Development And Psychometric Validation of the Profile of Neuropsychiatric Symptoms (Pons) Scale for Efficient Pediatric Neuropsychiatric Screening

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Abstract

PONS is a short, accurate and reliable tool used to check a wide range of neuropsychiatric symptoms in children and adolescents. Developed with extensive expert input and user feedback, PONS assesses key domains including attention deficit hyperactivity disorder, autism spectrum disorders, psychoses, personality dysfunction, anxiety, and depression within a 10-minute timeframe. Implemented via the HealthTracker™ platform, it offers online accessibility and developmental-age adaptation, facilitating efficient clinical assessment and remote monitoring. The tool proved to be reliable (Cronbach's alpha of 0.96), had a suitable factor structure and helped in distinguishing between patients and the general population. The PONS scale supports timely symptom identification, AI-assisted triage, and improved patient management. While certain limitations exist, including sample size and normative data scope, PONS represents a significant advancement in pediatric neuropsychiatric assessment. Future research should focus on validation across diverse populations and longitudinal sensitivity to symptom changes.

Keywords: Neuropsychiatric symptoms; Pediatric assessment; ADHD; Autism spectrum disorder; HealthTracker™; Psychometric validation

INTRODUCTION

Among children and adolescents, there are many mental disorders and a significant number of them suffer from disabilities in everyday life [1]. Even so, many of the people affected by BIDs are unable to find mental health specialists. Assessing how much these disorders affect this population has gradually become easier with the use of various interview and survey tools [2]. Neuropsychiatric PCOMs take a lot of time and can miss some important aspects of a patient's health. In most cases, kids with mental health issues show signs of a number of emotional or behavioral problems such as attention deficit hyperactivity disorder and disorders on the autism spectrum [5]. At this time, ratings for specific disorders are not available for children nor for parents, making it challenging to use them alone. It is essential to have brief PCOMs that outline the main symptoms of various disorders at the same time [6]. Genetics, neuroscience and behavioral science are used in this technique to progress from the present approaches used to identify mental illness. Having PCOMs online gives those with neurodisabilities timely data and access to assist them in medical care. The platform is made for monitoring health, providing options for different forms of questionnaires and automatically assigning them depending on the child's stage of development [7]. PONS was introduced to fix some of the gaps in existing tests by screening for symptoms relating to ADHD, ASD and psychoses, among other disorders.
Following FDA and NIH guidelines, the PONS tries to measure how symptoms occur and their effects on patients as time goes by [8]. The online version of the PONS is designed following both PROMIS and FDA guidelines. PONS adapts to the needs of parents, teachers and clinicians. Both the reliability and precision of the parent version of PONS are studied among children and children with neuropsychiatric disorders to help with diagnosing their symptoms.

Methodology
The participants involved in the study consisted of children, adolescents and their parents, who each gave their written agreement to participate. After getting consent, the study instruments were completed by participants who were in the control group. On the other hand, data from patients receiving clinical care were obtained in an anonymous fashion. Clinic visits included the use of the Profile of Neuropsychiatric Symptoms (PONS) scale. This type of scale uses descriptions of various symptoms in different domains to make it easier to understand each symptom's presence, instead of just listing certain items. A list of symptom domains for NDDs came from the agreement of experts and informed by thorough research [9]. To develop the PONS scale, child psychiatrists, pediatricians, neurodevelopmental pediatricians, psychologists and occupational therapists were invited as experts and joined the panel. During the meeting, each

participant scored how significant each domain was and every domain was accepted by all. During this step, any areas that described the same symptoms were condensed or removed. Young people and their parents were given the newest version of the PONS scale to offer their ideas on how accurate and straightforward it was. A separate group discussion took place with youth and another with parents, so that both groups could discuss the structure of the questions, the different response options, overall clarity of content, how often the scale should be used and the period between the actions and when they are recalled. The development of the PONS scale was completed based on summaries of the conversations in the focus groups. Some diagnoses outside this one were mentioned, including attention deficit hyperactivity disorder, autism spectrum disorders, psychoses, bipolar disorder, anxiety and depression. There were 30 domains on the PONS questionnaire (parent response), with each rated on a seven-point Likert scale. The choice was made because it was reported that seven-point Likert scales give a better understanding of minute changes occurring over time. Both researchers and clinicians used the PONS scales which were implemented in the HealthTrackerTM system.

STATISTICAL ANALYSES

The analysis was performed via the software SPSS 20. All the information was examined using descriptive statistics. I determined how reliable the research was by looking at Cronbach's alpha, alpha if deleted analysis, intraclass correlation and factor analysis involving the general population. Five rounds of Promax rotation and five rounds of Kaiser normalization were carried out in exploratory factor analysis. The principal axes could be found without knowing the number of factors involved. Based on the results, 0.25 (Kappa = 4) using Promax rotation was the amount that produced the greatest convergence. We determine the point at which the factors begin to impact the market. Since the purpose of the study was exploratory and the sample was moderate, the loading threshold for the factors was fixed at >0.25. If the gap between the loadings was larger than 0.2, that difference was considered important and given greater weight. To ensure the data set offers adequate overlap, the researchers looked at KMO, as well as Bartlett's and Kaiser-Meyer-Olikin sphericity tests.

RESULTS

Phase 1 involved working out the qualitative part of the PONS scale.
Such support was given for the PONS by focusing on particular areas of dysfunction, because adding several items to each domain would make the scale longer and less attractive to most users. The study put together the PONS scale (parent) consisting of 30 symptom areas. In all fields, the questions include the name of the problem, a description of it and two subjects dealing with the frequency and intensity of the impairment. Therefore, HealthTracker only asks about impairment if the individual experienced a condition in the past year. All members of the focus groups strongly mentioned and supported this option. All symptoms were rated from 0 to 6 points and the rating was collected for a month prior to the assessment.

Phase 2 an evaluation of the PONS scale was performed among the subjects.
Out of the 147 children and adolescents included in this group, some had more than one neuropsychiatric condition. 14 percent of these students were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD), one out of every six had autism, one out of every four had either oppositional defiance disorder (ODD) or conduct disorder, one out of twenty-one percent had bipolar disorder, 51.4% had anxiety or depression, 25.9% were found to have developmental coordination disorder and 24.4% were diagnosed with obsessive compulsive disorder.

Reliability

Factor analysis
After performing a factor analysis, it was found that a 4-factor model best explained the information from the 30 symptom domains. According to the study, the four factors were divided into these five groups: (1) Diseases where the main symptoms are ADHD and ASD, (2) An ODD and CD, (3) Any psychosis, differing blood pressure, growing PD and insistent abnormal movements, (4) Any anxiety or depression. Generally, these factors are managed by using clusters of clinical and diagnostic interventions for children and adolescents with mental health concerns. The value of KMO was 0.774 and the results of Bartlett's test were 378 with p = 0.001 and X2 20,507, 54.

Internal consistency
Cronbach's alpha revealed that the alpha for the 30 PONS symptoms domains (items here) is 0.96. All associations between different items were positive and the correlation between each item and the scale total was over 0.20. It was also found that none of the items could be eliminated, as this would lead to a decrease in Cronbach's alpha.

Intra-class correlation

Apart from the correlation of single measures among classes, the average measures had a value of 0.96 (95 % CI: 0.95-0.96), with an F-test statistic of 22.84 and a statistically significant p-value (p ≤ 0.001).

Validity

ROC test is one tool used in diagnostics. The table demonstrates that the area under the ROC curve for the 4-factors was 0.96 (SE = 0.006; 95 % CI: 0.95-0.97). You can see the outcomes from the ROC analysis for all the factors listed in Table 2.

T-test analysis

Patients with ASDs had a higher Neurodevelopmental Disability score compared to those with ADHD (p < 0.001). Between ODD and CD patients, the Behavioural and Emotional Dysregulation score differed significantly (p <0.001). Those people also often ranked higher for Psychoses and Personality Dysfunction (p<.0022). In the end, people struggling with depression and/or anxiety said they had higher anxiety and depression than others.

Table 1: The PONS parent-version was analyzed using population-wide data.

Domains	Neurodevelopmental Disability	Behaviour and Emotional Dysregulation	Psychoses and Personality Dysfunction	Anxiety and Depression
Language problems	0.695	0.061	0.075	0.048
Clumsiness	0.658	-0.145	0.132	0.120
Difficulties learning	0.679	0.002	-0.081	0.112
Social communication difficulties	0.616	0.031	0.063	0.093
Inattention	0.612	0.383	-0.201	-0.033
Mannerisms	0.566	-0.067	0.472	-0.159
Impulsivity	0.573	0.478	-0.096	-0.130
Hyperactivity	0.559	0.372	0.080	-0.197
Cognitive rigidity	0.547	0.158	-0.067	0.236
Sensory symptoms	0.518	-0.206	0.148	0.296
Circumscribed interests	0.423	0.044	0.217	0.123
Obsessions compulsions	0.408	-0.091	0.287	0.262
Body control	0.369	0.019	0.283	-0.115
Aggression	-0.059	0.887	0.038	0.008
Oppositionality	0.121	0.828	-0.107	-0.026
Explosive rage	0.222	0.726	0.024	0.108
Lack remorse	0.153	0.572	0.098	0.086
Labile mood	0.078	0.555	0.009	0.268
Eating problems	0.187	0.233	0.077	0.091
Hallucinations	0.021	-0.138	0.711	0.081
Spontaneous abnormal movements	0.232	-0.092	0.665	-0.159
Self-injury	0.044	0.151	0.531	0.078
Antisocial behaviour	-0.154	0.419	0.521	-0.072
Paranoid thoughts	-0.083	0.176	0.374	0.334
Manic symptoms	0.211	0.152	0.345	0.138
Worries	0.174	0.055	-0.147	0.731
Low mood	-0.045	0.178	0.007	0.682
Fears	0.190	-0.113	-0.071	0.611
Depressive thoughts	-0.245	0.261	0.338	0.501
Sleep problems	0.277	0.196	-0.061	0.308

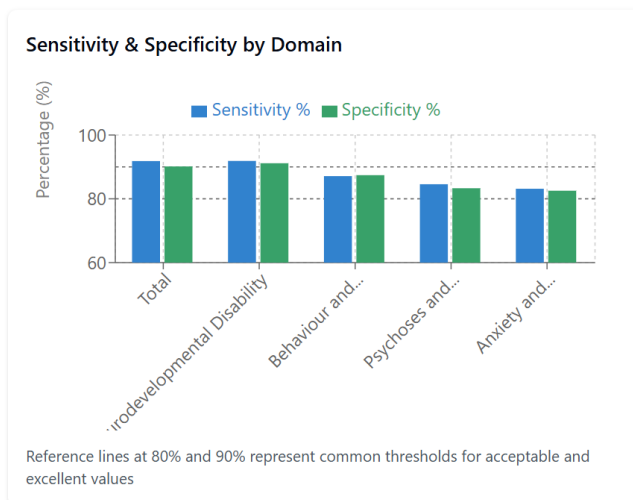**Figure 1: Factor Loadings Analysis**
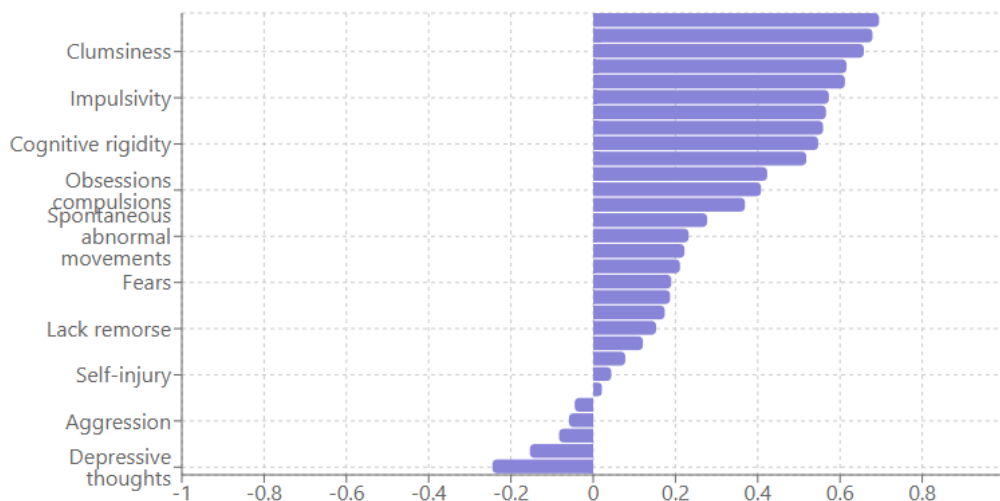
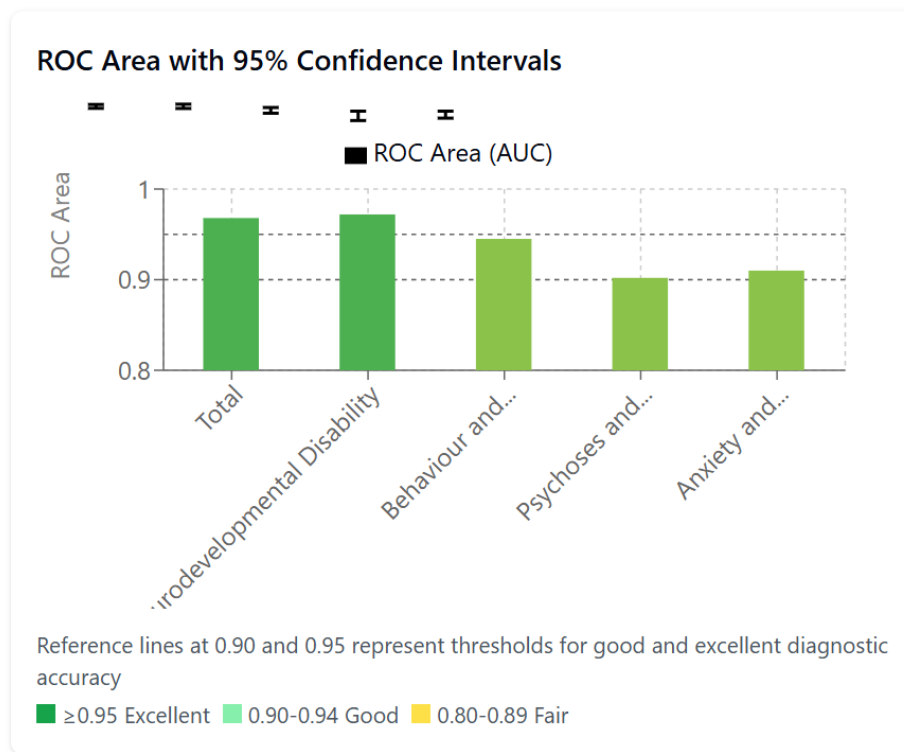**Key Symptoms for Neurodevelopmental Disability:**

- **Language problems**: 0.695
- **Difficulties learning**: 0.679
- **Clumsiness**: 0.658
- **Social communication difficulties**: 0.616
- **Inattention**: 0.612
- **Impulsivity**: 0.573

Table 2: General population and clinical sample

Domains	PONS Cut Off Scores	Sensitivity (%)	Specificity (%)	ROC Area	SE	Asymptotic Normal Lower	Asymptotic Normal Upper
Total	≥77.58	91.83	90.15	0.968	0.008	0.948	0.972
Neurodevelopmental Disability	≥37.62	91.87	91.15	0.972	0.007	0.947	0.974
Behaviour and Emotional Dysregulation	≥19.57	87.11	87.41	0.945	0.011	0.917	0.953
Psychoses and Personality Dysfunction	≥4.66	84.57	83.31	0.902	0.016	0.871	0.930
Anxiety and Depression	≥11.76	83.15	82.54	0.910	0.013	0.886	0.930

Figure 2: PONS Cut-Off Score Analysis

ROC Area with 95% Confidence Intervals

Reference lines at 0.90 and 0.95 represent thresholds for good and excellent diagnostic accuracy

■ ≥0.95 Excellent ■ 0.90-0.94 Good ■ 0.80-0.89 Fair

DISCUSSION

It is made up of 30 domains and requires scorers to state the frequency and level of difficulty for each which takes 10 minutes. The PONS allows us to add the ratings for attention deficit hyperactivity disorder and autism spectrum disorders by children and parents to the symptoms of schizophrenia, bipolar disorder, emerging personality disorders, anxiety and depression, all on one simple scale [11-14]. The PONS scale allows for the reliable and accurate screening of psychiatric disorders in children and teens with neuropsychiatric issues. It was shown that the scores from the symptom domains were very dependable and clearly indicated that they are all measuring the same important aspect. In addition, the domains showed a high level of association, but the full instrument only had a medium level of connection, meaning the domains are all different.

PONS' structure follows the same structure as the PROMIS domains. For example, the PROMIS Peer Relationship, Anger domain and Paediatric Anxiety and Depression areas may be impacted by four PONS factors: Neurodevelopmental Disability, Behavioural and Emotional Dysregulation, Psychoses and Anxiety and Depression. PROMISE does not currently cover issues such as psychological disorders and personality dysfunction in children. Apart from listing ADHD, autism spectrum disorders, obsessive compulsive disorders, motor coordination disorders, disruptive disorders such as ODD and Conduct Disorder, the PONS is unique in detecting depressive, anxious and bipolar symptoms. No measure can successfully assess all these changes in a patient in only 10 minutes at this time. The SDQ [15] is a popular and valid questionnaire, though it omits psychoses, personality disorders and bipolar problems and also isn't used for comparing changes after consultations. CBCL [16] takes a lot of time and cannot be happened in under 10 minutes. Parents cannot currently use online tools such as audio or animation for the child editions of PONS. There is explicit validation for using PONS on the web. Due to the NIH Research Domain Criteria (RDoC) guidelines, the PONS is structured differently than other tools. Moreover, the parents appreciated that PONS uses the PCOM format and was created with complete involvement from the users. It would be used more if the PCOM is efficient, accessible through the internet, offers branching to support learning progress, gives help with audio for those who have a hard time reading, provides easier-to-read materials for visual difficulties and is presented in several languages. All of this progress is thanks to the PONS system used on HealthTrackerTM.As a result, people will complete more questionnaires and be examined remotely when far from medical facilities, AI-based triaging could be set up and clinicians will receive fast scoring for the patients they see in the clinic, even if the exam was done while the patient was waiting. The focus group revealed that parents were very pleased with the information provided. With HealthTrackerTM'sintelligent system functioning online, learners spend less time completing the course. In addition, HealthTrackerTM randomly arranges the different symptom domains, so results are more resistant to the repetition effect.[18]

A specific test has been carried out on HealthTrackerTM that makes it convenient for children, adolescents and parents to use. A recorded voice can be used to listen to the scale, making it much easier for those with dyslexia. PONS

programs are picked using developmental age, rather than how old the person is which is necessary for people with neurological conditions. The HealthTrackerTM system can be applicable to neuropsychiatric screenings and to triage in busy clinics. The system will do the calculations and display your results as a graph using HealthTrackerTM. Feedback can be provided in the moment which allows time spent in the clinic to be used wisely, whether in person or online.

An issue with this study is that PONS was developed mainly to help quickly assess and handle patients. After finishing the tests, we included the instrument in epidemiological work and explored its value similar to that of other approaches. [19]Because the Hollingshead Scale is used online, all its normative data must be gathered using the internet. As a result, we did not check every internet submission and we used Receiver Operating Characteristics with PONS test scores from the general population and clinical group to identify the PSN cutoff scores Most of the errors should be small since we enrolled so many participants. Also, using the test where it is meant to be helps more than it hinders. Even though the sample is small, it was part of the UK nationwide CAMHS which may not reflect the kinds of symptoms seen in community CAMHS by mildly ill children.

In spite of this, PONS was able to identify psychiatric disorders in this group of patients. In communities, psychiatric teams focused on neurodisability should evaluate the correctness of PONS-based diagnoses in children and adolescents. This information will be helpful for future research on the changes in a person's symptoms and level of impairment.

CONCLUSION

With this brief and dependable tool, any number of neuropsychiatric issues in children and adolescents can be routinely identified. Paired with its efficiency, PONS ensures that clinicians can assess all relevant symptoms of ADHD, autism spectrum disorders, psychoses, personality dysfunctions, anxiety and depression in people living with varied conditions and within only 10 minutes. The input of many experts and thorough user feedback allowed us to keep the text relevant to clinicians, easy to understand and accessible for users, adding more benefits through being available online and adapted for diverse ages. Researchers have shown that the scale demonstrates the qualities of excellent internal consistency, good factor structure and strong discriminative validity. Besides, PONS is advantageous for clinics since it allows for early and reliable symptom description, supports remote assessments and uses AI to direct triage through the HealthTrackerTM system. PONS remains a notable improvement in evaluating children and teenagers with neurological and psychiatric conditions, despite certain shortcomings. In the future, investigations should concentrate on using the PONS in diverse medical conditions and determining how the scores vary over time. All in all, PONS may aid clinicians, researchers and families in detecting, treating and following up on neuropsychiatric problems among young people.

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