Significance of speech production errors on cross-linguistic processing in Sepedi-English individuals with bilingual aphasia: a case series analysis

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ABSTRACT

Background: Bilingual aphasia forms a significant part of speech-language pathologists' (SLP) caseload, globally, and specifically in South Africa. Few tools supporting clinical decision-making are available due to limited understanding of typical and disordered cross-linguistic processing (how the languages interact). Speech errors may provide insight about "hidden" bilingual mechanisms.

Objectives: To determine what speech errors can impart about cross-linguistic processing, as well as, associated language and impairment variables in Sepedi-English individuals with aphasia.

Method: The case series included six participants, purposively selected from three rehabilitation sites in South Africa. Detailed language and clinical profiles were obtained. Participants performed a confrontation naming task in their most dominant (MDL) and less dominant language (LDL). Responses were audio recorded, transcribed, and analyzed for overall accuracy and error type in MDL and LDL; verified by a Sepedi-speaking linguist and a qualified SLP.

Results: (1) No statistically significant differences in MDL-LDL naming accuracy were found, supporting recent literature of simultaneous inter-activation of both languages and shared word retrieval mechanisms. All types of speech errors occurred, and semantic errors were produced most frequently and consistently in each participant's MDL and LDL. (2) Language proficiency, language recovery patterns, and aphasia type (Broca's and Anomic) and severity (mild and/or moderate) appeared to be more strongly linked to cross-linguistic processing than Sepedi-English linguistic differences and age of acquisition of both languages.

Conclusions: Participants with bilingual aphasia may use typical cross-linguistic and word retrieval mechanisms, concurring with current theories of bilingualism. Findings are preliminary, warranting investigations of other language tasks, modalities, pairs, and related variables.

KEYWORDS

Case series; bilingual aphasia; cross-linguistic processing; speech production errors; language recovery; Sepedi and English; South Africa

Introduction

Aphasia presents in 40% of the surviving stroke population, with higher statistics in South Africa (SA) due to increased stroke rates.[1–3] An elevated number of strokes in SA is attributed to poverty, inaccessibility of health services and a high incidence of conditions such as hypertension, diabetes mellitus, and HIV.[2,3] Fifty to eighty percent of the global populace is bilingual and Africa has the highest prevalence of multilingualism.[4–8] Clinicians thus evidence a significant increase in bilingual individuals with aphasia.[4–7]

Bilingual aphasia is complex. Bilingual processing is different to that in monolinguals, with or without language impairment, where two (or more) languages may recover similarly (parallel) or differently (differential).[5,7,9,10] Lack of suitable bilingual therapy approaches persists.[7,11] The consequence thereof is far-reaching as language outcomes are generally poorer for persons with bilingual aphasia, negatively impacting the quality of life.[12,13] To inform appropriate management, improved understanding of bilingual processing is imperative.[7,10,14–16]

Cross-linguistic processing is the interaction of two languages within a bilingual individual.[17] Literature, particularly, Costa's[18] bilingual lexical access model explains word retrieval (top-down) and comprehension (bottom-up) during confrontation naming (Figure 1).[7,10,14,19–22] The conceptual level, shared by both languages, is activated first.[23–25] Activation then spreads to both languages' lexical (word) and phonological nodes, followed by production of the word(s).[18,26] Language-specific word selections in the target language occur by inhibiting the nontarget language.[10,14,18,20] Therefore, "meetse" and not "water" is produced when naming in Sepedi.

When processing is hindered at one or more of the three levels of representation, word retrieval difficulties, a pervasive characteristic of aphasia,[7,27] and speech errors result. A shared conceptual system and interconnectedness of the three levels may cause similar error patterns observed in both languages.[21] For example, difficulty on the phonological level may cause the individual to say "wader" instead of "water" or "meedse" for "meetse". Other speech errors include semantic, omission, mixed, neologism, and translation errors (Table 4).[21] Speech errors thus provide insight into "hidden" cross-linguistic processes.

Speech errors also have the potential to link language and impairment factors with cross-linguistic recovery post-stroke. Language proficiency pre-stroke is one of the best predictors of post-stroke outcomes.[10,28–30] In unbalanced language proficiency, stronger lexical-semantic connections exist within the pre-stroke most dominant language (MDL) and persist if this language remains the MDL post-stroke.[29,31] Increased connection strength between the conceptual, lexical, and phonological levels may result in more successful word retrieval and less speech errors in MDL.[21] This suggests recovery of MDL may be facilitated to a greater extent than the less dominant language (LDL).[21,29,31] MDL and LDL may, however, change post-stroke due to not being able to return to work or reduced social networks.[13,32,33]

Another factor influencing language recovery is the degree of similarity between languages that the person with aphasia speaks and understands.[14,21,34] If two languages differ extensively in structure (e.g. Sepedi and English), interference between these languages may occur when retrieving words that are identical at the conceptual level (e.g. *meetse*-*water*) causing speech errors.[14,35,36] This possibly affects the extent and pattern of language recovery in both languages.[15]

Impairment variables such as recovery patterns and aphasia type and severity also impact language recovery.[10,21] Speech errors may assist SLPs in determining the degree of impairment in each of the individual's languages.[7,10] If a bilingual person with aphasia produces significantly more errors in his or her LDL, it may be assumed that the degree of impairment is greater for that language indicating differential recovery.[7,10,37] Therefore, cross-linguistic recovery is controlled not only by interaction of the two languages but also by external influences.[7,30] Questions remain regarding these language and impairment factors and how they are related.[7,10,21,37]

Individuals with bilingual aphasia remain a clinically underserved population despite advances in research.[4,32,38,39] In SA, 77% of the population have a first language other than English or Afrikaans, while clinicians generally have either/or as their MDL.[32,38,39] Sepedi is one of the top three frequently used official languages of SA,[39,40] yet lack of Sepedi-English standardized aphasia tools persists.

Kendall et al.[21] investigated the significance of speech errors on cross-linguistic processing in English-Afrikaans individuals with aphasia, which is one of the language pairs in SA. The current study elaborates by focusing on a different language pair. Therefore, the following research questions are asked:

(1) What can speech production errors tell us about crosslinguistic processing in Sepedi-English individuals with aphasia?
(2)
(3) Which language and impairment variables may be associated with cross-linguistic processing in Sepedi-English individuals with aphasia?

Method

A case series was used as it considers participants with similar diagnoses and determines reasons for variance in the group by looking at specific aspects of communication.[41–43] Kendall et al.[21] was a retrospective investigation while the present research is prospective, allowing in-depth pre- and post-stroke clinical profiles to be determined for participants. Procedures for data collection and transcription were similar to Kendall et al.[21], but additional statistical analyses were conducted to answer the second research question. Guidelines were followed to prevent certain pitfalls implicit in case series analyses.[43,44]

Ethical clearance was obtained. Permission to interview and assess six Sepedi-English individuals with aphasia from three clinical sites was granted. Picture-based aphasia friendly material was used to obtain informed consent from participants.[45]

Participants

Six participants were purposively selected based on the following criteria:
(1) single left hemisphere stroke (confirmed by MRI and/or medical records)
(2) presence of aphasia verified by the referring SLP
(3) chronic aphasia, i.e. ≥6 months post-stroke
(4) understands and is able to speak Sepedi and English
(5) between the ages of 18 and 75
(6) adequate hearing and vision
(7) able to follow two-step instructions
(8) speaks at least three- to four-word phrases.

Exclusion criteria were stipulated as follows: severe aphasia, hearing and/or visual impairment, psychiatric illness and degenerative neurological disease. Tables 1, 2, and 3 provide pre- and post-stroke accounts for participant 1 (P1) to participant 6 (P6).

Participants were exposed to multiple languages, as they reported that it is a sign of respect to acknowledge different languages of community members. Sepedi and English were however their main languages. All participants suffered a single left hemisphere stroke. The MDL and LDL of P1, P4, and P5 changed due to differences in language exposure post-stroke. P1 and P4 reported that they rarely spoke English post-stroke due to not being able to return to work. Their communication partners were thus mostly Sepedi speaking family and friends, which resulted in Sepedi being their MDL post-stroke. P5 received speech therapy only in English and thus she preferred to mostly speak English (MDL) poststroke. Participants' time since onset of stroke ranged between six months and eight years. Aphasia type and severity were noted as either moderate Broca's (non-fluent: effortful, slow speech and limited verbal output) or mild to moderate Anomic aphasia (fluent: marked word-retrieval difficulties; continuous speech in search of the target word). All participants received individual speech-language therapy for a few months post-stroke, except P4, and attended weekly group therapy. P5 and P6 continued to receive individual speech-language therapy at the time of data collection.

Materials and procedures

The Western Aphasia Battery-Revised (WAB-R)[46], Boston Naming Test (BNT)[47] and visual and hearing screening tools[48,49] were used to establish that participants met inclusion criteria. During a structured interview with visual supports (Appendix A), a detailed language and clinical profile for each participant was obtained. Self-reported information was corroborated by a significant other to confirm trustworthiness.[44] The first author, who collected the data, has a basic ability to speak and understand Sepedi. A Sepedi-speaking senior SLP student was thus present during each first data collection session to ensure participants were provided the opportunity to answer and ask for clarification in Sepedi.

Goldstein[50] provides adjustment guidelines when administering standardized tests with culturally and linguistically diverse populations. Modifications were as follows: allowing participants to give answers to WAB-R and BNT items in Sepedi (e.g. saying "lebakere" for a picture of a cup in the WAB-R), participant-specific exclusion of BNT test items that were clearly not encountered in his or her cultural-linguistic context (e.g. "octopus", "volcano", "beaver", "hammock", and "sphinx") and rewording of instructions. All changes were indicated verbatim on record forms, and BNT naming accuracy was calculated as a percentage for each participant.

Picture naming stimuli were constructed using high and low frequency of use words from www.talkenglish.com and Kendall et al.[21] English words were translated by a qualified linguist into Sepedi. Seven Sepedi-English neurotypical adults validated stimulus items by ensuring picture-name correspondence in both languages before data gathering commenced. Data collection for this study occurred in a quiet, brightly lit room at the clinical sites. Identical pre-recorded audio instructions were given in MDL and LDL, respectively. Each participant named 45 color picture cards (Appendix C) first in their post-stroke MDL, followed by the LDL. Responses were written on the validated word list (Appendix B) and audio recorded. No cues were given to aid the participants in naming, unless clear misinterpretation of the picture card was observed.

Data processing and analyses

Recorded picture naming responses were transcribed for each participant and verified by the linguist, proficient in Sepedi and English. Speech production in MDL and LDL was scored for overall accuracy and error types (Table 4).[21] Only correct lexical units (single words) and final responses were noted.[21] Interjections such as "um" and "let me think" were omitted.[21]

Statistical analyses

A third of the data sets were used for consensus reliability ratings of overall accuracy and types of errors by the linguist as well as a qualified SLP. Consensus reliability scores were 97% and 98% for overall accuracy and 90% and 92% for error types. According to McHugh[51], 90% to 100% consensus is an "almost perfect" level of agreement. Error proportions were calculated statistically. The Shapiro–Wilk test of normality was run for each variable of interest. Parametric tests were used for variables with p-values greater than 0.05. Non-parametric tests were used for variables with p-values less than 0.05. Although the MDL and LDL of three participants changed post-stroke, there was no significant difference between overall naming accuracy in MDL ($p = 0.285$) and LDL ($p = 0.180$) pre- and post-stroke. All statistical analyses resultantly considered post-stroke MDL and LDL only. The level of significance was set at 0.05.

Results

Q1. Speech production errors and cross-linguistic processing

Overall naming accuracy in MDL and LDL

The Wilcoxon signed-rank test showed no significant differences in MDL-LDL naming accuracy for all participants, as seen in Figure 2. P1, P3, P5, and P6 had better accuracy in their MDL and P2 had one more item correct in LDL. In contrast, P4 clearly had higher naming accuracy in LDL and the largest difference in MDL-LDL percentage accuracy (23%). P5 had the highest overall naming accuracy and least severe aphasia of the participants. P1 and P6 had the lowest overall naming accuracy and more severe aphasia than the other participants.

Error types

All participants consistently produced semantic errors in both MDL and LDL, as shown in Figure 3. It was the most frequently produced error overall, with proportions ranging between 0.15 and 1.00. Phonological errors were also shown by all participants, but inconsistently in MDL and LDL. P1 and P6 produced the largest proportions of omissions (MDL = 0.6 and 0.42; LDL = 0.48 and 0.42) and neologisms (P1's MDL = 0.05 and P6's LDL = 0.08). P1 and P6 also presented with more severe aphasia in comparison to the other participants. P2, P3, P4, and P5 produced relatively more mixed errors (ranging between 0.125 and 0.22 across MDL and LDL) than P1 (MDL = 0.05 and LDL = 0.04), and P6 had none. P4 and P6 were the only participants who produced translation errors in both MDL and LDL. P1, P3, and P5 had translation errors in their LDL only.

Q2. Impairment and language factors influencing cross-linguistic processing

Table 5 depicts correlations and p-values for different impairment and language variables considered in this study.

Language recovery pattern

A significant positive correlation (Pearson) presented between overall naming accuracy in Sepedi and English for all participants. As naming accuracy increased (or decreased) in Sepedi/English, accuracy also improved (or lowered) in English/Sepedi, respectively.

Aphasia severity (WAB-R)

A significant positive correlation was seen between AQ and overall accuracy in Sepedi and English. This indicates the higher the AQ (less severe aphasia), the higher the naming accuracy in Sepedi and English; the lower the AQ (more severe aphasia), the lower the naming accuracy in Sepedi and English.

Age of language acquisition

Age of acquisition was calculated as years of exposure to Sepedi and English. Participants had more years of exposure to Sepedi (mean = 56.00) than to English (mean = 49.00). No significant correlation between years of exposure and naming accuracy presented for Sepedi or English. Therefore, the age at which participants acquired Sepedi or English could not be linked to their naming ability in that language. The acquisition-performance correlation was however stronger for Sepedi than for English.

Discussion

Speech production errors may inform us about cross-linguistic processing in Sepedi-English individuals with aphasia

Speech production errors found in this study may show that cross-linguistic connections (e.g. spread of activation and connection strength) relate to symptoms of bilingual aphasia, rather than damage to the entire language processing system.[10] Individuals with bilingual aphasia may thus use typical bilingual word retrieval.[7]

Higher MDL naming accuracy, in most cases, supports the assumption that stronger lexical-semantic connections exist in MDL which facilitate more efficient word retrieval and reduce speech errors.[7,21,29,31] Both languages may, however, remain connected post-stroke, accounting for the lack of a statistically significant MDL-LDL naming difference. Processing difficulties in either language may thus spread to the other language causing a similar number of errors.[21] Another explanation for MDLLDL naming similarity may be that both languages' word retrieval mechanisms were comparably impaired in participants, known as parallel language recovery.[7,10,37] P4 was the only participant with differential recovery, which may explain higher naming accuracy in her LDL.[7,10,37]

Semantic and phonological error proportions across all participants may indicate activation of both conceptual and phonological systems despite linguistic impairment.[21] Semantic errors may have resulted when a competing non-target concept received a higher level of activation than the target concept.[18,21] For example, activation of the concept *transparent liquid (H20)* versus *transparent liquid (H20) + bottle* may cause the error "water" for "bottle". Inconsistency of phonological errors across MDL and LDL may be expected. Sepedi-English word pairs often differ in phonology and structure, as these languages stem from Bantu (Sotho group) and West Germanic linguistic families, respectively.[35,36,52,53] Limited overlap between phonological nodes of both languages and reduced co-activation of sounds may have occurred (e.g. *window-lefastere*).[18,19,21,54] This is in contrast to semantic errors which occurred consistently. Therefore, Sepedi-English word pairs possibly share a conceptual level which may have caused processing difficulties to present in both languages (e.g. saying "children" or "bana" instead of "school" due to impaired activation of *place of learning for children*).

Patterns of omission, neologism and mixed errors seen may be associated with aphasia type and severity. Omissions result from insufficient semantic and lexical activation and thus no spread of activation between the processing levels occur (Figure 4).[21] Neologisms may be caused by severe lexical-phonological processing difficulties, suggesting a degree of disconnect between the conceptual and lexicalphonological levels.[54] P1 and P6 produced the most omissions and neologisms, which may be linked to more severe Broca's aphasia. Verbal output is often proportional to the degree of word retrieval difficulties in Broca's aphasia.[55]

Mixed errors signify bidirectional activation of the semantic, lexical, and phonological levels.[54,56] P2 and P5 present with mild and P3 and P4 with moderate Anomic aphasia. These participants had mixed errors in MDL and/or LDL. Strength of connectivity within and between languages of a person with aphasia may thus be compromised with an increase in aphasia severity.[10,30,54]

P4 presented with many translation errors in MDL due to interference from LDL, which may be as a result of her differential language recovery. Cognitive control involved in cross-linguistic processing is less preserved in differential as opposed to parallel recovery.[10] Cognitive mechanisms involved in inhibiting the nontarget language, when naming occurs in the target language, may thus also have been affected in P4.[7,10,14,20] P6 produced many translation errors in his MDL (Sepedi). He received speech language therapy only in English (LDL) post-stroke, which may have facilitated stronger connections in English thereby increasing LDL interference seen during picture naming.[7]

Language and impairment variables may be associated with cross-linguistic processing in Sepedi-English individuals with aphasia

Pre- and post-stroke language proficiency appeared to be linked to cross-linguistic processing post-stroke,[10,28–30,32] as more participants had better naming accuracy in their MDL. *Age of language acquisition* was not significantly correlated with naming accuracy in either language (p = 0.788 and 0.887). Language proficiency may thus be more strongly associated with post-stroke linguistic performance than the age of acquisition.[7,10] A stronger acquisition-performance correlation in Sepedi may be due to longer years of exposure to Sepedi. The age at which participants acquired Sepedi may still be connected to their post-stroke performance in this language, even though the relation is weak. This supports the findings of Kiran and Roberts.[30]

Another variable was *phonological and structural differences* between Sepedi and English as they have different linguistic origins.[52,53] It is proposed that increased interference between these languages will result when attempting to retrieve word pairs with a similar conceptual level.[14,35,36] However, interference may not be observed for all Sepedi-English word pairs, as processes of word adoption and adaptation between Sepedi and English (e.g. *sekolo-school* and *aesekhrimi-ice-cream*) may cause similarity in sounds and structure. Dissimilar words may thus be subjected to more interference than adopted/adapted word pairs (e.g. *bana-children* versus *aesekhrimi-ice-cream*). The validated word list contained similar and dissimilar word pairs, which may account for inconsistency in MDL-LDL translation errors across participants. Preliminary data in this study indicate that structural language differences may not necessarily be linked to patterns of language recovery and cross-linguistic processing in Sepedi-English persons with aphasia.

Language recovery patterns may be related to the degree of impairment in both languages of an individual with aphasia.[7,10,21] Participants with parallel language recovery had more similar accuracy of production in MDL and LDL as opposed to P4 with differential recovery. Therefore, word retrieval mechanisms of both languages may be equally impaired in parallel language recovery, whereas unequal damage to these mechanisms may be seen in differential language recovery.[10,37]

Aphasia type and severity may have interacted with crosslinguistic processing and recovery.[7,10,21] Statistically significant correlations showed that an increase in aphasia severity resulted in more frequent word retrieval difficulties and thus more speech errors in both languages. P1 and P6 with moderate Broca's aphasia produced the largest number of errors, whereas P5 with mild Anomic aphasia produced the least errors. Figure 5 indicates different language and impairment variables that may have been associated with participants' cross-linguistic processing post-stroke.

Kendall et al.[21] remarked that statistical differences in three of their four participants' MDL-LDL naming accuracy were unexpected. However, the lack of baseline data may have prevented their investigations of possible associated variables. This study's prospective data could, therefore, expand on their work by examining MDL-LDL accuracy and relating it to these factors.

Future research

This study had a small sample size due to a lack of availability of persons who meet the selection criteria. Future research should thus aim to obtain a larger number of participants and investigate other language pairs to verify replication of results. Exploration of other language tasks and modalities may permit in-depth understanding of cross-linguistic processing which in turn guides appropriate diagnosis and intervention in bilingual aphasia.[37] Intervention studies concerning language and impairment variables, standardized Sepedi-English bilingual aphasia tests, and objective language proficiency measures should be developed.

Conclusion

Preliminary data regarding important variables to crosslinguistic processing were provided. This study drew attention to the complexity of impaired processing in individuals with bilingual aphasia, which is significantly more intricate than in monolingual aphasia.[5,7,9,10] Improved knowledge of the circumstances surrounding aphasia in SA (i.e. elevated aphasia incidence, multilingualism, and language barriers) may contribute to research in the complex field of bilingual aphasia.[2,3]

Disclosure of interest

The authors report no conflict of interest.

Ethical clearance

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APPENDIX A INTERVIEW SCHEDULE

Date: ______________________

Participant's name*:____

1. What is your date of birth?

____

BEFORE **PELE**

2. What languages did you speak before your stroke?

____

3. Did you speak and understand Sepedi before your stroke?
   - Yes
   - No
4. Did you speak and understand English before your stroke?
   - Yes
   - No
5. Before your stroke, which language did you understand better?
   - Sepedi
   - English
6. Before your stroke, which language did you use more often?
   - Sepedi
   - English
7. Before your stroke, what did you use Sepedi for?
   - Speaking ● Reading
   - Writing
8. Before your stroke, what did you use English for?
   - Speaking ● Reading
   - Writing
9. Were you able to understand and speak Sepedi and English equally well?
   - Yes
   - No
10. Before your stroke, how often would you use Sepedi?
    - Every day, mostly
    - At work
    - Only if the person I was talking to only understood Sepedi
    - Not often
11. Before your stroke, how often would you use English?
    - Every day, mostly
    - At work
    - Only if the person I was talking to only understood English
    - Not often

12. Before your stroke, in which situations would you mostly speak Sepedi?
- With family members and friends
- At work
- At school

13. Before your stroke, in which situations would you mostly speak English?
- With family members and friends
- At work
- At school

14. How old were you when you started speaking Sepedi?_______________________________________
15. How old were you when you started speaking English?______________________________________
16. 16. Did you learn to speak English and Sepedi at the same time?
- Yes
- No

17. What language were you taught in at school?
- English
- Sepedi
- Other

18. How many years did you go to school (i.e. until what grade)?

____

19. Did you study further after school? If so, where did you study and what?

____

20. Before your stroke, how would you rate your language abilities in Sepedi?
- Very good
- Good
- Okay
- Not very good
- Not good at all

21. Before your stroke, how would you rate your language abilities in English?
- Very good
- Good
- Okay
- Not very good
- Not good at all

22. Did you work before your stroke?[1]
- Yes
- No

23. What work did you do before your stroke?

____

[1] Both images were used from Pearl G. Engaging with people who have aphasia: A set of resources for stroke researchers. 2014:1–104. http://www.crn.nihr.ac.uk/wpcontent/uploads/stroke/sites/Aphasia/Aphasiaresources project v2- 2.3 in sections - whole doc (1).pdf.

AFTER

KO MORAO

24. Did you have a stroke?
    - Yes
    - No
25. When did you have your stroke?

    ____

26. To which hospital did you go?

    ____

27. How long were you in the hospital?

    ____

28. After your stroke, did you receive speech-language therapy?______________________________
29. How long did you go to speech-language therapy?____
30. Which language did you receive speech-language therapy in?
    - English
    - Sepedi
31. After your stroke, which language do you understand better?
    - Sepedi
    - English
32. After your stroke, which language do you speak better?
    - Sepedi
    - English
33. After your stroke, do you feel that you speak English and Sepedi equally well?
    - Yes, I speak both languages equally well.
    - No, I speak Sepedi better than English.
    - No, I speak English better than Sepedi.
34. After your stroke, do you feel that you understand English and Sepedi equally well?
    - Yes, I understand both languages equally well.
    - No, I understand Sepedi better than English.
    - No, I understand English better than Sepedi.
35. After your stroke, which language do you feel more comfortable speaking?
    - English
    - Sepedi
36. After your stroke, in which situations do you mostly speak Sepedi?
    - With family and friends
    - At work
37. After your stroke, in which situations do you mostly speak English?
    - With family and friends
    - At work
38. After your stroke, how often do you speak Sepedi?
    - Every day, mostly
    - Only when the person I am talking to only understands Sepedi
    - Not often

39. After your stroke, how often do you speak English?
- Every day, mostly
- Only when the person I am talking to only understands English
- Not often

40. After your stroke, which language difficulties do you experience?
- It is difficult to repeat words or sentences that someone has said.
- I have difficulty understanding what people say.
- I know what I want to say, but have difficulty finding the right word.
- It is difficult to name pictures and objects.
- Sometimes the words that I say don't come out right (e.g. teeste for meetse)
- Sometimes I say a word that is similar to what I want to say, but not the right word (e.g. chair for couch).
- It requires a lot of effort to speak.
- I speak slow and use short sentences.
- Other. Please describe.

  ____-

____

41. How did speech-language therapyhelp with your language difficulties?
- I could repeat words or sentences that other people said after speech therapy.
- I could better understand what people were saying after speech therapy.
- I could better find the right word for what I wanted to say after speech therapy.
- I could better name pictures and objects after speech therapy.
- I made less speech errors e.g. teetse for meetse and couch for chair after speech therapy.
- It required less effort to speak after speech therapy.
- I speak faster and use longer sentences after speech therapy.
- Other. Please describe.

  ____

APPENDIX B VALIDATED WORD LIST

Word	English		Sepedi		
	Response (√/X)	Other response	Word	Response (√/X)	Other response
child			ngwana		
money			tšhelete		
night			bošego		
number			nomoro		
school			sekolo		
cigarette			sekerete		
newspaper			kuranta		
flower			leblomo/letšoba		
bread			borotho		
church			kereke		
glass			galase		
watch			sešupanako/watchi		
fish			hlapi		
man			monna		
heart			pelo		
children/kids			bana		
table			tafola		
tomato			tamati		
book			puku/buka		
telephone			mogala/motato/phone/phono		
wool			wulu		
butterfly			serurubele		
leaf			letlakala		
strawberries			distroperi		
hat			kuane/kefa		
dog			mpša		
ice-cream			aesekhrimi		
horse			pere		
eye			leihlo		
door			lebati/monyako		
cat			katse		
window			lefastere/mafestere		
computer			khomphutha		
soup			sopo		
comb			kamo		

pineapple	phaeneapola
zip	zipi
airplane/helicopter	sefofane/helikoptere
star	naledi
microwave/microwa ve oven	maekrowaevie/micro-oven
nose	nko
earring	lengina
house	ntlo
pizza	phitsa
chair	setulo

APPENDIX C EXAMPLES OF COLOR PICTURE CARDS[2]

[2] Cigarette image retrieved from: https://myaccount.news.com.au/sites/heraldsun/subscribe.html?sourceCode = HSWEB_WRE170_a_GGL&mode = premium&dest = https://www.heraldsun.com.au/news/tobacco-giant-shrinking-size-of-some-cigarette-packs-as-smokers-to-be-hit-with-another-tax-rise /news-story/535e6f0188faad2317a570620e6b7b26&memtype = anonymous Bread image retrieved from: https://us.royalquest.com/forum/index.php?/ topic/1227-bread/:

Tables

Table 1. Participant demographics.

	Age (years)	Gender	Educational level	Occupation (pre-stroke)	Occupation (post-stroke)
P1	58	Male	Degree in human resource management (university)	Human resource manager at a mine	–
P2	68	Male	Grade 7	Material handler in a factory	–
P3	71	Male	Grade 9	Client services manager and cashier at a bank	–
P4	42	Female	Diploma in human resource management (technical college)	Human resource manager at an investment firm	–
P5	48	Female	Grade 12	Home maker	–
P6	55	Male	Grade 10	Police officer	–

Table 2. Participants' pre-stroke clinical profile.

Most dominant (MDL) and less dominant language (LDL) or balanced dominance	Age of acquisition (years)	Language exposure	Educational exposure
P1 English (MDL) Sepedi (LDL)	Sepedi (birth) English (6)	Sepedi, English, Afrikaans	Sepedi, English, Afrikaans
P2 Sepedi (MDL) English (LDL)	Sepedi (birth) English (6)	Sepedi, English, Afrikaans, Zulu, Southern Sotho	Sepedi
P3 English (MDL) Sepedi (LDL)	Sepedi (birth) English (7)	Sepedi, English, Afrikaans, Zulu, Venda, Setswana	English, Sepedi, Afrikaans
P4 Balanced	Sepedi (6) English (7)	Sepedi, English, Afrikaans	Sepedi, English, Afrikaans
P5 Sepedi (MDL) English (LDL)	Sepedi (birth) English (14)	Sepedi, English, Setswana, Tsonga (home language)	Setswana, English, Afrikaans
P6 Sepedi (MDL) English (LDL)	Sepedi (birth) English (6)	Sepedi, English, Afrikaans, Tsonga, Zulu	Sepedi, English, Afrikaans

Table 3. Participants' post-stroke clinical profile.

	Time since onset	Most dominant (MDL) and less dominant language (LDL) or balanced dominance	Aphasia type (WAB-R)	Aphasia severity and quotient (WAB-R)	Confrontation naming accuracy % (BNT)	Speech-language therapy; individual (I) and/or group (G)
P1	5 y	Sepedi (MDL) English (LDL)	Broca's	Moderate (65.7)	40 60 (wa)	English (I and G)
P2	4 y	Sepedi (MDL) English (LDL)	Anomic	Mild (79.7)	40 50 (wa)	English and Sepedi (I); English (G)
P3	2 y	English (MDL) Sepedi (LDL)	Anomic	Moderate (72.7)	30 92 (wa)	English (I and G)
P4	8 y	Sepedi (MDL) English (LDL)	Anomic	Moderate (71.6)	20 50(wa)	English (G)
P5	7 m	English (MDL) Sepedi (LDL)	Anomic	Mild (90.6)	50 62 (wa)	English (I)
P6	6 m	Sepedi (MDL) English (LDL)	Broca's	Moderate (64.8)	50 50 (wa)	English (I)

Notes: The BNT considers correct responses as those which are spontaneously correct and/or the right answer in response to a stimulus cue (e.g. "used by doctors and nurses" for stethoscope). Phonemic cues (e.g. "hou" for house) and multiple choice options may also be given and were thus noted as responses with assistance (wa).

Table 4. Error types in Sepedi-English.

Error type	Description
1. Phonologic (P)	Substitutions, additions, transpositions, omissions.
2. Semantic (S)	– Related within language (RWL): ‘desk’ for ‘table’. – Unrelated within language (UWL): ‘knife’ for ‘tomato’. – Related across language (RAL): English ‘animal’ for Sepedi ‘pere’, meaning horse. – Unrelated across language (UAL): English ‘horse’ for Sepedi ‘mpša’, meaning dog.
3. Mixed (M)	Actual words with a phonological relationship to target words, for example, ‘wind’ for ‘window’.
4. Omission (O)	Circumlocutions and nonresponses.
5. Neologism (N)	Non-words that are not phonologically related to target words, ‘beba’ for ‘tomato’.
6. Translation (T)	Sepedi responses for items to be named in English and vice versa, ‘tomato’ for ‘tamati’ and ‘tafola’ for ‘table’.

Note: Error types one to six are derived from Kendall et al.[21]

Table 5. Descriptive correlations for overall accuracy, aphasia severity, and age of acquisition.

Variable 1	Variable 2	n	Pearson correlation	p-value
Significant correaltion				
Overall accuracy (Sepedi)	Overall accuracy (English)	6	0.855	0.030*
Severity of aphasia (AQ)	Overall accuracy (Sepedi)	6	0.917	0.010*
Severity of aphasia (AQ)	Overall accuracy (English)	6	0.842	0.035*
No significant correlation, but relevant in literature				
Age of acquisition (Sepedi)	Overall accuracy (Sepedi)	6	0.143	0.788
Age of acquisition (English)	Overall accuracy (English)	6	0.075	0.887

Figures

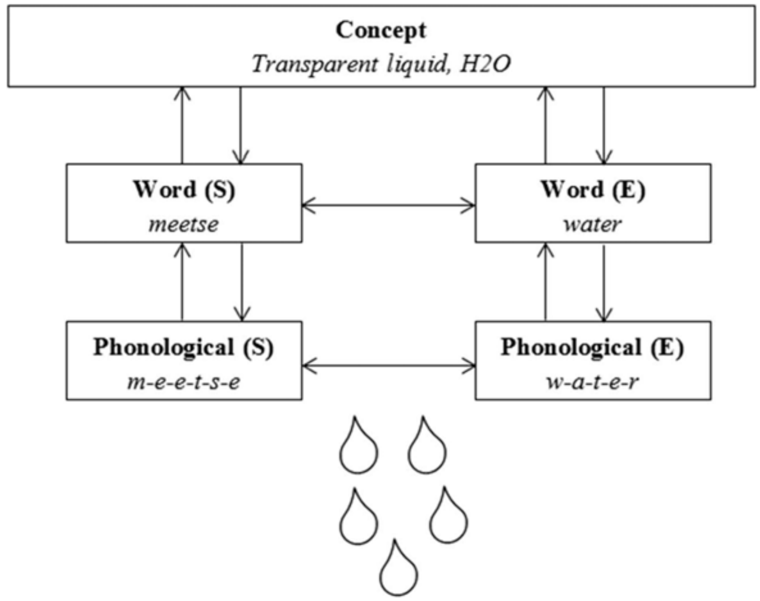

Figure 1. The mechanisms of word retrieval (↓) and comprehension (↑) in a Sepedi-English individual while naming a picture.

Notes: The conceptual level is where meaning and understanding of word(s) are created and stored (semantics). The lexical node is responsible for creating and storing whole word(s), not individual sounds. Lastly, the phonological node creates and stores individual sounds which make up word(s) which are then spoken.

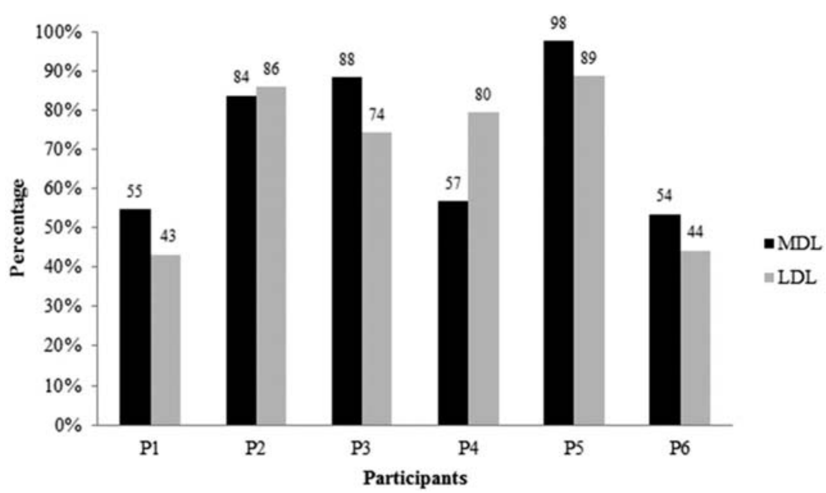

Figure 2. Overall accuracy of production in the most dominant language (MDL) and less dominant language (LDL) for P1 to P6.

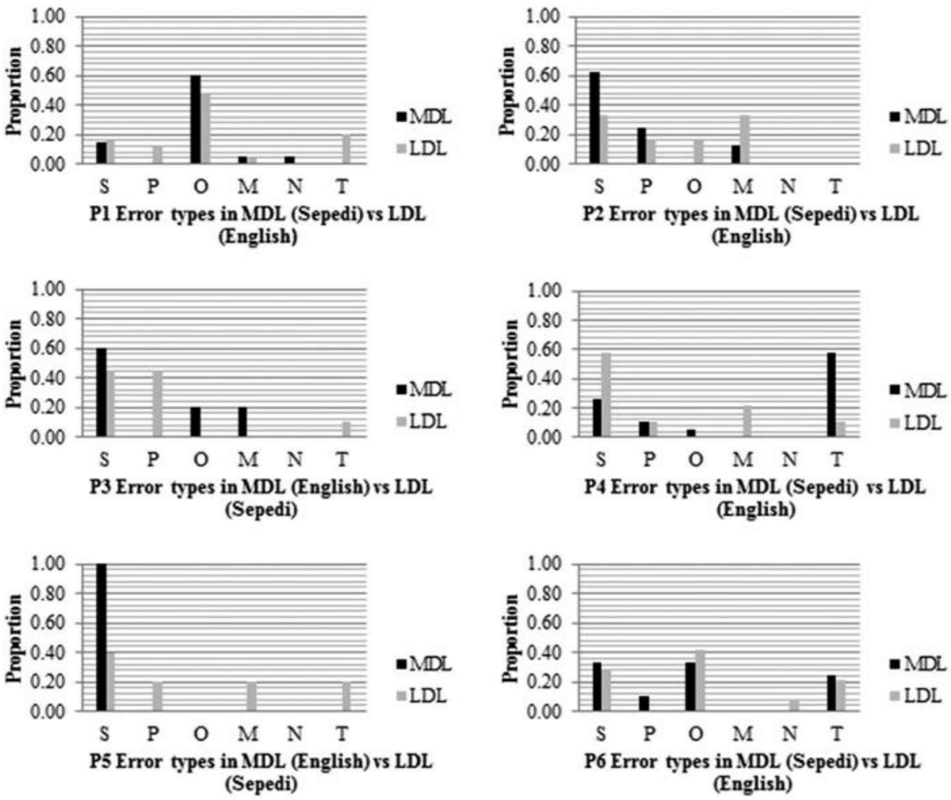

Figure 3. (P1) – (P6). Graphs detailing proportion of error types in participants' post-stroke MDL and LDL.

Notes: No significant differences existed between MDL-LDL naming accuracy, as p-values varied from 0.125 to 1.000.

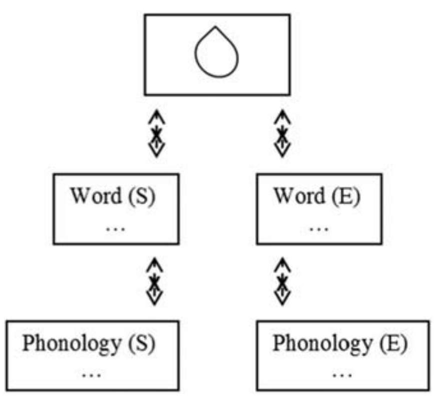

Figure 4. A theoretical account of an omission error when a Sepedi-English person with aphasia is expected to name a picture of water.

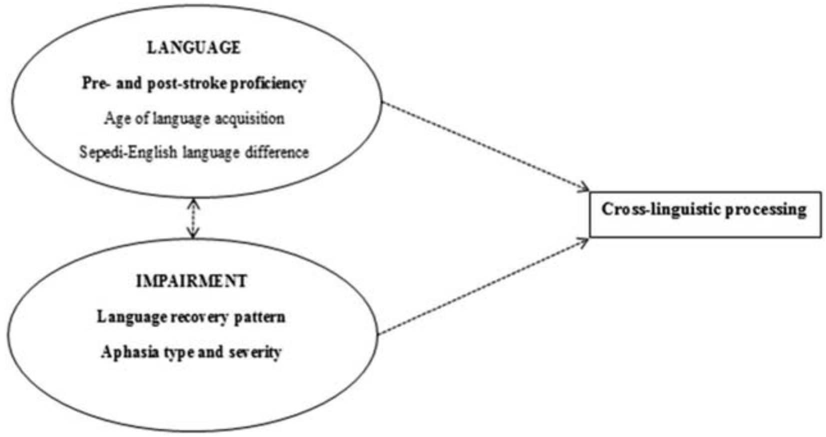

Figure 5. Language and impairment variables possibly related to cross-linguistic processing post-stroke.

Notes: Items in bold may have a stronger association with cross-linguistic processing.