondly, we compared the scores obtained by combining these three instruments in an integrated indicator of EE (low, moderate, and high) between two populations with different degrees of EE: a sample of control subjects and a sample of participants with major depression, used as a proxy of low EE.

We expected an adequate validity and reliability of the integrated indicator of EE, as well as in the used instruments, with a significant correlation between them, and hypothesized that participants with major depression would show lower scores on all three instruments, as well as a lower score in the indicator of EE, in comparison to control subjects.

Methods

Study design and participants

This is a cross-sectional comparative study that involved the measurement of convergent validity and internal consistency of three scales and the creation of an EE indicator.

Participants with major depression (MD) were recruited from the outpatient service at a psychiatric facility in Mexico City which provides clinical psychiatric and psychological attention. They were diagnosed with major depressive disorder in accordance with the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5) criteria; with a minimum score of 13 in the 17- items Hamilton Depression Rating Scale (HDRS). All participants were free of any psychiatric medication. Control subjects (CS) were recruited from the general population using brochures placed into and around the hospital; they were interviewed by a clinical psychiatrist to verify inclusion criteria and discard the presence of any mental disorder; also, the Mini Neuropsychiatric Interview (MINI) was applied to discard psychiatric disorders in the CS. All participants were adults (≥ 18 years old) and after the aims and procedures of the study were fully explained, they gave their oral and written informed consent for their participation in the study guaranteeing the anonymity of their information, which was only be used for research purposes. The study was approved by the ethics committee of the National Institute of Psychiatry (CEI/C/041/2020).

Assessment procedure

Demographic information such as gender, age, years of education, marital and occupational status was assessed with a face-to-face interview with all participants. For

those with major depressive disorder, additional clinical information was obtained, such as the age of illness onset, illness evolution (years), current episode features (with anxious or melancholic symptoms), and duration in weeks.

The following three scales were adapted and used together for the assessment of the environmental enrichment and were answered by participants with major depression and by control subjects.

- 1) Florida Cognitive Activities Scale (FCAS). This scale comprises 25-self reported items that assess activities of different levels of cognitive effort (e.g. listen to music vs. write a text) performed during the last month answered on a 5-point Likert frequency scale (0 = never did this activity to 4 = do this activity every day). A total score is obtained by the sum of the individual item scores with higher scores reflecting a higher level of cognition. The scale has shown moderate values of reliability and validity with authors suggesting further cross-validation studies [29].
- 2) Multidimensional Social Integration in Later Life Scale (SILLS). This scale comprises 22-self-reported items assessing social integration in accordance with the performance of several activities during the last month (e.g., get together with the family, get together with friends, go to a gym, etc.). All items are scored on a 5-point Likert frequency scale (0 = never did this activity to 4 = do this activity every day). Eight additional items assessed satisfaction with social integration and are scored on a 5-point Likert satisfaction scale (0 = very unsatisfied to 4 = very satisfied). Therefore, two separate scores (social integration and satisfaction) and a total SILLS score (the sum of social integration and satisfaction scores) can be obtained. Higher scores reflect higher social integration. In the study where the scale was developed, the overall internal consistency of the scale was adequate (Cronbach's alpha = 0.86) [30].
- 3) International Physical Activity Questionnaire (IPAQ). The short version of 7 items of the IPAQ was used for the present study. Items assessed the frequency (days per week), intensity (intense and moderate activities, walking and sitting), and duration (all assessed in minutes per day except for sitting which was evaluated by hours per day) of physical activities. This questionnaire has become one of the most widely used physical activity questionnaires and the short version is mostly used for surveillance purposes in several countries [31–33]. Weekly activity is reported in metabolic equivalent of task (MET) and three main categories of activity (low, moderate, high) can also be determined [34]. Moderate reliability and

validity values have been reported in the Mexican adult population [35], although its utility for surveillance purposes has been continuously reported.

In addition to the assessment of parameters related to EE with these scales, depressive symptom severity was assessed in all participants with the 17-item Hamilton Depression Rating Scale (HAM-D), one of the widest clinician-administered depression scales [36] with adequate concurrent validity values for its use in Mexican population [37].

Statistical analysis

For sample description, frequencies and percentages for categorical variables and means and standard deviations (S.D.) for continuous variables were used. Demographic features were compared between groups using chi-square (χ^2) tests for categorical variables and independent-sample t-tests for the comparison of continuous variables.

To evaluate convergent validity of the scales assessing the environment enrichment, Pearson correlation coefficients of the total scores of the FCAS, SILLS, and IPAQ with the total score of the HAM-D were determined as well as the correlation between the three environmental enrichment scales. Reliability of the FCAS, SILLS, and IPAQ scales was determined with Cronbach's alpha, with acceptable reliability values equal to or greater than 0.75. To test the hypothesis of a lower environmental enrichment in participants with major depression, independent samples t-tests were used to compare the total scores of the FCAS, SILLS, and IPAQ between participants with depression and control subjects.

To determine the EE indicator, we used the scores of the FCAS and SILLS of control subjects, dividing the scores into three main levels (low, moderate, and high) according to percentile 33.3 and 66.6, while these levels are already defined for the IPAQ. We define low, moderate, and high EE according to the following definitions:

Low EE: 2 or 3 of the cognitive, social, and physical dimensions identified in the low category.

Moderate EE: 2 or 3 of the cognitive, social, and physical dimensions identified in the moderate category or one category identified as low, another as moderate, and the third one as high.

High EE: 2 or 3 of the cognitive, social, and physical dimensions identified in the high category.

In accordance with these definitions, the EE levels were described and compared between participants with depression and control subjects.

Table 1 Demographic features between CS and MD participants

	Control subjects n = 50	Major depression n = 40	Statistic
Gender – Women n %	35 70	33 82.5	$\chi^2 = 1.8, df 1, p = 0.17$
Age (years) Mean S.D.	30.1 11.0	31.0 10.7	$t = -0.3, df 88, p = 0.69$
Marital status - single n %	39 78.0	31 77.5	$\chi^2 = 0.6, df 2, p = 0.71$
Education (years) Mean S.D.	16.0 3.8	14.1 3.1	$t = 2.5, df 88, p = 0.01$
Occupation n %			
Unemployed	2 4.0	8 20.0	
Housewife activities	1 2.0	4 10.0	$\chi^2 = 9.2, df 3, p = 0.02$
Students	33 66.0	13 32.5	
Remunerated activity	24 48.0	15 37.5	

Table 2 Convergent validity of the enriched environment scales – Pearson correlations with the HAM-D total score

Enriched environment scales	Ham-D Total score r (p)
Florida Cognitive Scale (FCAS total score)	-0.48 (< 0.001)
Multidimensional Social Integration in Later Life Scale (SILLS)	
Social integration dimension	-0.53 (< 0.001)
Satisfaction dimension	-0.43 (< 0.001)
Total score	-0.55 (< 0.001)
International Physical Activity Questionnaire (IPAC total score)	-0.39 (< 0.001)

All analyses were performed with the SPSS 21.0 software for Windows and the significance level for tests was established at $p \leq 0.05$.

Results

Sample description

A total of 90 participants were included for the study, 40 (44.4%) were participants with major depression and 50 (55.6%), control subjects. Most of the participants were women and single in both groups, with similar age at the time of the study. CS reported more years of education than MD. A higher number of MD participants were unemployed or dedicated to housewife activities (See Table 1).

For MD participants, the age of illness onset was at 21.2 (S.D.=8.9years – reported by 38 participants) with a total illness evolution of 8.9years (S.D.=8.5). The mean duration of the current episode was 26.2 (S.D.=28.2) weeks. The total score of the Hamilton Depression Rating Scale was higher in MD participants than in CS (22.8, S.D. 5.3 vs. 3.9, S.D.=2.8, $t = -21.5, 88 df, p < .001$) reflecting severe depression in the first group [38].

Convergent validity and internal consistency of the EE indicator

To obtain the convergent validity of the scale, we used the total score of the Hamilton Depression

Table 3 Internal consistency of the enriched environment scales: total sample, CS participants and MD participants

	Total sample n = 90	Control subjects n = 50	Major depression n = 40
Florida Cognitive Scale (FCAS)	0.85	0.78	0.84
Multidimensional Social Integration Scale (SILLS)			
Social integration dimension	0.91	0.88	0.88
Satisfaction dimension	0.86	0.80	0.86
Total score	0.92	0.88	0.91
International Physical Activity Questionnaire (IPAC)	0.23	0.07	0.29

Rating Scale. As seen in Table 2, the correlation analysis showed that higher depressive symptom severity is associated with lower levels of cognition (FCAS score), lower social integration, satisfaction, and global social integration (SILLS total scores), and lower weekly activity reported in metabolic equivalent of task (IPAQ total score).

Internal consistency of the scale was obtained for the total sample and CS participants and MD participants. All the scales, except for the IPAQ exhibited adequate Cronbach’s alpha values (see Table 3).

Comparison of scale results between control subjects and participants with major depression

Due to the low reliability obtained from the IPAQ, we decided to perform the comparison between groups of each of the IPAQ items and the total score. In general, CS reported higher scores in all items, except for item 5 “days per week walking”, item 6 “minutes of walking per day”, and item 7 “hours sitting in a business day in the last week”, where both groups display similar scores (see Table 4).

Environmental enrichment Indicator

The percentiles for dividing the sample into three levels for the FCAS (cognitive activities) were as follows: Low cognitive activities (score from 0 to 42), moderate cognitive activities (score from 43 to 56), and high cognitive activities (score from 57 onwards). For social integration (SILLS scale) levels were defined as follows: Low social integration (score from 0 to 78), moderate social integration (score from 79 to 98), and high social integration (score from 99 onwards).

The comparison between control subjects and participants with major depression showed that the latter exhibited lower levels of cognitive activities, social integration, and physical activities. We highlighted that 72.5% of participants with major depression report a low environmental enrichment when compared to the 24.0% reported by control subjects (see Table 5).

Discussion

Environmental enrichment is a broad concept that has been studied predominantly in animals, generating promising evidence for the prevention and treatment of mental disorders. Therefore, translational research on humans could be an important opportunity to evaluate the effects of the main EE components in human beings. Thus, our main objective was to create an indicator to measure EE based on cognitive, social, and physical activities performed daily, for clinical populations.

We observed that the internal consistency of the FCAS and SILLS was high as reflected by a Cronbach’s alpha > 0.8. However, the IPAQ had a low internal consistency, a finding coherent with other studies including a meta-analysis to validate IPAQ which reported high variability in the studies and lower correlation with objective measures of physical activities [39]. These differences could be derived from the evaluation of moderate-to-vigorous physical activity (MVPA) and the sedentary life. However, our results support its usefulness for discriminating subjects with less physical activity (patients with depression) when compared to control subjects and, along with the cognitive and social instruments, showed an inverse correlation with the HAM-D scores, confirming the validity of the instruments [40].

The comparison between participants with major depression and control subjects confirmed our hypothesis: this indicator clearly distinguishes between depressed subjects and controls, a finding that renders this EE indicator a promising tool for clinical practice and EE research.

Table 4 Comparative analysis of the enriched environment scales: Data from CS participants and MD participants

	Control subjects n = 50 Mean (S.D.)	Major depression n = 40 Mean (S.D.)	Statistic
Florida Cognitive Scale (FCAS)	47.9 (11.1)	34.8 (12.5)	t = 5.2, p < 0.001
Multidimensional Social Integration Scale (SILLS)			
Social integration dimension	60.2 (12.8)	45.4 (11.4)	t = 5.6, p < 0.001
Satisfaction dimension	28.5 (5.0)	22.6 (6.3)	t = 4.8, p < 0.001
Total score	88.7 (15.1)	68.1 (15.8)	t = 6.2, p < 0.001
International Physical Activity Questionnaire (IPAQ)			
Intense activities - days per week	3.0 (2.2)	1.3 (2.0)	t = 3.6, p < 0.001
Intense activities - minutes per day	41.3 (34.9)	24.2 (42.7)	t = 2.0, p = 0.04
Moderate activities - days per week	2.4 (2.1)	1.3 (1.7)	t = 2.6, p = 0.01
Moderate activities - minutes per day	35.7 (39.5)	17.0 (25.0)	t = 2.5, p = 0.01
Walking - days per week	4.8 (2.2)	4.1 (2.4)	t = 1.3, p = 0.17
Walking - minutes per day	40.7 (35.2)	32.5 (31.2)	t = 1.1, p = 0.24
Sitting - hours in a business day in the last week	7.1 (3.6)	7.3 (3.2)	t = -0.2, p = 0.78
Total score (MET)	2559.3 (1958.9)	1345.0 (1334.7)	t = 3.3, p = 0.001

Table 5 Levels of cognitive activities, social integration, physical activity, and level of environmental enrichment

	Total sample n = 90	Control Subjects n = 50	Major depression n = 40	Statistics
Level of cognitive activities n %				
Low	48 53.3	17 34.0	31 77.5	$\chi^2 = 17.0, p < 0.001$
Moderate	25 27.8	19 38.0	6 15.0	
High	17 18.9	14 28.0	3 7.5	
Level of social integration n %				
Low	48 53.3	17 34.0	31 77.5	$\chi^2 = 18.5, p < 0.001$
Moderate	23 25.6	16 32.0	7 17.5	
High	19 21.1	17 34.0	2 5.0	
Level of physical activities n %				
Low	22 24.5	8 16.0	14 35.0	$\chi^2 = 14.0, p = 0.001$
Moderate	28 31.1	11 22.0	17 42.5	
High	40 44.4	31 62.0	9 22.5	
Level of environmental enrichment n %				
Low	41 45.6	12 24.0	29 72.5	$\chi^2 = 23.1, p < 0.001$
Moderate	29 32.2	20 40.0	9 22.5	
High	20 22.2	18 36.0	2 5.0	

The most important limitation of the present study is the sample size, particularly as three different levels of environmental enrichment were established and analyzed, additional research should include larger samples sizes to avoid biases and support or not our results. Another limitation is the low generalizability of our findings as the recruitment was performed in a single location, and comparisons were performed with only one clinical entity. Also, the cut-off points obtained from the SILLS and FCAS scales were determined based on statistical procedures and not by sensitivity and sensibility analysis, which should be performed in future studies using other procedures. In addition, self-reporting of social integration and cognitive effort should be taken with caution as participants may include other problems not related to what the scales evaluate, may under- or over qualify these features, or may even be affected by social desirability. Other studies could investigate whether different approximations to measuring physical activity would further improve the accuracy of this EE indicator for detecting low EE environments. One last concern is the use of self-reported measures to evaluate EE, as.

Despite these important limitations, the relevance of the present study relies on the creation of an EE indicator that can be used to translate the investigations of the fascinating field of EE to humans. Thus, our study points to the direction of the relevance of the exposure to environmental stimuli to prevent depression. In this line, a previous study performed in rodents suggests that EE provided by cognitive, social, and physical stimuli prevent the development of depression-like behavior [41].

Then, the results of our study reflect an early approximation in the long road searching for an accurate evaluation of daily activities related to the so-called environmental enrichment in humans. The importance of an accurate assessment of these variables is now undeniable, as the aim of clinical treatment evolves from mere symptomatic recovery to an improvement in the quality of life as is suggested by studies done in animal models [42, 43].

Conclusion

We consider that the proposed EE indicator is valid to be used in clinical settings and allows us to evaluate the grade of EE according to daily activities in healthy people and depressed patients.

Abbreviations

CS: Control subjects; EE: Environmental enrichment; FCAS: Florida Cognitive Activities Scale; IPAQ: International Physical Activity Questionnaire; MD: Major depression; MET: Metabolic equivalent of task; MVPA: Moderate-to-vigorous physical activity; SILLS: Multidimensional Social Integration in Later Life Scale.

Acknowledgments

Not applicable.

Authors' contributions

MFR participated in the study protocol conceptualization, methodology, and manuscript elaboration. MYN contributed to manuscript drafting and revision for important intellectual content. RGZ contributed to the logistic procedures of the study, participants recruitment and evaluation, database management manuscript drafting and review. GBRR participated in the study conceptualization, data interpretation, manuscript review and editing. AMC contributed to the participants' recruitment and evaluation, data collection, database management, manuscript drafting and review. AFO conceived and designed the study protocol, carried out the data analysis, and contributed to manuscript drafting and revision for important intellectual content. All the authors reviewed and approved the final manuscript.

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Availability of data and materials

The information analyzed in the current study is not publicly available due to the confidentiality of the participants but is available from the corresponding author on request.

Declarations

Ethics approval and consent to participate

All methods were carried out in accordance with Good Clinical Practices and the Declaration of Helsinki. Also, all participants gave their oral and written informed consent to participate in the study which was approved by the Ethics Committee of the National Institute of Psychiatry (CEI/C/041/2020).

Consent for publication

Not applicable.

Competing interests

All authors declare that they have no competing interests.

Author details

¹Dirección de Enseñanza, Instituto Nacional de Psiquiatría "Ramón de la Fuente Muñiz", Calzada México-Xochimilco 101, Col. San Lorenzo Huipulco, Tlalpan, C.P. 14370 Ciudad de México, Mexico. ²Laboratorio de Epidemiología Clínica, Subdirección de Investigaciones Clínicas, Instituto Nacional de Psiquiatría "Ramón de la Fuente Muñiz", Calzada México-Xochimilco 101, Col. San Lorenzo Huipulco, Tlalpan, C.P. 14370 Ciudad de México, Mexico. ³Laboratorio de Neurogénesis, Subdirección de Investigaciones Clínicas, Instituto Nacional de Psiquiatría "Ramón de la Fuente Muñiz", Calzada México-Xochimilco 101, Col. San Lorenzo Huipulco, Tlalpan, C.P. 14370 Ciudad de México, Mexico.

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