

# Culturally adapted assessment tool for Autism Spectrum Disorder and its clinical significance

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## SUMMARY

Diagnosing of Autism Spectrum Disorder (ASD) using tools developed in the West is challenging in the Indian setting due to a huge diversity in sociocultural and economic backgrounds. Culturally adapted tools, such as the International Clinical Epidemiology Network (INCLIN) Diagnostic Tool for Autism Spectrum Disorder, have been developed in several Indian languages, yet, they do not accommodate all verbal abilities and education backgrounds. To address this disparity, we developed a home-based, audiovisual game app (Autest) suitable for ASD risk assessment in Indian children under 10 years of age. The game has five modules for each age group with specific peer interaction and play skill assessments. Each module follows a story from the Panchatantra, a popular Indian story series for children. Gameplay and behavior are tracked to assess risk. The effectiveness of Autest was rated by 30 psychologists with respect to current tools. Ratings suggested that the tool is effective and can reduce social inhibition and facilitate assessment due to the lack of a language barrier using emojis, cultural appropriateness, ease of administration, and simple scoring. This tool is particularly useful for minimally verbal, at-risk children. Further usage and development of Autest can improve risk assessment and early intervention measures for children with ASD in India.

## INTRODUCTION

Children with Autism Spectrum Disorder (ASD) struggle with social interactions, with verbal and non-verbal communication, and with restricted or repetitive behaviors (1). Estimates drawn from previous studies suggest that India could have more than 2 million people with ASD (2). Raina, *et al.* reported a prevalence rate of 0.9 cases per 1000 individuals (3). A 2018 study reported a prevalence rate of 1 in 100 for children under the age of 10 in India (4).

Diagnostic measures developed in the Western world, such as Childhood Autism Rating Scale (CARS), Gilliam Autism Rating Scale (GARS), Autism Diagnostic Observation Schedule (ADOS), and the Autism Diagnostic Interview Revised (ADI-R), pose challenges in the diverse sociocultural

Indian setting (5). Issues with interpretation, translation, or cultural understanding of behaviors may contribute to false positive results in traditional diagnostic tools (5). Furthermore, differences in language and cultural markers may contribute to poor diagnoses. Several studies have highlighted cross-cultural differences in autistic traits which must be addressed during diagnosis (6-7).

Various psychometric scales have been developed that are currently used for ASD diagnosis. Each of these methods involve observing the child's behavior and supplementing that information with parent's feedback. Furthermore, tests adapted to be effective in a specific cultural setting, such as India, have also been developed. Two widely used scales developed in India are the Indian scale for Assessment of ASD (ISAA) and the International Clinical Epidemiology Network (INCLIN) Diagnostic Tool for Autism Spectrum Disorder (INDT-ASD) (8-9).

The testing times for the ISAA are around 20–30 minutes. The assessment is carried out using an assessment kit comprised of daily life objects such as a toy car, ball (different sizes), mirror, handbell, etc. (8). The ISAA is a 40-item scale split up into six domains: social relationship and reciprocity, emotional responsiveness, speech (language and communication), behavior patterns, sensory aspects, and cognitive component (8). For scoring, each of the 40 items are rated in 5 categories. These are quantified by providing percentages to indicate frequency, degree, and intensity of behavioral characteristics observed. The range in which the final score lies is used to determine the degree of ASD (8). However, this current tool is not child-friendly and lacks a visual component and a cohesive storyline.

INDT-ASD is a diagnostic tool developed based on the fourth edition of the Diagnostic and Statistical Manual (DSM), consisting of two sections (9). The first section includes questions related to three cardinal domains: social interaction, communication, and restricted interests. The second section relates to scoring as well as arriving at diagnostic classifications that include Autism, Asperger's disorder, Rett's disorder, Childhood Disintegrative disorder, Pervasive Developmental disorder, Intellectual Developmental Disorder (IDD), and an indeterminate category (which indicates that criteria are not met for any of the above disorders or that there are too many unsure responses, or they could not be tested under appropriate conditions) (9). The questions in the

1 tool vary according to the age group of the subject (below  
2 4 years of age, above 4 years of age, and above 6 years of  
3 age) and are accompanied by simple, relevant, and easy-  
4 to-understand examples to increase comprehension for the  
5 caregivers. The time taken for the administration of the test  
6 may range from 30–45 minutes (9). However, it does not  
7 include newer diagnostic criteria for ASD introduced in DSM-  
8 5, such as sensitivity testing, which have been addressed  
9 with Autest.

10 Recent attempts have been made to introduce  
11 computerized forms of ASD testing, often through mobile  
12 applications (10). These tests have come into being with the  
13 aim of creating more accessible, reliable, and effective forms of  
14 ASD screening. This method acknowledges that professional  
15 administration is not scalable and that the children need to  
16 be observed in their natural environments (such as schools,  
17 homes, communities, etc.). Autism and Beyond is one such  
18 popular application that a caregiver can utilize (11).

19 There is an acute need to develop newer means of  
20 assessing ASD risk owing to inconsistencies across  
21 socioeconomic and cultural backgrounds in the Western  
22 world and the Indian setting (5-7). In the current study, we  
23 have developed one such culturally relevant risk assessment  
24 tool for ASD in the form of a computerized application  
25 based on DSM-5 guidelines, which will help to perform  
26 psychometric evaluations and identify children who show  
27 signs of developmental delays. Autest is a visual, child-  
28 friendly game app based on the Panchatantra that utilizes  
29 various psychological markers for autism risk assessment.

30 We hypothesized that Autest would be clinically significant,  
31 which we would test through experimental interviews of  
32 professionals. We predicted that the professionals would  
33 deem Autest clinically viable due to the ease of administration,  
34 absence of language barrier, child-friendliness, and cultural  
35 relevance. As a pre-diagnostic tool, Autest would be the first  
36 step for individuals to seek more evaluation and treatment  
37 based on risk score.

### 38 RESULTS

39 We developed a culturally adapted risk assessment tool  
40 for ASD. The game format is more engaging and culturally  
41 relevant than currently available diagnostic tests. The child  
42  
43  
44  
45

46 **Table 1. Professionals’ responses to question 7-12.**

Question	Response (n = 30)
7. In your tests how involved are parents/caretakers in the process? (1 = Not at all, 10 = Very involved)	3.967 ± 0.850
8. Do you think adding a "parental questions section" can be useful for our app?	26 out of 30 said yes
9. If so, up to what percentage of responses should come from them (say criteria like lack of social smile, speech history etc.)?	37% (± 8.3%)
10. (a) As our proposed test has a storyline and can be independently taken, do you think diagnosis would be quicker? (b) Would our app help prevent social inhibition?	(a) 14 out of 30 said yes (b) 26 out of 30 said yes
11. How effective do you think our app can be to detect early signs of autism? (1 = Not at all, 10 = Extremely effective)	6.834 ± 0.780
12. Lastly, on a scale of 1-10 how willing would you be to try our app?	7.8 ± 0.805



**Figure 1. Sample game scene from the Autest app.** The app utilizes bright colors and animations accompanied by music to generate an interactive audiovisual experience for the test-taker.

47 has to complete interactive tasks to pass levels and proceed  
48 through the game. As the child is engaged throughout the  
49 process and is not interviewed by someone they have not  
50 known beforehand, social inhibition is reduced, and testing  
51 is more reliable. The use of pictures, animations, emojis,  
52 and music removes a language barrier and thus, Autest can  
53 ideally be administered in most parts of India. A sample game  
54 scene (**Figure 1**) has been provided in this paper.

55 To understand the validity of Autest, we remotely  
interviewed 30 professionals, in two groups of 15 each, about  
the effectiveness of our diagnostic method. The questionnaire  
consisted of comparative questions in six elements of  
ASD diagnosis based on the ISAA: social relationship and  
reciprocity, emotional responsiveness, speech (language  
and communication), behavior patterns, sensory aspects,  
and cognitive component. The first group filled out a written  
questionnaire and the second group was interviewed  
through a telephonic conversation. Both male and female  
professionals were interviewed with a mean age of 42,  
ranging from 28 to 60. Eight of them specialized in autism  
diagnosis in children. They rated the effectiveness of our tool  
with respect to currently used diagnostic methods in India.

The mean ratings (**Figure 2**) for each domain suggested  
that the tool was effective. Specifically, our tool was determined  
to be most effective for Behavior Patterns and Emotional  
Responsiveness, and least effective for Social Relationship  
and Reciprocity. The responses to the descriptive answers

**Table 2. Results of one-way ANOVA.**

Domain	F-value	p-value*
Social Relationship and Reciprocity	0.215	0.646
Emotional Responsiveness	0.091	0.765
Speech - Language and Communication	0.160	0.692
Behavior Patterns	0.261	0.614
Sensory Aspects	0.040	0.843
Cognitive Component	0.254	0.618

\*p < 0.05 considered statistically significant

**Table 3. Scoring rubric for Autest (the numbers in brackets represent the score assigned).**

Criteria	Low range	Normal range	High range	Very high range	Maximum score
Average response delay <sup>a</sup>	< 0.5 sec (0)	0.5 - 1.5 sec (10)	1.5 - 4 sec (20)	> 4 sec (30)	30
Emojis <sup>b</sup>	9 - 10 (0)	7 - 8 (5)	4 - 6 (10)	< 4 (15)	15
Repetitive/unwanted clicks <sup>c</sup>	< 25 (0)	25-30 (5)	31 - 40 (10)	> 40 (15)	15
Observer questionnaire	0 - 10	10 - 20	20 - 30	30 - 40	40
Total					100

<sup>a</sup>average reaction time for humans is 0.25 sec to visual stimulus. Response time is reaction time and time taken to make a choice.  
<sup>b</sup>total 10 emoji checks, each with 3 options.  
<sup>c</sup>total 25-30 clicks are required to finish the game.

have been summarized in **Table 1**. A one-way ANOVA revealed that there was no significant difference between both randomly selected groups' ratings of Autest, as shown in **Table 2**. The scoring rubric used for Autest has been detailed in **Table 3**. The taxonomy in **Table 4** was adapted from the ISAA. Risk assessment can be followed by follow-up or referrals for at-risk individuals, thereby improving future diagnosis for quicker intervention.

**DISCUSSION**

Early diagnosis is recommended for effective intervention therapy for autistic children and their families. Often, particularly in rural areas, it becomes difficult to identify developmental delays by conducting screening tests due to lack of resources in primary and secondary care settings (12). The purpose of the game is to aid developmental-behavioral pediatricians and other medical professionals in evaluating ASD at an early age, particularly among at-risk youth. This, in turn, will lead to early intervention measures such as

**Table 4. Risk-assessment rubric for Autest.**

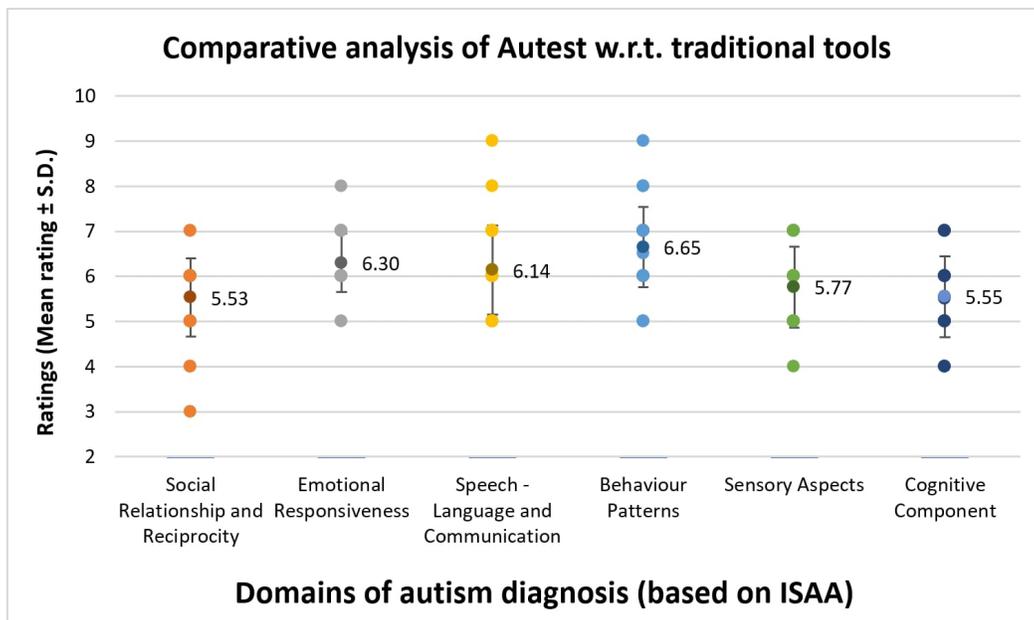
Autest Score Range	Risk Level	Corresponding ISAA diagnosis
0-20	Low risk	Normal
21-40	Moderate risk	Mild autism
41-70	High risk	Moderate autism
71-100	Very high risk	Severe autism

comprehensive diagnostic evaluation, improving the user's quality of life and integrating them into mainstream society.

As the test can be independently administered at home without prior experience, the child will be more cooperative and comfortable (13). The game is also suitable for pre-verbal and minimally verbal autistic children, who are difficult to diagnose (14). It is also the first autism risk assessment tool in India based on DSM-5 guidelines.

The 30 psychologists interviewed rated Autest in two groups of 15 each. After playing the game, the first group filled out the questionnaire by hand, whereas the second group was interviewed via telephone. Despite different modes of answering, both groups rated Autest as clinically significant across all six domains with no significant difference between the telephone group and written questionnaire group, as revealed by one-way ANOVA (**Table 2**). However, there might have been selection bias while recruiting professionals for the survey, and to address this, we will conduct a larger survey in the future.

Despite being clinically significant, Autest has certain limitations. Implementing Autest for diagnosing visually and/or hearing-impaired children could be challenging. Furthermore,



**Figure 2. Scatter plot representing questionnaire responses of professionals.** Lighter dots represent each individual rating, whereas the darker dot represents the mean value in each domain. Data is presented as mean ± S.D., n = 30.

1 interpreting the app and answering the observer questionnaire  
2 requires a certain degree of training, which may be limited  
3 in rural areas. Lastly, to use Autest, one needs access to a  
4 mobile phone, tablet, or computer with sufficient capabilities  
5 in terms of memory, graphics, etc. An internet connection is  
6 also initially required to download the app. Moreover, several  
7 studies have shown that the prevalence rate of ASD within  
8 India is highest in rural areas (15-17), which could make the  
9 implementation of Autest challenging (15).

10 The current study can be expanded on in the future by  
11 conducting beta-tests of our game app. Additionally, expanding  
12 our study to include more feedback from other related health  
13 workers involved in the ASD diagnosis process, such as  
14 social workers or pediatricians, can make our diagnostic tool  
15 more effective. In the future, we hope to improve upon the  
16 identified limitations. Additionally, we hope to expand our  
17 diagnostic tool by including levels, age-based modules, and  
18 a wider range of storylines to choose from. Finally, we plan  
19 on partnering with healthcare professionals, especially those  
20 involved with ASD patient care, to make Autest accessible  
21 throughout the country in conjunction with existing culturally  
22 relevant tools such as the INDT-ASD (18).

## 23 MATERIAL AND METHODS

24 As mentioned before, the ISAA consists of 40 test  
25 questions, divided into six domains. To develop the Autest  
26 application, the core idea was to integrate each of these test  
27 factors with an existing story line and quantify the responses  
28 by tracking interactions with the game in conjunction with the  
29 observer questionnaire.

### 30 Choosing the storyline

31 The Panchatantra is a popular story series for children in  
32 India. It contains the most widely known stories in the world  
33 (19). It is an abridged version of an ancient Indian collection of  
34 interrelated animal fables. We chose Panchatantra due to its  
35 simplicity, abundance of social hierarchies and relationships,  
36 and emotion-rich plots. Moreover, our target demographic has  
37 a high likelihood of previous exposure to the Panchatantra.  
38 This familiarity helps initiate the diagnostic process, and the  
39 subject is more likely to be cooperative (20). Other similar  
40 texts such as the Mahabharata have religious connotations  
41 or affiliations.

42 We chose the story, "The Gaining of Friends" from *Mitra*  
43 *labha*, the first book of the texts, due to ample number of  
44 social characters and its wide coverage of the emotional  
45 spectrum (19-20). The story is suitable for young children  
46 of different backgrounds. *Mitra bheda*, the second book of  
47 Panchatantra, has graphic elements, violence, and animal  
48 abuse, which is not suitable for a diagnostic tool and therefore  
49 was not considered (20). The average number of characters  
50 in other stories in the *Mitra labha* is six, whereas the number  
51 of characters in the selected story is nine, offering more  
52 opportunities for integrating social indicators in the domains  
53 of Social Relationships and Reciprocity (20).

### 54 Converting the story into game scenes

55 We converted the plotline into suitable scenes for our app.  
The story was divided into nine individual scenes based on  
the plot development and introduction of new characters. The  
story was shortened without loss of the original meaning or  
intention. The chosen story, "The Gaining of Friends", had  
two main scenes. The first takes place with the birds and  
the hunter, and the second takes place between the rats and  
the birds (20). The second scene was deleted to reduce the  
number of characters and character-specific monologues,  
in turn helping reduce complexity of the storyline. However,  
throughout this abridging process, we ensured sufficient  
characters and potential cues to help with appropriate risk  
assessment. The story was modified to make it playable as  
well as easily understandable for our target age group. Playing  
the game is estimated to take 20 minutes on average based  
on the administration of the professionals' questionnaire.

### 60 Developing the app

61 Unity was used to develop the final game app (21). We used  
62 the Indian Scale for Assessment of ASD as the reference  
63 diagnostic tool for our app (8). Essentially, the game will  
64 present the player a range of "situations", which are semi-  
65 structured tasks designed to "press" for communication  
and social interaction. These are situations with pre-  
determined behavioral and emotional reactions, such as  
social smiles or exhibition of empathy. Keeping in mind the  
gradual development of children, the game has five modules,  
increasing in complexity to account for social and language  
development.

### 66 Observer questionnaire (OQ)

67 Several parts of the game can lead to certain behavioral  
68 responses in the test-taker. To account for these in the  
69 assessment, we developed an observer questionnaire,  
70 available in English and Hindi. Usually, the observer would  
71 be the parent or legal guardian of the child present during  
72 gameplay in a natural setting.

73 The questionnaire comprises questions that quantify  
74 when the test-taker smiles, looks away, is aloof, mimics  
75 game sounds, produces infantile squeals or unusual noises,  
is hyperactive and aggressive, and is sensitive to change  
in color contrast and sudden sounds while playing. Each  
question has five options which are scored in the end.

### 76 Game design

77 The game has a choose-your-own-adventure setting.  
78 Throughout the game, we display emotion checkers, which  
79 are pop-ups with three emojis to check for emotional  
80 reactions to events in our game (**Figure 3**). One of the emojis  
81 depicts the appropriate emotion, another emoji depicts a  
82 contrasting emotion, and the third one either depicts a neutral  
83 or unrelated emotion. For example, if the appropriate emotion  
84 is 'happy', the other emotions depicted using emojis can be  
85 'sad' and 'angry'.

### 1 Game scoring

2 The test-taker receives a total score out of 100, with  
3 40 possible points from the observer questionnaire (OQ)  
4 and 60 from gameplay data (Table 3). A lower score on  
5 Autest indicates a lower risk of ASD. We kept this ratio after  
6 calculating from professionals' interviews that on average,  
7 40% is most widely accepted parental/observer involvement  
8 in ASD diagnosis. In the game, we track delay of response  
9 after every instruction, emojis selected in the emoji checker,  
10 and repetitive or unwanted clicks. The total score is compared  
11 with the norms to calculate risk assessment (Table 4).

### 12 Social relationship and reciprocity

14 To comprehensively test for social responses, the  
15 game uses emojis and music. This makes the tool suitable  
16 for children from various socioeconomic and educational  
17 backgrounds (22-23). Poor eye contact, lack of social smile,  
18 and aloof nature is checked using the OQ. Throughout the  
19 game, the characters maintain eye contact and smile at  
20 the player. Turn-taking is addressed by a particular section  
21 of the game which requires the player to wait for their turn.  
22 The number of clicks is also tracked and accounted for in the  
23 assessment.

### 24 Emotional responsiveness

26 Inappropriate emotional response is checked for using  
27 emojis. At crucial points in the game, a pop-up with three  
28 emojis appear. One of the emojis is relevant to the situation.  
29 The choice of the child is recorded. Fear of danger is checked  
30 using two choices provided in the game. Choice A is visually  
31 dangerous and choice B is visually appealing and safe.

### 32 Speech (language and communication)

34 Several instances of the game have the character pointing  
35 at certain objects. Where the child clicks during this point is  
36 tracked to determine whether they have difficulty in using non-  
37 verbal language to communicate. The game has a repetitive  
38 audio track for certain actions. If the right emoji is chosen,  
39 "Nice!" is played. If the wrong emoji is chosen, "Oh no!" is  
40 played. Echolalic speech (repetition of speech) is checked  
41 using the OQ. Similarly, infantile squeals or unusual noises  
42 and jargon/meaningless words while playing the game are  
43 checked using the OQ.

### 44 Behavior patterns

46 Hyperactivity, aggressive behavior, and temper tantrums  
47 while playing are evaluated using the emoji checker and as  
48 part of the OQ.

### 49 Sensory sensitivity

51 In 2013, sensory reactivity or interest was added as a  
52 symptom of ASD in the fifth edition of the DSM (15). In Autest,  
53 we evaluate sensitivity to visual and auditory stimuli. Different  
54 levels of the game have different color contrast schemes.  
55 Behavioral responses to this change are quantified using the

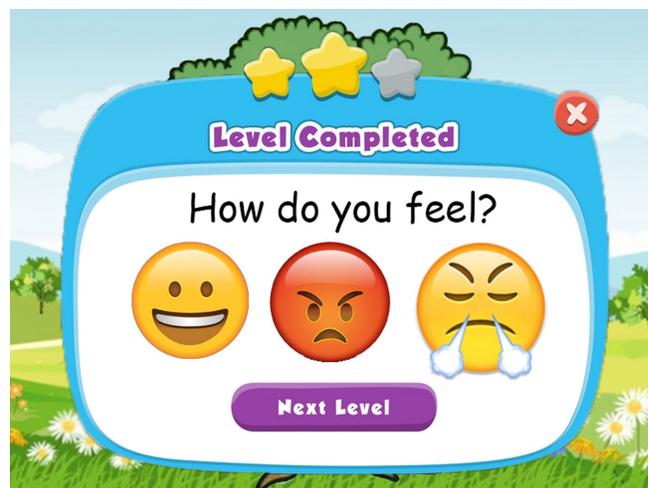


Figure 3. Emoji checker used throughout the app to check for Emotional Responsiveness.

observer questionnaire to determine if the child insists on sameness. A sudden auditory track is introduced at various points in the game. Behavioral responses to these sounds are quantified using emoji responses and the OQ.

### Cognitive component

Inconsistent attention and concentration are checked for using response frequency and time. In particular, delays in following game instructions are tracked. Checking for unusual memory or savant ability was not within the ambit of our game.

### Professionals' questionnaire

*The Economic Times* reports that in 2018, there were 898 psychologists in India (24). We interviewed a representative sample of two groups of 15 each (total of 30), who were chosen randomly and contacted via contact details provided online. We contacted professionals from different locations within India. A questionnaire consisting of 12 questions was developed. Instead of descriptive answers, we used a numerical rating scale of 1 to 10 wherever possible, so that it was easier to compare the data between the two groups. The questions were written in a concise manner so that it was easier for the psychologists to follow and answer. Additionally, we followed the guidelines of questionnaire design as suggested by Boparai *et al.* (25).

The first group, consisting only of psychologists, filled out the questionnaire by hand after testing Autest. The second group, which was more diverse - consisting of social workers, pediatricians, and psychologists - were interviewed via telephone. The questionnaire was read aloud, and their responses were noted accordingly.

The questions asked participants to rate Autest with respect to current diagnostic tools for each of the six domains of autism diagnosis. Furthermore, they were asked about the level of parental involvement in their tools, to determine the score to be assigned to the observer questionnaire for

1 Autest. They were asked if they think Autest would reduce  
2 social inhibition and provide quicker diagnosis based on the  
3 presence of a storyline. Lastly, they were asked how effective  
4 they think our app is and how willing they were to try it in a  
5 clinical setting.

6 The answers were either in a yes/no format or a numerical  
7 value ranging between one and ten. The psychologists  
8 were sent the app and instructed to test in an undisturbed  
9 environment. A post-survey was conducted after they  
10 responded that they finished the game—the first group was  
11 sent the questionnaire, and the second group was interviewed  
12 via telephone. The responses were compiled, mean values of  
13 responses for each domain were calculated (**Figure 2**), and  
14 a one-way ANOVA (**Table 2**) was conducted to determine  
15 statistical significance between questionnaire methods to test  
16 if there was a statistically significant difference between the  
17 two questionnaire methods.

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