Computer adaptive test performance in children with and without disabilities: Prospective field study of the PEDI-CAT

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Abstract

Purpose—To examine the discriminant validity, test-retest reliability, administration time and acceptability of the Pediatric Evaluation of Disability Inventory Computer Adaptive Test (PEDICAT).

Method—A sample of 102 parents of children three through 20 years of age with (n=50) and without (n=52) disabilities was recruited for this prospective field study. A sub-sample (n=25) also completed the PEDI-CAT a second time within one month. Parents completed 15 questions in

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each of the four PEDI-CAT domains (Daily Activities, Mobility, Social/Cognitive, Responsibility) using a laptop computer. Following completion, parents were asked four questions as part of a User Evaluation Survey.

Results—The PEDI-CAT was able to differentiate between groups of children with and without disabilities based on parent responses in all four domains. Test-retest reliability results were high (ICC=0.96 -0.99) for all four domains. The mean time to complete 60-items for the full sample (n=102) was 12.66 minutes (SD=4.47). Parents reported favorable reactions to the PEDI-CAT and were especially enthusiastic about the new Responsibility domain.

Conclusions—The PEDI-CAT offers a valid and reliable assessment acceptable to parents.

Keywords

PEDI; computer adaptive test; validity; reliability

Introduction

The Pediatric Evaluation of Disability Inventory Computer Adaptive Test (PEDI-CAT) was developed to respond to the need for an accurate and efficient functional measure with content for children and youth in multiple functional content areas. The new PEDI-CAT measures function in the three domains of Daily Activities, Mobility and Social/Cognitive for infants, children and youth from birth through 20 years of age. In addition, the PEDI-CAT's Responsibility domain measures the extent to which the caregiver or child takes responsibility for managing complex, multi-step life tasks. The PEDI-CAT can be used across all patient diagnoses, conditions and community settings [1].

The PEDI-CAT is based on the original paper-pencil Pediatric Evaluation of Disability Inventory (PEDI) [2,3]. The process for adapting the original PEDI to a PEDI-CAT began with the development of an item bank for an extended age range and developing a revised response scale from a two-point (unable/capable) scale to a four-point difficulty scale. In addition, the original PEDI's Caregiver Assistance Scale was replaced with a 'Responsibility Scale'. Each of the four PEDI-CAT domains (Daily Activities, Mobility, Social/Cognitive and Responsibility) is self-contained and can be used separately or in combination with the other domains. Administered by parent report or by professional judgment of clinicians or educators who are familiar with the child's performance in the relevant areas, the PEDI-CAT software is programmed for administration on desktop and portable PCs, and for Internet applications [1].

The PEDI-CAT provides an individualized and meaningful assessment for each child because the computer algorithm, using Item Response Theory statistical models, chooses which items are most appropriate and minimizes the number of items needed to ensure an accurate score. For each domain, all respondents begin with the same item in the middle of the scoring range and the response to that item then dictates which item will appear next (a harder or easier item), thus tailoring the items to the child and avoiding irrelevant items, similar to the methods of an experienced clinician. With each new response, the score and confidence interval are re-estimated and the CAT software determines whether the pre-set stopping rule, the desired level of precision (e.g. within a standard error of 0.5 or a pre-set number of items has been satisfied). If satisfied, the assessment of that domain ends and a score is provided. If not satisfied, new items are administered until the stopping rule is satisfied [1]. The use of the CAT platform is expected to provide accurate and precise scores efficiently and with reduced respondent burden due to the minimal number of items administered [4].

The psychometric properties, including validity and reliability [5-9] of the original PEDI [3] and its many translated versions [10-15], have been well-documented. The study of the psychometric properties of computer adaptive testing for assessing function in children and youth has shown promising results in both prospective and simulated CAT studies including good discriminant validity across groups based on levels of upper extremity and gross motor function in children with cerebral palsy [16, 17], concurrent validity [16-19], test-retest reliability [18, 19], efficiency [18, 20-23] and response burden [20, 21]. As a new assessment, the psychometric properties of the PEDI-CAT must be established for users to feel confident in its application to clinical practice and research. The objectives of this prospective field study were to examine discriminant validity (the ability to discriminate between children with and without disabilities); to assess test-retest reliability; to examine administration time; and to examine parental feedback of the new PEDI-CAT.

Methods

Participants

Following Institutional Review Board (IRB) approval from the Boston University Medical School, New England IRB, and Franciscan Hospital for Children (FHC), Boston, MA, USA, parents of children three through 20 years of age, with and without disabilities, and who were English-speaking were recruited via telephone, posted flyers, and e-mail from personal contacts and the inpatient, outpatient, day school and day care programs at FHC. A sample of 102 parents met the inclusion criteria (50 parents of children with various types of disabilities and 52 parents of children without a disability) and participated in this prospective field study of the PEDICAT.

In addition, a 25% convenience sub-sample (n=25) of parent respondents of children with (n=11) and without disabilities (n=14) completed the PEDI-CAT a second time within one month of the first assessment to assess test-retest reliability for each of the PEDI-CAT's four domains. A brief demographic form was completed to describe the parent respondents and their children. No differences were found between the groups of parents of children with and without disabilities or for the total sample when compared to the test-retest sample. Table 1 provides the demographic information of the total sample and test-retest sub-sample.

Instrumentation

The PEDI-CAT is a comprehensive clinical assessment that includes functional skills acquired throughout infancy, childhood and adolescence up through the age of 20 years. Each of the four PEDI-CAT domains (Daily Activities, Mobility, Social/Cognitive and Responsibility) is independent and can be used separately or in combination with the other domains. Items focus on the child's ability to perform each functional activity in a manner that is effective given their abilities and challenges [24]. Items do not require the child to perform the activity in a standardized manner for scoring.

During the development of the PEDI-CAT, the items and response scales were reviewed by parents and national and international clinicians and researchers [24] who are users of the original PEDI [3]. Based on this feedback, line drawings were created for each item in the Self-care and Mobility domains. Cognitive interviewing (qualitative interviews to determine whether or not respondents understand questions consistently, easily and as intended) was conducted with parents before the items were finalized [24]. Content areas for each of the PEDI-CAT domains, item examples and the corresponding response scales are presented in table 2.

The PEDI-CAT provides normative scores (provided as age percentiles) so that clinicians can interpret a particular child's functioning relative to others of the same age. As in the

original PEDI [3], criterion-based (scaled) scores are also available, for children not expected to exhibit or regain normative levels of functioning [1]. Age percentiles for the PEDI-CAT are based on the normative standardization sample and are available for infants, children and youth up to 21 years of age, while scaled scores are based on data from both the normative and disability samples [1,2]. For this study, parent participants completed a forced 15-item per domain (Daily Activities, Mobility, Social/Cognitive, and Responsibility) CAT. Although the number of items presented using a CAT can vary, administering a predetermined number of items was chosen for this study based on previous work indicating that 15 items provide an excellent score estimate [22, 23]. Of note, items from the Mobility-Device content area were not used in this study as the data collection for calibration of these items was ongoing simultaneously [1].

Parent participants completed the PEDI-CAT in the clinic or at their home using a portable laptop computer. A study coordinator (a physical therapist) was present to answer any questions. Following completion of the PEDI-CAT, the study coordinator asked participants four questions as part of a User Evaluation Survey. Parent participants received an honorarium in the form of a gift card for participating. Data were collected over a five-month period in 2010.

Data Analysis

To determine the ability of the PEDI-CAT to distinguish between known groups (discriminant validity), we compared the mean PEDI-CAT scaled scores for the group of children with disabilities (n=50) and the group of children without disabilities (n=52) for each of the four domains using a two-sample independent means t test. We also tested the variance equivalence between the two groups using the F test. If the groups' variances were unequal, then the Satterthwaite's approximation [25] for the degrees of freedom to approximate the t statistic was used.

Intraclass correlation coefficients and 95% confidence intervals (ICC (3,1)) [26] were calculated to assess agreement between test and retest scores for each domain. Assessment administration time was evaluated by examining the time it took parent respondents to complete the 60-item (15-items in each of the four domains) PEDI-CAT. This was done using the start and stop times of the PEDI-CAT program's internal clock and calculating a mean and standard deviation. In addition, we compared the administration time for the group of parents of children with disabilities with those parents of children without disabilities. Lastly, we examined what percentage of participants completed the PEDI-CAT in less than 10, less than 15 and less than 20 minutes.

Parent respondent feedback regarding item-relevance, provision of meaningful information about their own child, willingness to complete a CAT versus a full-length paper-pencil assessment and interest in completing a CAT on-line was collected and summarized using percentages. A Chi-square contingency table analysis was used to determine if the feedback was different between the group of parents of children with disabilities and the group of parents whose children did not have a disability.

Results

The PEDI-CAT was able to differentiate between groups based on parent responses to items in all four domains. Differences in mean scaled scores are presented in table 3. Figures 1-4 provides a plot of individual cases for each domain and illustrates the difference in scores between children with and without disabilities relative to their age percentiles. In each of these figures, the chronological age is displayed along the x-axis, and the summary score is arranged along the y-axis.

Re-tests were completed between seven and 30 days after the initial PEDI-CAT assessment. The average number of days between the initial assessment and the re-test was 14.92 (SD=7.69). Test-retest reliability results were high for all four domains of the PEDI-CAT. Intraclass correlation coefficients were lowest for the Responsibility domain (ICC=0.96, 95% CI=0.910.98) and highest for the Mobility domain (ICC=0.99, 95% CI=0.97-0.99).

The mean time to complete the full PEDI-CAT (15-items in each of the four domains) for the full sample (n=102) was 12.66 minutes (SD=4.47). There was no significant difference in mean time to complete the PEDI-CAT between parents of children without disabilities (11.85 minutes) and parents of children with disabilities (14.61 minutes). The least amount of time needed to complete the full PEDI-CAT was 3.96 minutes and the longest time was 26.68 minutes. Twenty-eight (28%) parents completed the PEDI-CAT in less than 10 minutes, 77 (76%) parents completed the PEDI-CAT in less than 15 minutes and 92 (90%) of the 102 parents completed the PEDI-CAT in less than 20 minutes. The mean time for the re-test sample to complete the PEDICAT a second time dropped slightly to 12.26 minutes (SD=4.65).

The majority of parent respondents indicated that they would be willing to answer questions about their child using a CAT versus a paper-pencil assessment. In addition, almost all parents indicated that they felt they provided meaningful information about their child and most parents were very enthusiastic about the content of the Responsibility domain. About half of the total sample however, felt they were asked questions that were irrelevant for their child and this percentage was significantly greater for parents of children with disabilities.

Discussion

The Pediatric Evaluation of Disability Inventory Computerized Adaptive Test was developed to respond to the need for an accurate and efficient functional measure with content for children and youth from birth up to 21 years of age in multiple functional content areas [2]. The PEDICAT promises to be a major advance in the sophistication of assessment tools available for measuring functional skills in children and youth. A new technology such as the PEDI-CAT, must however, offer clear value to clinicians and researchers if it is to be utilized. The objectives of this study were to examine discriminant validity, test-retest reliability, administration time, and feasibility of the new PEDI-CAT.

This is the first prospective use of the new PEDI-CAT, though there have been previous reports about the prospective use of the PEDI-MCAT, a multidimensional CAT combining self-care and mobility [18,27,28]. In one prospective study, Mulcahey et al reported that the PEDI-MCAT could detect expected differences between patient groups in a study of 77 children who were seen by a spine surgeon during a routine clinic visit for progressive spinal deformity [18].

We found the PEDI-CAT equally able to discriminate between groups of children with and without disabilities in this study in all four functional domains. This is particularly encouraging in the Mobility domain as the number of children with more severe physical disabilities was small. The reference curves in Figures 1-4 provide a visual representation of the differences between groups and can be used in a clinic setting to facilitate discussion of an individual child's strengths and functional deficits.

Parent respondents were asked to repeat the PEDI-CAT within one month to avoid the likelihood of major changes in the child's development and functional skills that would then have altered the stability of the scores We found the PEDI-CAT score estimates to be stable over time with excellent test-retest reliability demonstrated by the ICC values. This finding suggests that overall there is little measurement error when the PEDI-CAT is completed by

the same respondent over a short period of time (within one month). Parent respondents also were not informed of the score or their responses on the first administration so as to avoid rater bias and testing effects. We were not surprised with this result as Mulcahey et al found the PEDI-MCAT scores stable over a two-week interval when the measure was completed by parents of children with spinal impairments [18]. The test-retest reliability data have direct implications for responsiveness and will be used in future work to calculate Minimal Detectable Change (MDC) values for the PEDI-CAT.

While there was no significant difference in mean time to complete the PEDI-CAT between parents of children without disabilities (11.85 minutes) and parents of children with disabilities (14.61 minutes), it is noted that parents of children with disabilities, on average, took longer. In addition, there was a wide range of time used by parents to complete the CAT. With close examination of the times by case, we noted that all of the parents with times greater than the average were those parents who completed the PEDI-CAT in a clinic setting. These parents completed the CAT while waiting for a doctor or therapist and were often interrupted by their child or other clinical service personnel. We also noted that some parents needed assistance in using a laptop computer. Lastly, there were parents whose completion time was longer than the average because they chose to engage in conversation with the study coordinator who was present to answer questions related to the study. The average time to complete the PEDI-CAT in this study was comparable to previous studies [20,21] that examined administration time for early versions of the PEDI-CAT. Further studies regarding administration time are warranted.

In a 2005 study examining respondent ratings of burden using a prototype PEDI-CAT assessing mobility, more than 80% of parent respondents thought the paper-pencil version of the original PEDI was more burdensome and less efficient than the CAT [20]. Similar results were obtained in a 2008 study examining a prototype CAT of the self-care and social function domains of the PEDI [21]. In this present study, while parents reported very favorable reactions to the idea of a computer-adaptive test and the possibility of completing the assessment on-line, parents also reported that there were some items that were irrelevant to their child. We believe that some of this may be due to the use of the 15-item CAT, meaning that parents were presented with more items than were required to obtain an accurate score.

The primary reason parents reported that items were irrelevant was due to their child's age. For example, many parents reported that their child was too young (e.g. Daily Activity item asking about shaving) or too old (e.g. Mobility item asking about using a ride-on toy) for a particular item. The PEDI-CAT developed for use in practice will use gender and age filters to ensure the relevance of all items. Other reasons parents reported that items were irrelevant were that the parent does not allow a particular activity (e.g. Daily Activities item-Uses a grater or knife in food preparation); activities were simply too hard for their child (e.g. Mobility-Hikes 3 miles/5 kilometers); or that the activities simply did not apply to their child and family (e.g. Responsibility item-Keeping personal electronic devices in working order (e.g., cell phone, computer) and Mobility item -Gets on and off a public bus or school bus). Parents were highly enthusiastic about the Responsibility Domain, however, reporting that the subtle distinctions in this area were particularly useful for older children and teens. In anticipation of this, we had chosen to limit our study sample to parents of children 3 years and older, although the Daily Activities, Mobility and Social/Cognitive domains have items for children under three years of age.

Using the PEDI-CAT prospectively in a non-standardized environment was done in this study as it is anticipated that the PEDI-CAT will be used in a variety of settings for children including hospitals, schools, outpatient practices and at home. Previous studies using

simulated CATs based on both prospective and retrospective data have shown promising results in other areas. The PEDI-MCAT for example, was found to be sensitive to change over time for children with disabilities enrolled in a community fitness program [28] and for children admitted to a pulmonary rehabilitation program [29]. Also, good alternate-form reliability between the full-length PEDI and the PEDI-MCAT [22, 23] and self-care and social function PEDI-CAT prototypes has been demonstrated [20-23]. These are areas of future work for the PEDI-CAT.

This study adds to the overall findings that CAT programs can achieve high reliability and demonstrate evidence of validity. These results support CAT application in the field of child and adolescent rehabilitation. The ability of the PEDI-CAT scores to discriminate between known groups was demonstrated and scores were able to be replicated, demonstrating test-retest reliability. On average, parents were able to complete 60 items on the PEDI-CAT in under 15 minutes and reported they would prefer its use over traditional fixed format paper-pencil assessments. A valid and reliable PEDICAT accepted by parents has the potential to improve the information used in making decisions about individual and program outcomes, the impact of research interventions and children's eligibility for services.

Acknowledgments

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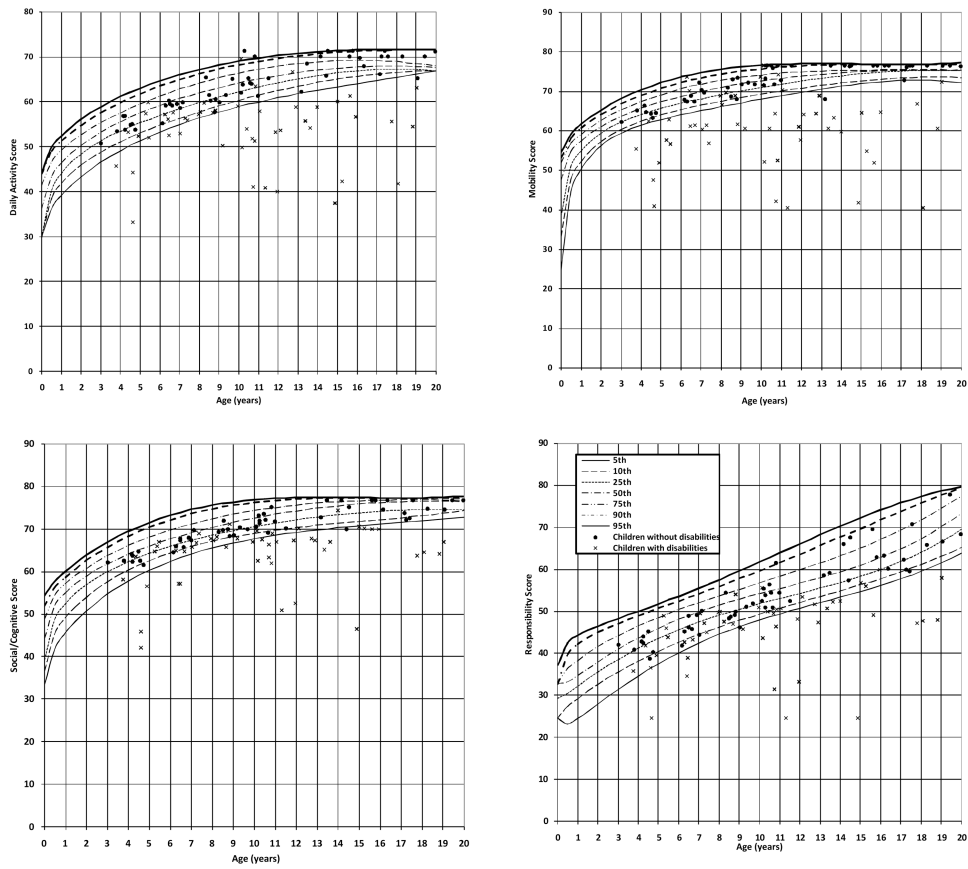
Figure 1. Plots of individual cases for each domain illustrates the difference in scores between the groups of children with and without disabilities
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Table 1

Participant Demographics

	Total Sample (n=102)	Parents/Children with Disabilities* (n=50)	Parents/Children without Disabilities* (n=52)	Re-Test Sample (n=25)
Respondent (n, % Mother)	94 (92%)	45 (90%)	49 (94%)	23 (92%)
Respondent Highest Level of Education				
Some High School	6 (6%)	2 (4%)	4 (8%)	0 (0%)
High School Graduate	8 (8%)	7 (14%)	1 (2%)	2 (8%)
Some College	20 (20%)	11 (22%)	9 (17%)	6 (24%)
College Graduate	47 (46%)	18 (36%)	29 (56%)	10 (40%)
Graduate School	21 (21%)	12 (24%)	9 (17%)	7 (28%)
Respondent Race (n, % White)	81 (79%)	41 (82%)	40 (77%)	19 (76%)
Child's Race (n, % White)	79 (78%)	39 (78%)	38 (76%)	19 (76%)
Child's Gender (n, % Male)	60 (59%)	34 (68%)	28 (54%)	15 (60%)
Children's Age (years) (mean, SD)	10.30 (4.64)	10.68 (4.34)	10.44 (4.96)	10.68 (5.16)
Children's Age Groups (years)				
3-5 years	16 (16%)	8 (16%)	8 (15%)	4 (16%)
6-9 years	30 (29%)	14 (28%)	16 (31%)	7 (28%)
10-13 years	28 (28%)	16 (32%)	12 (23%)	6 (24%)
14-17 years	18 (18%)	7 (14%)	11 (21%)	3 (12%)
18-20 years	10 (10%)	5 (10%)	5 (10%)	5 (20%)
Primary Medical Diagnostic Groups ADHD	N/A	3 (6%)	N/A	0 (0%)
Autism Spectrum Disorders		9 (18%)		3 (12%)
Cerebral Palsy		27 (54%)		5 (25%)
Other Genetic/Neuromuscular Disorders		11 (22%)		3 (12%)
				N/A 14 (56%)

Table 2

PEDI-CAT Domain Content Areas, Sample Items and Response Scales

Domain	Content Areas	Sample Item	Response Scale
Daily Activities (68 items)	Eating & Mealtime	Inserts a straw into a juice box	Please choose which response below best describes your child's ability in the following: • Unable = Can't do, doesn't know how or is too young. • Hard = Does with a lot of help, extra time, or effort. • A little hard = Does with a little help, extra time or effort. • Easy = Does with no help, extra time or effort, or child's skills are past this level. • I don't know.
	Getting Dressed	Puts on winter, sport, or work gloves	
	Keeping Clean	Puts toothpaste on brush and brushes teeth thoroughly	
	Home Tasks	Opens door lock using key	
Mobility (97 items)	Basic Movement & Transfers	When lying on back, turns head to both sides	
	Standing & Walking	Walks while wearing a light backpack	
	Steps & Inclines	Goes up and down an escalator	
	Running & Playing	Pulls self out of swimming pool not using ladder	
	Wheelchair	Goes up and down ramp with wheelchair	
Social/Cognitive (60 items)	Interaction	Greets new people appropriately when introduced	
	Communication	Writes short notes or sends text messages or email	
	Everyday Cognition	Recognizes his/her printed name	
	Self Management	When upset, responds without punching, hitting, or biting	
Responsibility (51 items)	Organization & Planning	Keeping personal electronic devices in working order (e.g., cell phone, computer) Includes: Having devices charged and available	How much responsibility does your child take for the following activities? • Adult/caregiver has full responsibility; the child does not take any responsibility. • Adult/caregiver has most responsibility and child takes a little responsibility. • Adult/caregiver and child share responsibility about equally.

Domain	Content Areas	Sample Item	Response Scale
		when needed; Updating software	• Child has most responsibility with a little direction, supervision or guidance from an adult/ caregiver.
	Taking Care of Daily Needs	Buying clothing at a store, from a catalog or online Includes: Purchasing clothing, including outerwear and undergarments	• Child takes full responsibility without any direction, supervision or guidance from an adult/ caregiver. • I don't know.
	Health Management	Following health and medical treatment requirements Includes: Taking prescribed medication as directed; Following dietary restrictions; Adhering to exercise or other treatment routines	
	Staying Safe	Using the internet safely Includes: Recognizing scams and inappropriate approaches from strangers; Avoiding posting inappropriate images; Evaluating safety of files before downloading	

Table 3

Known-Group (Discriminant) Validity

	Scaled Scores- Children with Disabilities	Scaled Scores- Children without Disabilities	t	p
Daily Activities-Mean (SD)	40 8(8 4)	51 2(6 1)	7 16(89 4)	<0001 *
Mobility-Mean (SD)	37 4(10 8)	50 1(4 7)	7 64(66 2)	<0001 *
Social/Cognitive-Mean (SD)	43 9(7 7)	50 9(4 8)	5 48(81 6)	<0001 *
Responsibility-Mean (SD)	43 2(7 9)	50 9(8 7)	4 70(100)	<0001

*
: Unequal variance and using Satterthwaite's approximation to degrees of freedom

Table 4

Test-Retest Reliability

	ICC(3,1)	95% CI
Daily Activities	0.997	(0.994, 0.999)
Mobility	0.986	(0.968, 0.994)
Social/Cognitive	0.979	(0.953, 0.991)
Responsibility	0.958	(0.908, 0.981)

Table 5

User Evaluation Survey

	Total Sample (n=100)	Parents/Children with Disabilities (n=50)	Parents/Children without Disabilities (n=52)
Were you asked irrelevant questions?	49 (48%) Yes	29 (58%) Yes [*]	20 (38%) Yes [*]
Do you feel you provided meaningful information about your child?	100 (98%) Yes	48 (96%) Yes	52 (100%) Yes
Would you be more willing to do this computer adaptive test rather than a paper/pencil test for ongoing assessments of your child?	99 (97%) Yes	47 (94%) Yes	52 (100%) Yes
Would you be willing to complete an assessment such as this on-line in the future?	100 (98%) Yes	48 (96%) Yes	52 (100%) Yes

[*] Significant between 2 groups $p = 0.048$ with Chi-square.