

Development of a Artificial Intelligence Dental Anxiety Scale (AI - CDAS) For Children: Validation And Reliability

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Assessing children's pain using patient-based pain scales can be challenging. Hence, there is a need of new version Artificial Intelligence Child Dental Anxiety Scale (AI-CDAS) to scale and test its psychometric properties (validity and reliability). This study was conducted to evaluate the validity and reliability of Artificial Intelligence version of the Child Dental Anxiety Scale (AI-CDAS) for anxiety detection scale in children using face as a response set from October 2022 to December 2023. Aim of this study was to examine the reliability and validity of Artificial Intelligence based Child Dental Anxiety Scale (AI-CDAS) using a wide range of age samples in dental clinics. A total of 100 outpatients (Age 03-09 years) from Bharati Vidyapeeth Deemed to be University Dental College and Hospital, Pune, India participated in this study. Dental anxiety was assessed using the Artificial Intelligence Child Dental Anxiety Scale (AI-CDAS) and comparing with a valid and reliable scale of Colored Version of Modified Facial Affective Scale. Reliability and validity was good and significant correlations were found between the AI-CDAS and the Colored Version of Modified Facial Affective Scale. This study suggests that the Artificial Intelligence based Child Dental Anxiety Scale (AI-CDAS) is a valid and reliable measure for assessing children's dental anxiety and may help encourage dentists to formally assess dental anxiety scale in day to day practice. Self-report measures are commonly employed in dental anxiety assessments. One advantage of self report measures is the ease of administration, taking relatively short period of time to complete. They can also assess the reaction to different aspects of the dental experience.

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Introduction

In order to improve children's dental wellbeing, pediatric dentists believe that treating kids properly during their dental visits and promoting a positive dental attitude are essential. Compared to other age groups linked to dental issues, dental anxiety in children is more complex since children are more sensitive and have less ability to communicate their emotions. Henceforth, it is very crucial to identify the distress or anxiety related behavior among the children in the earliest duration. Dental Anxiety (DA) is a complicated psychological phenomenon comprising physiological, psychological and social aspects associated with the patient who is visiting the dentist. Patients who are associated with extreme range of dental anxiety undergo distress and deny or postpone the needed medication responsible for decline in quality of dental wellness and deterioration of disorder¹. DA illustrates excessive and uncertain adverse emotion expressed by vulnerable patients, specifically children. Unsurprisingly, anxiety is related to the behavior that can be identified as the most significant factor

in dental treatment. As a result, assessment of dental anxiety has gained a lot of attention and is used extensively in pediatric dentistry. The practice is used as a guideline for treating individual children to deal with dental abnormalities effectively².

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Several studies³ illustrated that before obtaining therapeutic assistance it is very significant to identify dental anxiety so that a behavior management approach can be utilized that is medicinal and non - pharmacological practice in order to obtain successful oral therapy. To assess children's dental fear and anxiety, several measurement instruments are used, and dental anxiety can be initiated for varying lengths of time.

The Child Dental Anxiety Scale (CDAS):

Dental anxiety, especially in pediatric patients, poses a significant challenge in providing comprehensive oral healthcare. The Child Dental Anxiety Scale, a widely accepted instrument, traditionally relies on self-reported measures to gauge anxiety levels in young dental patients⁴. However, the subjective nature of self-reports can introduce variability and biases into the assessment process. Integrating AI into the CDAS aims to mitigate these challenges by providing a more standardized and objective evaluation.

Why Consider AI for Child Dental Anxiety Assessment?

Traditional methods often rely on self-reporting or parental observations, prone to biases and inaccuracies. Children might struggle to express their fears, and parents might misinterpret their anxiety levels.

AI offers a potentially objective and efficient approach:

Reduced subjectivity: AI algorithms can analyze facial expressions, body language and physiological responses like voice tremors or heart rate during dental procedures, capturing subtle cues children might not express verbally.

Convenience and efficiency: AI-based assessment could be quicker and less intimidating for children, potentially minimizing the time spent in the dental chair.

Real-time feedback: AI systems can provide instant feedback to dentists, guiding their interaction with anxious children and tailoring their approach to individual needs.

Traditionally, the CDAS has been a valuable tool⁵. Recognizing the need for more precise and objective assessment tools, researchers have turned to artificial intelligence (AI) to enhance traditional measures. This article delves into the reliability and validity of an AI-empowered version of the Child Dental Anxiety Scale (AI-CDAS), exploring the potential for this innovative

approach to revolutionize the understanding and management of dental anxiety in children. However, the rise of Artificial Intelligence (AI) presents an intriguing possibility: an AI-powered version of the CDAS, potentially offering new ways to assess and address this concern. But can such an AI tool truly capture the nuances of a child's anxieties, and how reliable and valid are its results? Let's delve into this exciting yet complex territory.

Methods

A total of 100 children (age 03-05 and 06-09 years) who reported to the department of Pediatric and Preventive Dentistry Bharati Vidyapeeth, Deemed to be University Dental College and Hospital, Pune, India for dental treatment were selected from October 2022 to December 2023. The institutional ethical review board provided the necessary approval (EC/New/ Inst/2021/MH/0029). The children were randomly selected for the study, and all of them of good general health. Verbal agreement was gained when they were asked whether they would be willing to participate in a study that looked into how kids feel emotionally when they see the dentist.

Following scales was used to assess children's Dental Anxiety⁶:

Group I: Colored Version of Modified Facial Affective Scale three faces (MFAS)

The Facial Image Scale (Figure 1) comprises a row of three faces ranging from no anxiety to very high anxiety.

Group II: Artificial Intelligence Child Dental Anxiety Scale (AI-CDAS)

Development

The Artificial Intelligence Child Dental Anxiety Scale (AI-CDAS) is a three item computerized trait dental anxiety scale, using faces as a response set, to assess dental anxiety in children. Faces have been used before when assessing children⁶, with two recent papers providing evidence that the Facial Image Scale is a valid indicator of child state anxiety in the dental clinic⁶. Therefore, in this trait anxiety scale, faces have been utilized as a response set.

What is an AI-CDAS?

An AI-CDAS would leverage AI algorithms to analyze various data points, potentially including facial expressions, body language, eye movements, and vocal responses, to infer and quantify a child's dental anxiety level.

Original contribution



1. No Anxiety

2. Some Anxiety

3. Very High

Figure 1: Anxiety Colored Version of Modified Facial Affective Scale



Figure 2: No anxiety

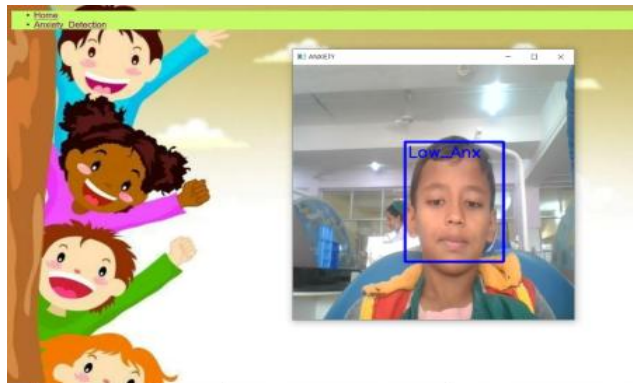


Figure 3: Low anxiety

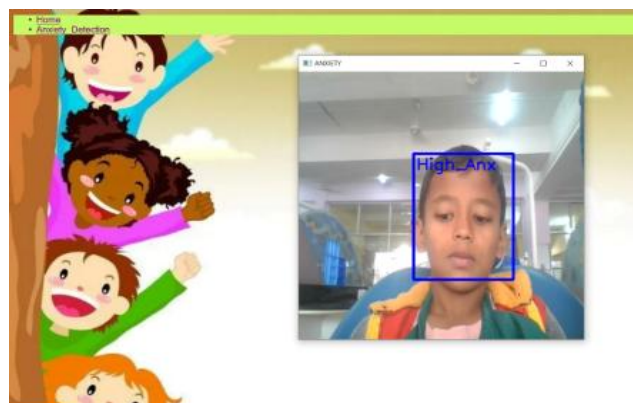


Figure 4: High anxiety

Artificial Intelligence Child Dental Anxiety Scale

Inclusion: absence of any systemic, mental and/or physical disorders; no history of medications for any psychiatric reasons; absence of any learning and understanding disabilities.

Exclusion: Patients with symptoms of acute toothache or any other dental emergency (bleeding, swelling, dental trauma) were excluded from the study. Patients who refused to give consent and those who were undergoing psychiatric therapy or were suffering from generalized anxiety disorders were excluded from the study.

Validity and reliability are both concerned with the accuracy of a method's measurements: The consistency of a measure that is, if the outcomes can be repeated under the same circumstances is referred to as reliability. The accuracy of a measure that is, if the outcomes actually reflect what the measure is intended to assess is referred to as validity.

Reliability assessment

Reliability is a cornerstone of any measurement tool, ensuring consistent and reproducible results. The AI-enhanced CDAS undergoes rigorous testing to ascertain its reliability. Initial findings indicate promising results, suggesting that the AI version of the CDAS consistently produces reliable measurements of dental anxiety in children.

Validity Assessment

Validity, the degree to which a measurement tool accurately assesses what it purports to measure, is another critical aspect of the evaluation process. Researchers assess the AI-enhanced CDAS's validity by comparing its results with established measures of dental anxiety, both traditional and contemporary. Initial analyses indicate a strong correlation between AI-generated scores and those obtained through conventional methods, supporting the scale's validity.

Ensuring reliability and validity in multi-faceted approach enhances the validity of the AI-CDAS, capturing a comprehensive picture of pediatric dental anxiety beyond what traditional self-reports can offer.

Validation and Comparison with Traditional Scales: Rigorous testing against established scales like the CDAS is essential to ensure the AI-based version accurately reflects the same underlying construct of dental anxiety in children.

Methodology

The child who full filled the inclusion and exclusion criteria where selected for the study. The child sitting on the dental OPD chair his anxiety rating was recorded using AI-CDAS (Figure 2, 3 & 4). After the OPD was done, the children were asked to point at which face they felt most like at that moment of Anxiety Colored Version of Modified Facial Affective Scale and the ratings were noted down. All this recording was noted down for validity. For reliability of the AI-CDAS the faces were kept in wrong sequence and he was told to arrange in correct order if he does it the rating was recorded and reliability of scale was done. The scale is scored by giving a value of one to the most positive affect face and three to the most negative affect face.

Results

The study comprised of 100 patients in total, amongst which 44.0% were male and 56.0% were female. Based on their age, they were divided into two groups, namely Category 1 (3-5 years) and Category 2 (6-9 years). There were 21 male and 26 female patients in Category 1, whereas Category 2 comprised of 23 male and 30 female patients according to Table I.

Table I: Demographic distribution of study population

Age group (years)	Total n (%)
3-5	47 (47.0)
6-9	53 (53.0)
Total	100 (100.0)

At the time of reporting to our department, using a simple randomization technique the study patients were grouped and a single evaluator employed a coloured version of the modified facial affective scale (MFAS) to assess the anxiety levels of the study participants. Among the patients in the age group of 3-5 years, 26 patients (55.3%) classified as highly anxious, 19(40.4%) as somewhat anxious and 2(4.25%) as not anxious about the dental visit. The data collected from AI-CDAS yielded similar results, which showed 24(51%) patients as highly anxious, 22(46.8%) as somewhat anxious and 1(2.12%) as not anxious according table II and III.

Table II: Distribution of study population: Responses based on MFAS

Parameters in MFAS	No anxiety	Some anxiety	Very high anxiety
3-5 years	2 patients (4.25%)	19 patients (40.4%)	26 patients (55.3%)
6-9 years	6 patients (11.3%)	23 patients (43.3%)	24 patients (45.2%)

Table III: Distribution of study population: Responses based on AI-CDAS

Parameters in AI	No anxiety	Some anxiety	Very high anxiety
3-5 years	1 patient (2.12%)	22 patients (46.8%)	24 patients (51.0%)
6-9 years	7 patients (13.2%)	20 patients (37.7%)	26 patients (49.0%)

According to Table II and Table III, 6(11.3%) kids in the 6-9 age range reported feeling no anxiety at all, 23 (43.3%) reported feeling some anxiety and 24(45.2%) were classified as highly anxious. An analogous finding was achieved using the data gathered by AI-CDAS. In accordance with it, 26(49.0%) patients had high levels of anxiety, 20(37.7%) had moderate levels, and 7(13.2%) had no anxiety. The AI-CDAS assessment's findings were comparable to the MFAS. On comparing the responses of the study population among Category 1 and 2, it is inferred that Category 2 patients were slightly more anxious according to both MFAS and AI-CDAS based scale.

Data analysis was conducted using SPSS software. In addition to mean and standard deviation, descriptive statistics included number and frequency (%) as described in Table IV and V.

Table IV: Distribution of study population (3-5 years) according to responses rating scale (MFAS and AI-CDAS)

MFAS assessment (%)			AI-CDAS assessment (%)		
No anxiety	Some anxiety	Very high anxiety	No anxiety	Some anxiety	Very high anxiety
n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
00 (00.0)	00 (00.0)	1 (02.12)	00 (00.0)	01 (02.12)	00 (00.0)
01 (2.12)	11 (23.4)	08 (17.0)	00 (00.0)	11 (23.4)	09 (19.1)
01 (2.12)	07 (14.8)	17 (36.17)	00 (00.0)	10 (21.2)	15 (31.9)
00 (00.0)	01 (2.12)	00 (00.0)	01 (2.12)	00 (00.0)	00 (00.0)

Table V: Distribution of study population (6-9 years) according to responses rating scale (MFAS and AI-CDAS)

MFAS assessment (%)			AI assessment (%)		
No anxiety	Some anxiety	Very high anxiety	No anxiety	Some anxiety	Very high anxiety
n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
00 (00.0)	00 (00.0)	03 (05.6)	00 (00.0)	01 (01.8)	02 (03.7)
01 (00.18)	15 (28.3)	03 (05.6)	04 (07.5)	14 (26.4)	01 (01.8)
03 (05.6)	07 (13.2)	13 (24.5)	03 (05.6)	13 (24.5)	07 (13.2)
02 (03.7)	01 (0.18)	05 (9.43)	02 (03.7)	04 (07.5)	02 (03.7)

Reliability

The t-test and Pearson correlation coefficients were employed in order to assess MFAS and AI-CDAS reliability. An examination of the AI-CDAS reliability using correlation analysis revealed a strong positive association between patient-reported AI-CDAS scores and MFAS. It proved to have a high degree of compatibility and dependability ($r = 0.88, p = 0.001$).

The paired sample t-test revealed no statistically significant difference ($t = 1.969; p = 0.058$) between the test and the other parameters. There was no statistically significant difference in the anxiety level between the MFAS and AI-CDAS measures. [Signed Wilcoxon rank test: $Z = 1.12, p > 0.05$]. This demonstrates AI-CDAS scale reliability in assessing the pain scale in pediatric age group patients undergoing dental treatment.

Validity:

The link between the AI-CDAS and the Modified Face Anxiety Scale anxiety levels is displayed in Table VI. Convergent validity was assessed by determining Spearman correlation coefficient between the MFAS and AI-CDAS scale. The scales had a significant positive association, in accordance with the Spearman correlation test. The MFAS and the AI-CDAS scale showed a substantial correlation ($r = 0.89; p < 0.001$). In the concurrent validity, both MFAS and AI-CDAS scores had a positive correlation indicating that both tools described similar behaviour ($r = 0.89, p < 0.001$). In order to simultaneously assess construct validity, the association between the anxiety ratings from the Face Anxiety Scale and AI-CDAS scale was also examined using the Pearson correlation coefficient, with $p < 0.05$ denoting a statistically significant relationship.

Table VI: Pearson correlation analysis to describe the relationship between the Modified Face Anxiety Scale and the AI-CDAS Scale

The relationship between the Modified Face Anxiety Scale and the AI-CDAS Scale		
	r^a	p
Face Anxiety Scale & AI-CDAS scale	0.89	0.001

^a Pearson correlation analysis

The AI-CDAS scale, created using traditional criteria, showed a statistically significant and showed positive correlation when compared to the conventional MFAS ($r = 0.88; p < 0.001$). The present results support the validity of the AI-CDAS scale and can be used as an adjunct when compared to the conventional MFAS technique. This result indicates that the AI-CDAS Scale is as dependable and user-friendly as traditional MFAS.

Also, on comparing the readings of the third person (blinded observer) who was kept blinded from the study protocols with the MFAS and AI-CDAS, there was a positive correlation and no significant statistical variation was noted between his reading and AI-CDAS according to table VIII. This again contributes to the subjective reliability and validity of AI-CDAS tool.

Table VII: Pain assessment readings by the Blinded Observer in the OPD

Sl. No.	No anxiety	Some anxiety	Very high anxiety
	n (%)	n (%)	n (%)
Total number of patients in 3-5 years age group	3 (6.38)	21 (44.6)	23 (48.9)
Total number of patients in 6-9 years age group	5 (9.43)	21 (39.62)	27 (50.9)

The results of this study merely serve as a springboard for a more thorough investigation of this intricate subject. It is reasonable to anticipate future developments in the identification and treatment of dental

anxiety in children as research and AI technologies advance. Our ultimate objective should be to build a future in which all children, irrespective of their circumstances or background, have access to secure and stress-free dental care. This study result concludes that the AI-CDAS pain assessment scale is both a valid and reliable tool for pain assessment in pediatric patients undergoing dental treatment.

Discussion

Neither the overall anxiety ratings nor any of the individual measures showed any gender differences. The literature has produced inconsistent findings as regards gender differences with some studies showing a clear distinction between males and females⁷. Girls indicating raised dental anxiety over boys and other work showing no differences. As past research has not shown a clear consensus (though the literature on adults has produced more clear-cut findings) the absence of gender differences does not lessen the validity of the AI-CDS⁸. Dental anxiety differed in a non-linear way by age group. Other researchers have also found this. Wong and colleagues note that it is difficult to develop a consensus as to how age and anxieties are associated, as the age ranges in studies vary⁹. The 6-7 year old age group had the highest levels of fear, according to Cuthbert and Melamed¹⁰, who speculate that this could be because it's a transitional period. AI-CDAS than many other children's self-report scales because the former allows comparison of scores between items. This is significant because some participants may have high results on one item even while their overall program scores are low. The AI-CDAS has a number of advantages. First of all, because it is brief, it should maximize the kids' responses and cut down on administration time. Second, it includes items that are relevant to most children's dental experience e.g. having a tooth drilled, sitting in the dental waiting room. Third, the use of gadgets should help the child engage with the dental anxiety scale.

Ideally, a scale should be: i) Short in length to maximize response from the children and minimize time for administration; ii) Items that are most pertinent to the child's dental experience should be included; iii) Easily hold the attention of the child; and iv) Be simple to score and interpret¹¹.

There are many self-report inventories available but none of them encompass all of the criteria outlined above but AI-CDAS does this.

The Potential of AI in Dentistry

This article is just a starting point for a deeper exploration of this complex topic. As research

progresses and AI technology evolves, we can expect further advancements in assessing and addressing dental anxiety in children. Ultimately, our goal should be to create a future where every child, regardless of background or circumstance, can access safe and anxiety-free dental care. As technology continues to advance, the AI-enhanced CDAS holds the potential to transform how dental professionals identify and address anxiety in young patients, ultimately improving the overall experience and outcomes in pediatric dentistry¹². AI has the potential to enhance pediatric dentistry in ways beyond anxiety evaluation. AI can personalize treatment plans, predict pain sensitivity, and even guide dentists during procedures. Therefore, it may be concluded that it can be used with confidence to assess dental anxiety in children. The AI-CDAS is a reliable measure of dental anxiety in children aged 03-09 years, demonstrating good reliability and validity. However, ethical considerations and ongoing research are crucial to ensure responsible and effective integration of AI in pediatric dentistry.

Conclusion

The results of the reliability and validity study support the efficacy of the Artificial Intelligence-Enhanced Child Dental Anxiety Scale (AI-CDAS) as a reliable and valid instrument for assessing dental anxiety in pediatric patients. The high ICC values and strong correlations with established measures underscore the consistency and accuracy of the AI-CDAS, highlighting its potential to enhance the precision of dental anxiety evaluations in children.

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