ISSN: 2083-389X
eISSN: 2084-3127

J Hear Sci, 2023; 13(2): 49–56
DOI: 10.17430/jhs/168653

DEVELOPMENT OF A PHONOLOGICAL PROCESSING TEST IN MARATHI (PPT-M) FOR YOUNG ADULTS

Aashral Virendra Surana[A-F], **Piyush Vikas Sone**[A-F]

School of Audiology and Speech Language Pathology, Bharati Vidyapeeth Deemed University, Pune, India

Corresponding author: Aashral Virendra Surana, School of Audiology and Speech Language Pathology, Bharati Vidyapeeth Deemed University, Katraj, 411043, Pune, India; email: aashusurana@gmail.com

Contributions:
A Study design/planning
B Data collection/entry
C Data analysis/statistics
D Data interpretation
E Preparation of manuscript
F Literature analysis/search
G Funds collection

Abstract

Introduction: Central auditory processing and phonological processing are interconnected as they both involve successful intertwining of auditory, cognitive, and language mechanisms. A deficit in the ability to process spoken language can result in CAPD. The aim of this study was to develop a test (PPT-M) to evaluate the level of phonological processing among young Marathi-speaking adults. A second aim was to investigate the difference in the phonological processing of words and non-words.

Material and methods: The PPT-M test included three subtests: phonological awareness, phonological working memory, and phonological retrieval. For the awareness and memory tasks, the stimulus was words and non-words, whereas rapid automatised naming (RAN) of digits and letters was used to assess the retrieval task. Data was collected from 40 young adults aged 18 to 25 years. We recorded accuracy and time taken to complete the tasks.

Results: Results of item analysis suggest that the developed tool has good reliability. No significant gender effect was observed. A stimulus effect was observed for the phonological processing test.

Conclusions: The Phonological Processing Test in Marathi (PPT-M) has good internal consistency and reliability. Words and non-words are processed differently and the time required to respond to both varies. There were no gender differences. In the phonological awareness test, blending and segmentation tasks required more time to complete and had reduced accuracy.

Key words: young adults • phonological processing • auditory processing

OPRACOWANIE TESTU PRZETWARZANIA FONOLOGICZNEGO W JĘZYKU MARATHI (PPT-M) DLA MŁODYCH DOROSŁYCH

Streszczenie

Wprowadzenie: Centralne przetwarzanie słuchowe i przetwarzanie fonologiczne są ze sobą powiązane, ponieważ zależy od nich efektywne połączenie mechanizmów słuchowych, poznawczych i językowych. Deficyty w zakresie zdolności do przetwarzania języka mówionego mogą skutkować centralnymi zaburzeniami przetwarzania słuchowego (CAPD). Celem niniejszego badania było opracowanie testu (PPT-M) do oceny poziomu przetwarzania fonologicznego wśród młodych dorosłych mówiących w języku marathi. Drugim celem było zbadanie różnic w przetwarzaniu fonologicznym słów i nie-słów.

Materiał i metody: Test PPT-M składa się z trzech podtestów: świadomości fonologicznej, fonologicznej pamięci roboczej i odtwarzania fonologicznego. W zadaniach dotyczących świadomości i pamięci bodźcem były słowa i nie-słowa, natomiast testy szybkiego zautomatyzowanego nazywania (ang. *rapid automatised naming*, RAN) cyfr i liter wykorzystano do oceny odtwarzania. Dane zebrano od 40 młodych dorosłych w wieku od 18 do 25 lat. Rejestrowano dokładność i czas wykonania zadań.

Wyniki: Wyniki analizy poszczególnych elementów testu sugerują, że opracowane narzędzie jest rzetelne. Nie zaobserwowano istotnego wpływu płci na wyniki. Zaobserwowano efekt bodźca dla testu przetwarzania fonologicznego.

Wnioski: Test Przetwarzania Fonologicznego w Języku Marathi (PPT-M) jest spójny wewnętrznie i rzetelny. Słowa i nie-słowa są przetwarzane w różny sposób, różny jest także czas potrzebny na udzielenie odpowiedzi w obu rodzajach bodźców. Nie stwierdzono różnic w tym zakresie między płciami. W teście świadomości fonologicznej zadania dotyczące łączenia i segmentacji wymagały więcej czasu, a dokładność ich wykonania była mniejsza.

Słowa kluczowe: młodzi dorośli • przetwarzanie fonologiczne • przetwarzanie słuchowe

Introduction

Central auditory processing is defined by the American Speech-Language-Hearing Association Working Group on Auditory Processing Disorders [1,2] as the "efficiency and effectiveness with which the central nervous system (CNS) utilizes auditory information (as well as) the perceptual processing of auditory information in the CNS and the neurobiological activity that underpins processing and gives rise to the electrophysiologic auditory potential". CAPD is a neurobiological deficit in the CNS that influences mechanisms that underpin fundamental auditory perception, such as localisation and lateralisation; speech and non-speech sound discrimination; auditory pattern recognition; temporal aspects of audition, such as integration, ordering, and masking; and auditory performance with competing and/or degraded acoustic signals [1,2]. A problem with phonological processing is thought to be the result of an underlying auditory processing abnormality [3]. According to the auditory temporal processing deficit hypothesis, reading impairment is the result of a perceptual deficit in processing fast-changing auditory information or spectro-temporal properties of phonemes and sounds [4].

Phonological processing involves spoken sounds and written language [5], and plays a crucial role in word processing in children. It interacts with other important aspects like IQ [6,7], lexicon and letter awareness [6,8], and grammatical skill [9]. Phonological awareness, phonological working memory, and phonological retrieval are all parts of phonological processing [5]. Firstly, phonological awareness is the understanding of a language's sound structure, which includes sound identification, isolation, discrimination, and manipulation [10]. The second component, phonological decoding, involves distinguishing between real and non-real words, as well as quickly labelling things, numbers, and colours using words. Both these processes are critical for both competent and inexperienced readers. The third component involves converting written symbols into sounds for easy retrieval. This is absolutely necessary for storage in working memory. A deficit in any of these components will lead to phonological processing deficits and affect the person's reading and writing skills.

Mattingly (1972) defined phonological awareness as "an individual's awareness of and access to one's language's phonology." It is a metalinguistic talent, according to Gillon [11], that demands conscious awareness as well as reflection on language structure. It was further reduced to include speech components such as perception, identification, and manipulation of spoken sounds [12]. Phoneme elision, phoneme deletion, phoneme stripping [13], and phoneme segmentation [14] are all examples of phoneme manipulation or phoneme substitution [14,15], and are methods which are widely used to assess phonological awareness. Tools to assess phonological awareness include the Yopp–Singer Test of Phoneme Segmentation [14], the Comprehensive Test of Phonological Processing – Second Edition (CTOPP-II) [16], and the Phonological Awareness Screening Test [17]. Indian tools to assess phonological awareness are Phonological Awareness in Marathi [18], which is based on a Phonological Awareness Test in English [19].

Phonological working memory is thought to help with a range of linguistic tasks, such as acquiring unique words and expanding one's vocabulary, maintaining knowledge during sentence and discourse processing, and learning to read [20,21]. Free recall, paired association task, recognition task, and probing discourse task are some of the techniques used to measure auditory short-term memory [22]. Working memory has been assessed using techniques such as conditioned recall [23]. Other measures of phonological working memory can be linked with the experimental pseudo-word repetition task [24]. Indian literature to assess phonological working memory are the Auditory memory and sequencing test in Kannada [25] and the Auditory memory and sequencing test [26]. Western tools are the Automated Working Memory Assessment (AWMA) [27].

The ability to acquire phonological information from long-term memory is known as phonological retrieval. Rapid Automatised Naming (RAN) is one way of assessing phonological processing skill as it measures how quickly a subject can retrieve phonological representations (objects, pictures, colours, or symbols) from long-term memory [28]. RAN [29] is a measure of general processing speed or general automation [30]. Variables that evaluate rapid serial naming of items and sizes [31,32] as well as letters and numbers have been used to quantify naming speed. RAN and RAS (Rapid Alternating Stimulus) tests [33] are western tools developed to assess the phonological retrieval component.

A review of literature shows that phonological processing has been assessed using varied methods. Phonological processing is important for speech, language, reading, and writing skills. The prevalence of SLI and dyslexia is growing in number. Since India is a multicultural and multilingual country, with a diverse population of various socioeconomic backgrounds, it is necessary to assess people across languages and cultures. Marathi is one of the Indo-Aryan languages which is spoken by 120 million people in the world (Modern Marathi at Ethnologue, 2019). Although a tool to test phonological awareness in Marathi is available [18], a standard tool to assess full phonological processing – all three of its components – is not. A phonological processing test in Marathi would help in assessing and managing adults who have phonological deficits. Hence, there was a need to develop a phonological processing test and obtain normative data for Marathi-speaking young adults. This was the aim of the present study.

Material and methods

The current work was conducted in two phases. In the first, a phonological processing test in Marathi (PPT-M) was developed. In the second phase, PPT-M was administered to 40 Marathi speaking participants aged 18 to 25 years. The current study was approved by the ethics committee, and was carried out in accordance with the University's ethical guidelines.

Phase I: Development of PPT-M

PPT-M was created from a word and non-word pool. There were 168 words in the wordpool which came from Marathi textbooks of 11th and 12th grade standard. The number of syllables (two, three, or four), the imageability of the words (high or low), and their syllabic structure were used to categorise the words (clusters or non-cluster). This was intended to balance the PPT-M's difficulty level. Further words were checked by a Marathi linguist for phonetic probability and phonetic neighborhood density. Based on the familiarity check carried out by five native speakers, words were selected. In a similar way, the non-word pool was constructed consisting of 60 non-words. We created non-words by changing one or two phonemes in each of the words while considering the phonetic principles of Marathi language. A Marathi linguist who was familiar with the rules of Marathi phonetic structure checked all the non-words for Marathi phonetic structure. The non-word pool was made up of 30 clusters and 30 non-clusters.

For the phonological awareness subtest, a total of 96 words and 48 non-words were chosen. From these, blending and segmentation tasks were each based on 12 words and 6 non-words. In the deletion and substitution tasks, 36 words and 18 non-words were prepared. For the blending task, a word was presented by creating a pause between the individual sounds (phonemes) and the word had to be constructed by putting those sounds together. Similarly, for the segmentation task, a word was presented which was segmented into individual phonemes. The deletion task involved presenting a word with the instruction to delete one of its sounds and then say the remaining word. The substitution task involved presenting a word in which one of the sounds had to be replaced by another sounds so as to form a new word. Every correct response was scored with a 1 and an incorrect response with a 0.

There were 59 bisyllabic words and 59 bisyllabic non-words in the phonological working memory subtest. A total of 10 tokens were created, with one token representing a three-word sequence, one token representing a four-word sequence, and two tokens each representing a five, six, seven, and eight word sequences. The participants had to listen to the sample and recall the words or non-words in the same order as presented. Every correct response for word/non-word from the sequence was scored with a 1 and incorrect responses as 0. The maximum score that could be obtained for this part of the subtest was 59 for words and 59 for non-words.

There were 50 letters and 50 digits in total in the phonological retrieval subtests. In each task, five high-frequency stimuli were distributed randomly in 10 columns and 5 rows for a total of 50 stimulus items. The participants were asked to read the letters/digits and the reaction time and accuracy were recorded. Every correct digit/letter response was scored 1 and incorrect response as 0.

Content validation was done using the developed PPT-M stimuli. Three speech-language pathologists checked the content. The pathologists were assistant professors in speech language pathology with three years' experience. They analysed the words based on high/low imageability, cluster/non cluster, and syllabic level. The words that fulfilled the criteria were kept. Words that did not meet the criteria were altered and applied in the PPT-M based on the content validity. After all these adjustments PPT-M had been made, audio recordings were created. Audio recordings was made with a native Marathi speaker selected on the basis of clarity of pronunciation and quality of voice. Recordings were made using an Apple Mac Intel computer, Pro Tools 10 digital audio workstation software, and an M Audio Nova condenser microphone at a sampling rate of 192 kHz in a sound-treated room. In this way, a total of 155 words and 107 non-words were prepared. To ensure that the sample was noise-free, Audacity Win 2.1.2 software was used to modify the captured signal. A check of goodness was carried out by 10 Marathi speaking adults. Thus, the PPT-M consisted of 96 word stimuli and 48 non-word stimuli for the phonological awareness subtest; 59 words and 59 non-words for the phonological memory subtest; and 50 digits and 50 letters for the phonological retrieval subtest.

Phase II: Administration of PPT-M

Participants. The developed PPT-M was administered on 40 Marathi speakers aged 18 to 25 years. There were 20 males (mean age 22; SD 2.45) and 20 females (mean age 22.6; SD 2.14) with Marathi as their first language. All participants had hearing sensitivity within normal limits. The Screening Checklist for Auditory Processing in Adults (SCAP-A) [34] was administered and those who scored over 6 were excluded from the study. Participants with any neurological, speech, language, psychological, or visual impairments were also excluded.

Procedure. All participants were given a participant information sheet and written consent was obtained. As well as SCAP-A [34], all participants were given the Indian Hearing Screening (IHS) test (Preetam et al., 2017), performed in a quiet environment using earphones. Individual ears were assessed at 0.25, 0.5, 1, 2, 4, and 8 kHz using a smart phone application. Preetam et al. (2017) have shown that this is a reliable method. PPT-M was administered through a laptop to each participant individually in a quiet and distraction-free room. All participants were advised to listen to the instructions prior to the test. PPT-M includes three subtests: phonological awareness, phonological memory, and phonological retrieval. Phonological awareness and phonological memory were tested using words and non-words. Each task from the subtests had two practice items. Audio recorded stimuli of PPT-M (phonological awareness and phonological memory tasks) and hard copies of the phonological retrieval task were given to each of the participants. The responses were recorded for further analysis. Accuracy score and total time taken to complete each task were recorded. Accuracy scores and total time required were calculated for the word blending task, non-word blending task, word segmentation task, non-word segmentation task, deletion task for words, deletion task for non-words, substitution task for words, and substitution task for non-words. The accuracy of the repetition of the words/non-words stimuli delivered through the audio recording were used to score the phonological memory test. The accuracy in naming the letters and digits shown visually, as well as the total time taken to complete the activity, were used to grade the phonological retrieval task.

Analysis. The information gathered from all the participants was compiled and statistical analysis conducted using SPSS version 23. To ensure the test's internal consistency and reliability, item analysis was performed using statistical tools. Each subtest's Cronbach alpha was calculated. Non-parametric tests were performed to look for gender and stimuli effects.

Results

Item analysis was carried out to study internal consistency and reliability of test. The values of Cronbach's alpha for phonological awareness, phonological memory for words, phonological memory for non-words, phonological retrieval for digits, and phonological retrieval for letters were 0.714, 0.834, 0.829, 0.628, and 0.684 respectively. Thus, the developed tests had good internal consistency. Shapiro–Wilk's test revealed that the data was not normally distributed and hence non-parametric tests were used. Mean accuracy scores and total time taken to complete the tasks are tabulated in **Table 1a** and **Table 1b**. Both show similar results regardless of gender.

Mann–Whitney *U*-tests were used to compare performance of PPT-M across males and females. Results indicated that

Table 1a. Total accuracy scores for PPT-M across gender using words (W), non-words (NW), digits (D), and letters (L) as stimuli

Subtest	Task	Stimulus	Total accuracy score											
			Males (*N* = 20)						Females (*N* = 20)					
			Mean	SD	Median	Min	Max	IQR	Mean	SD	Median	Min	Max	IQR
PA	Blending	W	5.6	1.9	5	3	8	4–7	5.1	1.4	5	3	10	4.2–6
		NW	2.5	1.3	2.5	0	4	1.2–3.7	2.7	1.1	3	0	5	2–3.7
	Segmentation	W	9.3	1.4	9.5	5	10	8–10	8.8	1.5	9	5	11	8–10
		NW	3.4	1.5	3	0	6	2.2–4	3.5	1.1	4	0	6	3–4
	Deletion	W	17.8	2.2	18	21	34	16–19	19.1	2.1	19	21	35	18–21
		NW	8.25	1.4	8	10	16	7–9	8.2	1.1	8	10	17	7.2–9
	Substitution	W	17.8	2.7	18	23	34	15–19.7	19	1.7	19	25	36	18–20
		NW	8.4	1.5	8	9	15	7–9.7	8.5	1.1	8	9	15	8–9.7
PM	Repetition	W	43.2	4.4	45	33	47	40.2–46	43.6	3.3	45	33	47	41–46
		NW	27.3	5.6	27	18	36	25.2–30	26.4	5.4	25.5	21	37	22.2–30
PR	Retrieval	D	49.7	0.6	50	47	50	50	49.4	0.9	50	48	50	49–50
		L	49.3	0.8	50	46	50	49–50	48.7	2	49	48	50	48.2–50

Note: PA, phonological awareness subtest; PM, phonological memory; PR, phonological retrieval

Table 1b. Total time to complete the task for PPT-M, divided by gender

Subtest	Task	Stimulus	Total time taken to complete the task											
			Males (*N* = 20)						Females (*N* = 20)					
			Mean	SD	Median	Min	Max	IQR	Mean	SD	Median	Min	Max	IQR
PA	Blending	W	4.9	1.7	4.7	35.89	107.31	3.4–5.7	4.9	1.6	4.5	32.35	98.67	3.7–5.9
		NW	5.8	2.3	6.4	13.22	66.26	3.7–7.3	5.5	2.2	4.9	13.88	52.44	4.5–7
	Segmentation	W	7.1	2.2	6.5	47	151.21	5–8.6	7.6	2.4	8.3	42.25	129.30	6.3–9.2
		NW	6.1	2	6	28.25	70.84	4.4–8	7.1	2.1	7.6	24.98	62.29	5.1–9
	Deletion	W	2.5	0.6	2.3	67.05	108.6	2.1–3	3	0.7	3	44.79	139.61	2.7–3.7
		NW	2.5	0.6	2.3	32.26	66.32	2–3.1	2.6	0.7	2.5	24	74.81	2.1–3.4
	Substitution	W	2.1	0.5	2	55.59	100.11	1.7–2.5	2	0.5	1.9	46.84	109.99	1.6–2.4
		NW	2.1	0.4	2.1	26	47.43	1.9–2.3	2.1	0.5	2	29.56	67.43	1.8–2.5
PM	Repetition	W	–	–	–	–	–	–	–	–	–	–	–	–
		NW	–	–	–	–	–	–	–	–	–	–	–	–
PR	Retrieval	D	23.7	4.1	23.1	17.28	32.9	20–26.3	22.9	3.7	22.2	17.28	33.90	20–25.5
		L	24.7	3	24.8	17.94	27.36	22–27.4	23.8	2.5	24.3	18.74	29.43	22–25.9

Note: D, digits; L, letters; NW, non-word stimuli; PA, phonological awareness subtest; PM, phonological memory subtest; PR, phonological retrieval subtest; W, word stimuli. Total time taken to complete PM was not measured

Table 2. Results of Mann–Whitney *U*-test across gender for PPT-M based on total accuracy score and total time taken to complete the task

Subtest	Task	Total accuracy score						Total time taken to complete the task					
		Mann–Whitney *U*-test for words			Mann–Whitney *U*-test for non-words			Mann–Whitney *U*-test for words			Mann–Whitney *U*-test for non-words		
		Z	*U*	*p*	*Z*	*U*	*p*	*Z*	*U*	*p*	*Z*	*U*	*p*
Phonological awareness	Blending	0.96	180	0.92	0.71	174	0.50	0.04	198.5	0.97	0.59	178	0.56
	Segmentation	0.59	178	0.57	1.02	163	0.33	0.8	170.5	0.43	1.42	147.5	0.16
	Deletion	2.05	125.5	0.43	0.14	194.5	0.89	2.14	121	0.03	0.72	173.5	0.48
	Substitution	1.22	155.5	0.23	0.59	178.5	0.57	0.35	187	0.74	0.34	187.5	0.74
Phonological memory	Repetition	0.04	198	0.98	0.16	193.5	0.87	–	–	–	–	–	–
Phonological retrieval	Digits	1.61	154.5	0.23	–	–	–	0.65	176	0.53	–	–	–
	Letters	1.11	172.5	0.47	–	–	–	1.3	152	0.2	–	–	–

Note: Total time taken to complete the task was not calculated for the phonological memory task for words and non-words. Phonological retrieval for digits and letters did not involve non-words

Table 3a. Total accuracy score for PPT-M across types of stimuli (words vs non-words)

Task	Total accuracy score											
	Words (*N* = 40)						Non-words (*N* = 40)					
	Mean	SD	Median	Min	Max	IQR	Mean	SD	Median	Min	Max	IQR
Blending	5.35	1.72	5	3	10	4–6	2.6	1.24	3	0	5	2–3.75
Segmentation	9.07	1.46	9	5	11	8–10	3.45	1.32	3	0	6	3–4
Deletion	18.47	2.25	18	21	35	25–28.75	8.22	1.29	8	10	17	7–9
Substitution	18.4	2.36	18.5	23	36	26–28.75	8.45	1.36	8	9	15	7.25–9.75
Phonological memory	43.42	3.89	45	33	47	41–46	26.9	5.51	26.5	18	37	23–30

Table 3b. Total time taken to complete the task for PPT-M across types of stimuli (words vs non-words)

Task	Total time taken to complete the task											
	Words (*N* = 40)						Non-words (*N* = 40)					
	Mean	SD	Median	Min	Max	IQR	Mean	SD	Median	Min	Max	IQR
Blending	4.96	1.67	4.63	32.35	107.31	3.67–5.74	5.66	2.28	5.75	13.22	66.26	4.21–7.28
Segmentation	7.37	2.34	7.37	42.25	151.21	5.53–9.03	6.65	2.18	6.45	24.98	70.84	4.97–8.22
Deletion	2.82	0.74	2.78	44.79	139.61	2.17–3.39	2.6	0.69	2.43	24.00	74.81	2.07–3.15
Substitution	2.12	0.55	2.01	46.84	109.99	1.70–2.43	2.14	0.49	2.05	26.00	67.43	1.85–2.39
Phonological memory	–	–	–	–	–	–	–	–	–	–	–	–

Note: Total time taken to complete the task was not calculated for phonological memory tasks for words and non-words

there was no significant difference between performance of males and females on PPT-M (**Table 2**).

Descriptive statistics were calculated to investigate whether there was a difference due to type of stimuli – i.e. words and non-words (**Table 3a** and **Table 3b**). It was observed that total accuracy scores for all tasks were higher for words than for non-words, and that total time taken to complete all tasks was lower for words than for non-words.

Results from Wilcoxon signed rank tests are tabulated in **Table 4**. It shows that for total accuracy score, a significant

Table 4. Results of Wilcoxon signed-rank test for words vs non-words

Task	Total accuracy score		Total time taken to complete the task	
	Z	*p*	*Z*	*p*
Blending	5.302	<0.001	1.6	0.11
Segmentation	5.470	<0.001	2.12	0.034
Deletion	5.523	<0.001	2.17	0.03
Substitution	5.530	<0.001	0.419	0.675
Phonological memory	5.519	<0.001	–	–

Note: Total time taken to complete the task was not calculated for phonological memory tasks for words and non-words

difference was observed across all tasks. However, for total time taken to complete the task, a significant difference was observed only for the segmentation and deletion tasks.

Discussion

The present study aimed to develop a tool to assess phonological processing in Marathi. Phonological processing plays important role in word processing and reading, and poor phonological processing skills may lead to spoken language processing disorder or CAPD. Words and non-words are required to measure phonological processing skills [35]. In the brain, words are semantically organised, and people tend to recall words based on the semantic field in which they are conceptually mapped [36]. When long-term information is accessed, it is remembered better as words than non-words [37]. In this study words and non-words were balanced depending on the number of syllables (two, three, or four syllables).

According to the literature, the frequency of syllables [38], the imageability of stimuli [39], and the sequence of syllables [38] are all major factors that affect the phonological awareness subtest. Here, the tool's frequency of syllables, imageability of stimuli, and syllable structure were all controlled during development. The complexity of stimuli was increased by increasing the frequency of syllables in the stimuli (two, three, and four syllables). Highly imaginable words are recalled and accessed more quickly, and are learned earlier. Many behavioural effects have been indicated in the study which includes effects on retrieval [40], lexical access [38,41], and age of acquisition [38,41]. Words with a low imageability are more context-dependent than words with high imageability [42]. Hence, words included in the phonological awareness subtest were balanced based on high–low imageability.

Non-word phonological memory was chosen because it demands less language load, and can assess phonological working memory without taking into account linguistic ability [43]. Repetition of words and non-words has been demonstrated to be a predictor of reading comprehension and fluency [44,45]. As a result, the PPT-M contained a phonological memory assessment task that incorporated repetition of both words and non-words.

According to the Comprehensive Test of Phonological Processing–Second Edition (CTOPP-II), internal consistency should range from 0.77 to 0.90, reflecting high reliability and sensitivity [16]. A reliability level of 0.6–0.7 is considered adequate, and 0.8 or more is considered exceptional; numbers above 0.95, on the other hand, are not always a good sign, as they imply possible redundancy [46]. PPT-M consists of three subtests – phonological awareness, phonological working memory and phonological retrieval – which together are recognised to be effective predictors of phonological processing ability and reading ability [47]. The coefficients discovered for the tests created in this study were greater than 0.62. As a result, the PPT-M test was created with a high degree of internal consistency and dependability.

The results of this study indicate that the performance of males and females on PPT-M is similar to some studies reported in the literature [18,19,48]. Some other studies have found that girls perform better than boys [49,50], perhaps because of earlier maturation of the dominant hemisphere or early acquisition of language. We found that accuracy scores were better for words than non-words, and the time taken to complete the task was less for words than non-words. A possible reason is that the processing of unfamiliar words (pseudo-words) requires more time than with words, since past exposure to words affects the quality and quantity of phonological content [51]. Since non-words do not have a phonological representation, the accuracy and time required to comprehend non-words is significantly higher than for words [52]. Familiarity with stimuli [53,54] and semantic association of the words [55] also has an effect on processing. This could explain why processing of words differs from non-words in terms of accuracy as well as the time taken.

Conclusions

Phonological processing test in Marathi (PPT-M) was developed to assess phonological processing test in Marathi speaking young adults aged 18 to 25 years. The study provides normative data among Marathi speaking young adults. PPT-M includes three subtests for phonological awareness, phonological working memory, and phonological retrieval. Phonological awareness measured blending, segmentation, deletion, and substitution tasks. Phonological working memory involved a word repetition and non-word repetition task. Rapid automated naming for digits and letters was the basis for the phonological retrieval subtest. We found there was no gender effect in our young adults. Although there was a difference between words and non-words, both can be used to assess phonological processing. The test developed had good internal consistency and reliability and can be used on a clinical population for assessing phonological processing. The findings invite questions and further investigations about phonological processing in young adults with central auditory processing disorders (CAPDs).

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