ORIGINAL ARTICLE

Reliability, Validity, and Adaptation of Computerized Revised Token Test in Normal Subjects

Meral Didem Turkyılmaz, Erol Belgin

University of Hacettepe E.N.T Audiology and Speech Pathology Department (MDT, EB)

Introduction: The aim of the present study was to study adaptation, reliability, and validity characteristic of the Turkish version of Computerized Revised Token Test (CRTT) in normal subjects. CRTT is a diagnostic test used to evaluate the auditory processing abilities. T-CRTT consists of 10 subtests that require following commands and identifying and manipulating objects of standardized shapes, colors and sizes.

Materials and Methods: The present study conducted at Hacettepe University Faculty of Medicine, E.N.T Department, Audiology and Speech Pathology Unit. For the reliability and validity analysis, 60 healthy subjects (28 men and 32 female) aged between 20 and 80 yrs were included in the study. Descriptive statistics of measurements were calculated as mean± SD. Cronbach's alpha coefficient was used to assess the internal consistency of the scales. Test-retest reliability was examined using Pearson correlation coefficient between first and second application of T-CRTT. In T-CRTT validity analysis, structural validation was thought to be useful.

Results: All of the subjects' subtest's mean scores, overall scores and efficiency scores were calculated. Cronbach's coefficients for subtests mean scores and efficiency scores were calculated respectively as (0.77), and (0.76). Results of our test-retest results indicated good reliability except for Subtest 8. ICC and α score was respectively 0.828 (ICC), 0.906 (α) and 0.764 (ICC), 0.866 (α). For validity, sex and age correlations were evaluated and it was found that overall scores and efficiency scores were not affected with gender differences, but were affected with age factor.

Conclusion: We believe that T-CRTT is a detailed and useful instrument for the evaluation of auditory processing inefficiencies and evaluation of suitable management programmes.

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Introduction

The Revised Token Test (RTT) was designed to quantify auditory processing abilities and give the clinician information about the individual's auditory attention, auditory memory, and temporal processing abilities [1,2]. In addition, RTT provides information regarding a subject's linguistic processing abilities at the lexical-semantic levels of processing [2]. The standart version of RTT [1] consists of 10 subtests varying in sentence length and complexity that require following commands and identifying and manipulating plastic objects of standardized shapes (circles and squares), colors (black, red, blue, white, and green) and sizes (big, and small). The objects are placed in front of subject in specified locations. The clinician gives an auditory stimulus, such as "Touch the red circle" or "Put the big green square behind the small black circle" [1] .The subjects respond by touching or manipulating the objects. In six of ten subtests the appropriate respond requires touching an object and in four of the ten subtests the appropriate respond requires the movement of an object [1] .Ten subtests, each containing ten commands, range in difficulty and linguistic elements. 15-point multidimensional scoring system is used to describe performance [3] .In scoring system, each linguistic element in each sentence receives a score ranging from 1-15 and the average of these scores forms a sentence mean. Means for each linguistic element are also derived within subtests and across all subtests [1,3] .Because of complexity

Corresponding address:
Dr. Meral Didem Türkyılmaz
Contact Adress: Ugur Mumcu Sokak No: 63-12 06700 Gaziosmanpasa-Ankara- Turkey
Mobil phone: 0090 5333201316, Home phone: 0090 3124470030
Work phone: 0090 3123054387, Fax: 0090 3123113500
E-mail: didemcanatan@yahoo.com

construction of scoring system of RTT, the clinician must be very familiar with the test to provide reliability criteria [4] . In order to increase reliability, and reduce training effects, RTT has been converted to computer administration and scoring and so a computerized version of RTT has been developed: The Computerized Revised Token Test (CRTT) [2] . CRTT allows auditory stimuli to be given with computer while the participant responds to test commands by manipulating tokens on a computer monitor. Also the other additional feature in the CRTT is an Efficiency Score (ES). This score gives information about response time [5] . Specific details on the development, administration, and scoring system were described in materials and methods section.The developers of the CRTT [2] presented construct, concurrent validity, and test-retest reliability [2,6-9] . They showed CRTT had strong validity and reliability characteristic. Because of its well established validity, reliability, highly redundant, and sensitive multidimensional scoring system, well-specified and standardized administration, and there is relatively limited information published on the assessment instruments of auditory language processing in Turkish population, adaptation of CRTT in Turkish was thought to be useful and necessary. For these reasons, the CRTT was judged to be a particularly appropriate tool for adaptation into Turkish language. The aim of the present study was to study adaptation, reliability, and validity characteristic of the Turkish-CRTT version in normal subjects.

Materials and Methods

CRTT

The RTT [1] consists of 10 subtests that require commands and identifying and manipulating objects of standart shapes, colors, and sizes. CRTT [2] consists of of the same 10 subtests used in the RTT. The subjects follows commands and manipulates objects equivalent to the RTT with spesified standardized shapes, colors, and sizes. However, instead of a clinician presenting the auditory commands from live voice, a computer presents auditory commands, and instead of the subject manipulation of actual objects, the participant manipulates the images on the computer monitor with the mouse. In the T-CRTT test protocol, the objects are represented as images on the monitor and rearranged according to the CRTT protocol, following that specified in the RTT [1] . Subjects manipulate the images or dragging an image with mouse across the monitor. T-CRTT consist of ten subtests varying in sentence length and complexity and every 10 subtests consists of 10 homogenous commands of equal length, syntactic complexity, and vocabulary level. There are five different sentence lengths that differ among three, four, six, and eight linguistic units scored per command [2] . Table 1 provides examples of stimulus commands from each of the subtests to show increasing linguistic complexity across different subtests in CRTT. Table 2 also shows all linguistic elements in the test protocol.

Table 1. Description of stimulus items from Computerized Revised Token Test

Subtests	Command type	Elements involved	Example of stimulus item
1	Simple imperative	Color, shape	Touch the black circle
2	Simple imperative	Color, shape, size	Touch the big green circle
3	Compound imperative	Color, shape	Touch the green square and the black square
4	Compound imperative	Color, shape, size	Touch the big green square and the little black square
5	General spatial prepositional	Color, shape	Put the black square above the red circle
6	General spatial prepositional	Color, shape, size	Put the big red square in front of the big white circle
7	Directional prepositional	Color, shape	Put the black circle to the left of the white square
8	Directional prepositional	Color, shape, size	Put the little green circle to the left of the big red square
9	Adverbial	Color, shape	Instead of the green square, touch the black square
10	Adverbial	Color, shape, size	Touch the big black square unless you have touched the little red circle

Table 2. Summary of linguistic elements contained in each subtest

Subtest	Verb1	Color 1	Shape1	Size1	Verb2	Color2	Shape2	Size2	Place	Clause
I	+	+	+							
II	+	+	+	+						
III	+	+	+		+	+	+			
IV	+	+	+	+	+	+	+	+		
V	+	+	+			+	+		+	
VI	+	+	+	+		+	+	+	+	
VII	+	+	+			+	+		+	
VIII	+	+	+	+		+	+	+	+	
IX	+	+	+							+
X	+	+	+	+						+

Scoring of CRTT

The scoring system used by CRTT represents multidimensional scale [8] . In CRTT, 15-point multidimensional scoring system is used. The computer scores the subject's response, automatically. The score represents a description of how the task was performed. In the Turkish version of CRTT (T-CRTT), the same scroring system was used. The T-CRTT scoring scale is shown Table 3. Multidimensional scoring system include providing useful information regarding individual's responses using a standarized format, describing individual's behaviors and deficits in detail [9] . This 15-point scale provides quantification of every response on the accuracy, responsiveness, completeness, promptness, and efficiency dimensions [6,9] . A score of 15 shows completely correct response and is the maximum score that a person can achieve on any part of the test. Each linguistic unit in each sentence receives a score ranging from 1-15. For example, each of ten commands in subtest 1 consists of three linguistic elements: a verb (command), an adjective (color I), and a noun (shape I). Thus each element will receive three seperate scores ranging from 1-15. Average of these scores forms a sentence mean. Overall mean scores for each sentence within a subtest are averaged to derive an overall mean subtest score. In the same way, overall mean subtests for all 10 subtests are averaged to derive an overall mean score for the all test. CRTT also provides an Efficiency Score (ES). It can be calculated for each individual command, for each subtest, and for the whole test. The ES is a measure of how long it takes the patient to respond relative to the score [2] . In the Turkish version of CRTT, also ES was used.

Table 3. CRTT scale score descriptions

Score	Description of response
15	Complete
14	Rehearsal
13	Delay
12	Immediacy
11	Self-correction
10	Reversal
9	Repeat
8	Cue
7	Error
6	Perseveration
5	Intelligible but incorrect response
4	Unintelligible response-differentiated
3	Unintelligible response-perseverated
2	Omission
1	No response

Subjects

For the reliability and validity analysis, 60 healthy volunteer subjects (28 men and 32 female) aged between 20 and 80 yrs were included in the study. The mean age of the participants was 42.73 yrs (SD 14.36). The mean of the education level of the participants was 12.95 yrs (SD 4.42). They were recruited among hospital employees and inpatients' and outpatients' relatives or caregivers. Each participant completed the informed consent form, and the biographical survey prior to administration of the T- CRTT. In addition, pure tone thresholds equal to or less than 25 dBHL were obtained, at between 250 Hz and 6kHz, with earphone. The biographical survey consisted of a series of questions regarding demographic information

such as age, self reported hand dominance, past medical history, and speech, language, hearing and learning history. Individuals were excluded if they had taken any drugs known to affect mental status, if they had neurological illness, major or minor brain injury, speech and language problems, and other health problems (psychiatric disease, disease known to affect vision, hearing, alcohol abuse). Finally, subjects were required to pass the pretest of the

T- CRTT to demonstrate knowledge of color, shape, and size of the objects used in the test and the basic movement abilities associated with the usage of mouse. All the subjects were native Turkish speakers and literate living in the different districts of Ankara. Of the subjects ten were re-tested after two-three weeks interval by the same clinician and at the same place, in order to collect test-retest reliability data.

Translation procedure

The present study approved by Hacettepe University Ethical Board (LUT 08/30-58) conducted at Hacettepe University Faculty of Medicine, Otorhinolarnygology Department, Audiology and Speech Pathology Unit.

Translation procedures started with permission obtained from Prof. Dr. Malcolm McNeil, developer of the test to use the Computerized Revised Token Test. The Turkish version of Computerized Revised Token Test installation programme was obtained from Pittsburgh University Communication Sciences and Disorders Department Laboratory. Since administration and scoring system of T-CRTT was performed via computer automatically, there was no need for translation for these procedures. The original CRTT [2] test items and test instructions were translated into Turkish independently by two specialists with advanced English in communication sciences and a professor in Department of English Linguistics. These Turkish translations of the CRTT were then translated back into English by different specialist with advanced English in communication sciences and an Lecturer in Department of English Linguistics. These texts were then compared with each other, and the final Turkish translation of the CRTT was formed.

Application procedures

The Turkish version of Computerized Revised Token Test items, and test instructions were recorded at the Professional voice studio by Turkish native speaker man in Ankara. After recording procedures, all the voice files, in the same sequence and manner with regard to original form, were saved as “wav files” and sent to “ Pittsburgh University Communication Sciences” and VA Pittsburgh Healthcare System and Necessity Consulting Research Department. In the laboratory, all of the acoustic analysis and recordings were formed with regard to original form and Turkish and English alternatives were added and sent back in the form of Compact Disc for Turkish usage. The test was installed onto laptop computer and two monitors were connected for the test administration. In the examiner’s screen, administration of the test, all of the test items, and results of subject were seen. In the subject’s monitor just test items were seen. For the test application procedure, test was performed in the silent test room and sitting side by side with the subject. Subject responded to test items with mouse.

Statistical Analysis

Data were analyzed by using SPSS for Windows 11.5 software programme. Descriptive statistics of measurements were calculated as mean± SD. Cronbach’s alpha coefficient was used to assess the internal consistency of the scales. Test-retest reliability was examined using Pearson correlation coefficient between first and second application of T-CRTT. In literature, there are different validation methods, i.e content validation, criterion validation, or construct validation. In T-CRTT validity analysis, structural validation was thought to be useful. Thus the literature was reviewed, and well known associated properties were examined and finally, the validity analysis performed on that two variables.

Reliability

The reliability of the adapted version of Turkish CRTT was initially tested by internal consistency and test-retest reliability. The internal consistency of an instrument is an estimate of the degree to which its constituent items are interrelated. That is, it refers to

the consistency of results obtained throughout a single test administration. The internal consistency of CRTT was measured using Cronbach's alpha coefficient. In addition the Intraclass Correlation coefficient (ICC) is calculated. Test re-test reliability was assessed by Pearson correlation coefficient.

Validity

Structural validity analysis was used in T-CRTT. For assessing validiy, gender and age factors were examined. In validity analysis Independent samples t-test performed to see differences in genders. Also correlations were calculated for age factor by Pearson's correlation coefficient.

Results

Descriptive data

Table 4 contains mean, standart deviation, and minimum-maximum scores for 60 subjects for overall mean, efficiency scores (ES), and individual CRTT subtest scores for 60 subjects.

Reliability analysis

Internal consistency was evaluated on T-CRTT subtest mean scores, and efficiency scores using Cronbach's alpha coefficients (Table 5).

Test-retest reliability was evaluated on CRTT subtests mean scores, overall scores, and efficiency scores using ICC, Cronbach's alpha, and Pearson correlation coefficient (Table 6).

Validity analysis

In validity assessment, structural analysis was used, and well known two associated properties, age and gender, were examined. In literature, auditory processing ability assessed by CRTT was affected by age variable [6,7,10,11] . The test scores of T-CRTT were decreased with increasing age, but the test scores of T-

Table 4. Means (M), standart deviations (SD), minimum (Min.), and maximum (Max.) scores for overall mean, efficiency scores (ES), and individual CRTT subtest scores for 60 subjects.

	CRTT Score				Efficiency Score			
	M	SD	Min.	Max.	M	SD	Min.	Max.
Overall	14.16	0.75	12.10	15.00	13.60	0.70	11.87	14.72
Subtests								
1	14.36	0.57	12.80	15.00	13.71	0.86	10.77	14.81
2	14.43	0.65	12.30	15.00	13.71	0.94	10.08	14.76
3	13.64	0.93	12.00	15.00	12.61	0.80	10.47	14.06
4	13.26	1.22	10.40	15.00	12.45	0.98	9.82	14.30
5	13.19	0.77	11.00	14.53	11.44	0.89	8.87	13.08
6	12.82	0.81	11.24	14.50	11.28	0.80	9.38	12.83
7	12.93	1.06	11.00	14.83	11.76	0.82	9.96	13.63
8	12.80	0.90	11.40	15.00	11.81	0.73	10.20	13.93
9	14.38	0.69	12.30	15.00	13.58	0.73	10.73	14.64
10	14.21	0.75	12.10	15.00	13.64	0.67	11.86	14.72

Table 5. Cronbach's alpha coefficients for subtest mean scores, and efficiency scores

Subtest no	Cronbach's alpha	
	CRTT mean score	Efficiency score
1	0.67	0.80
2	0.78	0.85
3	0.72	0.70
4	0.91	0.87
5	0.66	0.72
6	0.72	0.69
7	0.84	0.74
8	0.81	0.74
9	0.79	0.73
10	0.80	0.74

Table 6. ICC, Cronbach's alpha, and Pearson correlation coefficient (r) for CRTT subtest mean scores, overall scores, and efficiency scores.

Test-retest	CRTT Score			Efficiency Score		
	r	ICC	Cronbach's alpha	R	ICC	Cronbach's alpha
Overall	0.830**	0.828**	0.906	0.766**	0.764**	0.866
Subtests						
1	0.597	0.535*	0.697	0.689*	0.683*	0.812
2	0.946**	0.803**	0.891	0.846**	0.746**	0.855
3	0.951**	0.949**	0.974	0.847**	0.847**	0.917
4	0.965**	0.964**	0.982	0.978**	0.976**	0.988
5	0.803**	0.709**	0.830	0.849**	0.804**	0.891
6	0.753*	0.729**	0.843	0.801**	0.753**	0.759
7	0.921**	0.824**	0.904	0.697*	0.650*	0.788
8	0.465	0.459	0.629	0.546	0.489	0.657
9	0.542	0.501	0.667	0.709*	0.633*	0.775
10	0.830**	0.828**	0.906	0.766**	0.764**	0.866

** p< 0.05 **p< 0.01*

CRTT was not affected by gender variable. That is, test scores did not vary in genders. The fact that of literature information on these factors, in validity analysis that two factors were evaluated. The comparison of performance of the subjects regarding gender (was not affected by age, t-test performed and p: 0.879 was obtained) was made by independent samples t test. The comparison of performance of the subjects regarding gender was evaluated on overall score, and efficiency score (Table 7). Correlations between age and the test performance were computed by Pearson's correlation analysis (Table 8). The result showed there was negatively but statistically significant relation between the age variable and T-CRTT overall and efficiency test scores. That is, increasing with age, the performance of participants was decreased.

Table 7. The comparison of performance of the subjects regarding gender based on overall score, and efficiency score.

	Women (M±SD)	Men (M±SD)	T	P
Overall score	14.08±0.82	14.22±0.68	-0.739	0.463
Efficiency score	13.54±0.75	13.62±0.65	-0.448	0.656

Table 8. Correlations between age and test performance based on overall score and efficiency score.

	R	P
Overall score	-0.332	0.010*
Efficiency score	-0.456	0.000*

Discussion

CRTT, as far as the structure characteristics and objectives of the testing are concerned, it can be used both in normal populations and in developmental disorders or sustained brain damage problems [12-14] . CRTT measures the function of auditory language processing based on the concept of stimulus-response sequences and control over stimulus-function modalities and properties [2,6] . The acoustic stimuli of the test were constructed across all subtests varying in sentence lenght and complexity, with each subtest having ten homogenous items of equal length, syntactic complexity, and vocabulary level, but all other task characteristics kept constant. Thus careful construction of CRTT provides the unidimensinality property [1,2] . In the light of these facts, CRTT have been developed as a diagnostic test to evaluate the auditory processing abilities of individuals between the the age of 5 through the lifespan.

Here we reported a new Turkish auditory comprehension test which we have adapted as a guide to assess auditory language processing efficiency. In Turkey, there are very limited standarized tests to assess auditory comprehension. Some of them are commonly used for evaluating receptive language or part of language test battery. In this study, we aimed the Turkish adaptation, reliability, and validity study of Computerized Revised Token Test-CRTT. CRTT was selected because it is a well known test of auditory processing and all psychometric analyses of the test, described above section, demonstrated the CRTT is a valuable test used in clinical and research tool designed and standarized to assess the nature of auditory comprehension/processing efficiency.

Application Procedures of Turkish-CRTT (T-CRTT)

T-CRTT consisted of ten subtests varying in sentence lenght and complexity, with each subtest having ten homogenous commands. A computer presents the acoustically controlled commands, and the subject manipulates images on a computer monitor. Using circles and squares that differ in size, color, and shape, the listeners performs auditory commands to manipulate these objects. Comprehension of these commands was demonstrated by manipulating the correct objects or manipulating the objects in a particular position relative to another by dragging with the mouse. But in original CRTT [2] , listeners manipulate the images by either touching an image on the touchscreen monitor or by touching and dragging an image across the monitor. While the images are representations of actual objects and listeners may have difficulty with abstract concepts, the manual response using a touchscreen is concrete and does not require increased levels of abstraction compared to other methods of access such as the use of mouse, keyboard, or other pointing device [5,15]. So, to limit the amount of abstraction required of the patients, a touchscreen monitor was used in the development of CRTT [2] . A mouse is meant to represent a finger and a additional level of abstraction is required to use it. Since the purpose of the CRTT is designed to assess auditory processing and comprehension, it is advantageous to keep other aspects of the test as simple as possible. While the use of touchscreen appears to be valid and reliable, method of administering and scoring the test, there are limitations to its use. Though computers are almost universially available, touchscreen monitors are not [16] . Many clinics do not have the sufficient financial means to purchase a touchscreen monitor [15] . Also, clinicians may need to administer the test form a distance due to the ever increasing demand for telerehabilitation, and many listeners or subjects will not have access to a touchscreen monitor [15,16] . Also, some individuals might feel more comfortable using mouse. For example, children and young adults might be more comfortable and proficient with a mouse then older individuals. Researchers mentioned that there were not significant differences between the usage of mouse and touchscreen monitor [16,17] . Clinicians might also select to use a standart computer and mouse based on subject preference and familiarity with computers. Computers are being more often and earlier by individuals, and young children may prefer to use a mouse than touchscreen [16] .

Romeo, and et.al conducted a study to investigate the use of touchscreen monitors in childhood settings and they found that most of the children preferred the use of mouse. Possible explanations for this difference may be that the mouse is the most appropriate device or they are more familiar with and comfortable using a mouse [8] .

Wood, et al. also examined the use of different input devices in childhood education settings and found similar results and they mentioned that the mouse was considered to be the most effective input device for both teachers and students [19] .

Heilman and et al. studied the usage of mouse and touchscreen monitor preferences in CRTT in participants with language problems. They found that, while the touchscreen access method produced significantly higher subtest and overall CRTT scores than the mouse access method, along with equivalent reliability performance in language problems, it is not clear that it should be used as the preferred access method [5] .

McNeil, et. al. found that the CRTT touchscreen access mode generated significantly higher scores than the mouse version in normal healthy group and group with neurogenic language problem [15] . In application of T-CRTT, we had not any chance to use touchscreen access method, the application was performed with mouse method. In our participants, we did not observe any difficulty with mouse usage except for elderly participants. But in pretest applications, we showed the usage of the mouse and practiced with the mouse with

old participants. During petest application, we excluded the participants who could not use the mouse. When we look at the duration of application, the all the test takes 90- min. Original CRTT with tochscreen method takes 30-45 min. The duration of 90-min appears reasonable time for all the test items.

Scoring of Turkish-CRTT (T-CRTT)

Strategic selection of an appropriate scoring system for auditory comprehension assessment depends on the intended use and means of interpretation of test results. Auditory comprehension tests have employed a lot of different scoring methods [9] . Multidimensional scoring method is one of them. 15-point multidimensional scoring system was used in T-CRTT. The computer scores the subject's response. 15-point scale allows for quantification of each response on accuracy, promptness, completeness, responsiveness, and efficiency dimensions[2]. Advantages of multidimensional scoring sistem include providing useful information regarding responses, describing responses in detail within a standarized format, documenting effects of treatment and predicting recovery, and developing good observation skills in clinicians [9] . These scales provide valuable descriptions of an invidual's behaviors and information about the abilities underlying those behaviors. Despite the many advantages of multidimensional scoring, there are some disadvantages. For example, multidimensional scoring system requires training to perform intra and inter scorer reliability, it is time consuming, and also cost effective [9,15] .

McNeil and Prescott [1] advised 24 hr of training to provide reliability in scoring the RTT. But the computerized form of RTT (CRTT) eliminated the all disdavantages of multidimensional scoring method and provided more reliable and valid scoring system [2] .

The Turkish version CRTT consists of ten subtests and each subtests consist of ten homogenous test items. The individual score for each subtest takes into account the responses for each liguistic element as well as the overall responses for each command. The individual scores for each subtest are then used to define the overall score. The overall test score is the average score of the 580 linguistic elements and the ten commands per subtests across the ten subtests. The results also can be used to develop profiles that describe the subject's ability. Efficiency Score (ES) was also calculated in T-CRTT. It can be calculated for each individual test items, for each subtest, and for the whole test. Therefore the T-CRTT provides standarized administarion and scoring system, providing more valid assessment tool.

Statistical Analysis

In this study, we investigated the reliability and validity of the adapted Turkish version of CRTT instrument for normal subjects, before using it in our daily practice and studies. The Turkish tranlation of the original CRTT was employed in this study, without any making changes in its original form.

Reliability analysis of T-CRTT

The reliability of the adapted version of Turkish CRTT was initially tested by internal consistency and test-retest reliability. Internal consistency was evaluated on subtest mean scores, and efficiency scores using Cronbach's alpha coefficients. Cronbach's coefficients for subtests mean scores and efficiency scores were calculated respectively as (0.77), ranging (.66-.91); and (.76), ranging (.69-.85). Except for coefficients of CRTT subtest 1 (0.66) and subtest 6 (0.67), coefficients for CRTT subtests and efficieny scores were found adequately high. High Cronbach's alpha values indicate strong internal consistency of scale. Test-retest reliability was evaluated on CRTT subtests mean scores, overall scores, and efficiency scores using ICC, Cronbach's alpha, and Pearson correlation coefficient. Results of our test-retest results indicated good reliability except for T- CRTT Subtest 8. ICC and α score for overall test score and efficieny score was respectively 0.828 (ICC), 0.906 (α) and 0.764 (ICC), 0.866 (α). High Cronbach' alpha coefficients and high ICC values were found in our study, which indicated a good reliability for the Turkish translation of the CRTT. The original RTT [1] test-retest reliability for subtests was lower than intra-inter-rater reliabilities, but remains to be considered high [1] . Also Park et.al. examined short version RTT' reliability analysis. They found five-item RTT was a reliable tool that can be used confidently for clinical and research purposes [3] . McNeil et al. also examined test-retest reliability for elderly subjects and they found correlation coefficients between the test and retest for both the overall and

subtest scores were small and nonsignificant for the normal elderly participants. But they mentioned that the correlations were low and nonsignificant for the CRTT condition due to a limited distribution of scores for this group [6].

Validity analysis of T-CRTT

In validity assessment, structural analysis was used, and well known two associated properties, age and gender, were examined. In literature, auditory processing ability assessed by CRTT was affected by age variable [6,7,10,11] . The test scores of CRTT were decreased with increasing age, but the test scores of CRTT was not affected by gender variable. That is, test scores did not vary in genders. The fact that of literature information on these factors, in validity analysis that age and gender was evaluated. The comparison of performance of the subjects regarding gender was evaluated and no significant differences were found between men and women in overall and efficiency scores ($p>0.05$).

Ross and Wetz also found that gender factor did not affect the performance of normal subjects [10] . In original RTT, McNeil and Prescott also mentioned that gender did not affect the performance of RTT [1] . Correlations between age and the test performance were computed by Pearson's correlation analysis and the result showed there was negatively but statistically significant relation between the age variable and CRTT overall and efficiency test scores in this study. That is, increasing with age, the performance of participants was decreased. During informal observation of the test, we note that subtest V and the following subtests, the participants had begun to strain to drag the objects with the mouse especially in elderly participants. So the performance of these participants decreased significantly. Eberwein et. al.[2] found young normal-hearing listeners required only low-level signal amplitude relative to older participants to achieve maximum test performance on the application of CRTT.

Why did we select the CRTT? The CRTT has been developed as a sensitive measure of auditory processing/comprehension abilities of individuals between the age of five through the lifespan and means to document small amount of changes that may be used as documenting treatment effectiveness in auditory processing inefficiencies. The ability to identify supporting sources of language processing inefficiencies in specific populations can affect how clinicians or professionals categorize, treat, and manage these populations. CRTT gives the clinician information regarding a subject's linguistic processing abilities at the lexial-semantic and syntactic level [5] . The test also provides the clinician to deduce information regarding a subject's auditory attention, auditory memory, and temporal processing [2] . Because of these important properties, in order to assess the auditory comprehension and processing ability, we adapted CRTT and investigated reliability and validity of the instrument for Tukish normal healthy subjects, before using it in our clinical and research studies. We believe that T-CRTT is a detailed and useful instrument for the evaluation of auditory processing inefficiencies and evaluation of suitable management programmes. Further studies are required evaluation of effecetiveness of T-CRTT in different pathogic populations.

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