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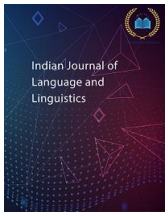

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Profiling word retrieval abilities in persons with aphasia - A preliminary study

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Abstract: Various methods are used to elicit the naming responses. The current study aimed to assess different naming abilities in persons with aphasia. Naming abilities were assessed using varied types of naming tasks for PWA. PWA was subjected to eight types of naming tasks [Confrontation Naming (CN), Phonemic Fluency (PF), Semantic Fluency (SF), Serial Naming (SN), Ordinate Naming (ON), Automated Naming (AN), Responsive Naming (RN) and Sentence Completion (SC)] and compared with age, education matched neurotypical individuals (n=15). The assessment was carried out in the Kannada Language. The raw scores obtained for each task were tabulated and subjected to statistical analysis. On eight naming tasks, neurotypical individuals performed better than persons with post-stroke aphasia. Mann Whitney U test revealed a significant difference in the phonemic fluency task in both groups of participants with a value less than 0.05. Friedman analysis with adjusted Bonferroni showed a significant difference in pairwise comparison for eight naming tasks. Among which pairs with phonemic fluency task had a significant difference in both the groups ($p< 0.05$). The correlation between language impairment in PWA and types of naming was studied using WAB AQ scores with accuracy scores on different types of naming tasks. A significant correlation was seen between WAB AQ and the Phonemic fluency task. The nature of the task and the factors affecting the naming of each task influence the performance of the individuals. PWA has a difference in brain mechanism for naming compared to NTI. Phonemic fluency is recommended for regular naming assessments as it is simple, easy, and quick to administer. Also, it taps both the cognitive and linguistic abilities of an individual. Language impairment and different types of naming are well related in the current study. The need to assess all types of naming to understand the word production deficit is justified.

Keywords: Aphasia, Naming, Types of naming, Assessment

1. Introduction

Anomia is one of the common problems in patients with aphasia, who often have a variety of language-related problems (Raymer & Ellsworth, 2002). A common cause of naming difficulty in aphasia is an impaired ability to map from semantics to existing but inconsistently retrievable lexical representations (Dell *et al.,* 1997; Rapp & Goldrick, 2000; Walker & Hickok, 2016). Naming difficulties can result from a deficit at different stages of the naming process: perception (decoding), storage, selection, retrieval, or actual production of words (encoding) (Barton *et al.,* 1969; Benson, 1979). Naming errors are seen in fluent and non-fluent aphasia types. The severity of anomia can range from mild to severe, including difficulty remembering a person's name; the severity of anomia also depends upon the extent of the lesion and site (Sinanovic *et al.,* 2011). These individuals may have difficulty with proper names (temporal lobe), common nouns (inferior temporal cortex), verbs (Broca's area), or damage to varying lesions in the areas of the brain (Damasio et al.,2001).

The traditional classification of types of naming, according to Chappey (1994), is repetition naming, category naming, confrontation naming, responsive naming, automatic closure naming, and automatic serial naming. Concerning the verbal task and patient response depending on the context of the task, naming can be assessed through confrontation naming, generative naming, defining referents, identifying super ordinate naming, automatic serial naming, recognition naming, repetition naming, and automatic closure naming levels (Murray & Chappey,

2001). Among these various tasks, confrontation naming is commonly used for diagnosis and is associated with perceptual cues used for therapeutic purposes (Caramaza & Hillis,1991).

1.1 Various tasks of naming assessments:

The naming responses of the person with aphasia are commonly assessed using various methods like Confrontation Naming (CN), Phonemic Fluency (PF), Semantic Fluency (SF), Super Ordinate Naming (SN), Ordinate Naming (ON), Automated Naming (AN), Responsive Naming (RN) and Sentence Completion (SC). The present study assesses naming abilities in the Kannada language. Thus, these methods of naming are discussed concerning the Kannada language.

The confrontation naming task is a structured task that elicits single-word responses. Typical confrontation naming tests used in Kannada for the clinical evaluation of aphasia include the Boston Naming Test (Shymala *et al.,* 2010) and the Action Naming Test adapted to the Kannada version (Girish, 2015). The advantages of confrontation naming tests are that the task is easy to administer and score, and they have high test-retest reliability (*Herber et al.,* 2008; Mayer & Murray, 2003). Meanwhile, this task has been criticized for lacking ecological validity and may not capture word retrieval ability impacting language production in everyday communication contexts (Herbert *et al.,* 2008).

Verbal fluency refers to the free generation of words that meet a given criteria in a fixed amount of time, such as 1 minute. Verbal fluency measures have been essential in assessing neurogenic populations for their quick administration duration, with good test quality, not relying on test materials, and not requiring culturally specific stimuli. Successful verbal fluency relies on semantic networks' integrity and cognitive control for effective search strategies for word retrieval (Faroqi *et al.,* 2018).

A verbal fluency task generating words that begin with phonemes for a given minute is termed a phonemic fluency task. Various neurocognitive test batteries include the letter fluency task (Dubois et al., 2000). Phonemic fluency tasks help to differentiate individuals with focal frontal lesions from neurotypically healthy individuals (Chapados & Petrides, 2013; Jurado *et al.*, 2000).

A double dissociation model suggests a role of left frontal and temporal regions for phonemic and semantic fluency, respectively, according to Baldo et al. (2010). Other naming tasks, like subordinate naming, ordinate naming, responsive speech, and sentence completion, receive less attention in naming assessment of aphasia.

Sentence completion and responsive naming abilities are covertly included as word retrieval tasks at the level of connected speech (Biran *et al.,* 2023; Boucher *et al.,* 2022). There are no standard outcome measures of word retrieval in connected speech due to poor substantial variability in methodology across studies (Dietz & Boyle, 2018). Responsive naming and sentence completion are easy and quick to assess naming in a linguistic context and give information on lexical processing abilities in Persons with Aphasia (PWA) (Miller *et al.,* 2010), as picture description task is time-consuming and also limit its applicability in clinical settings (Boucher *et al.,* 2022). Thus, the current study also implied using responsive naming and sentence completion rather than picture description tasks for naming assessments.

Earlier studies included naming assessments using confrontation naming, phonemic fluency, semantic fluency, responsive speech, and sentence completion (Geshwind, 1967; Off *et al.,* 2015; McKinnon *et al.,* 2018; Richardson *et al.,* 2023;Shah & Milman., 2018).

Geshwind (1967) initially identified the confrontation naming method as a classic approach to assessing naming impairments in individuals with brain damage. However, subsequent research endeavors explored alternative methods beyond confrontation naming to evaluate naming abilities in PWA. For instance, Shah and Milman (2017) compared verbal fluency, including animal and action categories, as well as phonemic fluency, in both aphasic and Neurotypical Individuals (NTI). Their findings indicated that verbal fluency tasks, particularly animal fluency, demonstrated high sensitivity even in cases of mild aphasia. Interestingly, despite documented difficulties with verb retrieval in aphasia, action fluency remained relatively less impaired among the verbal fluency tasks. including verbal and phonemic fluency in addressing naming difficulties in PWA is important here.

In a study by Richardson et al. (2023), the relationship between picture naming performance and the ability to convey the essential elements or gist of a story was investigated. It was found that picture naming could accurately predict gist production, particularly in individuals with Broca's and Wernicke's aphasia. However, it was acknowledged that picture naming might not universally serve as an appropriate surrogate measure for functional communication across all individuals with aphasia. Consequently, there's a recognized need to incorporate naming assessment within discourse tasks such as responsive naming and sentence completion to comprehensively evaluate communication abilities in aphasic populations.

While prior studies predominantly focused on individuals with non-fluent types of aphasia, the present research expands this scope by including individuals with both fluent and non-fluent aphasia who demonstrate varied comprehension abilities. This approach represents a novel endeavor to understand naming abilities comprehensively across different aphasia profiles.

A vast void is seen in the literature profiling all possible naming abilities in PWA or NTI. The current study acts as a preliminary study to profile types of naming in PWA and compare the performance with the NTI group. Hence, the present study aimed to measure the naming abilities through various naming tasks in PWA and NTI, considering accuracy scores.

2. Methods

The present study aimed to profile the naming abilities of persons with aphasia using eight tasks. Also, compare the performance measured with peer group neurotypical individuals. The study incorporated a standard comparison design.

2.1 Participants

Thirty individuals were recruited for the present study based on the convenient sampling method with specific inclusionary and exclusionary criteria, and two groups were formed with ten participants each. Group, I included fifteen Persons with Aphasia (PWA) (13 males in the age range of 22-63 years with a mean age of 35.48 years) forming a clinical group, and Group II participants were fifteen Neurotypical Individuals (NTI) (7 males in the age range of 22- 63 years with a mean age of 35.5 years) forming a control group. Participants were native speakers of the Kannada language with a minimum of 10 years of formal education in the English language and were Kannada-English Bilinguals. They did not report any history of neuropsychiatric disorders before the onset of Aphasia and no sensory issues related to hearing and vision as reported on general health questionnaires developed by the investigator. All the participants from the clinical group had sustained a left cerebrovascular accident (CVA) in the Middle Cerebral Artery Territory, confirmed by the neurologist on neurological investigations. Participants had at least six months post-morbid duration when recruited for the present study. These participants were diagnosed with Aphasia with an AQ score below 93.4 on the administration of Western Aphasia Battery in Kannada (Chengappa & Kumar, 2008) by a Speech-Language Pathologist. The participants from the neuro-typical group scored >26 and passed on the cognitive screening of Montreal Cognitive Assessment in Kannada (MoCA) (Kaul *et al.,* 2020) administered by the investigator. These aphasia participants had regular to mild cognitive impairment when administering MOCA. These aphasia participants were sub-classified as Anomic Aphasia (seven in number), Broca's Aphasia (Three in number), and Conduction Aphasia (five in number), based on the AQ, and the details are provided in Table 1. Persons with Aphasia were recruited from the Department of Clinical Services, All India Institute of Speech and Hearing (AIISH), Mysuru district, Karnataka, and the neurotypical individuals were residents of Mysuru district, Karnataka, and volunteered themselves to participate in the present study. The participants of the present study obtained AIISH ethical consent.

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Table 1 Demographic details of the participants

Persons with Aphasia										Neurotypical Individual			
Sl No	Age/ Gender	Years of Formal Education	Language Known	PSO (in months)	Handedness	WAB-AQ	WAB Naming score	MoCA scores	Diagnosis	Age/Gender	Years of Formal Education	MoCA Scores	Handedness
P1	34.4y/M	16yrs	K,E	6	R	83.2	9	20	AA	34	15yrs	28	R
P2	35y/M	16yrs	K, E ,H	8	L	89.6	7.8	21	AA	35	14yrs	27	R
P3	35y/M	14yrs	K , E	12	R	67.7	6.8	21	BA	35	16yrs	28	R
P4	35.7y/F	15yrs	K, E	14	R	97	9.7	24	AA	35	12yrs	30	R
P5	63y/M	16yrs	K, E	8	R	39.3	4.1	18	AA	63	16yrs	26	R
P6	22y/M	18yrs	K, E, Te	15	L	39.3	4.1	20	CA	22	15yrs	27	R
P7	47y/M	10yrs	K, E	14	R	35.6	0.9	21	BA	47	14yrs	29	R
P8	48y/M	12yrs	K, E	12	R	89.8	8.6	17	AA	48	10yrs	25	R
P9	34y/M	14yrs	K, E, H	10	L	75.2	6.8	18	CA	34	12 yrs	28	R
P10	28y/M	12yrs	K, E, H	6	R	62.4	7.2	22	BA	28	16 yrs	27	R
P11	50y/M	15yrs	K , E	8	L	84.7	7.9	21	AA	43	13yrs	29	R
P12	22y/M	14 yrs	K, E	9	R	85	6.5	24	AA	22	15yrs	30	R
P13	32y/M	12 yrs	K, E	12	R	71.9	6.8	23	CA	35	12 yrs	26	R
P14	22y/F	15 yrs	K, E, Te	14	R	86	8.5	22	CA	20	15yrs	24	R
P15	54y/m	12 yrs	K, E	8	R	77.9	8.5	21	CA	52	12 yrs	28	R

Note: M= Male, F= Female, P=Participant, PSO=Post stroke Onset, K=Kannada, E=English, T=Tamil, Te=Telgu, H= Hindi, BA=Broca's Aphasia, AA=Anomic Aphasia, CA=Conduction Aphasia.

2.2 Procedure

The persons with aphasia following the inclusionary criteria were subjected to profiling the naming abilities using eight naming tasks designed by the investigator. Eight methods of naming abilities selected included: 1. Confrontation Naming (CN), 2. Phonemic Fluency (PF), 3. Semantic Fluency (SF), 4. Subordinate naming (SN), 5. Ordinate Naming (ON), 6. Automated Naming (AN), 7. Responsive Naming (RN), and 8. Sentence Completion (SC).

The study's aim, procedure, and testing duration were explained to the participants. Prior written consent was obtained from the participants for their participation in the study. All the participants were tested in a quiet, noise-free environment at home or a clinical setting. The stimuli were presented in auditory/visual mode according to the need of test items. Scores were tabulated for each test item.

The investigator developed stimuli for each method of naming ability in the Kannada language. The stimulus was adapted from Western Aphasia Battery- Kannada (Chengappa & Kumar, 2008), Cognitive Linguistic Assessment Protocol in Kannada (Kamath & Prema, 2001), Boston Naming test, adapted to Kannada (Chenagappa *et al.,* 2010) and also developed by the author of the present study. Stimuli were subjected to validation using descriptive psycho-linguistic parameters (Goswami *et al.,* 2012) by three Speech-Language Pathologists (SLPs) who worked in Adult Language Disorders.

The first task of the study included a confrontation naming task and was assessed by line drawing pictures (frequent and infrequent) on an A4-sized picture card. Simple black and white line drawings of 'slipper, bangles, plate, tap, shirt, drum, frock, scissors, snake, and crocodile' were borrowed from BNT, adapted to the Kannada version, and used as a stimulus for confrontation naming task in the present study. Participants were seated comfortably and instructed to name the picture stimulus presented visually. Correct naming without any cue was scored as 1, and incorrect response or no response or naming with cues was scored as zero. Borrowed words from other languages were also considered for scoring. The maximum score for confrontation naming is 10.

The second task was the Phonemic fluency task. The phonemic fluency task was assessed using the /t/, /a/, /p/, /i/, and /s/ phonemes.(adapted from CLAP-K). Participants were instructed to name as many words as possible, starting from the above-given phonemes in the Kannada language, within a given time (one minute). The maximum score for this task is 100 (20 being the maximum score for each phoneme). Scoring for phonemic fluency was adapted from WAB-K. Correct naming was scored one, and incorrect response or no response was scored as zero. Borrowed words from other languages were also considered for scoring.

The third task in assessing naming in the present study was the verbal fluency task. The verbal fluency task was for five semantic categories (animals, vegetables, food items, vehicles, and flowers). These semantic categories were chosen based on the frequency of usage in everyday communication. Participants were instructed to name as many items as possible in each category within 1 minute. The maximum score for this task is 100 (20 being the maximum score for each semantic category). Scoring for the verbal fluency task was adapted from CLAP-K. Phonemic and Verbal fluency tasks are addressed under Generative naming (GN).

The fourth task of the present study was the Subordinate naming task. Ten sets of stimuli assessed the subordinate naming. Each set had five words falling under one semantic category. The stimulus was presented orally to the participants. Participants were instructed to name the semantic category to which the list of items falls. *For example: Stimulus:* ***Pencil, Pen, Eraser, Marker****. Expected Response:* ***Stationaries*****.** The correct response is scored 1, and the incorrect or no response is scored 0. The maximum score for the subordinate naming task was 10.

The fifth task of the present study in assessing naming was coordinating naming. The task for coordinating naming was to list at least five items for the given category. This task was similar to verbal fluency, but the number of items to name was restricted to five. A score of 1 is given for correct response, and a score of zero is given for incorrect or no response. ***For example:/manejallI baLasuva aidu peetopakarana gaLannu hesarisi/ (Name at least 5 furniture at home)***. A total of 10 stimuli were present. The maximum score for this task is 50.

The automated naming task was the sixth task of the present study. The task was assessed by instructing the participant to ***name the days of the week and months of the year, count from 20 to 30, name the seasons in a year, and list out multiples of 5***. The tasks were adapted from CLAP-K (Prema & Kamath., 2001).

A score of 2 was given if all the items in the category were named, a score of 1 was given if a minimum of 2 items were named, and a score of 0 was given for incorrect response or no response. The maximum score for the task was 10.

The seventh task in assessing naming abilities for the present study was Responsive naming. Participants were asked ten questions, and they were instructed to answer the question with one word. ***For example: /halIna banna javudu/ - /bIII/ (What is the color of the milk? white). A score of 1 is given for the correct answer, and 0 is given for the incorrect response.*** The maximum score was 10 for the responsive naming task.

The last and eighth task of the study was the sentence completion task. Participants had to complete the incomplete sentence by filling in the suitable word in the given blank. ***For example: /mallIge have _____ baNNa/ Answer - / bIII baNNa /- (color of Lilly is _____; Answer: White.*** Score 1 was given for all correct responses and 0 for incorrect responses. The sentence completion task has ten as the maximum score.

The total score of all the tasks adds up to 300 on the compilation. The obtained score of the participants for the maximum score of 300 was noted and considered for further statistical analysis. A summary of the scoring for each naming task is given in Table 2.

Table 2 Summary of scoring pattern for different naming tasks.

Tasks	Correct	Incorrect	Maximum score
Confrontation Naming	Score 1	Scored 0	10
Phonemic fluency	Score 1	Scored 0	100
Verbal Fluency	Score 1	Scored 0	100
Subordinate naming	Score 1	Scored 0	10
Coordinate naming	Score 1	Scored 0	50
Automated naming	Score 1	Scored 0	10
Responsive naming	Score 1	Scored 0	10
Sentence completion	Score 1	Scored 0	10

3. Results

A total of 10 percent of the data was subjected to interrater reliability, and a significant p-value > 0.05 was obtained, showing good interrater reliability of the naming data of PWA and NTI for two tasks. The study sought to understand the naming ability in PWA with different elicitation methods compared to age-matched neurotypical controls. The naming accuracy score for eight tasks of naming and AQ scores of WAB K were used to illustrate the performance difference between and within PWA and NTI in Sections A, B, and C.

3.1 Data analysis

Descriptive statistics were computed for mean accuracy scores obtained from eight methods of naming followed by naming treatment. The comparison was made between the group performance and within-group comparisons using eight different tasks.

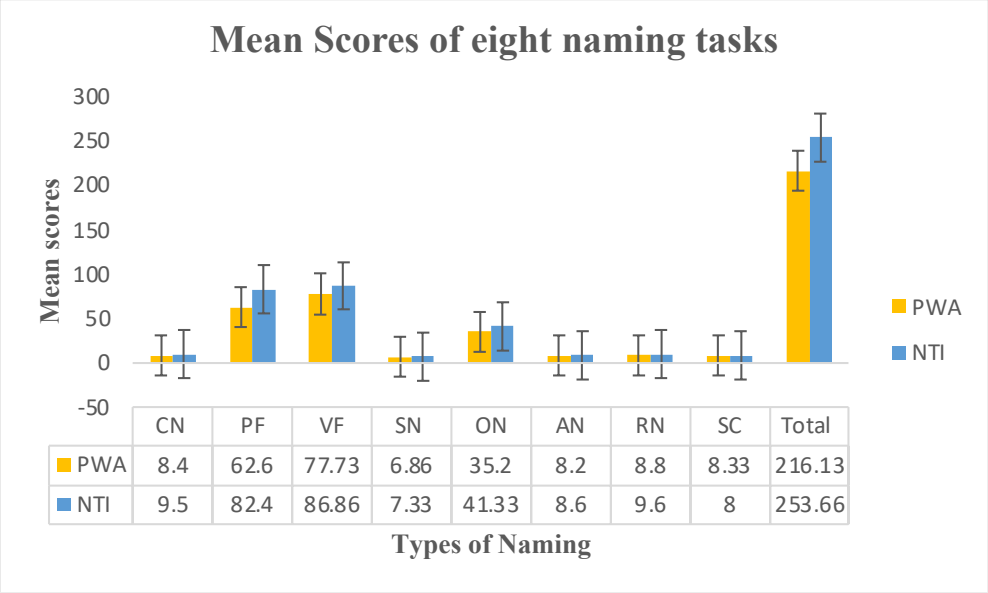
Mann Whitney U test was administered to compare the aphasia and neurotypical group performances for mean accuracy scores of eight types of naming tasks. Non-parametric tests like Friedman with adjusted Bonferroni were administered to address within-group comparison on the eight task performances in persons with aphasia and neurotypical groups. Kruskal Wallis test was administered to compare the performance on eight types of naming tasks with different types of aphasia included in the study. Also, Spearmen's correlation was used to correlate the AQ scores of WAB K with mean scores of eight types of naming tasks and Naming section scores of WAB K with an individual mean score of eight types of naming tasks and total mean scores of eight tasks with each mean scores of eight tasks. These analyses are discussed below, with the alternate hypothesis stating – that there is a significant difference between PWA and NTI in eight types of naming tasks.

A. Comparison of performance of PWA versus NTI across the various types of naming tasks given: - (between group comparison)

The current study aimed to examine the distinctions among the eight naming tasks conducted with individuals with post-stroke aphasia (PWA) and neurotypical individuals (NTI). The null hypothesis in this study suggests that there is no noticeable difference in performance between the PWA group and the NTI group across the eight naming tasks. However, the hypothesis was rejected as the study revealed a notable distinction in performance between the NTI and PWA groups across all eight types of naming tasks.

Accuracy scores obtained for each task for both groups were subjected to descriptive statistical analysis. PWA performed poorer, with a total mean score (SD) of 216.13 (36.21) obtained for eight naming tasks, compared to NTI, with a total mean score (SD) of 253.66 (10.78). Mean scores with standard deviation for different tasks administered to address types of naming for Persons with Aphasia and Neurotypical Individuals are given in Figure 1.

Figure 1 Mean scores and Standard deviation of accuracy scores secured by PWA and NTI groups for tasks assessing types of naming.



Further comparison was made on performance on mean accuracy scores in aphasia concerning their subtypes. The performance hierarchy was noticed from Anomic aphasia, 243.71 (13.45) to Conduction Aphasia, 201.0 (29.60) and Broca's Aphasia, 177.77 (36.75) for total scores of eight tasks of naming. Among them, all subtypes of aphasic performed poorer in phonemic fluency task, while individuals with Anomic aphasia and Broca's aphasia performed best in Responsive naming task, and individuals diagnosed with Conduction aphasia excelled in automated naming.

The normality pattern was not observed for mean scores. Hence, the Man-Whitney U test was carried out. A significant difference was seen in phonemic, verbal, and ordinate naming tasks across PWA and NTI ($p<0.005$). Other naming task scores did not show significant differences across the groups with a p-value greater than 0.05. The result of the Whitney U test is given in Table 3.

Table 3 Results of Mann Whitney on eight tasks of naming between PWA and NTI

Eight tasks of naming	**/z/**	***p*-value**
Confrontation Naming	1.29	0.19
Phonemic Fluency	3.96	0.00*
Verbal Fluency	2.26	0.02*
Serial Naming	0.106	0.91
Ordinate Naming	2.07	0.03*
Automated Naming	0.17	0.86

Responsive Naming	0.94	0.34
Sentence Completion	0.826	0.43

Note * Indicates Significant difference

B. Comparison between tasks of naming assessment in Persons with Aphasia (group 1) and Neurotypical individuals (Group 2): a within-group comparison.

The null hypothesis of the study posited that there would be no significant difference among the eight types of naming tasks within both the PWA and NTI groups. However, while differences were observed in some tasks and not all, indicating partial acceptance of the hypothesis. Different tasks were used to assess naming abilities in both groups. A comparison of performance concerning the accuracy score of participants of the PWA group across the tasks was made. Friedmen's analysis with an adjusted Bonferroni significance level of less than 0.05 was used. A significant difference was seen between the tasks in PWA with a score of $x^2(8) = 106.61$, $p<0.05$. A pairwise comparison was made between the tasks in the PWA group, as shown in Table 4.

Table 4

Pairwise comparison of eight tasks of naming in the PWA group

Pairs	/z/	p value
SN-AN	1.00	1.00
SN-SC	1.00	1.00
SN-CN	1.33	1.00
SN-RN	1.60	1.00
SN-ON	4.00	0.002*
SN-PF	5.06	0*
SN-VF	5.93	0*
AN-SC	0.06	1.00
AN-CN	0.33	1.00
AN-RN	0.60	1.00
AN-ON	3.00	0.097*
AN-PF	4.06	0.002*
AN-VF	4.93	0*
SC-CN	0.26	1.00
SC-RN	0.53	1.00
SC-ON	2.93	0.121
SC-PF	4.00	0.002*
SC-VF	4.86	0.00*
CN-RN	0.26	1.00
CN-ON	2.66	0.276
CN-PF	3.73	0.007*
CN-VF	4.60	0.00*
RN-ON	2.40	0.590
RN-PF	3.46	0.019*
RN-VF	4.33	0.001*
ON-PF	1.06	1.00
ON-VF	1.93	1.00
PF-VF	0.86	1.00

Note *Indicates significant difference

Note- CN-Confrontation Naming, PF- Phonemic Fluency, VF- Verbal Fluency, SN- Subordinate Naming, ON- Ordinate Naming, AN- Automated Naming, RN- Responsive Naming, SC- Sentence Completion.

Kruskal Wallis was used to compare types of naming with different types of aphasia. No significant difference is seen for types of naming specific to any aphasia. Table 5, given below, gives Kruskal Wallis's analysis values.

Table 5 Kruskal Wallis H results between eight PWA group naming types

Naming tasks	CN	PF	VF	SN	ON	AN	RN	SC
X (2)	3.66	5.96	8.37	2.60	6.50	1.79	10.74	6.63
P	0.16	0.05*	0.01*	0.27	0.03*	0.407	0.00*	0.03*

Note * indicates a significant difference.

Note- CN-Confrontation Naming, PF- Phonemic Fluency, VF- Verbal Fluency, SN- Subordinate Naming, ON- Ordinate Naming, AN- Automated Naming, RN- Responsive Naming, SC- Sentence Completion.

A similar comparison of accuracy scores across the tasks for Neurotypical participants was made using Friedmen's analysis with an adjusted Bonferroni significance level of less than 0.05. A significant difference was seen between the tasks in NTI with a score of x^2 (8) =108.06 ($p<0.05$). A pairwise comparison was made between the tasks, as shown in Table 6.

Table 6 Pairwise comparison on eight tasks of naming in the NTI group

Pairs	/z/	p-value
SN-AN	1.13	1.00
SN-SC	0.33	1.00
SN-CN	1.93	1.00
SN-RN	2.10	1.00
SN-ON	3.9	0.03*
SN-PF	5.3	0.00*
SN-VF	5.83	0.00*
AN-SC	0.80	1.00
AN-CN	0.96	1.00
AN-RN	2.76	0.204
AN-ON	4.16	0.001*
AN-PF	4.70	0.00*
AN-VF	1.60	1.00
SC-CN	1.76	1.00
SC-RN	3.56	0.013*
SC-ON	4.96	0.00*
SC-PF	5.50	0.00*
SC-VF	0.167	1.00
CN-RN	1.967	1.00
CN-ON	3.367	0.027*
CN-PF	3.90	0.003*
CN-VF	1.80	1.00
RN-ON	3.20	0.049*
RN-PF	3.73	0.007*
RN-VF	1.40	1.00
ON-PF	1.93	1.00
ON-VF	0.533	1.00
PF-VF	0.800	1.00

Note * indicates a significant difference.

Note- CN-Confrontation Naming, PF- Phonemic Fluency, VF- Verbal Fluency, SN- Subordinate Naming, ON- Ordinate Naming, AN- Automated Naming, RN- Responsive Naming, SC- Sentence Completion.

C. Co-relation Analysis for PWA

The null hypothesis of the study proposed that there would be no correlation observed between WAB AQ scores and scores from the Naming section of WAB-K with eight distinct naming tasks. However, although correlations were not evident in all naming tasks, some correlations were identified. Therefore, partial acceptance of the hypothesis is considered.

C.1Corelation between WAB AQ score versus total accuracy scores of eight naming tasks assessed in the PWA group:

WAB AQ scores of PWA were co-related, with the total accuracy score of eight naming tasks administered using Spearmen's Co-relation procedure with a significance level of less than 0.05. A strong Correlation was found between WAB AQ scores and total accuracy scores of various naming tasks.

Further co-relation analysis was made concerning WAB AQ scores with various tasks used to assess naming abilities. Spearmen's correlation was used to compare the WAB AQ scores with the mean accuracy scores of eight naming tasks. A significant statistical difference was seen when the WAB-AQ score was compared with the accuracy score of the phonemic fluency task.

C 2. Co-relation between Naming section scores of WAB-K versus total accuracy scores of eight naming tasks assessed in the PWA group.

The score of the naming section in WAB- K of PWA participants was co-related, with a total accuracy score of naming tasks administered using the Spearman Co-relation procedure with a significance level of less than 0.05. A correlation was observed between WAB naming section scores and total accuracy scores of different naming tasks of PWA.

Table 7 Results of Spearman's correlation for the WAB Naming section with mean accuracy scores on types of naming.

Eight Tasks of Naming	WAB Naming scores		WAB AQ scores	
	/z/	p value	/z/	p value
Confrontation naming	0.337	0.046*	0.081	0.719
Phonemic fluency	0.632	0.002*	0.598	0.003*
Verbal fluency	0.482	0.027*	0.071	0.755
Subordinate naming	0.444	0.319	0.046	0.839
Ordinate naming	0.559	0.192	0.206	0.357
Automated naming	0.692	0.085	0.150	0.505
Responsive naming	0.211	0.050*	0.210	0.349
Sentence completion	0.604	0.011*	0.208	0.352
Total score	0.667	0.012*	0.397	0.037*

Note * indicates a significant difference.

Further correlation analysis was made with WAB scores on the naming section with mean accuracy scores of each naming task of the study using Spearman's correlation. A statistically significant correlation was seen between WAB naming scores and accuracy mean scores of confrontation naming, phonemic fluency, verbal fluency, responsive naming, and sentence completion ($p < 0.05$). The correlation coefficient obtained for each comparison is mentioned in Table 7.

4. Discussion

The eight types of naming assessment of PWA were compared with the age-matched neurotypical individuals. Firstly, persons with aphasia scored poorly compared to neurotypical individuals in all eight naming tasks. The difference between persons with aphasia and neurotypical individuals could be attributed to various factors, including brain mechanisms for speech and language functions. The present study focused on naming abilities.

Naming tasks is a complex task that includes various levels of processing. The 'Naming tasks' involve recognition of stimulus based on familiarity, accessing the meaning, accessing the phonological form, involving motor programming, and planning articulators to say the word, the processes involved in naming (Gordon, 1997). Although these functions may not be wholly segregated anatomically, they can be individually impaired by brain damage. Disruption of the mechanism linking the semantic representation of a particular word form representation via lexical semantics is frequently observed after a stroke (DeLeon *et al.,* 2007).

Kemeny et al. (2006) highlighted the involvement of the Left Broadman Area (BA) 37 neuronal network, spanning parts of the posterior/lateral and ventral inferior temporal gyrus, in word retrieval processes compared to picture naming tasks. However, functional imaging studies (Harrington *et al.,* 2006; Kemeny *et al.,* 2006) have shown inconsistent activation of left BA39 during oral picture naming tasks. Other functional MRI experiments have also indicated that semantic judgments elicit greater BA39 activation than phonological judgments (Mummery *et al.,* 1998). Notably, there is some correlation between "Automated naming" and cerebellar activity. In our present study, individuals with aphasia exhibited lesions primarily in the prefrontal and temporal lobes. Their diminished performance across various naming tests is attributed to these lesions compared to neurotypical individuals without such brain lesions.

The other exciting factors could be psychosocial factors like language (specifically naming), processing speed of the stimulus, and working memory in post-stroke sequel conditions contributing to the naming performance in any naming tests (Decker *et al.,* 2013). Two different sorts of cognitive processes are enlisted for the verbal fluency task. One is linguistic, particularly efficient access to lexical–semantic representation. The other is executive processing, including speeded strategic search, allocation of attentional resources, ongoing monitoring of task requirements, and inhibition of previously generated responses (Unsworth *et al.,* 2011). The 'verbal fluency tasks' are comparable with 'subordinate naming' and 'ordinate naming.' Within the semantic category of verbal fluency tasks, the presence of clusters and transitioning from one cluster to another may suggest the presence of subordinate and ordinate naming skills. PWA produces fewer clusters than NTI (Bose *et al.,* 2017; Kiran *et al.,* 2014). Semantic clusters are words that fall under the same semantic category based on function, visibility, location, properties, and use. Subordinate and ordinate naming tasks include clusters of words that fall near and far to the semantic category with the abovementioned variables. The performance of automated naming tasks in persons with aphasia and neurotypicals may be attributed to working memory skills, which were poorer in persons with aphasia compared to neurotypical individuals (Christensen *et al.,* 2018).

The 'responsive naming' and 'sentence completion' encourage recall of a content term from associated speech forms or discourse. The responsive naming and sentence completion tasks involve discourse as the central contextual cue to name the word. PWA performs poorly in these situations (Alyahya *et al.,* 2021). Word retrieval at discourse levels is influenced by cognitive processes, including memory and inhibition (Alyahya *et al.,* 2022). The literature lacks specific studies on subordinate naming, ordinate naming, responsive naming, and sentence completion tasks. The investigator thus matches the characteristics of these tasks and discusses them with variables like discourse and semantic cluster variables, as explained earlier.

The performance on eight naming tasks was further observed to check the mean accuracy score for each naming task, and an attempt was made to rank the performance in a hierarchy from best to worst. The activity with the highest performance in NTI and PWA was for 'responsive naming,' followed by 'automated naming,' 'confrontation naming,' 'ordinate naming,' 'verbal fluency,' 'sentence completion,' 'subordinate naming,' and 'phonemic fluency.' Both groups showed a similar pattern, and the word retrieval process might be responsible for this performance pattern. Word retrieval is the cognitive linguistic ability of an individual to retrieve a suitable word in the presence of contextual cues (Shah *et al.,* 2021; Takeda, 2001). The contextual cues may be semantic, phonological, or syntactical. In 'confrontation naming,' 'subordinate naming,' 'ordinate naming,' 'automated naming,' and 'verbal fluency tasks,' semantic cues are the prominent cue that aids naming. At the same time, the 'phonemic fluency task' alone contributes to the phonological cueing method. Other naming methods, like 'sentence completion' and 'responsive naming,' are associated with semantic and syntactic cues. Again, here, semantic cues are more dominant than syntactic cues for sentence completion and responsive naming tasks. Phonological and syntactic cues are more cognitively involved and linguistically sophisticated than semantic cues (Herbert *et al.,* 2021; Akhavan *et al.,* 2022). Word retrieval is simpler on tasks that combine contextual signals, like the task of responsive naming and

sentence completion, than it is on tasks that only require single cues. Thus, both PWA and NTI groups continue to use the same word retrieval hierarchy. In naming, phonological and syntactic information is retrieved separately (Caramaza & Miozzo, 1997; Vigliocco *et al.,* 1999), although neither is necessary for full access to the other. Therefore, 'responsive naming' and 'sentence completion' are superior to phonemic fluency.

The brain networks that process semantic, syntactic, and phonological information processing are affected in PWA, resulting in language-related issues. Compared to healthy brains, PWA, particularly those with non-fluent aphasia, have different phonological execution abilities (Johansson et al., 2021; Naranjo et al., 2023). As a result, the present study, which included primarily non-fluent aphasia patients, revealed a statistically significant difference between different naming tasks, particularly in phonemic fluency tests.

Further, the eight naming tasks designed by the investigator to assess word retrieval ability correlated with Western Aphasia Battery AQ scores and WAB naming section scores. The total accuracy scores on eight naming methods correlated well with WAB AQ scores. Concerning mean scores of individual naming tasks, phonemic fluency mean accuracy score had a better correlation with WAB AQ and scores on the naming section of WAB- K. Therefore, the 'automated naming,' 'serial naming,' 'subordinate naming,' 'ordinate naming,' and 'phonemic fluency' which is absent in any standard tool to address naming abilities of PWA are recommended to be included in the standardized tools. Among them, as the phonemic fluency task showed significant differences and a better correlation with WAB-K AQ scores, there is a need to recommend the usage of the 'phonemic fluency task' in the regular assessment of word retrieval of PWA. Thus, the current study highlights addressing methods of word retrieval abilities other than the traditional methods used in standardized tools. Also, it highlights the 'phonemic fluency task,' which is more outstanding than other naming tasks by providing better insight into word retrieval abilities in aphasia.

5. Conclusions

Investigations about word retrieval abilities are essential in routine language assessments for persons with aphasia. The naming task takes relatively less time to complete and is simple to follow and execute for a person with aphasia. Various naming tasks address all aspects of word processing and are very important to assess. Thus, naming assessment at eight different task exercises aids in more accurately identifying individuals with aphasia compared to neurotypical individuals. In the current study, the phonemic fluency task significantly affected the standard naming techniques used in the standardized language assessment battery of aphasia. Additionally, including such a task in routine assessments could help quickly identify those with brain damage and thus recommend phonemic fluency tasks regularly for persons with aphasia.

Limitations and Future Directions

The current investigation represents an initial exploration, focusing on naming abilities across eight distinct tasks. This study is the first to incorporate a wide array of naming assessments. However, the generalizability of our findings is limited by the relatively small sample size within specific aphasia subtypes. Furthermore, contrary to the existing literature, our study did not reveal significant discrepancies between tasks across different types of aphasia. This underscores the need for larger and more evenly distributed sample sizes across aphasia subtypes to elucidate task-related differences. Additionally, establishing normative data for phonemic fluency in Kannada could offer a valuable tool for interpreting word retrieval deficits. This measure demonstrated strong correlations with Western Aphasia Battery (WAB) Aphasia Quotient (AQ) scores in the present study. It proved efficient for identifying word retrieval deficits in clinical settings due to its quick administration process.

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Participants/ Caregivers had given their written informed consent. The ethical clearance according to the declaration of Helsinki was obtained from the institutional review board, AIISH Ethics Committee (AEC), Approval Number. No.DOR.9.1/Ph.D./YBC/929/2021-2022 DT 10.02.2023

Author contributions
YBC and HN: Conceptualizing and designing the research study, seeking ethical approval, analyzing the data, and drafting the manuscript in whole or in part. All the authors approved the final manuscript.

Data availability statement
All data generated or analyzed during the study are included in the article. Further enquires can be directed to the corresponding author.

Conflict of interest
The Authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.