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Facilitation and Interference Effects During Cognate Retrieval in a Multilingual Person With Aphasia

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ABSTRACT

Purpose: In this study, we investigated the phenomenon of cognate status–based picture-naming abilities before and after anomia treatment in a multilingual person with poststroke aphasia whose languages vary in relation to language typology, age of acquisition, proficiency, and exposure/use in the years leading up to the stroke. We examined baseline abilities as well as the efficacy of within- and cross-language generalization.
Method: In a multiple-baseline study, we measured cognate versus noncognate picture-based naming in one multilingual person with mixed transcortical aphasia in three of his languages: Swahili, English, and Hebrew. We provided 18 hrs of word retrieval treatment in English and then retested his cognate versus noncognate retrieval in all three languages.
Results: At baseline, no cognate advantage was observed in English (high proficiency, early acquisition, high daily use). A cognate advantage was observed for Hebrew (late acquisition, moderate proficiency, oft-used) and potentially for Swahili (high proficiency, early acquisition, rarely used). After treatment in English, our results indicated greater interference effects for cognates relative to noncognates in Hebrew and Swahili, but not English.
Conclusions: Retrieval ability may be more influenced by prestroke usage than by age of acquisition or proficiency, with a facilitative cognate advantage for less proficient and/or less used languages. Furthermore, treating a stronger language may result in interference of cognate retrieval more than noncognate retrieval in weaker languages. More studies are needed in this field to better understand the contribution of each factor and how we can manipulate them to our advantage in the aphasia clinic.
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There is much debate in the literature as to whether the lexicons of a bilingual person are separate (e.g., the Revised Hierarchical Model [RHM]; Kroll & Stewart, 1994; Kroll et al., 2010) or shared (e.g., the Bilingual Interactive Activation Plus [BIA+] model; Dijkstra & van Heuven, 2002), whereas most models assume a (mostly) shared semantic network between both languages (e.g., Dijkstra & van Heuven, 2002; Dijkstra et al., 2019; Kroll & Stewart, 1994; Kroll et al., 2010). The RHM was developed to illustrate word retrieval abilities in each language and accounts for relative proficiencies of each language as well as age of acquisition (Kroll & Stewart, 1994; Kroll et al., 2010). The RHM was also used to predict directionality of translation abilities and language mixing in neurotypical bilingual adults as well as directionality of post-treatment cross-language generalization in bilingual people with aphasia (PWA; Lerman et al., 2022). The BIA+ model was originally developed as a model of word recognition (Dijkstra & van Heuven, 2002) but has been recently updated to incorporate word production and renamed the "Multilink model" (Dijkstra et al., 2019).

The Multilink model posits that there is a triangular architecture connecting semantic, phonological, and orthographic representations, with activation spreading across these three representations in all languages relative to the task. When activation surpasses a certain threshold across

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the representations, including activation of a target language node, successful word recognition and/or production will occur in the target language (Dijkstra et al., 2019; Paradis, 2000). The amount of activation necessary depends on several factors relative to the available resources of a particular target language in a specific context. Two connected factors are the proficiency of the target language and its status as a first-acquired language (first language [L1]) relative to a later-acquired language (second language [L2], third language [L3], etc.; Goral et al., 2006; Kroll et al., 2010). Similarly, the degree of language use at any given time should also affect lexical access (Goral et al., 2006; Midgley et al., 2011). Furthermore, based on the adaptive control hypothesis (Green & Abutalebi, 2013), the interactional context will also be a factor, with goal maintenance and interference control (conflict monitoring and interference suppression) demanding more resources in a dual- or single-language context than in a translanguaging (i.e., dense code-switching) context. Additionally, the psycholinguistic properties of lexical items will also contribute to the amount of activation that occurs, with the Multilink model accounting for words of different lengths, frequency, language families, and cognate status (Dijkstra et al., 2019).

Cognates

Cognates are words that have both shared meaning and similar word forms across two languages. Similar word forms can be measured through phonological and/or orthographic overlap and are commonly accepted to have ≥ 70% overlap of form (e.g., Roberts & Deslauriers, 1999), although overlap of form can also be considered as a continuum, rather than resulting in a dichotomous cognate-versus-noncognate distinction (Dijkstra et al., 2010; Strangmann et al., 2023). How many and what type of cognates occur across languages will be linked to factors such as language families, language typology, and the borrowing history of words across languages which is based on language contact both historically and geographically (e.g., Batsuren et al., 2022; Schepens et al., 2012; Tsvetkov et al., 2015).

Some language pairs are known to have many cognates, due to them belonging to the same language family and having high language contact throughout history. For example, Dutch–German, Italian–Spanish, and English–French all have very high numbers of cognates for these reasons (Schepens et al., 2012). However, the languages discussed in this article—Swahili, English, and Hebrew—are all from different language families: Swahili is a Bantu language from the coast of East Africa, English belongs to the West Germanic branch of the Indo-European language family, and Hebrew is a Semitic language.

Historically, Biblical Hebrew had some influence on English, mostly through religious texts (Glinert, 2017) although not exclusively, whereas English influences Modern Hebrew through its status as a global language, for example, with many borrowed words from English to Hebrew in the field of technology. Thus, there are a fair number of cognates across English and Hebrew (e.g., "television" [ENG] – "televizia" [HEB]). Regarding Swahili and English, the languages came into close daily contact during the years of British colonial rule in East Africa (from 1888 to the 1960s; Britannica, n.d.), with many borrowed words from English making its way into some dialects of Swahili, with a more limited influence of Swahili on English, which resulted in many cognates across the two languages (e.g., "blanket" [ENG] – "blangeti" [SWA]; Dzahene-Quarshie, 2010). There has been limited contact between Hebrew and Swahili, with the exception of some derivatives from the Hebrew bible into Swahili (Dube, 2019). However, Arabic has been a major influence on Swahili due to both trade and the Islamic influence on Africa (Lapidus, 2014), and Arabic and Hebrew share many cognates due to their shared Semitic language typology. Thus, there are also some cognates that can be identified across Swahili, Arabic, and Hebrew (e.g., "arobaini" [SWA] – "arbauna" [ARA] – "arbayim" [HEB] = *forty*; "salamu" [SWA] – "salaam" [ARA] – "shalom" [HEB] = *greetings*).

Research shows that neurotypical multilingual people activate and retrieve cognates differently than they do noncognates (e.g., Costa et al., 2000; de Groot et al., 2002; Dijkstra et al., 2019; Hughes & Tainturier, 2015; Robinson Anthony & Blumenfeld, 2019). Based on the RHM, the auditory activation of a cognate simultaneously activates the word in the nontarget language because the two words are linked semantically and phonologically (Kroll & Stewart, 1994; Kurland & Falcon, 2011), as well as orthographically in many cases (Dijkstra et al., 2019). Similarly, the Multilink model posits that co-activation of orthography and shared semantics of cognates will result in direct and indirect activation of their shared phonological representations. Thus, a cognate facilitation effect will occur, whereby retrieval and/or translation of cognates will be faster and more accurate than that of noncognates (Dijkstra et al., 2019), a finding supported by empirical observations (e.g., Costa et al., 2000, 2006; de Groot et al., 2002, 2011; Hughes & Tainturier, 2015).

However, not all cognate effects are faciliatory. Cognate effects can occur at both the lexical and sublexical (phonological/orthographical) levels of retrieval. Whereas lexical-level effects are considered facilitative, sublexical-level effects may result in a weaker facilitative effect or even a negative cognate effect due to interference (Muscalu & Smiley, 2019; Muylle et al., 2022). For example, facilitative cognate effects are considered stronger when there is orthographic and phonological overlap (e.g., Dijkstra et al., 2019; Strangmann et al., 2023), because the less orthographic overlap that exists across word pairs, the more interference of phonological overlap is expected to occur (Muylle et al., 2022). Nonetheless, it should be noted that many theories of bilingual lexical processing are based on languages that have both phonological and orthographic overlap for many cognates, such as the Multilink model that was developed based on English and Dutch. For other language pairs, orthographic overlap may be weaker or nonexistent, and yet, cognate facilitation effects have also been observed across languages that do not share the same script (Hoshino & Kroll, 2008).

Different factors have been associated with strength and/or directionality of cognate effects. For example, language proficiency has been found to manipulate cognate facilitation, such that a cognate advantage will be more salient in a less proficient language than in a more proficient language (e.g., de Groot et al., 2002; Robinson Anthony & Blumenfeld, 2019; Rosselli et al., 2014; van Hell & Tanner, 2012), even when orthographic overlap is not taken into consideration (Kroll & Stewart, 1994). Furthermore, language use and exposure have also been suggested as factors that may influence cognate facilitation and interference (e.g., Bultena et al., 2014; Midgley et al., 2011; Pérez et al., 2010; Stadthagen-González et al., 2013), with more exposure to an L2 being linked to a larger facilitation effect of cognates for either the L2 (Stadthagen-González et al., 2013) or the L1, at least at the level of processing measured by the N400 component in an event-related potential study (Midgley et al., 2011). Thus, cognate effects in neurotypical adults have mostly been observed to be facilitative, at least at the lexical level, but will be affected by a combination of language proficiency, exposure and use, script overlap, and task, among other factors. Conversely, in adults with acquired language disorders, such as aphasia, cognate effects have been observed to be both facilitative and interfering.

Cognate Retrieval in Bilingual and Multilingual PWA

PWA have difficulty with language, and common to all types of aphasia is word retrieval impairment, to varying severity levels. Clinically, treating aphasia in multilingual people may focus on one or all of their languages, depending on factors such as available resources, the potentially differential language abilities poststroke in each language, and patient preference. Research on aphasia treatment in multilingual people has focused on the potential transfer of treatment effects both within and across languages (known as within-language generalization and cross-language generalization, respectively), and how treatment might be manipulated to increase those transfer effects (e.g., Goral & Lerman, 2020; Kiran et al., 2013; Kohnert, 2004).

One of the factors that has been studied in this context is that of cognate versus noncognate retrieval, with a view to better understanding cognate effects in multilingual PWA for both theoretical and clinical purposes. To date, there is conflicting evidence regarding whether retrieval of cognates is better or worse relative to that of noncognates in PWA (e.g., Kendall et al., 2015; Lalor & Kirsner, 2001; Marte et al., 2023; Roberts & Deslauriers, 1999; Tiwari & Krishnan, 2015; Verreyt et al., 2013) and almost no evidence for potential differences of treatment effects of cognates versus noncognates (Hameau & Köpke, 2015; Kohnert, 2004; Kurland & Falcon, 2011). At the group level, both Marte et al. (2023) and Roberts and Deslauriers (1999) found higher accuracy of lexical retrieval for cognates compared to that for noncognates in bilingual PWA. This was found for both highly proficient, balanced bilingual PWA (French–English speakers; Roberts & Deslauriers, 1999) and for highly proficient, unbalanced bilingual PWA (Spanish–English speakers; Marte et al., 2023) in both languages, but the cognate facilitation effect was smaller in PWA compared to that in neurotypical control participants (Marte et al., 2023). Furthermore, Marte et al. found that, for bilingual PWA, greater cognate facilitation was observed in participants with less severe aphasia in their L2 (as opposed to neurotypical control participants, in which cognate facilitation was associated with proficiency, exposure, and use). Others have found that any observed cognate advantage was greater during retrieval of a postmorbidly weaker language compared to a stronger language (e.g., in Italian–English speakers, Lalor & Kirsner, 2001; in French–English speakers, Roberts & Deslauriers, 1999).

However, whereas Roberts and Deslauriers (1999) found a greater cognate advantage overall in a postmorbidly more impaired L2 English than in a postmorbidly less impaired L1 French in their group of PWA, Tiwari and Krishnan (2015) describe the case of a premorbidly highly proficient, balanced Malayalam–Kannada-speaking person with aphasia whose cognate retrieval was worse in his premorbidly less used, postmorbidly more impaired Malayalam than in his premorbidly more used, postmorbidly less impaired Kannada. They suggested that cognate retrieval was thus more inhibited in the less used Malayalam than in the more used Kannada because lexicosemantic connections were weaker in the less used language (Tiwari & Krishnan, 2015), thus implying a less effective suppression of interference of Kannada when attempting to retrieve cognates in Malayalam, than vice versa. Furthermore, the amount of cognitive control required for any given task has been observed to modify the efficacy of interference suppression that occurs during cognate processing in a less impaired language relative to a more impaired language; thus, the presence or absence of cognitive control deficits notwithstanding the language deficits in PWA will affect performance on different types of cognate tasks (Van der Linden et al., 2018; Verreyt et al., 2013).

Regarding treatment effects in multilingual PWA, there has been much debate in the literature about both within- and cross-language generalization. While it is beyond the scope of this article to discuss this in detail, we note that in a recent review by Goral et al. (2023), within-language generalization was observed to be more robust than cross-language generalization, and as a rule, treating one language is not detrimental to the untreated language. Furthermore, cross-language generalization is most likely when treatment is provided in either an L1 or an L2 that became the language of the environment, suggesting that language use modulates the strong effects of treatment efficacy for L1; proficiency and language distance were not observed to be driving factors for generalization effects (see Goral et al., 2023, for a detailed meta-analysis).

Specifically, regarding cross-language generalization of treatment targeting cognate versus noncognate retrieval, Kohnert (2004) found that in a Spanish–English speaker with severe transcortical motor aphasia, 4 hrs of treatment (2 hrs in Spanish, 1-week break, then 2 hrs in English) focusing on lexical-semantic processing of cognates and noncognates resulted in general improvement to lexical retrieval of both, but that improvement was maintained for cognates only. In other words, she found a facilitative effect of treatment for cognates relative to noncognates. Conversely, Kurland and Falcon (2011) describe an interference effect of cognates after treatment of a Spanish–English speaker with severe expressive aphasia, such that after 25 hrs of anomia treatment in the better spared Spanish followed by 25 hrs of anomia treatment in the more impaired English, lexical retrieval of noncognates showed greater improvement relative to cognates, with retrieval being generally better in Spanish than in English. They attributed the cognate interference effect that was observed to damage the control network (in addition to the language network) due to their participant's brain lesion (Abutalebi & Green, 2007; Kurland & Falcon, 2011).

For PWA who speak three or more languages, Goral et al. (2006) note that lexical connections between two later-acquired languages may be strong if they share orthography and/or vocabulary and that this may influence cross-language generalization and/or interference. We found only two studies directly investigating cross-language generalization effects on cognates versus noncognates in this population (Goral et al., 2012; Hameau & Köpke, 2015). Goral et al. (2012) tested a person with aphasia who spoke five languages, four of which were assessed during the study (one of his two early-acquired, highly proficient languages [Spanish but not Catalan] and his three moderately to highly proficient, later-acquired languages [French, English, and German]). Treatment focused on lexical retrieval of objects and actions, and he received between 22 and 25 hrs of treatment in Spanish and then between 22 and 25 hrs of treatment in English. During treatment, the participant was engaged in a modified semantic feature analysis (SFA) task (Boyle & Coelho, 1995), a sentence generation task, and a rapid naming task. The researchers did not observe improvement in cognates relative to noncognates after treatment in each of the treated languages; however, they observed a cross-language cognate facilitation effect whereby after treatment in either Spanish or English, retrieval in each of the untreated languages was better for cognates than for noncognates, for either objects, actions, or both. Conversely, in their study on a German–English–French-speaking person with aphasia, Hameau and Köpke (2015) tested two of the participant's three languages (L1 German and L3 French) with stimuli that differentiated between cognates across German–French and across German–English–French, as well as noncognates. The participant received between 21 and 25 hrs of lexical-semantic anomia treatment in French. They found no significant difference for treatment efficacy of cognate retrieval compared to noncognate retrieval for either the treated or the untreated language.

In summary, very few studies have investigated cross-language effects for lexical-semantic treatment of anomia, specifically for cognates versus noncognates. Two studies provided treatment for bilingual PWA (Kohnert, 2004; Kurland & Falcon, 2011), and two more studies provided treatment for PWA who speak three or more languages (Goral et al., 2012; Hameau & Köpke, 2015). The results were varied: Two case studies observed cognate facilitation effects on treatment outcomes in both or most languages (Goral et al., 2012; Kohnert, 2004), one case study observed interference effects on treatment outcomes (Kurland & Falcon, 2011), and one case study observed no difference for cognate retrieval in either of the languages they tested relative to noncognate retrieval after treatment (Hameau & Köpke, 2015).

The Current Study

To date, there is still much debate as to whether cognate status has a facilitative or interfering effect on retrieval in multilingual PWA as well as the factors that might be driving these effects. Furthermore, because the processing of cognates could either benefit or harm naming improvement in multilingual PWA and as it is unclear from the current literature as to which is likely to occur, in people with varying aphasia profiles, language backgrounds, and language of treatment, it is critical to further examine cognate effects and the potential predictors of these effects. This line of investigation is important for improving language treatment practices in multilingual PWA. Additionally, this study aligns with recent efforts to identify the influencing factors of treatment outcomes in this population (Goral & Lerman, 2020; Goral et al., 2023; Lee & Faroqi Shah, 2024). In this study, we investigated cognate versus noncognate retrieval in a multilingual person with aphasia, where we measured retrieval in three of his four languages (Swahili, English, and Hebrew, but not his native tribal language). We aimed to better understand the contribution of age of acquisition and related language proficiency, as well as use and exposure of each language, on retrieval of words based on cognate status before and after treatment. Thus, we asked the following research questions:

1. How does cognate status affect picture-naming abilities across languages in a multilingual person with aphasia, relative to age of acquisition, pre- and post-stroke language abilities, and language use at the time of the stroke?
2. In a multilingual person with aphasia, does treatment in one language affect picture-naming abilities in the treated language and/or the untreated languages, relative to cognate status, and which factors can be attributed to the patterns of retrieval observed?

We hypothesized that cognates would be retrieved better than noncognates pretreatment, but not equally across the three languages that we tested (Marte et al., 2023; Roberts & Deslauriers, 1999). On the basis of the cognate literature in neurotypical multilingual people, we might expect a larger cognate advantage in a premorbidly less proficient language (de Groot et al., 2002; Robinson Anthony & Blumenfeld, 2019; Rosselli et al., 2014; van Hell & Tanner, 2012). However, current literature regarding cognate advantage in multilingual PWA is somewhat conflicting. On one hand, we expect to observe a larger cognate advantage in a postmorbidly more impaired L2 (Lalor & Kirsner, 2001; Roberts & Deslauriers, 1999), but on the other hand, we expect to observe a smaller cognate advantage in the language least used at the time of the stroke, which may also be considered a postmorbidly more impaired language due to reduced exposure and use (Tiwari & Krishnan, 2015). For posttreatment cognate retrieval, the literature is minimal and inconclusive. Only on the basis of Goral et al.'s (2012) study, we could hypothesize that treatment in a postmorbidly less impaired language will improve cognate retrieval in the treated and untreated languages relative to noncognates. However, there is also the possibility that treatment in one language will result in no difference to cognates versus noncognates in the untreated language (Hameau & Köpke, 2015) or even be worse for cognate retrieval relative to noncognate retrieval (Kurland & Falcon, 2011). There is currently too little evidence to make robust hypotheses; thus, our study is exploratory in this regard.

Methodology

This study received ethics approval from the institutional review board of Hadassah Academic College in Jerusalem (Approval No. 03-08-2020). The participant provided informed consent before taking part in the study.

Participant

Our participant (SEH07) was a 36-year-old male speaker of four languages. He was born in Kenya and completed high school there. He speaks both his native tribal language and Swahili (Sheng dialect[1]) as his first-acquired languages. He later acquired English from childhood (aged 5–6 years) and Hebrew as an adult (from the age of 25 years when he moved to Israel). At the time of the study, the participant reported that his native tribal language was no longer in use and that he did not count it as one of his main languages of communication. In this study, therefore, we assessed only Swahili (L1), English (L2), and Hebrew (L3). Both SEH07 and his wife reported that Swahili and English were highly proficient before the stroke, including literacy, and Hebrew was moderately proficient (with low prestroke proficiency in Hebrew literacy). Furthermore, using a revised version of the Language Experience and Proficiency Questionnaire (Marian et al., 2007), SEH07 indicated that he lived in a Swahili-speaking country (Kenya) for 17 years, which included schooling in English for 8–9 years. He then traveled around to a number of countries, speaking mostly Swahili and English. Finally, he lived in a Hebrew-speaking country for the last 11 years. He rated his prestroke Swahili and English as 10/10 for comprehension, speaking, and

[1]Sheng, a dialect of Swahili, is a mixture of Swahili and English. Sheng originated in Nairobi, Kenya, as an urban youth slang but has spread to other countries, such as Tanzania and Uganda. It can be considered as the first language of many people living in urban areas in Kenya, rather than Swahili or English, depending on the individual's use of Sheng. Sheng is a spoken dialect and not written, as opposed to conventional Swahili, which is both a spoken and written language.

reading and his Hebrew as 8/10 for comprehension, 7/10 for speaking, and 5/10 for reading. In the year leading up to the stroke, SEH07 used mainly English to communicate with his wife and stepdaughter, Hebrew outside the house for work or generally in the community (as the language of the environment), and occasionally Swahili when talking to family members abroad or meeting friends.

SEH07 is right-handed and suffered a single left hemisphere middle cerebral artery (MCA) M2 infarct 10 months prior to taking part in this study, resulting in aphasia and hemiparesis of his right side. He reported intact hearing and eyesight (corrected with glasses) that had not changed since the stroke and no other known neurological conditions. An initial assessment was conducted 4–5 weeks poststroke in all three languages by a qualified speech and language therapist (SLT). His English and Hebrew were assessed with the Western Aphasia Battery–Revised (English, Kertesz, 2006; Hebrew nonstandardized adaptation, Soroker, 1997), and Swahili was assessed via an interpreter with several subtests of the Bilingual Aphasia Test (Paradis, 2011). The report from the assessment showed that SEH07 was diagnosed with mixed transcortical aphasia in all three languages. Repetition was less impaired relative to auditory comprehension and production skills, and it was noted that single-word confrontation naming was particularly impaired in all three languages relative to other production skills, such as sentence production. Overall, SEH07 was diagnosed with moderate–severe aphasia in Swahili and English and severe aphasia in Hebrew; when the contribution of prestroke language skills to poststroke language abilities is taken into consideration, SEH07 can be considered to have parallel impairment across all three languages (Lerman et al., 2019). The assessment report also indicated that nonlinguistic cognitive skills were only mildly impaired (based on the Cognitive Linguistic Quick Test [CLQT] administered in English; see Table 1). Poststroke, SEH07 and his wife reported that he used or was exposed to English daily (about 70%–75% of the time) as well as Hebrew (about 15%–20% of the time), but rarely Swahili (less than 10%).

SEH07 received speech and language therapy in English and Hebrew for almost 8 months, and a discharge letter from the SLT indicated improvement in both languages, particularly for auditory comprehension, reading comprehension, and word retrieval during conversation and discourse. Single-word confrontation naming was still disproportionately impaired relative to other language skills, in all three languages. For the 6 weeks before joining this study, SEH07 received no speech therapy services.

Procedure

Picture-Naming Battery

We designed a unique battery of three sets of stimuli tailored to three of the participant's four languages: Swahili, English, and Hebrew. The battery included 60 pictures in

Table 1. Scores from the Western Aphasia Battery–Revised (WAB-R), the Bilingual Aphasia Test (BAT), and the Cognitive Linguistic Quick Test (CLQT) administered shortly after SEH07's stroke.

Assessment tests and/or subtests	English (WAB-R and CLQT)	Hebrew (WAB-R)	Swahili (BAT)
WAB-R Aphasia Quotient (/100)	47.4	40.5	
WAB-R Spontaneous Speech (/20)	10	9	
WAB-R Auditory Comprehension (/10)	3.9	4.15	
WAB-R Repetition (/10)	7.0	5.7	
WAB-R Naming and Word Finding (/10)	2.8	1.4	
BAT Auditory Comprehension – Objects			40%
BAT Auditory Comprehension – Pictures			76%
BAT Auditory Comprehension – Simple Commands			40%
BAT Auditory Comprehension – Complex Commands			0%
BAT Repetition of Words			100%
BAT Confrontation Naming			15%
Spontaneous speech			Less than normal amount, poor fluency and grammar, fair vocabulary, normal pronunciation
Symbol cancellation (/12)	11		
Clock drawing (/13)	10		
Symbol trails (/10)	10		
Design memory (/6)	5		
Mazes (/8)	8		
Design generation (/13)	6		

total: Set 1 consisted of 20 pictures of objects whose names are phonological cognates in Swahili and English but not in Hebrew, Set 2 consisted of 20 pictures of objects whose names are phonological cognates in English and Hebrew but not in Swahili, and Set 3 consisted of 20 objects whose names are noncognates across all three languages. We were unable to find 20 imageable Swahili–Hebrew cognates that were not cognates in English; thus, we did not include such a set in our battery. All stimuli were colored photographs or drawings. See Figure 1 for some examples. We defined cognates based on Goral et al.'s (2012) definition: translation equivalents sharing either three consecutive sounds or three consonants, allowing for common phonological shifts across languages (e.g., /ɹ/ in English vs. /ʁ/ in Hebrew). We did not account for orthographic cognates, because the three languages use different orthographic systems (English is written in Latin script, Hebrew is written in Hebrew script, and Swahili is sometimes written in Arabic script and sometimes in Latin script). Three original sets of pictures were piloted in English and Hebrew on three neurotypical participants in each language, to confirm that the expected responses to naming were elicited. Simultaneously, the lists were sent to two Swahili speakers to review. After minimally adjusting the sets of pictures based on the pilot responses and the Swahili consultations, all three sets of pictures were compared for frequency (based on subtitle use), word length, concreteness, and average age of acquisition based on English norms using the website https://elexicon.wustl.edu (Balota et al., 2007). The three sets of stimuli were found to be comparable to each other for each of these psycholinguistic factors ($p > .05$). We relied on English norms only for these psycholinguistic factors because English was the common language across the three groups in terms of cognate status and also the language that treatment was provided in. In addition, we did not have access to norms for all these psycholinguistic factors in both Hebrew and Swahili.

Figure 1. Examples from the English–Hebrew–Swahili naming battery.

Assessment and Treatment

At baseline, SEH07 was administered the full naming battery of 60 pictures in each of his three languages, twice per language. These six assessment sessions were conducted over four consecutive days in a pseudorandom order across languages, with a long break between languages when more than one language was assessed on any given day. The assessments were conducted via Zoom software (https://zoom.us/), and sessions were recorded. The pictures were presented on the computer screen using a PowerPoint presentation, one picture per slide. For each individual assessment session, the order of picture presentation was randomly assigned across all 60 pictures. The instruction "Please name these pictures" was presented in writing for all three languages. In English and Hebrew, the instruction was also presented verbally. At the start of each session, two practice pictures were also presented. Each assessment session lasted for about 30 mins. Each language was assessed by a different researcher (either a speech and language therapy student or a qualified SLT). All researchers spoke English and Hebrew to high proficiency, but not Swahili. During the English assessment, the researcher spoke only English, and during the Hebrew assessment, the researcher spoke only Hebrew. During the Swahili assessment, the researcher refrained from speaking as much as possible. When speaking was deemed necessary, the comment/instruction was provided in English. The researchers controlled the rate of presentation by moving to the next slide after SEH07 named the picture or after he said he did not know and asked to move on. Feedback on responses was not provided during any assessment session, with one exception. During the Swahili assessment sessions, the non–Swahili-speaking SLT clarified unexpected responses with a request in English: "Do you know any other name for that in Swahili?"

Following the 4 days of assessment, SEH07 was administered treatment in English only (by the speech and language therapy student who assessed English naming and two other speech and language therapy students not involved in data collection) via Zoom. The three speech and language therapy students who provided treatment had been trained on the treatment protocol prior to the study, and all three spoke English as an L2 to high proficiency. SEH07 was originally scheduled to receive 40 hrs of treatment, with three sessions per week (one per speech and language therapy student) for 10 weeks. However, due to several unforeseen issues, SEH07 received 18 hrs of treatment overall, with two sessions per week, on average, for 8 weeks. Each speech and language therapy student provided treatment for 8, 6, or 4 hrs, respectively. Fifty percent of the sessions were conducted with a second researcher present during the Zoom session, who confirmed treatment fidelity was > 99% based on the predetermined protocol steps described below.

For each of the three sets of 20 pictures in the battery, half were treated in English and half were not. Overall, therefore, 30 pictures were treated during the treatment block. There was no difference between the two halves for each of the three sets of words for frequency, word length, concreteness, and average age of acquisition based on English norms ($p > .05$; Balota et al., 2007).

The treatment protocol included the following:

1. SFA (Boyle & Coelho, 1995; Coelho et al., 2000): This included presenting a picture to the participant and asking him to identify the category it belongs to, describe its use, an action associated with it, some properties associated with it (i.e., a description of the object), and where you might find it; and provide an association with the object (e.g., "It reminds me of … "). The participant was encouraged at each stage of the SFA to provide answers independently when possible. When it was not possible, he was provided with a cue (e.g., for the category a carrot belongs to: "It grows in the ground, what would you call food that grows in the ground?" or for the category a piano belongs to: "Piano, drum, guitar, they are all … ?"). When the participant was unable to provide an answer at any stage of the SFA, the speech and language therapy student would provide the correct answer and ask if he agreed if it was correct.
2. Producing four sentences: The participant was encouraged to produce any relevant and complete sentence in English using the target word.
3. Conducting a short conversation about the object between 1 and 3 mins: The speech and language therapy student initiated this, encouraging the participant to participate.
4. Auditory comprehension of the treated words: This involved choosing the correct picture out of six options. Options included all the words treated in that day's session plus other words from the treatment word pool of 30 words to make up a group of six pictures; the participant was asked to first identify two words in a row, then identify three and then four.

Stages 1, 2, and 3 were completed for each picture during the treatment session, with one picture at a time shared on the screen. Stage 4 was completed once per session at the conclusion of that session; six pictures were presented to the participant on the screen, and he used the "Annotate" function in Zoom to mark the pictures that he heard.

In each session, between two and five pictures were trained. During the entire treatment block, each picture was trained between one and four times (four pictures were trained only once, 24 pictures were trained twice, one picture was trained three times, and one picture was trained four times). Therefore, overall, the protocol was completed 59 times on the pool of 30 different pictures.

Following the treatment block, the same battery of 60 words was reassessed via Zoom again in each of his three languages, twice per language, over 4 days (out of 5 consecutive days) in a pseudorandom order. The same languages were assessed pre- and posttreatment by the same researchers. However, immediately at the end of the treatment block but before the posttreatment assessment sessions could be conducted, SEH07 unexpectedly spent 10 days in Tanzania where he was reexposed to Swahili on a daily basis, as well as using English daily (but not Hebrew). His posttreatment assessments began the day after he returned home.

Analyses of the Data

SEH07's responses to picture naming pre- and posttreatment were transcribed by three researchers (each in the language they conducted the assessment) on the 60 words in the naming battery, twice at each time point, pre- and posttreatment (240 responses per researcher = 720 in total). One third of all 720 responses were transcribed by a second researcher, with 99% interrater reliability (IRR) across the two researchers. Accuracy of responses was scored, and the retrieval times for accurate responses were recorded (the time it took for SEH07 to produce a correct response after the picture was presented, in seconds). For English and Hebrew, an accurate response was counted as the predetermined word based on the pilot or an appropriate, reasonable alternative agreed upon by at least two researchers. For Swahili, an accurate response was counted as one of the words predetermined by our Swahili-speaking consultants. For the small number of words that did not meet this criterion and that were unclear to the researchers, a further consultation occurred with one of our Swahili-speaking consultants. In all languages, semantic and/or phonemic paraphasias and "pass" or "I don't know" responses were counted as incorrect.

All 720 responses were scored blind to the time of presentation (i.e., pre- or posttreatment) by two different researchers, and the initial IRR on one third of the data was found to be above 95%. For the 5% of responses that were not scored the same by the two researchers, a third researcher arbitrated. After arbitration, the IRR increased to > 99% (with only one disagreement out of all 240 responses). The accuracy scores across the two time points in each language were averaged for both pre- and posttreatment assessments when calculating percent accuracy.

Accuracy of retrieval was measured twice: (a) all responses produced within 5 s after stimulus presentation and (b) all responses produced within 30 s after stimulus presentation. We considered retrieval within 5 s to represent independent retrieval ability within a functional response time and retrieval within 30 s to represent a commonly used retrieval ability cutoff within a clinical research context, based on previous literature (e.g., Bihovsky et al., 2023; Evans et al., 2020). Since cognate facilitation and interference are expected to occur relatively early in the retrieval process (e.g., Midgley et al., 2011), the faster cutoff point is valuable to better understand retrieval in this population as well as being more ecologically valid. However, in order to allow for comparison across studies, we also included the 30-s cutoff, which is more commonly described in the literature (e.g., Marte et al., 2023).

The data were grouped based on cognate status per language, as well as treated versus untreated stimuli. Due to an issue that arose during the study regarding the categorization of cognates in the Sheng dialect of Swahili, we reevaluated five stimuli with our Swahili consultants, which led to them being removed from the data set. See Table 2 for a summary of the number of treated and untreated cognates and noncognates that were included in the final analyses, per language.

To answer Research Question 1, regarding how cognate status affects word retrieval across languages in a

Table 2. Number of cognates and noncognates in English, Hebrew, and Swahili included in the final analyses.

	Stimulus set						Overall			
	English–Hebrew cognates		English–Swahili cognates		Noncognates		Cognates		Noncognates[a]	
Language	Tr.	Untr.	Tr.	Untr.	Tr.	Untr.	Tr.	Untr.	Tr.	Untr.
English	10	6	10	10	10	9	20	16	10	9
Hebrew	10	6	10	10	10	9	10	6	20	19
Swahili	10	6	10	10	10	9	10	10	20	15

Note. Tr. = treated stimuli; Untr. = untreated stimuli.

[a]For Hebrew, noncognates include the stimuli from the noncognate group plus the English–Swahili cognates. For Swahili, noncognates include the stimuli from the noncognate group plus the English–Hebrew cognates.

multilingual person with aphasia, relative to age of acquisition, pre- and poststroke language abilities, and language use at the time of the stroke, we analyzed accuracy of responses at baseline (i.e., pretreatment) for cognates versus noncognates. Due to the small number of stimuli in each subgroup, within the context of a single-case study design, we present descriptive statistics and trends across the data.

To answer Research Question 2, regarding how treatment in one language affects word retrieval abilities in the treated and untreated languages relative to cognate status and other factors in a multilingual person with aphasia, we analyzed accuracy of responses pre- and posttreatment for cognates and noncognates in each language for both treated and untreated stimuli. We originally intended to separately analyze treated and untreated cognates and treated and untreated noncognates. However, due to our removal of some of the English–Swahili stimuli from analysis after reconsulting with our Swahili consultants, some of these groups contained less than 10 stimuli. Thus, to make sure the results remained meaningful, we only present accuracy scores for all the cognates and noncognates (per language) and, separately, accuracy scores for all the treated and untreated stimuli. We also present Cohen's (d) effect sizes pre- to posttreatment, following Beeson and Robey's (2006) protocol, which calculates effect size (d) by dividing the difference of the baseline average from the posttreatment average by the standard deviation of the baseline: $d_1 = \frac{\bar{X}_{A_2} - \bar{X}_{A_1}}{S_{A_1}}$, where A_1 = pretreatment (n = 2) and A_2 = posttreatment (n = 2). On the rare occasion when pretreatment variance was zero, we divided the difference of the baseline average from the posttreatment average by the square root of the weighted average of the variances of the baseline and posttreatment (S_{pooled}; Beeson & Robey, 2006): $d_2 = \frac{\bar{X}_{A_2} - \bar{X}_{A_1}}{S_{\text{pooled}}}$. For treated stimuli in the treated language (or mixed treated and untreated stimuli), we used benchmarks of 2.3, 3.7, and 5.5 for small, medium, and large effects, respectively, and for untreated stimuli or treated stimuli in the untreated language, we used benchmarks of 1.2, 1.7, and 3.3, respectively (Edmonds et al., 2014).

Results

Pretreatment (Baseline) Data

We found that retrieval was highest in L2 English (early-acquired, highly proficient, most used in the years leading up to the stroke and in the months poststroke, treated poststroke), second highest in L3 Hebrew (later-acquired, moderately proficient, used often in the years leading up to the stroke, treated poststroke), and lowest in L1 Swahili (early-acquired, highly proficient, rarely used in the years leading up to the stroke and poststroke, not treated poststroke). For fast retrieval, within 5 s, no cognate advantage was observed in English or Swahili (about 1%–1.5% difference between cognate and noncognate retrieval). However, for Hebrew, we observed a 15.95% higher retrieval rate for cognates relative to noncognates, which suggests a potential cognate advantage. For retrieval within 30 s, we observed small differences for all three languages (about 5%–8% difference between cognate and noncognate retrieval). For Hebrew and Swahili, cognate retrieval was higher than noncognate retrieval; for English, the trend was in the opposite direction. See Table 3 for retrieval accuracy scores in each language for cognates and noncognates pretreatment.

Pre- and Posttreatment Data: A Comparison

Overall Accuracy

For English and Swahili, we observed higher retrieval accuracy posttreatment compared to pretreatment for retrieval within 5 s. However, the observed increase passed the predefined thresholds for effect sizes only in Swahili (large effect size). For retrieval in Hebrew within 5 s, accuracy was slightly lower posttreatment relative to pretreatment. For retrieval within 30 s, we observed higher retrieval accuracy posttreatment compared to pretreatment for Hebrew and Swahili, but again, the observed increase passed the predefined thresholds for effect sizes only in Swahili (large effect size). For English, accuracy was slightly lower posttreatment relative to pretreatment. See Table 3 for the total accuracy data pre- versus posttreatment in each language.

Treated Versus Untreated Stimuli

We found that in the treated English, for retrieval within 5 s, the observed increase in treated stimuli passed the predefined thresholds for effect sizes (small effect size), but the observed decrease for untreated stimuli did not. When measuring retrieval within 30 s, no change was observed for treated stimuli, and the observed decrease for the untreated stimuli did not pass the predefined thresholds for effect sizes (see Table 4). For the untreated Hebrew, for retrieval within 5 s, observed changes from pre- to posttreatment accuracy did not pass the predefined thresholds for effect sizes for either treated or untreated stimuli. For retrieval within 30 s, the observed increase for treated stimuli passed the predefined thresholds for effect sizes (small effect size), but for untreated stimuli, it did not (see Table 4). For Swahili, for retrieval within both 5 and 30 s, posttreatment accuracy was much higher overall compared to pretreatment accuracy for both treated and untreated stimuli, passing the predefined thresholds for

Table 3. Retrieval accuracy pre- and posttreatment for cognates, noncognates, and total scores in English (Eng), Hebrew (Heb), and Swahili (Swa).

	Total accuracy			**Cognate accuracy**			**Noncognate accuracy**			
	Pretreatment (%)	**Posttreatment (%)**	**Effect size (*d*)**	**Pretreatment (%)**	**Posttreatment (%)**	**Effect size (*d*)**	**Pretreatment (%)**	**Posttreatment (%)**	**Effect size (*d*)**	**Pretreatment accuracy difference between cognates vs. noncognates[a] (%)**
No. of stimuli	***n* = 55**	***n* = 55**		**Eng *n* = 36 Heb *n* = 16 Swa *n* = 20**	**Eng *n* = 36 Heb *n* = 16 Swa *n* = 20**		**Eng *n* = 19 Heb *n* = 39 Swa *n* = 35**	**Eng *n* = 19 Heb *n* = 39 Swa *n* = 35**		
English (under 30 s)	66.36	63.64	–0.42	63.89	63.89	0	71.05	63.16	–2.12	–7.16
English (under 5 s)	46.36	52.73	0.61	45.83	51.39	0.31	47.37	55.26	1.06	–1.54
Hebrew (under 30 s)	55.45	59.09	0.94	59.38	62.50	0.71	53.85	57.69	1.06	5.53
Hebrew (under 5 s)	41.82	39.09	–0.53	53.13	46.88	–1.41*	37.18	34.62	–0.47	15.95
Swahili (under 30 s)	38.18	50.00	**6.12*****	42.50	50.00	2.12**	35.71	50.00	7.07***	6.79
Swahili (under 5 s)	21.82	39.09	**26.87*****	22.50	32.50	2.83**	21.43	42.86	10.61***	1.07

Note. Single (*), double (**), and triple (***) asterisks indicate small, medium, and large effect sizes, respectively, based on treated versus untreated stimulus benchmarks for Cohen's *d* (treated stimuli/language: small = 2.3, medium = 3.7, and large = 5.5; untreated stimuli/language: small = 1.2, medium = 1.7, and large = 3.3). Bolded data indicate effect sizes that were calculated using pooled variances due to zero variance pretreatment.

[a]A positive value supports a cognate advantage.

Table 4. Accuracy of treated versus untreated stimuli in English, Hebrew, and Swahili.

	Treated stimuli accuracy			Untreated stimuli accuracy		
	Pretreatment (%)	Posttreatment (%)	Effect size (*d*)	Pretreatment (%)	Posttreatment (%)	Effect size (*d*)
No. of stimuli	***n* = 30**	***n* = 30**		***n* = 25**	***n* = 25**	
English (under 30 s)	35.45	35.45	0	30.91	28.18	−1.06
English (under 5 s)	20.91	26.36	2.59*	25.45	21.82	−0.35
Hebrew (under 30 s)	30.00	31.82	1.41*	25.45	27.27	0.71
Hebrew (under 5 s)	23.64	22.73	−0.35	18.18	15.45	−0.71
Swahili (under 30 s)	20.00	27.27	2.81**	18.18	22.73	1.77**
Swahili (under 5 s)	10.00	21.82	3.06**	11.82	17.27	1.41*

Note. Single (*) and double (**) asterisks indicate small and medium effect sizes, respectively, based on treated versus untreated stimulus benchmarks for Cohen's *d* (treated stimuli/language: small = 2.3, medium = 3.7, and large = 5.5; untreated stimuli/language: small = 1.2, medium = 1.7, and large = 3.3).

effect sizes (as observed by small or medium effect sizes; see Table 4).

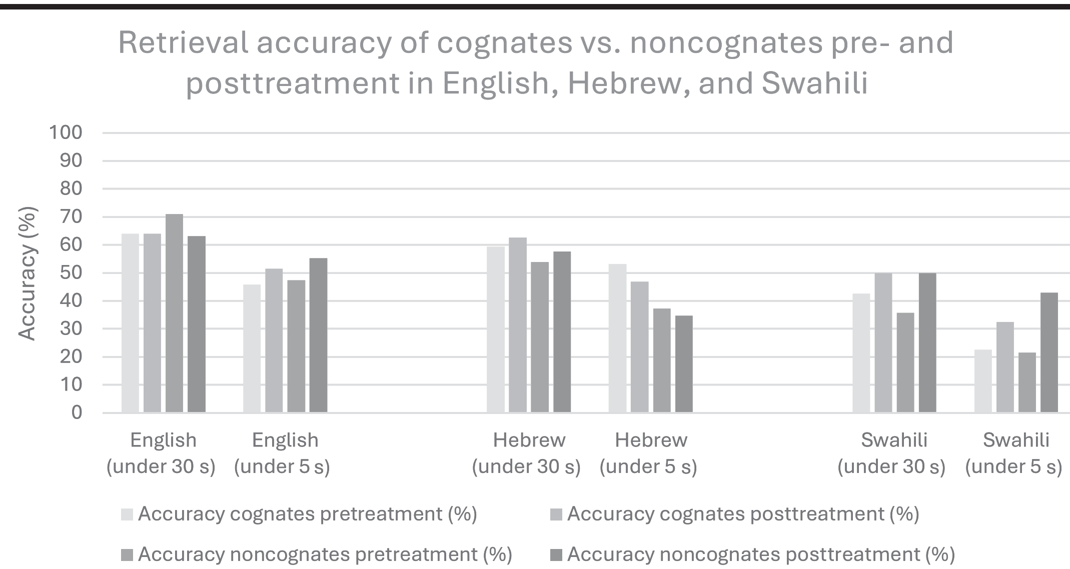
Cognates Versus Noncognates

We found that in English, the retrieval accuracy of cognates and noncognates within 5 s increased from pre- to posttreatment relatively equally, whereas within 30 s, there was no change for cognates, and noncognates showed a decrease. However, none of these measures passed the predefined thresholds for effect sizes. In Hebrew, we observed that retrieval accuracy for both cognates and noncognates within 5 s decreased from pre- to posttreatment (cognates > noncognates); for cognates, the observed decrease passed the predefined thresholds for effect sizes (small effect size). For retrieval accuracy within 30 s, both cognates and noncognates increased by a similar percentage; however, neither of these measures passed the predefined thresholds for effect sizes. In Swahili, we observed that retrieval accuracy within 5 and 30 s for both cognates and noncognates increased (noncognates > cognates), and all these measures passed the predefined thresholds for effect sizes (as measured by medium or large effect sizes). See Table 4 and Figure 2 for the accuracy scores pre- and posttreatment for cognates and noncognates in English, Hebrew, and Swahili.

Error Analyses

SEH07's responses were categorized into "pass" or "I don't know" answers, semantic paraphasias, language mixing (i.e., produced the answer in a nontarget language), or

Figure 2. Percentage of accurate retrieval pre- and posttreatment for cognates and noncognates in each language.



"other." We observed that for English, 66% of the responses were "pass" or "I don't know," 25% were semantic paraphasias, and 8% were language-mixed responses in Hebrew (mostly cognates). For Hebrew, 71% of the responses were "pass" or "I don't know," 9.5% were semantic paraphasias, and 17% were language-mixed responses in English (mostly noncognates). For Swahili, 79% of the responses were "pass" or "I don't know," 13% were semantic paraphasias, and 3.5% were language-mixed responses in either English (cognates) or Hebrew (noncognates).

Discussion

Our study investigated the retrieval accuracy of phonological cognates versus noncognates across language pairs in a multilingual person with aphasia who spoke Swahili (L1), English (L2), and Hebrew (L3). At baseline, we observed that in his early-acquired, highly proficient, and most used language in the years leading up to the stroke (English), retrieval was more accurate than in his other languages, and no cognate advantage was observed; rather, for retrieval within 30 s, the data trended toward better retrieval for noncognates, although the differences were small (a difference of 7.89%) and should be interpreted with caution. Conversely, in his other two languages, retrieval was higher overall in his later-acquired, moderately proficient, and oft-used language in the years leading up to the stroke (Hebrew) than in his highly proficient but least used L1 in the years leading up to the stroke (Swahili). In Hebrew, a salient cognate advantage was observed for functional retrieval (within 5 s—a difference of 15.95%), which was reduced when more time was allowed for responses (within 30 s—a difference of 5.53%). In Swahili, although the data trended toward better retrieval for cognates than for noncognates (for 30-s retrieval), the differences were small and, thus, should be interpreted with caution (see Table 3).

These results suggest that overall retrieval ability appears to be more influenced by usage in the years leading up to the stroke than by age of acquisition or proficiency levels, a finding that supports existing literature (Goral et al., 2006; Midgley et al., 2011). This has been hypothesized to be due to a recency effect that lowers the activation threshold for retrieval for oft-used languages (Paradis, 2000). However, we also acknowledge that receiving treatment in English and Hebrew, but not in Swahili, prior to taking part in this study may have contributed to better retrieval in those treated languages relative to the untreated language, again because of a potentially lowered activation threshold for retrieval due to treatment. It is likely that a combination of both language use and prior-treatment efficacy contributed to the better retrieval of English and Hebrew, relative to Swahili at baseline.

Regarding cognate status, our hypotheses were partially supported. We expected to see a cognate advantage in all three languages, which we did not. However, our results indicated that SEH07's later-acquired, moderately proficient Hebrew showed a facilitative effect of cognate retrieval, which supported our hypotheses that a cognate advantage is more likely in a premorbidly less proficient language relative to a more proficient one in PWA (de Groot et al., 2002; Robinson Anthony & Blumenfeld, 2019; Rosselli et al., 2014; van Hell & Tanner, 2012). Furthermore, regarding Swahili, we found support for the hypothesis that a small cognate advantage in the language least used at the time of the stroke would be expected (Tiwari & Krishnan, 2015) but not for the hypothesis that a large cognate advantage in a postmorbidly more impaired language would be expected (Lalor & Kirsner, 2001; Roberts & Deslauriers, 1999). However, we note that Lalor and Kirsner (2001) and Roberts and Deslauriers (1999) were looking at postmorbidly more impaired L2, and for SEH07, Swahili was his L1.

Thus, our results support the RHM if we consider that a later-acquired language, especially one that is still not fully proficient (i.e., Hebrew in the case of SEH07), may rely on a more proficient language for retrieval (through translation, differential memory storage, etc.; Kroll et al., 2010), or in terms of the Multilink model, activation spreads more easily across cognates than across noncognates in the case of a language with weaker links to the semantic system due to its lower proficiency status. Furthermore, based on the Multilink model, if we take into account Swahili's status as an L1 in juxtaposition with its postmorbid impairment and reduced use, we might expect no or a very small cognate advantage, because L1 status should reduce the expected cognate advantage (Goral et al., 2006; Kroll et al., 2010) whereas postmorbid impairment and reduced use should raise it (Lalor & Kirsner, 2001; Roberts & Deslauriers, 1999), thus balancing them out. Regarding the results in English potentially trending toward better retrieval for noncognates than for cognates, although very small, they may indicate an interference effect of cognates. Indeed, looking at the error analyses, we observed that for the four responses that were language mixed at baseline (11% of errors at baseline), they were all produced in Hebrew, the other language used daily at the time of testing, and three out of the four responses were cognates. Although these results in Swahili and English are interesting, they are inconclusive due to the small differences observed across a relatively small number of stimuli. Further research is needed to examine these effects in other multilingual PWA with different ages of acquisition, proficiency levels, and degrees of language use prestroke across languages to try to replicate these results and identify patterns of retrieval relative to cognate status and the factors driving them.

We also explored the effects of treatment on word retrieval in the treated and untreated languages relative to cognate status (see Table 4). Only Swahili passed the predetermined effect-size threshold, showing improvement from the pretreatment assessment time to the posttreatment assessment time, with large effect sizes (d = 26.87 using the 5-s cutoff and d = 6.12 using the 30-s cutoff). We associate this improvement, at least partly, with the unexpected 10-day exposure to Swahili before reassessment posttreatment due to the large treatment gains in Swahili (relative to changes in English and Hebrew, particularly English as the treated language where we would expect the highest gains; Goral et al., 2023). Nonetheless, we also found some support for the partial efficacy of the 18 hrs of treatment that was provided, in that the retrieval accuracy of treated items in English improved posttreatment relative to pretreatment for retrieval within 5 s (showing a small effect size), whereas untreated items did not. Furthermore, in Hebrew, the retrieval accuracy of treated items also passed the predetermined effect-size threshold, showing improvement (also showing a small effect size), whereas untreated items did not, although only for retrieval within 30 s. Similarly, for Swahili, the retrieval accuracy of treated items increased more than that of untreated items percentagewise—a result that was also reflected in the effect-size values (3.06 and 2.81 for treated stimuli and 1.77 and 1.41 for untreated stimuli). Thus, the results support the hypothesis that treatment lowered the activation threshold for the retrieval of treated stimuli relative to untreated stimuli (Paradis, 2000), which generalized across languages but not across stimuli. This result supports the findings of Goral et al. (2023), who found that cross-language generalization was most likely to occur if treatment was provided in either the L1 (not the case in our study) or the L2, which became the language of the environment (the case in our study, because SEH07's English was reported as being used 70%–75% of the time poststroke). This is despite the fact that 18 hrs of treatment is relatively low for clinical aphasia research (*Mdn* = 20 hrs, interquartile range: 12–30 hrs), although it is considered high compared to clinical care dosage (*Mdn* = 7.5 hrs, interquartile range: 3.75–15 hrs; Cavanaugh et al., 2021). Thus, we concluded that the treatment provided did start to have some effect on word retrieval across languages, although more hours of treatment would likely have shown more robust results. Furthermore, any treatment effects on Swahili were likely boosted by the 10-day sudden reexposure to that language.

Due to these results that support partial treatment efficacy for the treated stimuli, not only improvement due to exposure (i.e., in Swahili), we further analyzed our data regarding the retrieval of cognates versus noncognates posttreatment relative to pretreatment. Due to the very small numbers of stimuli in some of the subgroups (see Table 2), we compared all cognates (treated and untreated) to all noncognates (treated and nontreated; see Table 3). For English, the strongest of SEH07's languages in terms of age of acquisition (early), proficiency (high), and usage (most used in the years leading up to the stroke), we observed no clear cognate advantage or disadvantage for functional (5-s) retrieval, although when given 30 s to respond, we observed a decrease in noncognate retrieval (−7.89%) relative to no change for cognate retrieval. However, we note that this change did not pass the predetermined effect-size threshold for treated stimuli.

These results are in contrast to the findings of Kurland and Falcon (2011), who found a noncognate advantage in a highly proficient language after treatment, but support the findings of Kohnert (2004), who found a cognate advantage even after just 4 hrs of treatment, although—as with our results—the measure of this facilitation was not direct and, thus, inconclusive. The result that we observed might reflect the effect of Swahili on SEH07's English, such that due to the increase in exposure to Swahili immediately before reassessment, the effect on his other early-acquired, highly proficient language (English) may have been negative for noncognates, whereas for cognates, there was no such effect because he was able to access those words through his now more accessible Swahili, when necessary. However, we note that the error analysis does not support this explanation, because no language mixing during the posttreatment assessment of English resulted in a Swahili word being produced (only Hebrew). Alternatively, the results may be due to a facilitative effect of cognates relative to noncognates, although based on the data we collected pretreatment, it is unclear why this might occur; either way, we observed very small differences across groups of stimuli, and thus, the results are difficult to interpret without replication across similar participants.

For Hebrew, the only language to show a salient cognate advantage pretreatment, we observed a decrease for retrieval within 5 s for both cognates and noncognates posttreatment relative to pretreatment, but the decrease only passed the predetermined effect-size threshold for cognates (small effect size). We suggest that this supports the hypothesis that after treatment in English, there was an interference effect for English–Hebrew cognates that made retrieval harder for cognates relative to noncognates when retrieving within 5 s. These findings contradict those of Goral et al. (2012), whose treatment protocol was similar to ours, but are similar to those of Kurland and Falcon (2011), in that after treatment of one language, an interference effect of cognates relative to noncognates may be observed in a nontreated language. However, these potential interference effects disappeared in Hebrew when retrieval was allowed for up to 30 s after stimulus presentation, suggesting that interference effects may be more salient earlier in the retrieval process. It is important to note, though, that studies that have looked at the timing of facilitation and/or interference of cognates have measured in milliseconds rather than seconds (Marchetti, 2015; Midgley et al., 2011). We suggest that further research should investigate patterns of cognate retrieval from a more functional standpoint, that is, not only at a millisecond level or a testing standard of 20+ s for retrieval (e.g., Marte et al., 2023; Roberts & Deslauriers, 1999) but also within a time frame that is relevant for functional communication (Evans et al., 2020).

For Swahili, we observed a greater increase posttreatment for noncognates (large effect sizes) relative to cognates (medium effect sizes) when retrieval was measured within both 5 and 30 s, supporting the possibility that after treatment in English, interference effects were observed in this untreated language for cognates, thus restricting the potential improvement to cognate retrieval. Again, these results contradict the cross-language generalization of cognate facilitation observed by Goral et al. (2012) but support Kurland and Falcon's (2011) observation of interference effects of cognates. Similar to our findings in Hebrew, the difference between noncognate and cognate retrieval was larger for retrieval within 5 s than for retrieval within 30 s, supporting our hypothesis that interference effects may be more salient earlier in the retrieval process. We also consider the possibility that exposure to Swahili for 10 days before retesting had a greater effect on the retrieval of noncognates relative to cognates, because SEH07 would likely have heard English–Swahili cognates more often than noncognates prestroke due to his daily use of English, thus increasing his exposure. However, we are unable to tease apart these different factors based on the current study.

Another factor to consider is the issue of cognitive control. Our participant was asked to retrieve words in a single-language context during any given session, thus increasing the resources necessary for effective interference suppression (Green & Abutalebi, 2013). In Kurland and Falcon's (2011) study, their participant had a clear lesion in the basal ganglia, known to be a core component of the language control network. Thus, they suggested that this lesion may have caused the difficulty in suppressing interference from cognates, because cognates are so similar it takes more resources to suppress the interference compared to noncognates. In our study, we do not know whether SEH07's brain lesion included parts of the language control network because we did not have access to his brain scans or summaries of them. However, although his medical documents recorded a left hemisphere MCA M2 infarct, he did not have classic symptoms of expressive aphasia that might be expected (Harvey, 2008); rather, he was diagnosed with transcortical aphasia, leaving open the question as to which areas and/or brain networks were impaired. We note, however, that on the basis of his CLQT scores, SEH07's cognitive abilities were relatively spared, including tasks that require preserved interference suppression (e.g., those measuring attention and/or executive functions). Thus, we suggest that the source of the observed interference in our study is more linguistic based than control based. Future research should combine brain imaging with behavioral studies, wherever possible, to help understand why some multilingual PWA show interference effects rather than facilitation effects of cognates.

In summary, our results in Hebrew and Swahili, the two untreated languages, potentially support the presence of greater interference effects posttreatment for cognates relative to noncognates, although how they manifest and what drives them are still unclear. Clearly, more research is needed to test the hypothesis that there is an interaction between language exposure and use, relative proficiencies, and specific treatment effects that affects the retrieval of cognates and noncognates differently in treated and untreated languages. Future research should focus on understanding interference effects during word retrieval in languages with different proficiencies and degrees of use relative to cognate status and time after stimulus presentation. Sensitive methodologies such as eye tracking, in conjunction with behavioral studies measuring retrieval accuracy and retrieval time, may help us shed more light on this issue (Duncan & Conner, 2024).

There were several limitations to this study that restrict the interpretations and generalization of our findings. First, we were only able to recruit one participant with this rare combination of languages who had been diagnosed with aphasia. We designed the study specifically for his languages, but we were limited as to how many imageable words we could include in each group due to both the limitations of language typologies and contact histories and the testing time we had available. Specifically, because our participant spoke the Sheng dialect of Swahili, it was challenging to select words that were not cognates of Sheng and English due to the high overlap of cognates across the two. Thus, the comparisons between cognates and noncognates across languages were based on relatively small groups of stimuli, which makes it more difficult to interpret the data and to generalize findings. Second, the participant's sudden 10-day trip to a Swahili-speaking country was not planned and introduced a very strong confound of exposure to any effects due to treatment. However, the reexposure inadvertently provided an encouraging factor to consider in the rehabilitation of multilingual PWA, in that word retrieval improved significantly after just 10 days of immersion into a language that was proficient but had not been used daily for over 10 years. Third, the participant received less than half the planned treatment hours, which ended up being below the median dosage for clinical aphasia research—a likely factor driving the small treatment effects in both the treated and untreated languages and the lack of robust generalization across stimuli and/or languages. It is, however, interesting to note that most words in the treatment stimulus pool were trained only twice on average, and yet, we still observed an improvement in the retrieval of treated stimuli in the treated language, which is highly encouraging. Furthermore, 18 hrs of treatment is high relative to the usual clinical care dosage, so the results are still somewhat encouraging for clinical practice. Finally, we note that premorbid proficiency was measured subjectively using self-ratings. Although self-ratings are not necessarily considered an accurate measure of proficiency in different populations of multilingual people across the lifespan (Kiran & Robets, 2012; Neveu & Gollan, 2024), for multilingual PWA, it is rarely possible to obtain an objective measure of premorbid proficiency; self-ratings are thus commonly used in this field and considered good clinical practice, especially when paired with information on years of immersion (Kiran et al., 2014; Neveu & Gollan, 2024).

Conclusions

It is clear from this study and the handful of other previous studies that have investigated cognate retrieval in aphasia that more research is needed to understand the underlying factors driving poststroke retrieval in multilingual PWA pre- and posttreatment, relative to cognate status. Our study adds to the literature by describing the rarely studied phenomenon of cognate status–based retrieval in a multilingual person with aphasia, whose languages vary in relation to age of acquisition, proficiency, and exposure in the years leading up to the stroke. Our results supported the hypothesis that there is no equal cognate advantage across languages for word naming in PWA; rather, a cognate advantage is qualified by factors such as age of acquisition, proficiency, and usage in the years leading up to the stroke. Although our results for treatment effects on cognates and noncognates are inconclusive, we did observe higher potential interference effects in the two untreated languages for cognate retrieval relative to noncognate retrieval, particularly for retrieval within 5 s. This will be an important avenue for future research to better understand how treating multilingual PWA can be manipulated to increase facilitation across languages and decrease interference. Furthermore, we observed that even a relatively short treatment period may improve the retrieval of treated stimuli in both the treated and untreated languages and that reexposure to a rarely used language, even for a brief period, can have a large effect on retrieval ability after a stroke. These are all avenues for future research that will be invaluable as we continue to improve our understanding of aphasia treatment in multilingual PWA.

Data Availability Statement

The list of stimuli is provided in Supplemental Material S1.

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