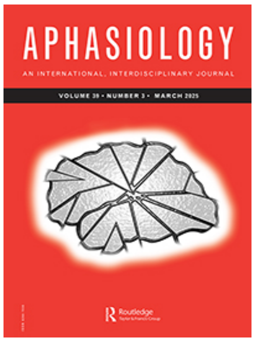

Aphasiology

Routledge
Taylor & Francis Group

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/paph20

How about that? Psycholinguistic characteristics of formulaic language that predict fluency in individuals with post-stroke aphasia

Catherine Torrington Eaton, Sarah Thomas, Danielle Jones & Giselle Carnaby

APHASIOLOGY
https://doi.org/10.1080/02687038.2025.2451659

How about that? Psycholinguistic characteristics of formulaic language that predict fluency in individuals with post-stroke aphasia

Catherine Torrington Eaton [a], Sarah Thomas [a], Danielle Jones [b] and Giselle Carnaby [a]

[a]Communication Sciences and Disorders, University of Texas Health Sciences Center at San Antonio, San Antonio, TX, USA; [b]Communication Disorders and Sciences, University of Oregon, Eugene, Oregon, USA

ABSTRACT

Purpose: Formulaic language is an under-explored area of research in the field of acquired language disorders as compared to propositional language. The primary purpose of this study was to explore the utility of a proposed theoretical formulaic language model (Van Lancker Sidtis, 2022) for individuals with post-stroke aphasia to inform research and clinical practice.

Method: The dataset included previously described formulaic language extracted from Aphasiabank speech samples produced by 144 individuals with fluent and non-fluent aphasias. Formulaic language items were coded according to six psycholinguistic characteristics from the theoretical model. Between-group comparisons and regression analyses were run to determine whether particular psycholinguistic characteristics of produced formulaic items could predict speaker fluency.

Results: Findings revealed formulaic language differences between fluent and nonfluent aphasias based on the theoretical model. Importantly, psycholinguistic characteristics of frequency and syntactic completeness along with presence of apraxia of speech predicted fluency status with high accuracy (88.4% of individuals with fluent and 70.3% with nonfluent aphasia).

Conclusions: Findings in this study illustrate how theoretically-driven analyses of formulaic language production may enhance diagnostic and intervention practices in post-stroke aphasia.

ARTICLE HISTORY
Received 24 May 2024
Accepted 6 January 2025

KEYWORDS
Formulaic language; post-stroke aphasia; spontaneous language

Introduction

Formulaic language offers an alternative and useful perspective of expressive language. In propositional or novel language models, speakers retrieve and assemble individual lexical items when constructing an utterance (Sidtis et al., 2018; Wray & Perkins, 2000). By contrast, non-propositional or formulaic language approaches suggest that speakers rely heavily on stored "chunks of language" (i.e., multi-word expressions) to increase predictability for the listener and reduce cognitive effort for the speaker (Gholami, 2022; Wray, 2017). To illustrate, an utterance consisting of 26 morphemes requires retrieval of only eight to ten chunks: "[Hey how's it going,] [sorry to interrupt but] [would you mind]

CONTACT Catherine Torrington Eaton torringtonea@uthscsa.edu University of Texas Health Sciences Center at San Antonio, 7703 Floyd Curl Drive, San Antonio, TX 78229

picking up [a few things] while you're [out and about]?". This example demonstrates a variety of formulaic item types, which vary by structure and function (Van Lancker Sidtis, 2022). The first item type, speech formulas, are independent, pragmatically-useful utterances that vary across speaker contexts. The second, third and fourth items are examples of lexical bundles, which are cohesive, semantically-neutral discourse organizers that introduce, bridge, or qualify novel language. The last formulaic item is a collocation consisting of a pair of words with shared semantic meaning that co-occurs in discourse. Propositional versus non-propositional, holistic versus analytic mode, and idiom versus open-choice principle and are similarly proposed conceptualizations for these complementary approaches to natural language production is constructed (Gholami, 2022; Jackson, 1879).

The systematic study of formulaic language has significant implications for applied language sciences. In recent decades, the field of second language acquisition has embraced the use of formulaic language in pedagogy. Based on mounting evidence, researchers encourage instruction of formulaic items, which relate to perceptions of fluency, instead of a singular focus on combining vocabulary through knowledge of grammatical rules (Cancino & Iturrieta, 2022). Research in communication sciences and disorders has documented relatively preserved formulaic language use in several populations including individuals with Alzheimer's disease and aphasia (Bridges & Van Lancker, 2013; Van Lancker Sidtis & Postman, 2006). Some scientists have encouraged clinicians and researchers to not only explore but capitalize on non-propositional language abilities in individuals with aphasia, although propositional language models continue to underlie most assessment and intervention practices (Davis et al., 2023; Stahl & Van Lancker Sidtis, 2015).

Formulaic language production in individuals with aphasia

To date, much of the relevant literature for acquired communication disorders consists of basic science studies that document quantitative differences in formulaic language usage according to neurological and/or speech and language profiles. Researchers have found that individuals with Alzheimer's and Parkinson's disease show inverse formulaic production patterns; the former group produces a higher proportion, and the latter group a lower proportion of formulaic language as compared to healthy controls (Van Lancker Sidtis et al., 2015; Wray & Perkins, 2000). Individuals with left-hemisphere damage produce similar or higher proportions of formulaic language relative to healthy controls, whereas individuals with right-hemisphere damage produce significantly less than the other two groups (Baldo et al., 2016; Van Lancker Sidtis & Yang, 2017; Zimmerer et al., 2018). Based on these data, some researchers have posited involvement of the basal ganglia, specifically the left caudate nucleus, and right frontal areas in non-propositional language production that are distinct from traditional propositional language networks (Van Lancker Sidtis & Sidtis, 2018). A recent magnetic resonance imaging (MRI) study, however, offers alternate evidence in which motor speech networks play a dominant role in processing well-rehearsed or frequently used (i.e., formulaic) language (Skipper et al., 2022).

Other literature has explored qualitative differences in formulaic language usage according to clinical classifications on the Western Aphasia Battery-Revised (WAB-R; Kertesz, 2006), and how language severity relates to usage patterns. For example, findings demonstrated that individuals with non-fluent aphasia relied heavily on conversational, stand-alone formulaic utterances (e.g., speech formulas such as *oh man* and *sure thing*.). This observed usage pattern was shown to relate to propositional language severity as measured by the aphasia quotient (WAB-R AQ; Torrington Eaton & Burrowes, 2021). Individuals with fluent aphasias also demonstrated unique usage patterns according to clinical subtype (Torrington Eaton & Thomas, 2023). For example, as compared to other fluent aphasia subtypes, individuals with anomic aphasia used lower proportions of discourse organizers with neutral connotation (i.e., lexical bundles such as *in order to* and *I believe . . .*). Individuals with conduction aphasia demonstrated formulaic usage patterns that were closer to Broca's aphasia (i.e., high proportions of speech formulas such as *you bet!*). Unlike individuals with nonfluent aphasia, no relationship was found between proportion of formulaic language use and WAB-R AQ, or severity, in individuals with fluent aphasias. These compelling differences in production patterns across aphasia subtypes suggest the potential for using formulaic language diagnostically and therapeutically. Descriptive analyses, however, are only an initial step towards translation and implementation.

A handful of recent studies have recognized or purposefully targeted non-propositional language in speech and language assessment practices. Zimmerer et al. (2018, 2020) have developed software that calculates the frequency of word combinations, or collocations, as a proxy for formulaic language usage. Results have shown the ability to detect differences in fluent versus nonfluent post-stroke aphasia based on the proportion of collocations in language samples (i.e., fluent < nonfluent). Although somewhat difficult to interpret, their results also distinguished collocation profiles across PPA variants (i.e., profiles consisted of word count, content word and combination ratios, content word frequency, and collocation strength). A different research group, Stahl et al. (2017), has demonstrated how assessment prompts that utilize formulaic language items enhance linguistic performance in individuals with aphasia (e.g., confrontation naming tasks with the pragmatically-oriented elicitation phrase "what do you want?" versus the conventional prompt "what is this?"). In another study, for individuals diagnosed with both aphasia and apraxia of speech, findings showed improved production accuracy when speech sound targets were elicited in formulaic rather than propositional language contexts (Stahl et al., 2020).

In terms of intervention, Stahl and colleagues have suggested that formulaic language is the actual mechanism of change for some traditional language approaches such as Melodic Intonation Therapy and Constraint-Induced Aphasia Therapy (i.e., *My name is* ____. *Do you have a* ____; Stahl & Kotz, 2014; Stahl et al., 2020). Bruns et al. (2021) examined the effectiveness of using formulaic language items to increase production of functional syntactic structures in individuals with non-fluent aphasia. In their approach, high-frequency fixed expressions were trained as carrier phrases in which novel vocabulary could be inserted (i.e., *I like* ___). Although the therapy was positively regarded by participants, outcomes across the five individuals were mixed. Though limited in number, these studies underscore the potential of purposefully integrating formulaic language into clinical practice. Unfortunately, the lack of an overarching theoretical framework is a limitation for advancing such research. A unifying framework would provide much needed systematicity in the selection of elicitation prompts and design of interventions for individuals with aphasia that capitalize on relatively preserved non-propositional language networks.

The introduction of a testable model of formulaic language usage, as proposed by Van Lancker Sidtis (2022), offers a solution for moving forward. The proposed theoretical model consists of three main categories – formulaic expressions, lexical bundles, and collocations – each of which includes a variety of recognized types such as a speech formulas, idioms and proverbs, and sentence stems. More importantly, the three categories vary according to inherent psycholinguistic characteristics: frequency, syntactic construction, compositionality, context-boundedness, nuance, and literality (Figure 1). The next section provides brief descriptions of each characteristic, justification for supporting its inclusion in the formulaic language model, and methodological information that informed the design of this study.

Psycholinguistic characteristics in the formulaic language model

The first and most recognized characteristic is frequency of the formulaic language item. Numerous experimental studies across disciplines have demonstrated processing advantages based on frequency of multi-word expressions (i.e., language chunks; e.g., Janssen et al., 2012; Jiang & Nekrasova, 2007; Siyanova-Chanturia et al., 2017). Studies of language production in aphasia have identified frequency effects in multi-word expression retrieval and completion (Martínez-Ferreiro et al., 2020; Torrington Eaton & Newman, 2018). As

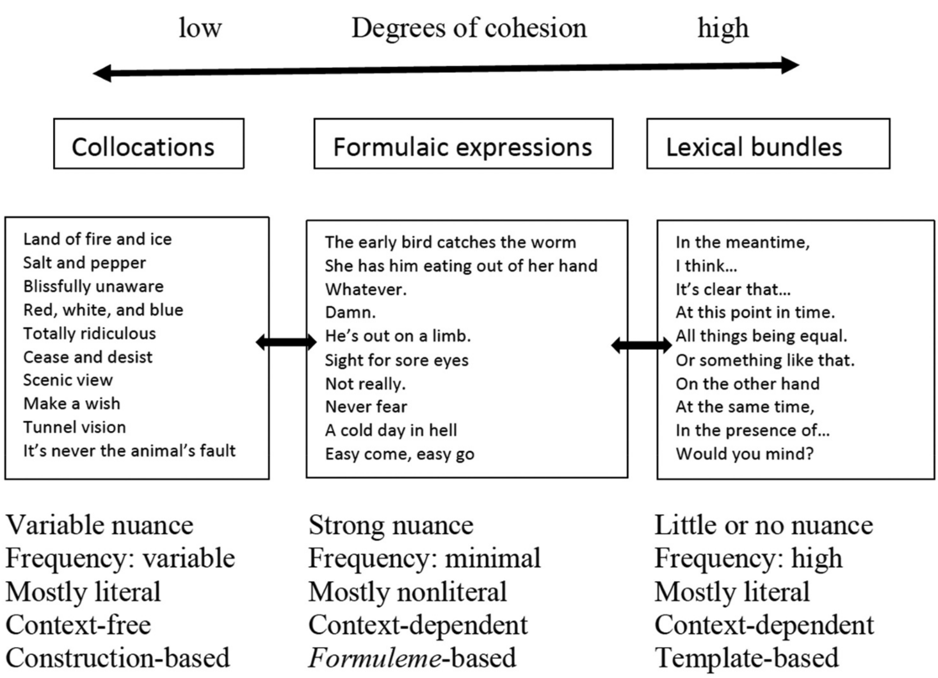

Figure 1. Proposed formulaic language model. From Van Lancker Sidtis (2022). © John Benjamins. Reprinted with permission.

mentioned, frequency has been used to identify and quantify collocations in corpus-based analyses of impaired language due to Alzheimer's disease (Zimmerer & Varley, 2016), post-stroke aphasia (Zimmerer et al., 2018), and primary progressive aphasia (PPA; Zimmerer et al., 2020). An interesting outlier in the frequency-based literature is idioms and proverbs, which are characterized by notably low frequency (Van Lancker Sidtis, 2022); these items serve as a reminder that psycholinguistic variables aside from just frequency likely explain formulaic usage patterns.

The next two psycholinguistics characteristics in the model include syntactic structure and cohesiveness. Although all formulaic language is, by definition, canonical or pre-established in form, Van Lancker Sidtis uses the terms construction-, formuleme-, and template-based to describe and delineate syntactic structure (Carrol & Conklin, 2019; Wray, 2017). Cohesiveness, also referred as fixedness or compositionality, is nested in her descriptions of each syntactic category and represented along a continuum from low to high. Accordingly, construction-based items are least restricted in terms of grammatical structure and are designated as the least cohesive, most flexible category (e.g., *fast and loose/furious*, *make a wish/racket/killing*). Formuleme-based items are complete, independent phrases that are cohesive yet with some flexibility according to the speaker's intent (e.g., *See you/y'all [a bit] later, The grass is [for the most part] greener*.). Template-based items require the speaker to insert information and are largely invariable (e.g., *I can't believe that …* , … *in terms of…*).

A broader search of the literature provided mixed justification for the inclusion of both characteristics in this study. As mentioned, previous research has suggested that syntactic structure influences formulaic production (Torrington Eaton & Burrowes, 2021; Torrington Eaton & Thomas, 2023); specifically, results of two descriptive studies indicated that individuals with non-fluent aphasia and more severe language deficits produced a high proportion of stand-alone formulaic utterances (i.e., formuleme-based constructions; e.g., *I don't know*. *You got this*.), whereas individuals with fluent aphasia subtypes did not demonstrate this tendency. Although Erman et al. (2015) used a binary system of classification, a three-part distinction aligns more closely with Van Lancker Sidtis' model: grammatically complete utterances, complete yet dependent phrases, and incomplete and dependent phrases (e.g., *Fancy that*. vs. *All of a sudden* … vs. … *a bunch of* …). In contrast, a review of the literature on the construct of cohesiveness revealed significant limitations in its operationalization. Although mutual information (MI) scores, t-scores, and various algorithms have been utilized in formulaic language research, the decision was ultimately made to exclude this psycholinguistic characteristic from the current study due to inconsistencies in measurement (Fioravanti et al., 2020; Yeldman, 2020; Zhu & Fellbaum, 2015).

The next two characteristics, context boundedness and nuance, are potentially important variables related to aphasic individuals' sensitivity to and relative strengths in pragmatics. Context-boundedness indicates the degree to which a formulaic item is tied to a specific situation or speaker (e.g., *Step out of the car, please*. vs. *You might be right*), whereas nuance refers to how the speaker uses formulaic items to reflect emotional valence or attitude (*What the hell? No worries*; Kecskes, 2007). Linguists have examined how healthy speakers vary the meaning of single formulaic phrases according to situation and/or nuance (e.g., *and everything*; *That's what she said*; Kirner-Ludwig, 2018; Overstreet & Yule, 2002). Similarly, Bruns et al. (2018) observed that the formulaic expression "I don't know" is used to accomplish a variety of communicative functions in individuals with aphasia including, most commonly, to hold the conversational floor or express a lack of knowledge. A conversation analysis by Tuomenoksa et al. (2021) noted that aphasic individuals often produced formulaic items, specifically speech formulas, to initiate conversation, although no information was provided about the constitution of these phrases. In summary, these studies suggest that the context and/or nuance may – or may not – influence formulaic language production patterns in individuals with aphasia.

The final psycholinguistic characteristic included in the formulaic language model is literality, or semantic transparency. The majority of research in this area has examined idioms, which show longer processing times for both native and non-native speakers when items are not transparent (i.e., the figurative meaning is not directly linked to its literal interpretation); however, less is known with regard to production (Carrol & Conklin, 2019). Van Lancker Sidtis and Yang (2017) considered literality in their study comparing expressive language performance in individuals with left- and right-hemisphere lesions. Unfortunately, experimental stimuli were constructed such that all formulaic language items were non-literal whereas matched propositional phrases were literal, thus limiting interpretation. One additional design feature of their stimuli was that experimental items were matched by length in words. Although not included in the proposed formulaic language model, number of words in multi-word expressions seemed an important consideration for individuals with aphasia due to limitations in expressive language (e.g., free grammatical morphemes); therefore, length in words was also considered in this study.

In conclusion, Van Lancker Sidtis's (2022) formulaic language model is comprised of a number of psycholinguistic characteristics taken from the literature. To our knowledge, no study has explicitly tested this model for individuals with aphasia, which is crucial for systematically integrating formulaic language into assessment and intervention practices. The purpose of this study was to explore the utility of the proposed theoretical model. For this preliminary investigation, we used a retrospective dataset from published descriptive studies to examine the following research questions:

(1) Do the psycholinguistic characteristics of formulaic language items produced by individuals with aphasia differ by post-stroke aphasia subtype (i.e., WAB-R classifications)?
(2) Can formulaic language production patterns, as distinguished by psycholinguistic characteristics, be used to predict language severity (i.e., WAB-R AQ), fluency performance (i.e., WAB-R fluency subtest score), or fluency status (i.e., fluent vs. nonfluent per WAB-R classification)?

Method

Participants

Data were from AphasiaBank, an online data repository of individuals with aphasia. Contributions to the site adhere to a standard testing protocol for gathering patient data (MacWhinney et al., 2011). Data from the published descriptive studies, from which these analyses were derived, included individuals from four clinical subtypes based on

WAB-R performance as reported in Aphasiabank's test results document (Torrington Eaton & Burrowes, 2021; Torrington Eaton & Thomas, 2023). By combining participant data from the two descriptive studies, the total number of participants was 219, which included of 77 individuals with Broca's, 77 with anomic, 43 with conduction, and 22 with Wernicke's aphasia. Individuals with Broca's and anomic aphasias were matched by age and gender. Data for the other two aphasia subtypes were based on what was available in the repository when the original study was initiated.

Coding procedures

Participants' language samples were previously analyzed to identify, categorize, and describe types and frequencies of formulaic language produced by clinical subtype (Torrington Eaton & Burrowes, 2021; Torrington Eaton & Thomas, 2023). Formulaic items from these descriptive studies were coded according to six psycholinguistic factors. Fillers and vocatives (e.g., *um*, *I mean*, *well . . .* , *so . . .*) were excluded from the analysis because they inherently differ from other formulaic language types. Frequency was derived using the spoken section of The Corpus of Contemporary American English (COCA; Davies, n.d.), a database of over one billion words that measures multi-word expressions (Nekrasova, 2009). Length was determined by counting the number of words in each item from the transcript (Dai et al., 2017). Contractions were counted as two words (e.g., *I'm; it's*) with the exception of phonetic reductions such as "wanna" and "kinda", which were considered single words (Bybee et al., 2016).

Four psycholinguistic factors were coded using a novel rubric informed by the formulaic language literature and developed to align with the formulaic language model (Table 1). Syntactic completeness was coded according to categories from the model: formuleme-based items were scored as complete, stand-alone utterances to include single word responses (score of 3; e.g., *Good morning*; *Yeah*.); construction-based items were scored as complete but dependent phrases (score of 2; e.g., *quite a few*; *other than that*); template-based items were scored as incomplete utterances spanning phrasal boundaries that require speakers to insert information (score of 1; e.g., *I can't remember if . . . ; in terms of*). Context-boundedness was coded using a binary system: collocations or formulaic items that are pervasive across language contexts were considered context-free (score of 1; e.g., *a couple of times*; *around the world; okay*), in contrast to formulaic items that selected according to language context, listener, or situation (score of 2; e.g., *life is good; hell of a . . .*). Nuance was rated along a continuum: formulaic items with a purely grammatical function or neutral semantic content such as to convey time or location were

Table 1. Rubric for coding formulaic language items according to psycholinguistic characteristics.

	Syntactic completeness	Context boundedness	Nuance	Literality
1	Incomplete utterance, spans phrasal boundaries	Independent of context	None; purely grammatical constructions, such as items that convey time or location	Literal
2	Complete noun, verb or prepositional phrase, but dependent	Specific to listener OR setting OR situation	Minimal to moderate nuance (between 1–3)	Nonliteral
3	Complete utterance and/or able to stand alone	-	Strong nuance, swear words or utterances that convey emotion or attitude	-

scored as nuance-free (score of 1; e.g., *I wanna say*; *a week ago*), in contrast to items conveying strong emotion or attitude (score of 3; e.g., *any of that shit*; *are you crazy?*). A third option included items somewhere in between the two anchor ratings (score of 2; e.g., *ready to go*; *waste of time*). Literality was coded using a binary system: items with a literal meaning (score of 1; e.g., *around that time*; *long story short*), versus items requiring a non-literal interpretation (score of 2; e.g., *let's see*; *a ton of*).

Syntactic completeness, context-boundedness, nuance, and literality were coded independently by the first three authors. After inter-rater reliability was calculated, the second author determined values for items in which there was disagreement; final values for psycholinguistic characteristics required a minimum of two out of three agreement. Upon completion of this consensus approach, a master list of psycholinguistic values was devised for each formulaic language item.

Datasheets were created for study participants consisting of all formulaic items the individual produced. To create the most representative repertoire for each participant, repeated items were treated as follows: each formulaic language item was listed only once even if produced multiple times in a given sample; however, because language tasks (i.e., Cinderella retell, stroke story, speech status, and important event) were treated as unique samples, a single item could be counted up to four times if the participant produced the item in each of the four language tasks. The rationale for this decision was to include a complete inventory of formulaic items produced in response to a distinct topic or prompt. After creating lists of formulaic language productions and inserting psycholinguistic values from the master list, means were calculated for each psycholinguistic characteristic. Consequently, each participant's formulaic language production across the four language tasks was represented numerically for the six dimensions (Table 2).

In addition to psycholinguistic characteristic means, the final dataset for analysis included the following independent variables: age, education, race, presence or absence of apraxia of speech (AOS), and presence or absence of dysarthria (the latter two variables accounted for the influence of motor speech deficits). These data were reported in the

Table 2. Sample calculation of one participant's formulaic language production across tasks according to psycholinguistic characteristics.

Item	Context	COCA value	No. of words	Syntactic completeness	Context-boundedness	Nuance	Literality
let's see	Cinderella	4027	3	3	2	1	2
long story short	Cinderella	152	3	2	1	1	1
okay	Important	20961	1	3	1	1	1
life is good	Important	54	3	3	2	2	2
okay	Speech	20961	1	3	1	1	1
I wanna say	Speech	7963	3	1	1	1	1
and (a) half	Speech	7490	3	1	1	1	1
yeah	Stroke	161230	1	3	1	1	1
ready to go	Stroke	1728	3	3	2	2	1
from there	Stroke	2181	2	2	1	1	1
	Mean	22674.7	2.3	2.4	1.3	1.2	1.2

Note: COCA = frequency of multi-word expression from the Corpus of Contemporary American English; # of words = length in words.

English-Aphasia-Current Demographics Database spreadsheet in Aphasiabank. Dependent variables in this study, found in the English Test Results spreadsheet, consisted of language severity (i.e., WAB-R AQ), fluency score (i.e., subtest score from 1 to 10 that describes fluency, grammatical competence, and paraphasias in spontaneous speech tasks), and fluency status (i.e., > 4 for fluent subtypes, < 5 for non-fluent per WAB-R fluency score criteria).

Reliability

Inter-rater reliability between the first and second authors for coding psycholinguistic variables, as measured by Pearson's correlations, included: syntactic completeness, $r = .964$, context-boundedness, $r = .898$, nuance, $r = .840$, and literality, $r = .908$.

Data analysis

Bivariate correlations of age, race, education, and psycholinguistic variables were run to determine potential influences of demographic variables on formulaic language production. Histograms and mean plots were inspected while running correlations. Continuous variables (psycholinguistic and other) were evaluated for parametric normality assumptions prior to model building. The variable mean COCA (i.e., frequency of multi-word expression) was log transformed and literality was accepted with a minor deviation from normality. A multivariate factorial analysis was run to compare psycholinguistic variables across WAB-R aphasia subtypes. Next, Pearson's and Spearman's correlations determined which independent variables were significantly related to each of the dependent variables; independent variables that were not significantly correlated were removed from subsequent regression analyses. For remaining independent variables, collinearity data were inspected to determine any significant relationships between psycholinguistic variables using a conventional criterion of > 0.70 (Tabachnick & Fidell, 2006). Data were inspected for outliers, multicollinearity, and assumptions of normality, homoscedasticity, and linearity.

Backward regression was used to test the proposed formulaic language model and assess the strength of psycholinguistic variables. Backward stepwise multiple linear regressions were used for the continuous dependent variables WAB-R AQ and WAB-R fluency scores, whereas logistic regression with backward Likelihood Ratio elimination was used for the dichotomous dependent variable of fluency. Values from the latter model were used to construct a natural log formula (i.e., In equation) to predict the likelihood of fluent/nonfluent aphasia based on an individual's formulaic language characteristics. The equation consisted of the constant plus or minus each predictive variable included in the best fitting logistic regression model.

Results

Demographic information, presence of motor speech disorder, and fluency status, as reported in the Test Results Dataset, are summarized in Table 3 according to aphasia subtype on the WAB-R. There were no statistically-significant between-group differences for gender, χ^2 (3, 197) = .994, $p = .803$, age, $F(3, 214) = 2.183$, $p = .091$, education, $F(3, 207) = 1.995$, $p = .116$, race, χ^2 (18, 218) = 18.44, $p = .427$, or presence of dysarthria, χ^2 (3, 190) =

Table 3. Participant demographics, motor speech status, and fluency by WAB-R subtype.

*n =	Mean age (SD) 219	Mean edu (SD) 208	% male 219	% white 218	% AOS 197	% dysarthric 190	% fluent 216
Anomia	61.1 (11.5)	15.9 (2.8)	67.5	88.3	27.7	7.9	99.7
Conduction	61.5 (11.3)	15.5 (2.7)	67.4	83.7	37.5	5.4	100
Wernicke's	58.5 (12.5)	15.7 (2.6)	77.3	90.5	0	0	100
Broca's	60.7 (11.8)	14.9 (2.7)	66.2	75.3	71.6	16.4	0

Notes: *Actual number of participants included in descriptive statistic due to missing datapoints; edu = number of years of education; AOS = apraxia of speech; fluent = > 4, non-fluent <5 on WAB-R spontaneous speech fluency score.

6.417, $p = .093$. There was a statistically-significant difference observed in the prevalence of AOS across subtypes, χ^2 (3, 197) = 44.826, $p < .001$. Individuals with Broca's aphasia had the highest incidence of AOS followed by conduction, anomic, and finally Wernicke's aphasia.

Age, years of education, and race were not correlated with most of the psycholinguistic variables. There were weak correlations between age and both context-boundedness, $r = .150$, $p = .027$, $r^2 = .023$, and nuance, $r = -.137$, $p = .043$, $r^2 = .019$, and between race and length in words, $r = -.161$, $p = .081$, $r^2 = .026$; due to the underwhelming strength of these relationships and an inflated testwise error, all demographic variables were not included in the later analyses. Dysarthria was unassociated with psycholinguistic characteristics aside from length in words, $r = .143$, $p = .049$, but AOS was correlated with three variables including frequency, $r = .416$, $p < .001$, $r^2 = .019$, length in words, $r = .225$, $p = .001$, $r^2 = .051$, and syntactic completeness, $r = -.307$, $p < .001$, $r^2 = .094$. Thus, AOS was included and dysarthria excluded in regression analyses.

A preliminary multifactorial analysis of variance (ANOVA) was run to examine differences in psycholinguistic characteristics across WAB-R aphasia subtypes (Figure 2). There were statistically significant between-group differences in means for the following psycholinguistic characteristics: frequency, $F(3) = 24.503$, $p < .001$, $\eta_p^2 = .255$, length, $F(3) = 12.464$, $p < .001$, $\eta_p^2 = .148$, syntactic completeness, $F(3) = 23.146$, $p < .001$, $\eta_p^2 = .244$, and literality, $F(3) = 3.491$, $p = .017$, $\eta_p^2 = .046$. There were no between-group differences for context-boundedness, $F(3) = .730$, $p = .535$, $\eta_p^2 = .010$, or nuance, $F(3) = 2.406$, $p = .068$, $\eta_p^2 = .032$.

Do psycholinguistic characteristics of spontaneously produced formulaic language predict language severity (WAB-R AQ) or fluency subtest scores on the WAB-R?

Consistent with results from the ANOVA, Pearson's correlations yielded statistically significant relationships between WAB-R AQ and frequency, length, syntactic completeness, literality, and AOS (Table 4). Context-boundedness and nuance were not correlated and thus not included in the initial linear regression models. An analysis of standard residuals was conducted demonstrating that the data contained no outliers, standard residual min = −2.563, max = 1.725. Further, multicollinearity was not of concern and the assumption of independent errors was met, Durbin-Watson value = .957. Out of the five independent variables entered, results identified the strongest predictive model consisted of only frequency and syntactic completeness, $F(2, 195) = 19.391$, $p < .001$, $r^2 = .167$. Although

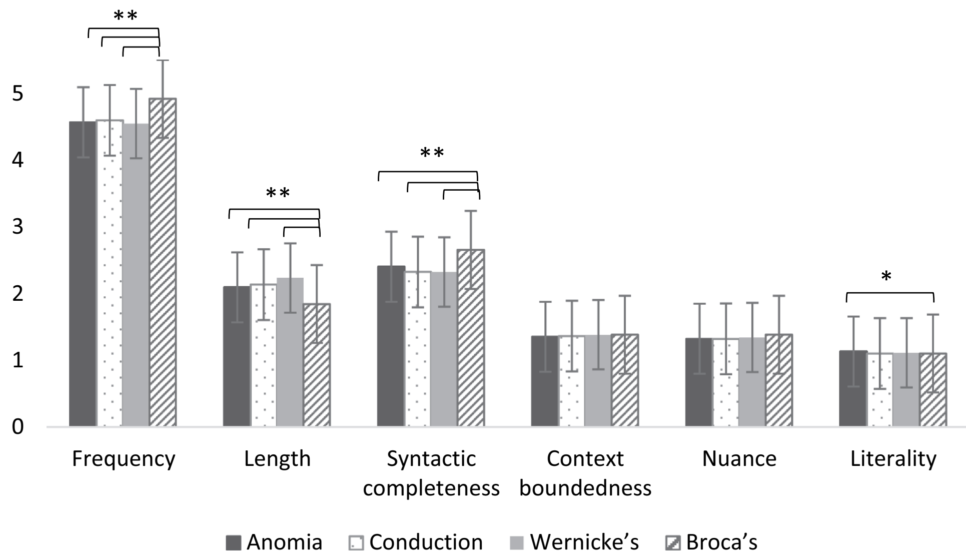

Figure 2. Psycholinguistic characteristics of produced formulaic language by WAB-R aphasia subtype. Note: ** > .001; * > .01; Error bars represent standard error; Frequency = log transformed values from Corpus of Contemporary American English (COCA); Length = number of words; Syntactic completeness: 1 = incomplete, 3 = complete, independent utterance; Context boundedness: 1 = independent of context, 2 = specific to listener, setting or situation; Nuance: 1 = purely grammatical construction, 3 = strongly conveying emotion or attitude; Literality: 1 = literal, 2 = nonliteral

Table 4. Correlations distinguishing strength of relationships between dependent and independent variables.

	Frequency	Length	Syntactic completeness	Context boundedness	Nuance	Literality	AOS
WAB-R AQ	−.364**	.283**	−.330**	−.072	−.119	.181*	.231**
WAB-R Fluency score	−.470**	−.409**	−.466**	−.061	−.146	.232*	.391**
♦Fluent/ nonfluent	−.496**	.373**	−.485**	−.081	−.152*	.184*	.442**

Note: ** <.001; * <.01; ♦ = Correlation results using Spearman's Rho for a dichotomous dependent variable versus Pearson's correlations; AOS = apraxia of speech.

both psycholinguistic variables were statistically significant (Table 5), the model only accounted for 17% of the variance in WAB-R AQ scores.

The second linear regression model was constructed to predict fluency subtest scores on the WAB-R. In this model, five psycholinguistic characteristics were entered (Table 5). The analysis of standard residuals identified no outliers, standard residual min = −2.286, max = 3.005, no concerns for multicollinearity, and no violations in independent errors, Durbin-Watson value = 1.186. The most parsimonious model ordered by strength included syntactic completeness, frequency, AOS and literality, $F(4, 190) = 107.76$, $p < .001$, $r^2 = .361$. Length was excluded from the model. In sum, three psycholinguistic characteristics and the presence of AOS accounted for 36% of the variability in fluency subtest scores indicating a much stronger model as compared to WAB-R AQ.

Table 5. Results of backward stepwise linear regressions of final models for dependent variables WAB-R AQ and fluency scores.

	F	*R*	R^2	SE	B	Beta	Coefficients 95% confidence interval for B Lower	Upper
WAB-R AQ								
Model summary	19.391	.409	.167	.159				
Constant					180.662		143.35	217.97
Frequency					−17.576	−.294	−26.059	−9.093
Syntactic completeness					−12.902	−.188	−22.646	−3.158
WAB-R Fluency								
Model summary	26.830	.601	.361	2.004				
Constant					15.640		8.150	23.129
Syntactic completeness					−2.700	−3.050	−3.821	−1.579
Frequency					−1.890	−.246	−2.955	−.824
AOS					.917	.184	.276	1.557
Literality					3.833	.124	.149	7.517

Note: F = regression model statistic; *R* = model coefficient; R2 = coefficient of determination; SE = standard error; B = unstandardized coefficient; Beta = standardized coefficient.

Table 6. Results of final binary logistic model for the dependent variable of fluency status.

	B	SE	p	Exp(B)	95% Confidence intervals Lower	Upper
Constant	15.579	4.976	.002	5834376.3		
AOS	1.371	.782	<.001	3.939	1.779	8.723
Frequency	−2.808	.782	<.001	.060	.013	.279
Syntactic completeness	−1.718	.837	.040	.179	.035	.926
Nuance	−3.763	1.506	.012	.023	.001	.445
Literality	6.217	2.932	.034	501.14	1.600	156993.9

Ln = 15.579 + 1.371 (AOS) − 2.808 (frequency) − 1.718 (syntactic completeness) − 3.763 (nuance) + 6.217 (literality)
Note: B = unstandardized coefficient; SE = standard error; *p* = statistical significance; Exp(B) = odds ratio; AOS = apraxia of speech.

Do psycholinguistic characteristics of spontaneously produced formulaic language predict fluent versus nonfluent aphasia?

Spearman's Rho correlations for the dichotomous dependent variable demonstrated statistically significant relationships between fluent/nonfluent status and frequency, length, syntactic-completeness, literality, nuance, and AOS (Table 4). Multi-collinearity was not present between dependent variables. Results for the most parsimonious model (Table 6), with goodness of fit, Hosmer and Lemeshow χ^2 (8, 219) = 5.974, $p = .650$, included five fitted variables. Specifically, fluency was predicted by presence of AOS, and frequency, syntactic completeness and literality of produced formulaic language, χ^2 (5, 219) = 92.458, $p < .001$. Importantly, 88.4% of individuals with fluent and 70.3% with nonfluent aphasia were accurately classified with this model accounting for 80.5% of the variability. This model resulted in the predictive equation: Ln = 15.579 + 1.371 (AOS) − 2.808 (frequency) − 1.718 (syntactic completeness) − 3.763 (nuance) + 6.217 (literality).

Discussion

The purpose of this study was to explore the utility of Van Lancker Sidtis's (2022) model of formulaic language for individuals with post-stroke aphasia. The analysis was run using formulaic items described in two retrospective studies, as well as corresponding patient demographics, motor speech information, and standardized language scores. Findings demonstrated that aphasic individuals' formulaic production in spontaneous language samples – as characterized by aggregated psycholinguistic characteristics – was distinguishable across fluent and nonfluent aphasia classifications on the WAB-R. Importantly, certain psycholinguistic characteristics of spontaneously produced formulaic items predicted fluency performance and status as measured by standardized language assessment. To our knowledge, this is the first study to demonstrate that non-propositional language analyses yield similar results to WAB-R fluency classifications in individuals with post-stroke aphasia.

While previous studies have found quantitative between-group differences in the types of formulaic items used, the current study goes a step further by distinguishing formulaic usage patterns according to aggregated characteristics (Torrington Eaton & Burrowes, 2021; Torrington Eaton & Thomas, 2023; Van Lancker Sidtis, 2022). Results from the between-group comparisons demonstrated that formulaic language items produced by individuals with nonfluent aphasia were inherently higher in frequency, shorter in length, less literal and more often syntactically complete (i.e., stand-alone utterances) as compared to formulaic language produced by individuals with fluent aphasia. Results of the regression analysis using fluency subtest scores on the WAB-R validated these findings as did the analysis using fluency as a dichotomous variable with the addition of nuance. Though automated analyses based on frequency of multi-word expressions are undoubtedly efficient (Zimmerer et al., 2018), this study illustrates the contribution and influence of many psycholinguistic factors in formulaic usage by individuals with post-stroke aphasia that are specified in the formulaic language model (2022).

Although regressions varied by dependent measure, two psycholinguistic variables – length in words and context-boundedness – were not predictors in any model. The first of these was not included by Van Lancker Sidtis (2022) and likely for good reason. Dai et al. (2017) suggested that length and frequency are highly correlated variables in formulaic language. In this study, length fell just below the 70% threshold for collinearity with the syntactic completeness variable. Due to this lack of orthogonality, length in words likely need not be included in future studies of formulaic language in individuals with aphasia. In terms of context-boundedness, previous studies have suggested that individuals with nonfluent aphasia rely on specific formulaic items (e.g., "I don't know") regardless of language context, which lends support for this study's null result (Bruns et al., 2018; Tuomenoksa et al., 2021). On the other hand, it is quite possible that the nature of language samples taken from the retrospective datasets affected the predictive power of this psycholinguistic characteristic. Research has documented how individuals with aphasia benefit from using their environments during communicative attempts (e.g., Doedens & Meteyard, 2020). The inclusion of various genres, conversational partners, and emotional content will be an important consideration for future studies in formulaic language analysis.

The utility of using formulaic language production to differentially diagnose fluency in post-stroke aphasia has the potential to inform and streamline evaluation practices. Similar efforts are underway in other areas of language assessment such as the Severity-Calibrated Aphasia Naming Test (SCANT; Walker et al., 2022), which uses performance on a 20-item naming task as a proxy for language severity scores on the WAB-R. This efficient alternative to administering a full standardized assessment frees evaluation time to measure functional impacts of aphasia and communication strengths that directly inform intervention planning. Similarly, recent advances have increased the efficiency of propositional language sample analysis, a tool that provides valuable data about functional communication (Dalton et al., 2020). Importantly, this study's findings indicate that an efficient means of formulaic language analysis could be a useful adjunct to conventional (i.e., propositional) language sample analysis with the potential to provide fluency status as well as preserved language that may be usable in intervention.

The concept of purposefully targeting formulaic language in intervention is an under-explored area in aphasia research. The findings from this study could offer both a compelling rationale and conceptual framework to guide future efforts in this area. For instance, the intervention proposed by Bruns et al. (2021), which incorporates formulaic items in treatment, might be improved by treating formulae-based, high-frequency items rather than template-based sentence frames. Traditional interventions that likely already incorporate formulaic language (i.e., MIT, script training; Stahl & Van Lancker Sidtis, 2015) could also be refined by manipulating syntactic completeness, nuance, literality, and frequency. To illustrate, a clinician might purposefully choose high-frequency targets with high emotional valence in a patient with more severe expressive deficits to increase likelihood of success. This latter point relates to identifying the actual mechanism behind treatment approaches, which to date has largely focused on the propositional language network.

The neural basis of non-propositional language is a somewhat controversial yet important area of research that will further inform the proposed model. Van Lancker Sidtis and colleagues have purported a formulaic language network consisting of the right inferior frontal gyrus and left caudate nucleus (Sidtis et al., 2018; Van Lancker Sidtis & Sidtis, 2018). These assertions are based on small-scale MRI studies with healthy individuals as well as observable disassociations between formulaic language patterns in individuals with lesions or neurodegenerative disease processes affecting cortical versus subcortical areas. Skipper et al. (2022) more recently argued that the non-propositional network involves bilateral sensorimotor areas. In their study, neurotypical individuals practiced propositional sentences for a period of two weeks to the point of overlearning, which the researchers argued essentially mimicked the process of storing formulaic phrases in memory. Post-intervention, imaging was conducted while participants listened to the sentences they had practiced. Pre versus post comparisons showed neural network change in the form of decreased activation of frontal and temporal regions (i.e., the propositional language network) and increased activation of bilateral sensorimotor cortex. These results indicate the role of motor speech in formulaic language, which aligns with this study's regression findings in which apraxia of speech was found as a significant predictor variable in formulaic language models. Future efforts should seek to elucidate the relationship between formulaic language and automatic speech.

Limitations

We recognize limitations inherent in this exploratory study. First, analyses using retrospective datasets – particularly from large-scale repositories – are limited by the nature of the reported data. As such, there were a few unexpected findings such as noteworthy percentages of individuals with fluent aphasia subtypes who presented with apraxia of speech. In addition, analyzing formulaic language from naturalistic contexts rather than structured prompts may produce different results particularly regarding context-boundedness, nuance, and possibly word length (i.e., use of phonetic reductions based on language context). Second, the constructs of clinical subtype and fluency as derived from the WAB-R have been questioned in recent years (Bunker & Hillis, 2022; Fromm et al., 2021; Gordon & Clough, 2020; Kasselimis et al., 2017). Despite these justifiable contentions, this study ran regression models using measures from one of the core language outcome tools established in aphasia research (Wallace et al., 2019). Future studies using prospective designs will allow researchers to utilize language measures that better characterize the nature of participants' expressive, propositional language. Lastly, the variable of cohesiveness, a prominent psycholinguistic characteristic in the proposed formulaic language model, should clearly be included in future research once operationalization has been established (Fioravanti et al., 2020).

Conclusion

Results of this study expand the foundation of theoretically-driven research of formulaic language production in aphasia. Future work should refine methodologies for examining psycholinguistic characteristics of non-propositional language and explore effects related to functional language context. The predictive equation will be useful for testing the model's utility with other datasets and populations including samples of diverse language contexts and individuals with PPA. Neuroimaging and experimental studies in different speech- and language-impaired populations will help advance efforts so that formulaic language can be used to improve the efficiency of assessment practices and efficacy of current and new interventions.

Acknowledgements

We would like to thank members of the San Antonio Network for Aphasia (SANA) lab at UT Health especially Melanie Smith who was instrumental in assisting with coding and data analysis. Thanks also to Dr. Rochelle Newman for her advice on coding and analyses when this study was first conceptualized.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Catherine Torrington Eaton http://orcid.org/0000-0002-1874-0854

Data availability statement

Language samples are freely available on the data-sharing platform Aphasiabank.

References

Baldo, J. V., Kacinik, N. A., Mondcrief, A., Beghin, F., & Dronkers, N. F. (2016). You may now kiss the bride: Interpretation of social situations by individuals with right and left hemisphere injury. *Neuropsychologia*, *80*, 133–141. https://doi.org/10.1016/j.neuropsychologia.2015.11.001

Bridges, K. A., & Van Lancker, S. (2013). Formulaic language in Alzheimer's disease. *Aphasiology*, *27*(7), 799–810. https://doi.org/10.1080/02687038.2012.757760

Bruns, C., Beeke, S., Zimmerer, V. C., Bruce, C., & Varley, R. A. (2021). Training flexibility in fixed expressions in non-fluent aphasia: A case series report. *International Journal of Language & Communication Disorders*, *56*(5), 1009–1025. https://doi.org/10.1111/1460-6984.12652

Bruns, C., Varley, R., Zimmerer, V. C., Carragher, M., Brekelmans, G., & Beeke, S. (2018). "I don't know": A usage-based approach to familiar collocations in non-fluent aphasia. *Aphasiology*, *33*(2), 140–162. https://doi.org/10.1080/02687038.2018.1535692

Bunker, L. D., & Hillis, A. E. (2022). Vascular syndromes: Revisiting classification of poststroke aphasia. *Handbook of Clinical Neurology*, *185*, 37–55. https://doi.org/10.1016/B978-0-12-823384-9.00002-5

Bybee, J., File-Muriel, R. J., & Napoleão De Souza, R. (2016). Special reduction: A usage-based approach. *Language and Cognition*, *8*(3), 421–446. https://doi.org/10.1017/langcog.2016.19

Cancino, M., & Iturrieta, J. (2022). Assessing the impact of the lexical approach on EFL perceived oral proficiency: What is the role of formulaic sequences? *Vigo International Journal of Applied Linguistics*, *19*(19), 41–66. https://doi.org/10.35869/vial.v0i19.3759

Carrol, G., & Conklin, K. (2019). Is all formulaic language created equal? Unpacking the processing advantage for different types of formulaic sequences. *Language and Speech*, *63*(1), 95–122. https://doi.org/10.1177/0023830918823230

Dai, X., Qu, Y., & Feng, Z. (2017). A synergetic approach to the relationship between the length and frequency among English multiword formulaic sequences. *Journal of Quantitative Linguistics*, *25*(1), 22–37. https://doi.org/10.1080/09296174.2017.1338119

Dalton, S. G., Hubbarb, H. I., & Richardson, J. D. (2020). Moving toward non-transcription based discourse analysis in stable and progressive aphasia. *Seminars in Speech and Language*, *41*(1), 32–44. https://doi.org/10.1055/s-0039-3400990

Davies, M. (n.d.). *The corpus of contemporary american english state scholarships foundation (*COCA). https://www.english.corpora.org/coca/

Davis, B. H., Troutman-Jordan, M., & Maclagan, M. (2023). Your phrases matter: Third waves in research approaches and new contexts for formulaic language. *International Journal of Language & Communication Disorders*, *59*(1), 84–93. https://doi.org/10.1111/1460-6984.12915

Doedens, W. J., & Meteyard, L. (2020). Measures of functional, real-world communication for aphasia: A critical review. *Aphasiology*, *34*(4), 492–514. https://doi.org/10.1080/02687038.2019.1702848

Erman, B., Denke, A., Fant, L., & Forsberg Lundell, F. (2015). Nativelike expression in the speech of long-residency L2 users: A study of multiword structure in L2 English, French and Spanish. *International Journal of Applied Linguistics*, *25*(2), 160–182. https://doi.org/10.1111/ijal.12061

Fioravanti, I., Senaldi, M. S. G., Lenci, A., & Siyanova-Chanturia, A. (2020). Lexical fixedness and compositionality in L1 speakers' and L2 learners' intuitions about word combinations: Evidence from Italian. *Second Language Research*, *37*(2), 1–32. https://doi.org/10.1177/0267658320941560

Fromm, D., Greenhouse, J., Pudil, M., Shi, Y., & MacWhinney, B. (2021). Enhancing the classification of aphasia: A statistical analysis using connected speech. *Aphasiology*, *36*(12), 1492–1519. https://doi.org/10.1080/02687038.2021.1975636

Gholami, L. (2022). The efficacy of incidental attention to formulaic and nonformulaic forms in focus on form. *Modern Language Journal*, *106*(2), 449–468. https://doi.org/10.1111/modl.12781

Gordon, J. K., & Clough, S. (2020). How fluent? Part B. Underlying contributors to continuous measures of fluency in aphasia. *Aphasiology*, *34*(5), 643–663. https://doi.org/10.1080/02687038.2020.1712586

Jackson, H. (1879). On affections of speech from disease of the brain. *Brain A Journal of Neurology*, *2*(3), 323–356. https://doi.org/10.1093/brain/2.3.323

Janssen, N., Barber, H. A., & Rodriguez-Fornells, A. (2012). Phrase frequency effects in language production. *PLOS ONE*, *7*(3), e33202. https://doi.org/10.1371/journal.pone.0033202

Jiang, N., & Nekrasova, T. M. (2007). The processing of formulaic sequences by second language speakers. *Modern Language Journal*, *91*(3), 433–445. https://doi.org/10.1111/j.1540-4781.2007.00589.x

Kasselimis, D. S., Simos, P. G., Peppas, C., Evdokimidis, I., & Potagas, C. (2017). The unbridged gap between clinical diagnosis and contemporary research on aphasia: A short discussion on the validity and clinical utility of taxonomic categories. *Brain and Language*, *164*, 63–67. https://doi.org/10.1016/j.bandl.2016.10.005

Kecskes, I. (2007). Formulaic language in English Lingua Franca. In I. Kecskes & L. R. Horn (Eds.), *Exploration in pragmatics: Linguistic, cognitive and intercultural aspects*. Mouton Series in Pragmatics [MSP]. https://doi.org/10.1515/9783110198843

Kertesz, A. (2006). *Western aphasia Battery-revised (WAB-R) [database record]*. APA PsycTests. https://doi.org/10.1037/t15168-000

Kirner-Ludwig, M. (2018). Trying to make it fit … *That's what she said*: An argument for a new category on the formulaic continuum. *Journal of Pragmatics*, *137*, 76–91. https://doi.org/10.1016/j.pragma.2018.08.001

MacWhinney, B., Fromm, D., Forbes, M., & Holland, A. (2011). AphasiaBank: Methods for studying discourse. *Aphasiology*, *25*(11), 1286–1307. https://doi.org/10.1080/02687038.2011.589893

Martínez-Ferreiro, S., Bastiaanse, R., & Boye, K. (2020). Functional and usage-based approaches to aphasia: The grammatical-lexical distinction and the role of frequency. *Aphasiology*, *34*(8), 927–942. https://doi.org/10.1080/02687038.2019.1615335

Nekrasova, T. M. (2009). English L1 and L2 speakers' knowledge of lexical bundles. *Language Learning*, *59*(3), 647–686. https://doi.org/10.1111/j.1467-9922.2009.00520.x

Overstreet, M., & Yule, G. (2002). The metapragmatics of *and everything*. *Journal of Pragmatics*, *34*(6), 785–794. https://doi.org/10.1016/S0378-2166(01)00036-4

Sidtis, J. J., Van Lancker Sidtis, D., Dhawan, V., & Eidelberg, D. (2018). Switching language modes: Complementary brain patterns for formulaic and propositional language. *Brain Connectivity*, *8*(3), 189–196. https://doi.org/10.1089/brain.2017.0573

Siyanova-Chanturia, A., Conklin, K., Caffarra, S., Kaan, E., & van Heuven, J. B. (2017). Representation and processing of multi-word expressions in the brain. *Brain and Language*, *175*, 111–122. https://doi.org/10.1016/j.bandl.2017.10.004

Skipper, J. I., Aliko, S., Brown, S., Jo, Y. J., Lo, S., Molimpakis, E., & Lametti, D. R. (2022). Reorganization of the neurobiology of language after sentence overlearning. *Cerebral Cortex*, *32*(11), 2447–2468. https://doi.org/10.1093/cercor/bhab354

Stahl, B., Gawron, B., Regenbrecht, F., Flöel, A., Kotz, S. A., & Ries-Cornou, S. (2020). Formulaic language resources may help overcome difficulties in speech-motor planning after stroke. *PLOS ONE*, *15*(6), E0233608. https://doi.org/10.1371/journal.pone.0233608

Stahl, B., Mohr, B., Dreyer, F. R., Lucchese, G., & Pulvermüller, F. (2017). Communicative-pragmatic assessment is sensitive and time-effective in measuring the outcome of aphasia therapy. *Frontiers in Human Neuroscience*, *11*, 223. https://doi.org/10.3389/fnhum.2017.00223

Stahl, B., & Van Lancker Sidtis, D. (2015). Tapping into neural resources of communication: Formulaic language in aphasia therapy. *Frontiers in Psychology*, *6*, 1526. https://doi.org/10.3389/fpsyg.2015.01526

Stahl, B., & Kotz, S. A. (2014). Facing the music: Three issues in current research on singing and aphasia. *Frontiers in Psychology*, *5*, 1033. https://doi.org/10.3389/fpsyg.2014.01033

Tabachnick, B. G., & Fidell, L. S. (2006). *Using multivariate statistics* (5th ed.). Pearson.

Torrington Eaton, C., & Burrowes, L. (2021). Comparing patterns of familiar language use across spontaneous speech contexts in individuals with nonfluent aphasia and healthy controls. *Aphasiology*, *36*(12), 1399–1418. https://doi.org/10.1080/02687038.2021.1966375

Torrington Eaton, C., & Newman, R. (2018). Heart and ___ or give and ___? An exploration of variables that influence binomial completion for individuals with and without aphasia. *American Journal of Speech-Language Pathology*, *27*(2), 819–826. https://doi.org/10.1044/2018_AJSLP-17-0071

Torrington Eaton, C., & Thomas, S. (2023). To make a long story short: A descriptive study of formulaic language use in post-stroke fluent aphasia. *Aphasiology*, *38*(7), 1180–1194. https://doi.org/10.1080/02687038.2023.2265101

Tuomenoksa, A., Beeke, S., & Klippi, A. (2021). People with non-fluent aphasia initiating actions in everyday conversation with familiar conversation partners: Resources for participation. *Aphasiology*, *36*(5), 575–568. https://doi.org/10.1080/02687038.2020.1852518

Van Lancker Sidtis, D., Choi, J., Alken, A., & Sidtis, J. J. (2015). Formulaic language in Parkinson's disease and Alzheimer's disease: Complementary effects of subcortical and cortical dysfunction. *Journal of Speech, Language, & Hearing Research*, *58*(5), 1493–1507. https://doi.org/10.1044/2015_JSLHR-L-14-0341

Van Lancker Sidtis, D., & Postman, W. A. (2006). Formulaic expressions in spontaneous speech of left- and right-hemisphere-damaged subjects. *Aphasiology*, *20*(5), 411–426. https://doi.org/10.1080/02687030500538148

Van Lancker Sidtis, D., & Sidtis, J. J. (2018). The affective nature of formulaic language: A right-hemisphere subcortical process. *Frontiers in Neurology*, *9*, 573. https://doi.org/10.3389/fneur.2018.00573

Van Lancker Sidtis, D., & Yang, S. Y. (2017). Formulaic language performance in left-and right-hemisphere damaged patients: Structured testing. *Aphasiology*, *31*(1), 82–99. https://doi.org/10.1080/02687038.2016.1157136

Van Lancker Sidtis, D. (2022). Familiar phrases in language competence: Linguistics, psychological, and neurological observations that support a dual process model of language. In A. Haselow & K. Gunther (Eds.), *Grammar and cognition: Dualistic models of language structure and language processing* (pp. 29–57). John Benjamins Publishing Company.

Walker, G. M., Fridriksson, J., Hillis, A. E., den Ouden, D. B., Bonilha, L., & Hickok, G. (2022). The severity-calibrated aphasia naming test. *American Journal of Speech-Language Pathology*, *31*(6), 2722–2740. https://doi.org/10.1044/2022_AJSLP-22-00071

Wallace, S. J., Worrall, L., Rose, T., Le Dorze, G., Breitenstein, C., Hilari, K., Babbitt, E., Bose, A., Brady, M., Cherney, L. R., Copland, D., Cruice, M., Enderby, P., Hersh, D., Howe, T., Kelly, H., Kiran, S., Laska, A. C. … Webster, J. (2019). A core outcome set for aphasia treatment research: The ROMA consensus statement. *International Journal of Stroke*, *14*(2), 180–185. https://doi.org/10.1177/1747493018806200

Wray, A., & Perkins, M. R. (2000). The functions of formulaic language: An integrated model. *Language & Communication*, *20*(1), 1–28. https://doi.org/10.1016/S0271-5309(99)00015-4

Wray, A. (2017). Formulaic sequences as a regulatory mechanism for cognitive perturbations during the achievement of social goals. *Topics in Cognitive Science*, *9*(3), 569–587. https://doi.org/10.1111/tops.12257

Yeldman, M. (2020). Does the presence of formulaic language help or hinder second language listeners' lower-level processing. *Language Teaching Research*, *24*(3), 338–363. https://doi.org/10.1177/1362168818787828

Zhu, F., & Fellbaum, C. (2015). Quantifying fixedness and compositionality in Chinese idioms. *International Journal of Lexicography*, *28*(3), 338–350. https://doi.org/10.1093/ijl/ecv018

Zimmerer, V. C., Hardy, C. J. D., Eastman, J., Dutta, S., Varnet, L., Bond, R. L., Russell, L., Rohrer, J. D., Warren, J. D., & Varley, R. A. (2020). Automated profiling of spontaneous speech in primary progressive aphasia and behavioral-variant frontotemporal dementia: An approach based on usage-frequency. *Cortex, A Journal Devoted to the Study of the Nervous System and Behavior*, *133*, 103–119. https://doi.org/10.1016/j.cortex.2020.08.027

Zimmerer, V. C., Newman, L., Thomson, R., Coleman, M., & Varley, R. A. (2018). Automated analysis of language production in aphasia and right-hemisphere damage: Frequency and collocation strength. *Aphasiology*, *32*(11), 1267–1283. https://doi.org/10.1080/02687038.2018.1497138

Zimmerer, V. C., & Varley, R. (2016). Formulaic language in people with probable Alzheimer's disease: A frequency-based approach. *Journal of Alzheimer's Disease*, *53*(3), 1145–1160. https://doi.org/10.3233/JAD-160099