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Sentence Production in a Discourse Context in Latent Aphasia: A Real-Time Study

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ABSTRACT

Purpose: The purpose of this study was to improve our understanding as to which factors determine online, spoken sentence production abilities of adults with latent aphasia in a discourse context.
Method: Discourse samples of the story of Cinderella elicited from AphasiaBank were analyzed with speech analysis software. Participants comprised people with latent and anomic aphasia as well as neurotypical controls (10 per group). Durations of pauses (silent and filled) were analyzed according to (a) the location they occurred (between or within sentences), (b) the syntactic complexity of sentences (simple, complex), and (c) sentence length (number of words). Statistical comparisons were conducted using mixed-effect models.
Results: The two clinical groups (latent and anomic) differed from controls in the duration of pauses, both between and within sentences. Syntactic complexity did not exert an effect on either of the two clinical groups as compared with controls. As compared with controls, both clinical groups paused more before long in comparison with short sentences.
Conclusion: Reduction in processing speed, which affects the ability to simultaneously maintain multiple linguistic and other cognitive demands associated with planning and monitoring of utterances, is a major factor that compromises sentence production in spoken discourse in latent aphasia.
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The spoken discourse production of people with aphasia has been a topic of intense research in clinical aphasiology because of its clinical utility as an ecologically valid level of linguistic description. Discourse refers to the level of linguistic analysis (in comprehension or production) beyond single sentences or utterances and may be monologic or dialogic (i.e., conversations). Types of discourse include personal narratives, telling stories, and procedural narratives. For people with aphasia, discourse production is a key to participation in communicative interactions and enables them to maintain effectively their social roles, which in turn enhances well-being (e.g., Beeke et al., 2011; Dipper et al., 2021; Hazamy & Obermeyer, 2020; Kagan & Simmons-Mackie, 2013; Milman, 2016). This study examined the distribution and duration of pauses produced by individuals with latent aphasia in order to improve our understanding of real-time discourse production in this group. This study also compared people with latent aphasia to people with anomic aphasia and neurotypical controls to understand better real-time discourse production in each group. This study builds on previous work on latent aphasia (DeDe & Salis, 2020), which examined discourse from a macrolinguistic perspective (analyses of episodes) and rate of delivery of information (e.g., words per minute), which may be conceived as a processing speed measure.

Discourse production is highly complex, because it relies on the simultaneous engagement and seamless interaction and integration of multiple microlinguistic (e.g., lexical and syntactic), macrolinguistic (e.g., story grammar, topic maintenance, and inferential processing), and broader cognitive abilities (e.g., memory and attention). In the context of aphasia, all these factors have been shown

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to be problematic to a greater or lesser extent (e.g., Alyahya et al., 2020; Cahana-Amitay & Jenkins, 2018; Fergadiotis et al., 2011; Karaduman et al., 2017; Olness et al., 2010; Richardson et al., 2021; Ulatowska et al., 1981; Webster et al., 2007). For example, studies that utilized microlinguistic analyses of discourse samples of people with aphasia found reduced lexical diversity and predicate-argument structure difficulties, with both these findings evident in fluent and nonfluent people with aphasia (e.g., Alyahya et al., 2020; Webster et al., 2007). From a macrolinguistic perspective, Ulatowska et al. (1981) found that people with mild aphasia produced well-structured narratives that observed linguistic rules of narrative macrostructure. However, there is also evidence that aspects of narrative sequencing can be problematic for many people with aphasia, especially in more severely affected individuals (Richardson et al., 2021). From a broader cognitive perspective, Cahana-Amitay and Jenkins (2018) found that working memory (indexed by word and sentence span) influenced macrolinguistic narrative structure in people with aphasia. These authors argued for a potential deficit in the episodic buffer component of working memory (Baddeley & Wilson, 2002), affecting sequential and hierarchical narrative information processing.

Critically, all the micro- and macrolinguistic processing that underlies normal discourse production must occur within a very short time span. However, most research has focused on measures that can be described as *offline* as opposed to *real time* (or online). This is evident in seminal reviews that discuss the range and nature of discourse impairments in people with aphasia (Armstrong, 2000; Boyle, 2011; Bryant et al., 2016; Dietz & Boyle, 2018; Dipper et al., 2020; Linnik et al., 2016; Pritchard et al., 2017; Simmons-Mackie et al., 2014; Ulatowska et al., 1990; Webster et al., 2015). Offline measures (micro- and macrolinguistic) are typically coded after the discourse sample has been orthographically transcribed and seldom consider how quickly words, sentences, episodes, or other building blocks of discourse have been produced in real time. Few studies have focused on real-time, temporal measures such as speech or articulation rate expressed as words per minute, duration of pauses, and other disfluencies to study discourse in aphasia. Furthermore, most studies focused on moderate–severe aphasia rather than mild aphasia (e.g., Andreeta et al., 2012; Armstrong et al., 2013; Clough & Gordon, 2020; DeDe & Hoover, 2021; Gordon & Clough, 2020; Pritchard et al., 2018, but see Crutch & Warrington, 2003; DeDe & Salis, 2020; Fromm et al., 2017; Harmon et al., 2019; Law et al., 2015, for studies of latent aphasia). However, it is critical to examine real-time discourse production in very mild, or latent, aphasia in order to optimize both treatment targets and outcome measures.

Processing Speed as a Diagnostic Marker for Latent Aphasia

Latent aphasia is not an established diagnostic category, like other aphasia syndromes. Perhaps as a result, this population has been described using several different terms and is not yet well understood. Adults with acquired neuropathologies who, after initial recovery, perform within norms on aphasia tests have been described as presenting with *latent aphasia* (DeDe & Salis, 2020; Pichot, 1955; Salis et al., 2021; Vallar et al., 1988). Other synonymous diagnostic labels include *subliminal aphasia* (Boller, 1968), *people who have become nonaphasic* (Neto & Santos, 2012), *not aphasic by WAB* (Western Aphasia Battery; Dalton & Richardson, 2015; Fromm et al., 2017), and *very mild aphasia* (Cavanaugh & Haley, 2020). The term *latent aphasia* was coined by Pichot (1955) in the context of people affected by atherosclerosis, although other researchers described similar conditions earlier according to Boller and Vignolo (1966). Typically, people with latent aphasia sustained a left hemisphere stroke and their linguistic skills fall within normal limits on aphasia tests that do not log response time (Neto & Santos, 2012; Vallar et al., 1988). In this study, the term *latent aphasia* is used in this manner.

Despite within-normal-limits performance on aphasia test batteries, recent evidence shows that people with latent aphasia face communication difficulties in their everyday lives. In two qualitative studies, Haley and colleagues (Cavanaugh & Haley, 2020; Harmon et al., 2019) examined perceptions of communication abilities in people with latent aphasia (i.e., who scored above the cutoff score on the WAB). Their participants reported that they needed to prepare more for communication, were slower to respond, experienced anomia, and expended more effort during communication in comparison with their preinjury communication skills. One person described their language as follows: "*I have to think about what I'm going to say and the words I'm going to use.... I have to slow down*" (Cavanaugh & Haley, 2020; p. 8), whereas another person said *"my words are not fluent, the language is not nice.... It comes out in parts and pieces"* (Cavanaugh & Haley, 2020; p. 8). Such findings are broadly similar to those reported in the general stroke literature, which found that mental slowness is a long-term and significant issue based on subjective (Visser-Keizer et al., 2002; Winkens et al., 2009) and objective measures (Egelko et al., 1989; Gerritsen et al., 2003).

In previous work (DeDe & Salis, 2020), the authors argued that processing speed, a construct that originated in the neurotypical aging literature (Birren, 1965; Hartley, 2006; Salthouse, 1993), is a useful diagnostic marker and explanatory construct in latent aphasia. Processing speed refers to how quickly cognitive operations are performed (Purdy, 2002; Salthouse, 1996). This theoretical position

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was motivated primarily from the seminal work of Neto and Santos (2012) who argued that "aphasia implies not only a disorder of linguistic functions but also a disorder of processing speed of the received information and of the speech generation, at least when the level of language is complex." (pp. 1359–1360). The previous study by DeDe and Salis (2020) affirmed this thesis. These authors found that slowed narrative production as measured by words per minute differentiated latent aphasia from neurotypical controls. Temporal speech measures may be regarded as task-specific processing speed measures (Cowan & Kail, 1996; Kail & Salthouse, 1994; Salis et al., 2018) as opposed to global processing speed measures such as the digit symbol substitution (Salthouse & Coon, 1993). DeDe and Salis (2020) also found that speed of narrative production (words per minute) in people with anomic aphasia was slower than people with latent aphasia, suggesting a continuum of impairment. These findings and implicitly those of others (e.g., Fromm et al., 2017) suggest that processing speed is a useful marker of severity of linguistic impairments. In this study, the authors expand on their previous work by examining duration of pauses between and within utterances in a discourse context.

Distribution of Pauses in Spoken Sentences and Discourse Production

Pauses (silent and filled; e.g., "uhm" "erh") are established real-time measures in psycholinguistics (e.g., Goldman-Eisler, 1972; Hawkins, 1971; Levelt, 1989) and aphasiology (e.g., Angelopoulou et al., 2018; Mack et al., 2015; Schlenck et al., 1987). Pauses reveal the subtle difficulties people with aphasia have with aspects of language planning and production, monitoring, and speed of information processing. For example, Angelopoulou et al. (2018) argued that long pauses in aphasia reflect both lexical retrieval and sentence planning difficulties. Schlenck et al. (1987) found impaired postarticulatory monitoring in people with Broca's and Wernicke's aphasia. Speech monitoring behaviors, operationalized as pauses, repetitions, and revisions during a single sentence production task, differed as a function of overall aphasia severity: Pauses occurred in approximately 50% of responses in amnesic (i.e., anomic) aphasia, 70% in Broca's aphasia, and 80% in Wernicke's aphasia. They also examined 10 nonaphasic individuals who had almost recovered from vascular aphasia (i.e., presented with latent aphasia). These individuals evinced trouble-indicating behaviors (i.e., pauses) in about 30% of responses, whereas in neurotypical controls the proportion was 10%. Taken together, the results suggest that aphasia severity and pauses correlate positively.

Pauses occur both between and within sentences (Holmes, 1988). Several authors postulate that within-sentence pauses reflect word-finding difficulties in neurotypical and atypical adults (Gayraud et al., 2011; Goldman-Eisler, 1961, 1968, 1972; Levelt, 1989; Mack et al., 2015; Peach, 2013; Pistono et al., 2016). In a sentence repetition study, Salis et al. (2021) reported no significant difference in pauses within sentences between controls and a latent aphasia group. However, the repetition task reported by Salis et al. (2021) may not have been challenging enough to induce longer pause durations.

In contrast, pauses *between* sentences may relate to sentence planning (Goldman-Eisler, 1972; Kircher et al., 2004; Levelt, 1989), similar to speech onset latencies in single sentence production studies in neurotypical and aphasia studies (Ferreira, 1991, 2007; Lee, 2020; Lee et al., 2015; Lee & Thompson, 2011). Similarly, speech onset latencies in sentence repetition are slower in people with latent aphasia compared with neurotypical controls (Salis et al., 2021). Several authors suggested that spoken sentence production in discourse proceeds incrementally, meaning that planning of a subsequent sentence occurs concurrently with production of preceding utterances (Ferreira, 2007; Ferreira & Swets, 2002; Ford & Holmes, 1978; Levelt, 1989).

Moving beyond individual sentences, the present authors are unaware of any studies examining pause distribution in discourse in people with latent aphasia. There is however a study by Peach (2013) from the traumatic brain injury (TBI) literature that examined silent pauses and disfluencies in clauses elicited from discourse in people who had language impairments secondary to TBI and neurotypical controls. Peach measured silent pauses (> 200 ms) in a picture description task and then classified them according to location, that is, between or within clauses. The number of between-clause silent pauses was greater in the TBI than the control group. This finding was explained as a need for additional time for planning well-formed sentences. In contrast, the number of silent pauses *within* clauses did not significantly differ between the two groups, even though several participants in the TBI group evinced anomia in confrontation naming (Peach, 2013).

To summarize, pauses within and between utterances have been interpreted as reflecting different aspects of linguistic processing. There is evidence that people with latent aphasia differ from controls in pause durations, but this is based on sentence repetition tasks. In a discourse task, people with TBI produced more pauses than controls between but not within clauses. In this study, the present authors extend their previous work by examining distribution of pauses between and within utterances produced during a story retell task.

Effect of Sentence Complexity on Pause Duration

Although sentence complexity has attracted a great deal of interest and controversy in aphasiology, it has

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seldom been studied in a discourse context with real-time measures. Sentence complexity metrics are abundant in both neurotypical (e.g., Bock, 1982; Obler et al., 1991; Yngve, 1960) and aphasia literature domains (e.g., Edwards, 2005; Saffran et al., 1989; Thompson & Edwards, 1995). Complexity has been defined in different ways, including subordination of clauses, canonical and noncanonical word order, and verb complexity, for example, ergative-unaccusatives (e.g., Caplan et al., 2007; Faroqi-Shah & Thompson, 2003; Ferreira, 2003).

Experimental studies of constrained sentence production often show protracted response times and erroneous responses for more complex sentences across populations (Faroqi-Shah & Thompson, 2003; Ferreira, 1991; Lee et al., 2015). However, results are less clear-cut with respect to the role of sentence complexity in discourse, where speakers exercise linguistic choices freely. Cook et al. (1974), who used a subordination index of sentence complexity, found no association between filled pauses and syntactic complexity. A corpus study of filled pauses in the conversational speech of 333 neurotypical adults (age range: 17–68 years) found that pause rate was more strongly associated with sentence length ($r = .31$, $p < .001$) than sentence complexity ($r = .16$, $p < .01$; Horton et al., 2010; also cf., Rochester & Gill, 1973). These findings are congruent with Goldman-Eisler's (1968) assertion that total pause time increases with sentence length.

More recently, Lee et al. (2019) analyzed silent pauses in Cinderella narratives elicited from neurotypical adults (younger and older) and people with Parkinson's disease. They did not find a greater number of pauses in complex sentences with subordinate clauses. However, in the older adult and Parkinson's groups, there were moderate negative correlations between clause density (mean number of embedded clauses) and a syntactic pause index, which was computed by dividing the number of pauses by the total number of possible syntactic positions. Because the two groups had similar mean length of utterance (MLU), the results suggest that sentence complexity may elicit different pause patterns in neurotypical older adults.

This Study

In this study, duration of pauses within and between sentences in latent aphasia was examined. People with latent aphasia were compared with both neurotypical controls and a group with anomic aphasia in order to delineate the symptoms that distinguish latent aphasia from other groups and to further examine whether processing speed deficits—operationalized as pause duration—varies as a function of aphasia severity. Unlike previous studies that considered number (i.e., frequency) of pauses (silent or filled), this study examined duration of these pauses because pause duration captures real-time sentence production more accurately. Thus, durational measures of silent and filled pauses from the story of Cinderella were elicited, which was categorized according to location (between and within utterances).

Three research questions were addressed. (a) Are pause durations longer between or within sentences, and does this factor differ as a function of group? (b) Are pauses longer before versus within complex and simple sentences, and if so, does this change as a function of group? (c) Is the "cost" (as measured by longer pause durations) associated with producing a longer sentence constant across groups? Cost is a term that features in sentence processing studies to denote protracted response times in linguistic structures that are considered complex (e.g., Bultena et al., 2014; Gibson, 1998). It is intuitive to assume that sentences with more words will be longer in duration. The question was whether the additional time associated with each additional word was similar across groups. On the basis of previous work (DeDe & Salis, 2020) and Neto and Santos (2012), the prediction was that people with latent aphasia would be significantly slower than neurotypical controls; contrastingly, people with latent aphasia would be faster than people with anomic aphasia.

Method

Participants

Thirty participants were selected from AphasiaBank (MacWhinney et al., 2011), 10 in each of the following groups: People with latent aphasia, anomic aphasia, and neurotypical controls—the same participants as in DeDe and Salis (2020). Participants in the three groups were selected based on English as their primary language. The two clinical groups were also selected on the basis of absence of a motor speech disorder and left hemisphere stroke. An aphasia quotient (AQ) of greater than 93.8 in the WAB-R (Kertesz, 2006) was the basis of the diagnostic category of latent aphasia. Note that AphasiaBank refers to this group as being "nonaphasic" based on their WAB-R performance. People in the anomic category were classified by AphasiaBank researchers based on standard behavior featured according to the WAB-R. No other selection criteria were used. The two clinical groups (i.e., latent aphasia and anomic aphasia) were similar in time poststroke. The three groups were matched for age, sex, and years of education. Biographical information and statistical comparisons are shown in Table 1.

Analyses Procedures

Participant video data of the first narration of the story of Cinderella were downloaded from AphasiaBank. Audio files were created from the videos and were then imported into Praat speech analysis software (Boersma &

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Table 1. Biographical information about the participants and between-group comparisons.

Characteristics	Participant groups			Comparisons
	Latent aphasia	Anomic aphasia	Neurotypical controls	
Age	61.5 (12.9)	58.5 (6.4)	60.3 (12.1)	K-W (2) = 4.61, p = 1.00
Education	15.9 (2.7)	16.0 (3.6)	15.2 (1.9)	K-W (2) = 0.58, p = .75
Sex	7 F, 3 M	7 F, 3 M	6 F, 4 M	χ^2 (2) = 0.30, p = .86
TPO	5.5 (4.8) [1–15.7]	5.8 (4.3) [0.75–14.8]	N/A	U = 0.57, p = .57
AQ	97.2 (1.8) [95.8–99.6]	87.2 (6.9) [68.7–93.2]	N/A	U = 3.74, p < .001

Note. Values shown are means (*SDs*), unless stated otherwise; statistical comparisons are two-tailed; K-W = Kruskal–Wallis test; F = female; M = male; TPO = time poststroke in years [range]; N/A = not applicable; *U* = Mann–Whitney test; AQ = aphasia quotient [range].

Weenink, 2016). Using Praat's semiautomated function of silent pause identification (which was set at ≥ 200 ms), each audio file was segmented into speech and silent segments. Then, the audio files were segmented and coded into utterances in a Praat TextGrid following the utterance segmentation of the AphasiaBank transcripts.

In a separate TextGrid, each utterance was then given one of the following three sentence codes: *simple*, *complex*, or *incomplete*. Durations of all sentences were logged. Simple sentences were defined as structures that comprised one independent clause, which contained a subject and a predicate. Simple sentences may have contained a compound noun or verb making the length of the sentence vary. Complex sentences were structures that consisted of one or more dependent clauses to an independent clause. Sentences that were connected with a coordinating conjunction (e.g., and, but, and or) were classified as simple sentences. Complex sentences included at least one embedded clause and typically had a subordinating conjunction (e.g., because, when, and although) or a relative pronoun (e.g., that, which, and who). Complex sentences did not necessarily have noncanonical word order, because so few were produced during the narrative samples. Incomplete sentences contained errors of omission or substitution that are semantic, syntactic, or morphological in nature. Abandoned utterances were also logged as incomplete. Incomplete utterances were excluded from further analysis.

Additionally, each sentence was segmented and coded for silent pauses (including breaths, if audible) and filled pauses (i.e., "uh," "er," "eh," "uhm," and "mm") separately. Durations of these behaviors were also logged. In this study, no other disfluent speech behaviors were included in the analyses. For each sentence, silent and filled pauses were also coded separately according to location, that is, whether they occurred either between or within sentences. The durations of each silent and filled pause were logged. Durations of silent and filled pauses were combined, because both types are hesitation phenomena that relate to planning and monitoring processes (Levelt, 1989). Durations of both types of pauses reveal processing speed difficulties. Also, there is no universally accepted distinction for the different cognitive underpinnings of the two types of pauses.

The TextGrid files from each participant and all information they contained (durations of speech and silent segments, orthographic transcriptions, and all other coding) were converted to text files using Praat. These text files were then converted to separate Excel files (one per participant) in order to generate summaries of the following measures: Total durations of speech and silent segments and word counts per sentence were carried in Excel. Words in each sentence were counted following previously established rules (DeDe & Salis, 2020). Coding of silent segments between and within utterances was carried out in Excel. Finally, the information from each individual participant Excel file was copied into one large Excel file that was coded further with participant identifier and group identifier information for statistical analyses.

Fidelity

Formal fidelity data were not calculated. However, all data codes were checked at every stage. Identification of utterance boundaries was based on coding in the AphasiaBank transcripts. Two research assistants independently coded all utterances as simple, complex, or incomplete. Codes were compared and discrepancies resolved through discussion with the second author. Number of words were calculated by a research assistant and checked by the first author. Pauses were coded as filled or silent by a research assistant and checked by the second author. Pause durations were calculated by a research assistant and checked by the first and second authors.

Statistical Analyses

Data were explored using methods outlined by Casa (2018). Outliers were removed following use of the *tukey_outlier* function of R (*funModeling* package), separately for each group. These resulted in less than 1% of the data being excluded. The variables *pause duration* (collapsing filled and silent pauses) and *number of words* were centered to facilitate data interpretation. Filled and silent pauses were considered together, because both types of

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Table 2. Effects of pause location and group on pause duration.

Fixed effects	Statistical information				
	Estimate	*SE*	*df*	*t* value	*p*
Model 1 - anomic vs. latent aphasia					
(Intercept)	−.218	.162	21.2	−1.343	.194
Number words*	.437	.042	937.8	10.329	< .001
Group	.293	.230	21.4	1.271	.217
Location	.380	.101	920.7	3.754	< .001
Group × Location	.340	.141	920.7	2.407	< .001
Model 2 - control vs. latent aphasia					
(Intercept)	−.174	.057	26.30	−3.074	.005
Number words*	.149	.014	1317.4	10.568	< .001
Group	−.150	.077	22.8	−1.943	.064
Location	.380	.046	1302.5	8.234	< .001
Group × Location	−.349	.057	1302.5	−6.106	< .001

Note. *SE* = standard error; *df* = degrees of freedom.

*Covariate.

pauses can be attributed to pre-utterance planning and/or within-utterance monitoring processes (Levelt, 1989). Unless otherwise noted, data were analyzed with linear mixed-effect (LME) models using the lme4 package in R (Bates, 2010). All models included random intercepts for participants. Variables were treatment coded, with the latent aphasia group serving as the reference for group analyses and simple sentences for analyses of sentence complexity. Models comparing the control group to the latent aphasia group were run separately from models comparing the latent aphasia group to the anomic group, in deference to the sample size ($n = 10$ per group) and to facilitate interpretation. Alpha was set at $p < .05$.

Results

Question 1: Are pause durations longer between or within sentences, and does this factor differ as a function of group? To address this question, two LME models were run with the independent variables group (anomic vs. latent; latent vs. control) and pause location (between vs. within utterance). Number of words were included as a covariate to control for effects of utterance length. Table 2 contains the results of the analyses. Descriptive statistics are in Table 3. In both models, number of words was significant, with longer sentences containing more pauses. There was an interaction between group and pause location in both models (latent vs. anomic and latent vs. control). People with latent aphasia (see Model 2) had significantly longer pause durations than the control group and significantly shorter pause durations than the anomic group, and pause durations were longer within than between sentences. The magnitude of the location effect was greater in people with latent aphasia than controls and smaller in people with latent aphasia than people with anomic aphasia.

Table 3. Descriptive statistics of pause duration by group and pause location.

Group	Pause location	
	Between utterances	Within utterances
Latent	0.760 (0.849)	1.603 (2.373)
Anomic	1.25 (2.1)	2.828 (4.39)
Control	0.374 (0.467)	0.451 (0.796)

Note. Statistics are reported in means (*SDs*); figures are in seconds.

Question 2: Are pauses longer before versus within complex and simple sentences, and if so, does this change as a function of group? Table 4 presents the average number of utterances and words per utterance by group. To examine effects of complexity on pause duration, two LME models were ran with group (anomic vs. latent; latent vs. control) and sentence complexity (simple vs. complex) as independent variables. Again, number of words was the covariate to control for effects of utterance length. The results are shown in Table 5, with descriptive

Table 4. Descriptive statistics of number of utterances and words per utterance by group.

Variables	Participant groups		
	Latent	Anomic	Control
# of utterances			
Simple	14.9 (5.45)	19.0 (14.9)	30.3 (28.84)
Complex	8.1 (3.41)	5.2 (3.82)	13.0 (10.87)
Incomplete	0.80 (1.55)	2.1 (1.66)	0.20 (0.42)
# of words per utterance	10.19 (1.29)	8.81 (2.69)	11.62 (3.17)

Note. Statistics are reported in means (*SDs*). Incomplete utterances were omitted from analysis.

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Table 5. Effects of group and sentence complexity on duration of pauses between sentences.

	Statistical information				
Fixed effects	**Estimate**	***SE***	***df***	***t* value**	***p***
Model 1 - anomic vs. latent aphasia					
(Intercept)	–.152	.102	21.4	–1.487	.152
Number of words*	.003	.040	464.2	0.068	.946
Group	.170	.143	20.6	1.187	.249
Sentence complexity	.012	.096	454.6	0.122	.903
Group × Complexity	.019	.133	458.0	0.141	.888
Model 2 - control vs. latent aphasia					
(Intercept)	–.141	.028	31.4	–5.065	< .001
Number of words*	.020	.014	637.5	1.483	.14
Group	–.165	.036	21.5	–4.541	< .001
Sentence complexity	–.011	.041	653.0	–0.259	.80
Group × Complexity	–.006	.048	655.7	–0.124	.90

Note. *SE* = standard error; *df* = degrees of freedom.

*Covariate.

statistics for pause duration by utterance type in Table 6. As Table 5 shows (Model 1), there were no significant effects of group, complexity, or number of words on between-sentence pause duration when the anomic group was compared with the latent aphasia group. As Model 2 shows, the control group had shorter pauses between sentences compared with people with latent aphasia, but there was no main effect or interaction with sentence complexity.

Next, within-sentence pause durations were examined. The results of this analysis are shown in Table 7. Descriptive statistics is shown in Table 6. When the anomic group was compared with the latent aphasia group (Model 1), complex sentences were associated with longer pause duration in both groups. There was no main effect of group and no interaction between complexity and group. In the comparative analysis with neurotypical controls (Model 2), people with latent aphasia had longer within-sentence pauses than controls. There was no main effect of complexity, nor was there an interaction between group and complexity.

Question 3: Is the "cost" (as measured by longer pause durations) associated with producing a longer sentence was constant across groups? Two LME models were run (see Table 8) with independent variables group (anomic vs. latent; latent vs. control) and sentence length as measured by number of words (continuous variable). Mean pure word rate per sentence was included as a covariate to reduce the contribution of time taken to produce the words, including pauses within the words. Pure word rate only includes the duration of spoken (i.e., word) segments and is devoid from duration of silent and filled pauses (DeDe & Salis, 2020). Table 9 shows pause duration for short utterances, which had centered scores less than 0 (i.e., less than the mean) and long utterances, which had centered scores greater than 0. The interaction between group and number of words was significant when the latent aphasia was compared with both the anomic group and the control group. The latent aphasia group showed a smaller "cost" of adding words to the utterance (289 ms) than the anomic group and a greater "cost" of adding words than the control group (290 ms).

Post hoc analyses were run to elucidate whether pause duration differed between groups for short and long utterances, as defined above. Pairwise comparisons (e.g., short utterances in latent vs. control groups, long utterances in latent vs. control groups, short vs. long utterances in the latent group, short vs. long utterances in the control group) were calculated using *emmeans* in R. Of note, all

Table 6. Descriptive statistics of pause duration by group, complexity, and pause location.

	Sentence complexity & pause location			
	Simple		Complex	
Group	**Between**	**Within**	**Between**	**Within**
Latent	0.751 (0.744)	1.402 (2.150)	0.763 (0.994)	1.979 (2.784)
Anomic	1.172 (2.00)	2.585 (4.066)	1.067 (1.588)	3.398 (4.834)
Control	0.362 (0.456)	0.270 (0.585)	0.408 (0.494)	0.857 (1.029)

Note. Statistics are reported in means *(SDs)*; figures are in seconds.

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Table 7. Effects of group and sentence complexity on duration of pauses within sentences.

Fixed effects	Statistical information				
	Estimate	*SE*	*df*	*t* value	*p*
Model 1 - anomic vs. latent aphasia					
(Intercept)	0.327	.259	19.1	1.262	.222
Number of words*	1.01	.080	459.4	12.655	< .001
Group	0.599	.365	18.6	1.642	.117
Sentence complexity	−0.719	.192	451.7	−3.742	< .001
Group × Complexity	0.413	.267	454.2	1.545	.123
Model 2 - control vs. latent aphasia					
(Intercept)	0.179	.099	21.8	1.809	.084
Number of words*	0.324	.030	653.3	10.673	< .001
Group	−0.434	.136	19.5	−3.195	.005
Sentence complexity	−0.010	.089	644.1	−.115	.908
Group × Complexity	−0.188	.106	645.7	−1.769	.077

Note. *SE* = standard error; *df* = degrees of freedom.

*Covariate.

relevant[1] pairwise comparisons for people with latent aphasia and controls were significant (all *t*s > 3.79; all *p*s < .001), except the comparison between short utterances in the two groups, $t = .67$, $p = .90$. Similarly, all pairwise comparisons for the latent and anomic aphasia groups were significant (all *t*s > 4.7; all *p*s < .0001), except the comparison between short utterances in the two groups, $t = 2.382$, $p = .11$. Descriptive statistics of individual data can be found in Supplemental Material S1.

Discussion

The purpose of this study was to improve our understanding of factors that determine online, spoken sentence production abilities of adults with latent aphasia in a discourse context. It built on a previous study (DeDe & Salis, 2020) that focused on temporal aspects of macrostructure and rate of information delivery.

The first research question of this study focused on how pauses (silent and filled) are distributed throughout spoken discourse with respect to their location (between and within utterances). Previous work showed that people with latent aphasia paused longer before introducing new episodes (DeDe & Salis, 2020). Here, the research question was whether pause duration was greater between utterances or within utterances. All groups had longer pause duration within than between utterances. This difference was greater in the latent aphasia group than the control group. It was also greater in the anomic than latent aphasia group. Because the two clinical groups differ also in terms of aphasia severity (as measured by AQ), the present finding underscores that not only measures of accuracy such as AQ but also measures of time can differentiate aphasia severity (DeDe & Salis, 2020; Fromm et al., 2017). Similar findings in terms of pause location are also evident in Peach (2013). An analysis of the data presented in Table 2 of Peach's study shows a significant difference in the two pause locations, $t = (28) = 3.341$, $p = .0024$ (two-tailed); within clause pauses occurred on average 5.73 whereas between clause pauses averaged 1.33 occurrences. A similar pattern was also evident in the six controls. Thus, Peach's and our present results are consistent with the view that utterance planning is incremental, meaning that its realization in speech proceeds in a piecemeal fashion (e.g., Ferreira & Swets, 2002; Levelt, 1989). The within-utterance pauses may reflect syntactic and semantic processes related to clause-by-clause planning and/or monitoring as well as phonological and prosodic processes that operate simultaneously or in parallel akin to Salthouse's (1996) simultaneity mechanism. However, unlike controls, people with latent aphasia interrupt themselves and therefore slow down to cope with the linguistic demands.

The second research question focused on the factors that may lead to longer pause durations during discourse production. Thus, this question examined whether two utterance-level metrics—sentence length and sentence complexity—were associated with longer pause durations. Sentence complexity did not interact with group for within- or between-sentence pauses. On the basis of previous work, the prediction was that complex sentences would elicit longer sentence initiation latencies (e.g., Lee et al., 2015). In this study, people with latent and anomic aphasia showed longer pause duration within simple than complex sentences. However, the previous studies focused on people with more severe aphasia (e.g., agrammatic aphasia) and on production of single sentences. In our data, there were relatively few complex sentences, and only three had noncanonical thematic role order (i.e.,

[1]Irrelevant comparisons included, for example, short utterances in the latent group versus long utterances in the control group.

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Table 8. Pause duration by utterance length (short vs. long utterances).

Fixed effects	Statistical information				
	Estimate	*SE*	*df*	*t* value	*p*
Model 1 - anomic vs. latent aphasia					
(Intercept)	0.301	.201	21.9	1.5	.147
Utterance length	0.511	.135	456.3	3.794	< .001
Group	1.110	.291	23.9	3.821	< .001
Utterance Length × Group	0.920	.197	459.7	4.672	< .001
Model 2 - control vs. latent aphasia					
(Intercept)	3.157	.258	25.99	12.21	< .001
Utterance length	1.701	.209	653.0	8.147	< .001
Group	−1.793	.356	23.39	5.034	< .001
Utterance Length × Group	0.955	.261	651.9	3.658	< .001

Note. *SE* = standard error; *df* = degrees of freedom.

patient, verb, and agent). Thus, it was not possible to examine sentences with noncanonical thematic role order separately. It may be that the types of complexity that are typically found in discourse (i.e., embedded clauses that preserve canonical thematic role order) are not associated with increased planning effort, when they are licensed by the context and number of words is controlled.

The third research question focused on the "cost" (as measured by longer pause durations) of producing longer sentences and whether "cost" was constant across groups. In contrast to sentence complexity, sentence length in number of words was significantly different among groups. This finding was true even when pure word rate, which excluded all silent and filled pauses between words, was controlled for. Similar findings are evident in Peach (2013). The present authors conducted two correlational analyses of Peach's data (see Table 2; p. S289) to explore the presence of an association between number of pauses and utterance length (MLU in morphemes; MLUm). There were statistically significant correlations between MLUm and number of between- and within-clause pauses (ρ = .493, p = .031; ρ = .605, p = .008, both one-tailed). Thus, across populations, people with mild language impairments may produce more and longer pauses in longer sentences. This finding is also consistent with previous work showing that length contributes to pause duration to a greater extent than complexity (cf., Horton et al., 2010). It may be that pause duration is greater in longer sentences due to increased working memory demands for conceptual-semantic planning as well as simultaneous monitoring of what has been said, similar to the backtracking function of auditory-verbal short-term memory (McCarthy & Warrington, 1999) and other executive functions as well as processing speed.

Table 9. Interaction between utterance length and pause duration by group.

Group	Utterance length	
	Short utterances	Long utterances
Latent	1.606 (1.8)	3.183 (3.1)
Anomic	2.528 (3.1)	6.604 (6.6)
Control	0.509 (0.62)	1.330 (1.5)

Note. Statistics are reported in means (*SDs*); durations are in seconds.

DeDe and Salis (2020) suggested that impairment in Salthouse's (1996) simultaneity mechanism of processing speed might underlie slowed discourse production in people with latent aphasia. A deficit in the simultaneity mechanism might affect the speaker's ability to concurrently retrieve information from verbal long-term memory, lexico-semantic, and syntactic processing and maintain representation in short-term/working memory. This conclusion was based in part on slower speech rate for people with latent aphasia versus neurotypical controls. The present results suggest that there is a "cost" of adding words to utterances, above and beyond the time taken to produce each word. Of note, all three groups showed similar pause durations for relatively short utterances. In contrast, for longer utterances, people with anomic aphasia had longer pause durations than those with latent aphasia, and people with latent aphasia had longer pause durations than controls. Taken together, these results are consistent with the view that people with latent aphasia expend additional effort to produce discourse, as compared with neurotypical controls.

The following clinical implications emerge from this study's findings. First, people with latent aphasia may benefit from advice and/or training to produce shorter sentences. This strategy may reduce perceived or real stigma associated with people with latent aphasia producing discourse. Rehabilitation programs that focus on advice in the form of counseling for mild cognitive problems after minor stroke have started emerging in the psychological rehabilitation literature (Kontou et al., 2020,

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2021) but are less systematically documented in speech-language pathology. Our clinical experience suggests that such approaches are commonplace in clinical practice. People with latent aphasia often report difficulty communicating in their everyday lives despite performing at ceiling on standardized test batteries. For this reason, it is important to discern how their discourse production compares to both healthy controls and people with anomic aphasia in order to identify sensitive diagnostic markers and potential therapeutic targets. For example, interventions for people with latent aphasia may focus on metalinguistic or metacognitive strategies to cope with the demands of communication in real-life challenging environments, similar to Kersey et al. (2021).

Second, there was not a sentence complexity effect in this study. However, this should not be taken to mean that time for planning and producing discourse with complex sentences should be disregarded when clinicians discuss the nature of the communication difficulties people with latent may have or perceive to have (see Cavanaugh & Haley, 2020).

Third, as knowledge about the nature of communication difficulties and their effective clinical management in people with latent aphasia and related cognitive impairments in relatively mild neurological conditions such as minor stroke and transient ischemic attacks continues to grow, temporal, online measures should become more commonplace in research.

Finally, the authors acknowledge the exploratory and retrospective nature of our study and its key limitations, which arise from the sample size and external validity as well as by discourse elicitation choice (Cinderella narrative). Other limitations include the use of secondary data, the lack of specific demographic and medical information for participants as well as the lack of other cognitive tests that may assist in interpretation of findings.

Conclusions

The aim of this study was to improve our understanding as to the factors that determine online, spoken sentence production abilities of adults with latent and anomic aphasia in a discourse context. Real-time, online temporal measures were used to investigate the location of pauses (silent and filled) and where they occurred (between or within sentences). Duration of pauses and whether they occurred in syntactically simple or complexity of sentences (simple or complex) were also examined. Sentence length (number of words) and whether this variable determined pause time was also examined. The two clinical groups (latent and anomic) differed from controls in the duration of pauses, both between and within sentences. Syntactic complexity did not exert an effect on either of the two clinical groups as compared with controls. As compared with controls, both clinical groups paused more before long in comparison with short sentences. The findings underscore the value of temporal measures in understanding the nature of language difficulties in people with latent aphasia. The authors argued that reduction in processing speed, which affects the ability to simultaneously maintain multiple linguistic and other cognitive demands associated with planning and monitoring of utterances, is a major factor that compromises sentence production in spoken discourse in latent aphasia. Future studies should explore the nature of processing speed deficit in latent aphasia from a broader processing speed perspective and other cognitive constructs, notably executive functions.

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