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Research Article

Temporal and Episodic Analyses of the Story of Cinderella in Latent Aphasia

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Purpose: The purpose of this study was to improve our understanding of the language characteristics of people with latent aphasia using measures that examined temporal (i.e., real-time) and episodic organization of discourse production.
Method: Thirty AphasiaBank participants were included (10 people with latent aphasia, 10 people with anomic aphasia, and 10 neurotypical control participants). Speech material of Cinderella narratives was analyzed with Praat software. We devised a protocol that coded the presence and duration of all speech segments, dysfluencies such as silent and filled pauses, and other speech behaviors. Using these durations, we generated a range of temporal measures such as speech, articulation, and pure word rates. Narratives were also coded into episodes, which provided information about the discourse macrostructure abilities of the participants.
Results: The latent aphasia group differed from controls in number of words produced, silent pause duration, and speech rate, but not articulation rate or pure word rate. Episodic organization of the narratives was similar in these 2 groups. The latent and anomic aphasia groups were similar in most measures, apart from articulation rate, which was lower in the anomic group. The anomic aphasia group also omitted more episodes than the latent aphasia group.
Conclusions: The differences between latent aphasia and neurotypical controls can be attributed to a processing speed deficit. We propose that this deficit results in an impaired ability to process information from multiple cognitive domains simultaneously.

Stroke often affects multiple aspects of cognition, such as memory, attention, processing speed, and language (e.g., Barker-Collo, Feigin, Parag, Lawes, & Senior, 2010; Gerritsen, Berg, Deelman, Visser-Keizer, & Meyboom-de Jong, 2003; Tang et al., 2018; Vallar, Papagno, & Cappa, 1988). When language is affected, the resulting impairment is aphasia (Basso, 2003; Caplan, 1987). In routine clinical practice, aphasia is typically diagnosed when a person attains lower scores than neurotypicals on standardized tests that comprehensively assess language ability at different levels of linguistic description (e.g., words, sentences) in input and/or output modalities. Although case history information and the person's account of their language difficulties are also considered, identification of aphasia relies, to a large extent, on a test's sensitivity, that is, the test's ability to correctly classify an individual as presenting with aphasia. However, aphasia tests vary in their ability to reliably identify individuals with subtle language difficulties. This is an important issue because performance on objective measures, rather than patient-reported outcome measures, is often used to determine access to speech-language services (especially by third-party payers) and to document treatment progress. In addition, understanding the types of persistent yet subtle language difficulties in some individuals may shed light on both the nature of the impairments and appropriate treatment techniques. Thus, the purpose of this study was to investigate whether a set of measures that target linguistic and psycholinguistic processes differentiate people with subtle language difficulties from neurotypical controls and people with anomic aphasia.

In the aphasiology literature, individuals whose language was affected by stroke but perform within the normal range of performance on aphasia tests such as the Western Aphasia Battery (WAB; Kertesz, 1982, 2006) have been described by different diagnostic labels. These include *minimal dysphasia* (Critchley, 1972), *latent dysphasia* (Boller & Vignolo, 1966; Vallar et al., 1988), *subliminal*

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aphasia (Boller, 1968), *people who have become nonaphasic* (Neto & Santos, 2012), and *not aphasic by WAB* (Dalton & Richardson, 2015; Fromm et al., 2017). Other related labels that have been used include *mild aphasia* (Armstrong, Fox, & Wilkinson, 2013; Rönnberg et al., 1996), *subclinical aphasia* (Sarno, Buonaguro, & Levita, 1986), and *high-level aphasia* (Graham, 2006). Such a range of terms makes this clinical entity difficult to identify in the aphasiology literature. In addition, this literature is not restricted to stroke-related aphasia but extends to other pathologies, such as atherosclerosis (Pichot, 1955) and traumatic brain injury (Sarno et al., 1986). In this article, we will adopt Pichot's (1955) diagnostic label and use the term *latent aphasia*.

Overview of Latent Aphasia

Previous studies have documented the presence of language impairments in individuals with latent aphasia using a range of different tests and criteria (e.g., Boller, 1968; Boller & Vignolo, 1966; Fromm et al., 2017; Vallar et al., 1988). One challenge is identifying tasks that are reliably sensitive to subtle or latent language deficits. Individual differences can make it difficult to determine which tasks will be challenging for individuals with latent aphasia. In a study of auditory comprehension, a group with latent aphasia performed more poorly than a neurotypical control group, but inspection of the data revealed that many individuals with latent aphasia scored in a similar range as the neurotypical controls (Boller & Vignolo, 1966). With respect to single-word production, Vallar et al. (1988) found that five of 11 individuals with latent aphasia scored in the normal range in a naming task. Thus, there is often overlap between people with latent aphasia and neurotypical adults.

Spoken discourse may reveal the language impairments associated with latent aphasia. People with latent aphasia after stroke often report that speaking is a more cognitively demanding task compared to prestroke, even when they are ultimately able to communicate their thoughts. This difficulty is most apparent when producing discourse in challenging contexts. For example, Armstrong et al.'s (2013) participant expressed great frustration with her verbal abilities, particularly when using arguments in conversation. Other studies also noted subtly reduced discourse production abilities in prolonged or hurried conversation (e.g., Boller & Vignolo, 1966; Fromm et al., 2017). The increased cognitive demand likely reflects multiple variables, including covert and overt circumlocution to compensate for lexical retrieval difficulties, and increased effort with lexicosemantic and syntactic planning.

Our clinical experience and studies from the wider stroke literature (e.g., Winkens, Van Heugten, Fasotti, Duits, & Wade, 2006) suggest that the spoken output of individuals who present with latent aphasia is slower than that of age-matched neurotypical adults. However, most previous studies used accuracy of performance to identify language deficits in latent aphasia, rather than how long it takes a person to achieve accuracy. In a relatively early study, Vallar et al. (1988) found no significant difference in speech rate[1] between people with latent aphasia and neurotypical controls. However, their task did not involve propositional language, as participants were required to count from 1 to 20 as quickly as they could. More recent work has reported reliable group differences between participants with latent aphasia and neurotypical controls, when the time taken to perform language tasks is a dependent measure in input or output tasks (Fromm et al., 2017; Neto & Santos, 2012).

The idea that people with latent aphasia take more time to complete language tasks points to a potential impairment in processing speed. *Processing speed* is a general term that refers to how quickly cognitive operations are performed (Purdy, 2002; Salthouse, 1996). Slowed processing speed is a common sequela of stroke, even in the absence of aphasia (Gerritsen et al., 2003). Neto and Santos (2012) examined accuracy and speed of performance of 23 participants with latent aphasia on a range of linguistic tasks at the word and sentence levels. Using accuracy as a measure, group performance was within normal limits compared to neurotypical norms on all tasks. In contrast, when speed was the dependent measure, participants with latent aphasia were consistently slower than neurotypical controls. However, there were individual differences, and most people with latent aphasia overlapped with controls on at least one language task. The authors claimed that a defining feature of aphasia, in general, and of latent aphasia, in particular, is a processing speed impairment, which affects input and output language processes. The conceptualization of latent aphasia as a processing speed impairment relates to a more general view of speed of processing as a fundamental part of the architecture of the cognitive system (Salthouse, 1996). We return to this view in the Discussion section.

Fromm et al. (2017) recently compared the speech rate of Cinderella narratives among anomic aphasia, latent aphasia, and neurotypical control groups. Speech rate was expressed as words per minute, which was derived by dividing the total duration of the narrative by the number of words the person produced. Speech rate was slower in the latent aphasia group as compared with both neurotypical speakers and the people with anomic aphasia. They also identified other measures that distinguished latent aphasia from neurotypical controls, such as the number of utterances and main concepts, that is, detailed information about the story of Cinderella. For the purposes of this study, the critical finding was that speech rate is more sensitive to latent language impairments than the Aphasia Quotient of the WAB, which is a composite measure based on accuracy of performance. These results are also consistent with the idea that challenging discourse production tasks are good candidates for capturing communication impairments in people with latent aphasia.

[1]Vallar et al. (1988) use the term *articulation rate,* but the way it was derived seems to have followed the same method as the one used by Fromm et al. (2017). As it will become apparent later in the article, we use the term *articulation rate* differently.

The Present Study

This study focused on temporal measures of speech and language production, such as speech rate and articulation rate. Although speech rate is a useful measure, it is relatively coarse-grained. This is because speech rate comprises not only words that convey meaning but also silent pauses and other dysfluencies (e.g., filled pauses, revisions). Such speech behaviors have been noted in people with latent aphasia by other researchers (Armstrong et al., 2013; Boller & Vignolo, 1966; Fromm et al., 2017). These dysfluencies, by their very nature, disrupt the speed by which information is produced (Horton, Spieler, & Shriberg, 2010).

Dysfluencies have been associated with planning, monitoring, and editing aspects of language production in the aphasiology (e.g., Angelopoulou et al., 2018; Butterworth & Howard, 1987; Peach & Coelho, 2016; Sahraoui, Mauclair, Baqué, & Nespoulous, 2015) and neurotypical (e.g., Goldman-Eisler, 1968; Levelt, 1989) literatures. However, dysfluencies in latent aphasia have not been studied systematically to date. Consequently, it is not known how much time people with latent aphasia spend on planning, monitoring, and editing versus actual information production. To address this gap in the literature, we calculated both speech rate and more refined temporal measures of spoken output: (a) articulation rate, (b) pure word rate, and (c) silent pause duration. Articulation rate, as defined in our study, involves articulatory movement, and as such, it includes the duration of words and dysfluencies (e.g., filled pauses such as "uhm," "er," and revisions) but excludes silent pauses. Pure word rate can be described as a pure measure of information rate as it excludes silent and filled pauses and other dysfluencies. Speech rate included all dysfluency behaviors. Finally, we were interested in silent pauses ($\geq$ 200 ms) because pauses of this duration are thought to relate to lexicosemantic and syntactic aspects of planning (e.g., Goldman-Eisler, 1968; Peach & Coelho, 2016; Quinting, 1971).

We were also interested in whether fluctuating processing demands during narrative production influence the amount of dysfluency. Spoken discourse, particularly storytelling, is challenging. It involves producing a well-organized and sequential narrative that contains all critical information about participants and events. Introducing a new topic within a narrative may exert processing demands associated with switching attention to the new topic, retrieval of relevant lexical items, sentence planning, and tapping into verbal long-term memory to access key details of the story. For example, the introduction to the Cinderella story includes details such as *servant* and *stepmother,* whereas later episodes involve *the prince* and *the fairy godmother*. These processing demands might result in increased dysfluency and more silent pauses when transitioning between topics within a narrative.

We are not aware of any previous studies that examined whether switching topics within a narrative is associated with increased dysfluency. However, there is evidence that the ability to shift attention, which is likely involved in switching from one topic to the next, is related to impairments in functional communication and conversational abilities in aphasia (Frankel, Penn, & Ormond-Brown, 2007; Fridriksson, Nettles, Davis, Morrow, & Montgomery, 2006). Peach and Coelho (2016) found that adults without aphasia (according to the WAB) who had suffered traumatic brain injuries exhibited a particular deficit in connecting sentences in a picture description task, as evidenced by increased silent pauses and mazes within sentences. Thus, there is reason to expect that shifting from one part of a narrative to the next might be associated with increased processing demands, which might manifest as more dysfluencies.

To address this question, we compared the amount of dysfluency that occurred in utterances that did and did not introduce a new episode. Episodes are related to analysis of story grammar, in that both analyses are concerned with the main sequences of events and the macro- or superstructure of the narrative. Episodes of the Cinderella story were taken from Stark's (2010) analysis, which defined episodes based on Labov and Waletzky's (1967) description of narrative structures. These episodes represent the main sequence of events in the story, such as the orientation/setting of the story, the complication, and the solution.

Given that all episodes were coded, we examined a final question regarding how many episodes were mentioned in each narrative. Previous studies about narrative structure in latent and other types of aphasia focused on the information content. For example, there is evidence that spoken narratives of people with latent aphasia contain fewer main concepts than neurotypical controls (Dalton & Richardson, 2015; Fromm et al., 2017). This is also true for other types of aphasia (e.g., Andreetta & Marini, 2015; Armstrong, Ciccone, Godecke, & Kok, 2011; Linnik, Bastiaanse, & Höhle, 2016). Richardson et al. (2015) found that people with latent aphasia differed from neurotypical controls only in one aspect of the story of Cinderella, that of setting, which conveys information about Cinderella's domestic situation. In this study, we examined whether individuals with latent aphasia are more likely to omit episodes or whether episodes are likely to recur, which would indicate a reduced ability to organize narrative macrostructure.

To summarize, this study investigated three research questions. The first question was whether temporal measures, including silent pause duration, speech rate, articulation rate, and pure word rate, distinguish individuals with latent aphasia from those with aphasia and from neurotypical controls. We predicted that individuals with latent aphasia should differ from controls with respect to overall speech rate and silent pause duration but might not differ with respect to articulation rate or pure word rate. When compared to those with anomic aphasia, individuals with latent aphasia would likely show significantly faster speech rate and fewer silent pauses due to less severe language impairments.

The second question was whether speakers require more time to formulate utterances that introduce a new episode of a narrative, as indexed by an increase in behaviors such as dysfluencies and silent pauses. This question has not previously been examined, but we predicted that utterances that introduced a new episode would be associated with greater processing demands. We also predicted these effects would be greater in people with latent aphasia than in neurotypical controls and greater in people with anomic aphasia than those with latent aphasia.

Finally, we asked whether the episodic structure of Cinderella narratives differed among people with latent aphasia, those with anomic aphasia, and neurotypical controls. We predicted that people with latent aphasia would produce a similar number of episodes as neurotypical controls but that they might be more likely to revisit episodes due to difficulty in organizing the narrative efficiently.

Method

Participants

There were three groups of participants: neurotypical adults, individuals with latent aphasia, and individuals with anomic aphasia (n = 10 per group). Data were downloaded from AphasiaBank (MacWhinney, Fromm, Forbes, & Holland, 2011). As Table 1 shows, groups were matched with respect to age, education level, and gender. The groups with latent and anomic aphasia were matched with respect to time postonset of stroke but differed significantly with respect to the WAB-R Aphasia Quotient. The Aphasia Quotient of the WAB-R was the basis of these two diagnostic groups. The selection criteria were as follows: English as the primary language and absence of a motor speech disorder (apraxia of speech, dysarthria). No other selection criteria were used. The identifying AphasiaBank codes of each participant are shown in Appendix A.

Procedure

All participants completed the AphasiaBank protocol for either people with aphasia (latent and anomic groups) or healthy adults (neurotypical control group). For all participants, the Cinderella story audio files and orthographic transcriptions were imported into Praat software (Boersma & Weenink, 2016). Files were coded for both timing and linguistic variables. The audio files were segmented into utterances as defined by the AphasiaBank transcripts. The complete Cinderella story narrative was coded for all participants. Figure 1 shows a sample of how the files appeared in Praat, after coding (described below).

Coding Scheme

The theoretical rationale of the coding scheme focuses on how processing and transmission of linguistic information is realized over time. The principle of this analysis is grounded on the construct of dysfluency, which has a long history in aphasiology, yet behaviors of dysfluency have not been studied systematically as a tool for identifying latent aphasia previously. Furthermore, such behaviors have not been previously related to the construct of processing speed in latent aphasia. Our coding scheme comprises two parts: base and rate measures and discourse organization.

Base and Rate Measures

To derive durational measures, which were used to calculate other measures such as articulation rate and speech rate, we coded several behaviors, some of which (silent pauses, filled pauses, mazes) relate to the concept of speech fluency, as well as other behaviors such as sighs, breaths, and laughter. More details and definitions can be found in Appendix B. Silent pauses that occurred between utterances were assigned to the beginning of the next utterance. Filled pauses, laughter, or mazes were assigned to the utterance designated by AphasiaBank coders.

Discourse Organization

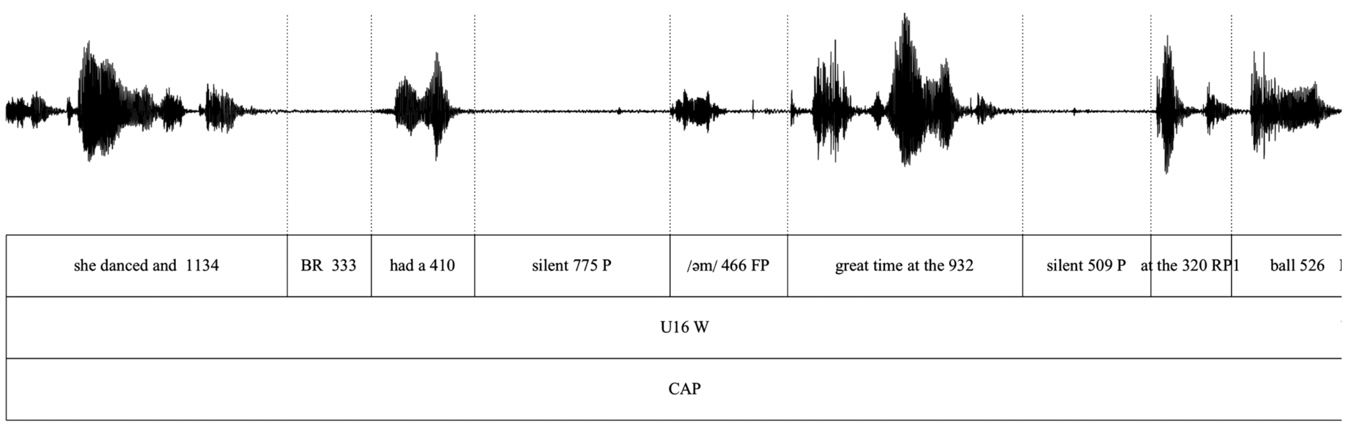
To investigate the episodic structure of narratives, we created a different text grid on Praat and divided each narrative into a series of episodes. We used the episodic structure of Cinderella narratives proposed by Stark (2010) and revised the codes from numerical to semantically based abbreviations (see Appendix C). Episode boundaries were identified independently from utterance boundaries. Thus, each utterance was also coded to indicate whether it introduced a new episode or continued the episode from the previous utterance. In some cases, the episode transition occurred within an utterance, rather than at the beginning of a new utterance. In this case, the utterance was coded as introducing a new episode. Note that these codes included all switches from one episode to another, meaning

Table 1. Biographical characteristics of the participant groups and between-groups comparisons.

	Participant groups			
Variables	Anomic aphasia	Latent aphasia	Controls	Group comparisons
Age	58.5 (6.4)	61.5 (12.9)	60.3 (12.1)	K-W(2) = 4.61, p = 1.00
Education	16.0 (3.6)	15.9 (2.7)	15.2 (1.9)	K-W(2) = 0.58, p = .75
Gender	7 F, 3 M	7 F, 3 M	6 F, 4 M	$\chi^2(2)$ = 0.30, p = .86
TPO	5.8 (4.3)	5.5 (4.8)	n/a	U = 0.57, p = .57
WAB Aphasia Quotient	87.2 (6.9)	97.2 (1.8)	n/a	U = 3.74, p < .001

Note. Values shown are mean (standard deviation), unless otherwise indicated. All comparisons are two-tailed. K-W = Kruskal–Wallis test; F = female; M = male; TPO = time poststroke in years; n/a = not available; U = Mann–Whitney test; WAB = Western Aphasia Battery.

Figure 1. Praat tiers. From top to bottom: (a) Speech and silence tier with associated durations of segments in milliseconds (BR = breath, FP = filled pause, P = pause, RP = repetition). (b) Utterance tier (U = utterance and its number, W = well-formed). (c) Episode tier and code.



that utterances that initiated a previously mentioned episode (recurrence) were coded as introducing a new episode.

Data Analyses

The following base measures were calculated first: (a) number of words (see Appendix D for word counting rules); (b) total duration of each narrative including silent pauses, filled pauses, words in mazes and false starts, laughter, coughs, and sighs; (c) silent pause duration (including breaths); (d) articulation duration (i.e., total duration of the narrative, excluding silent pauses and breaths but including filled pauses, words in mazes and false starts, laughter, coughs, and sighs, divided by number of words); and (e) pure word duration (i.e., duration of words, excluding silent pauses, filled pauses, words in mazes and false starts, laughter, coughs, and sighs, divided by number of words). Then, from these measures, we calculated three rate measures, namely, speech rate (i.e., total duration divided by number of words), articulation rate (i.e., articulation duration divided by number of words), and pure word rate (i.e., pure word duration divided by number of words).

We were also interested in whether introducing a new episode was associated with a measurable increase in processing demands, as indexed by the presence of behaviors such as dysfluencies and silent pauses. We refer to this measure as formulation time. Speech-timing measures were analyzed separately for utterances that marked the transition to a new episode and utterances that continued an episode. Formulation time was conceptualized as content not related to the story that could be used for processes such as planning, monitoring, or editing speech. Thus, we measured the following: (a) total formulation duration, which was the duration of all silent pauses, filled pauses, and mazes (repetitions, false starts, and revisions were disregarded), and (b) duration of utterances, which was measured separately for new versus continued episodes. The rationale for using such a broad measure was that time not spent producing propositional speech could be used to complete operations involved in initiating a new episode. To control for utterance duration, total formulation duration was divided by utterance duration, yielding the percentage of formulation time in the utterance. Finally, we devised an episode recurrence index, which counted how often a previous episode recurred in a narrative, and an episode omission index, which counted the number of episodes omitted from the narrative.

Data were analyzed using Kruskal–Wallis (K-W) rank sum tests to identify main effects of group, followed up with pairwise Dunn tests with Holm corrections for multiple comparisons at alpha levels of $p < .05$. Effect sizes are reported using epsilon squared (small effect < .08, medium effect < .26, large effect ≥ .26; cf. Mangiafico, 2016). Some within-group pairwise comparisons were carried out with Wilcoxon V tests (uncorrected). Effect sizes were calculated by dividing the absolute value of the z score by the square root of the sample size (Corder & Foreman, 2009). Effect sizes for Wilcoxon tests (ES) ranged from 0 to 1 and were interpreted following Cohen's (1988) conventions (small = .10, medium = .30, large = .50).

Reliability

Episode boundaries were coded independently by two trained undergraduate research assistants who met to resolve any inconsistencies. The resulting codes were then checked by a third coder (G. D.). Any discrepancies were resolved through discussion. The speech behavior codes (e.g., silent pauses, filled pauses) were coded by a trained research assistant and then checked by another trained student and the first author (G. D.). Word count was completed by a trained undergraduate student and checked by the second author (C. S.). For total formulation duration, 50% of the files were coded twice by the same individual (G. D., for intrarater reliability). Intrarater reliability was 95.3% for total formulation duration in the utterance.

Results

Base and Rate Measures

We first report base measures that were used to subsequently calculate rate measures. Descriptive statistics of both base and rate measures are shown in Table 2. Table 3 summarizes statistical differences and similarities between groups.

Number of Words

K-W tests showed a significant effect of group on the number of words in the sample, K-W = 9.9, $df = 2$, $p = .01$, $\varepsilon^2 = .34$. Post hoc comparisons showed that the control group produced more words than the clinical groups, that is, people with anomic aphasia, $Z = -2.9$, $p = .01$, or people with latent aphasia, $Z = 2.5$, $p = .01$. The latent aphasia group produced numerically more words than the anomic aphasia group (242 vs. 92 words), but this difference was not significant, $Z = -0.38$, $p = .35$.

Duration Measures

There were no significant group differences on total duration of the narratives, K-W = 2.2, $df = 2$, $p = .34$, $\varepsilon^2 = .07$, or pure word duration, K-W = 5.12, $df = 2$, $p = .08$, $\varepsilon^2 = .18$. There were no significant group differences on articulation duration, K-W = 4.83, $df = 2$, $p = .09$, $\varepsilon^2 = .17$. There was a significant effect of group on silent pause duration, K-W = 15.36, $df = 2$, $p < .001$, $\varepsilon^2 = .53$. Post hoc comparisons showed that silent pause duration was shorter in the control group compared to both clinical groups, anomic aphasia ($Z = 3.7$, $p < .001$) and latent aphasia ($Z = -3.04$, $p < .001$). The clinical groups did not differ from one another, $Z = 0.61$, $p = .27$.

Rate Measures

In terms of speech rate, there was a significant effect of group, K-W = 18.26, $df = 2$, $p < .001$, $\varepsilon^2 = .63$. Post hoc comparisons showed significantly higher speech rates in the controls compared to the anomic aphasia, $Z = -4.2$, $p < .001$, and latent aphasia, $Z = 2.8$, $p < .001$, groups, but the clinical groups did not differ from one another, $Z = -1.4$, $p = .09$.

There was also a significant effect of group on articulation rate, K-W = 8.5, $df = 2$, $p = .01$, $\varepsilon^2 = .29$. The post hoc comparisons showed significantly slower articulation rates in the anomic group compared to the controls, $Z = -2.87$, $p = .01$, and the latent aphasia group, $Z = -2.4$, $p = .02$. The control and latent aphasia groups did not differ from one another, $Z = -0.30$, $p = .38$.

For pure word rate, the main effect of group was significant, K-W = 8.8, $df = 2$, $p = .01$, $\varepsilon^2 = .30$, but the only significant pairwise comparison was between the anomic aphasia group and the control group, $Z = -2.9$, $p = .01$. People with anomic aphasia showed a slower pure word rate than controls. The comparison of anomic and latent aphasia groups approached significance, $Z = -1.9$, $p = .06$, with the anomic aphasia group having a numerically slower pure word rate than the latent aphasia group. The latent aphasia group did not differ significantly from the control group, $Z = 1.0$, $p = .15$.

Discourse Organization

Percentage of Formulation Time

This percentage represents the relative amount of formulation time in the utterance, controlling for the total utterance duration. Table 4 presents descriptive statistics, including total formulation duration for each group. Table 5 summarizes the pairwise comparisons.

First, we asked whether each group showed a significant difference in the percentage of formulation time in utterances that did and did not introduce a new episode. The neurotypical group's utterances contained proportionally more formulation time when they introduced episodes than when they continued episodes, $V = 3$, $p = .01$, ES = .82. The latent aphasia group showed a similar effect, $V = 5$, $p = .02$, ES = .74. However, the anomic aphasia group did not show a significant difference in the percentage of formulation time in the two types of utterances, $V = 17$, $p = .32$, ES = .31.

Next, we asked whether the percentage of formulation time differed across groups, separately for utterances that did and did not introduce a new episode. There was a significant effect of group for utterances that introduced a new

Table 2. Base and rate measure results.

	Participant groups		
Variables	Anomic aphasia	Latent aphasia	Controls
Word count	218 [156, 286]	242 [190, 292]	447 [321, 620]
Total duration	223 [145, 327]	139 [104, 172]	169 [118, 233]
Silent pause duration	95 [48, 156]	52 [34, 69]	10 [4, 17]
Articulation duration	129 [92, 174]	87 [69, 104]	158 [108, 223]
Pure word duration	92 [65, 128]	73 [58, 86]	122 [87, 167]
Speech rate	1.22 [0.84, 1.64]	1.83 [1.59, 2.04]	2.73 [2.47, 3.00]
Articulation rate	1.91 [1.43, 2.48]	2.83 [2.48, 3.20]	2.96 [2.63, 3.29]
Pure word rate	2.56 [2.02, 3.20]	3.34 [3.03, 3.67]	3.72 [3.46, 4.00]

Note. Figures are means, followed by the 95% confidence intervals. Duration figures are in seconds. Rate figures are in words per second.

Table 3. Base and rate measures: Summary of differences and similarities between groups.

Variables	Participant groups		
	Latent aphasia vs. controls	Latent aphasia vs. anomic aphasia	Anomic aphasia vs. controls
Word count	✓	x	✓
Total duration	x	x	x
Silent pause duration	✓	x	✓
Articulation duration	x	x	x
Pure word duration	x	x	x
Speech rate	✓	x	✓
Articulation rate	x	✓	✓
Pure word rate	x	x	✓

Note. ✓ denotes statistically significant difference; x denotes absence of significant difference.

episode ("new utterances"), K-W = 29.9, $df = 2$, $p < .001$, $\varepsilon^2 = .14$. Pairwise comparisons showed that the control group differed from the people with anomic aphasia, $Z = 5.03$, $p < .001$, and the latent aphasia group, $Z = -4.33$, $p < .001$. The percentage of formulation time in new utterances was smaller in the control group (27.2%) than in the clinical groups. The latent aphasia and anomic aphasia groups did not differ from one another, $Z = 0.80$, $p = .21$, meaning that the percentage of formulation time in the new utterances was similar in the two clinical groups (44.7% for people with anomic aphasia and 41.8% for people with latent aphasia).

The percentage of formulation time also differed across groups for utterances that continued an episode ("continued utterances"), K-W = 130.0, $df = 2$, $p < .001$, $\varepsilon^2 = .18$. All pairwise comparisons were significant. The percentage of formulation time in the continued utterances was greater in people with anomic aphasia than in those with latent aphasia, $Z = 2.77$, $p < .0013$, and in the latent aphasia group compared to controls, $Z = -6.94$, $p < .001$. The controls also produced proportionally less formulation time than the anomic aphasia group, $Z = 10.86$, $p < .001$.

Episode Omission and Episode Recurrence

Descriptive statistics for episode omission and episode recurrence indices are shown in Table 4, and pairwise comparisons are summarized in Table 5. The effect of group on episode omission was marginally significant, K-W = 5.9, $df = 2$, $p = .05$, $\varepsilon^2 = .20$. The anomic aphasia group was more likely to omit episodes than the latent aphasia, $Z = 2.1$, $p = .047$, or control, $Z = 2.0$, $p = .04$, groups. The episode that was omitted more than others was PAL *(Stepmother and stepsisters arrive at ball. Prince greets all guests. Guests are dancing and eating)*. There were no significant group differences in the episode recurrence index, K-W = 0.98, $df = 2$, $p = .61$, $\varepsilon^2 = .03$.

Discussion

The primary motivation for this study was to further characterize the language characteristics of people with latent aphasia using measures that tap into temporal aspects of discourse production ability.

Temporal Measures and Corresponding Impairments

First, the latent aphasia group produced, on average, almost half the number of words as their neurotypical counterparts. Furthermore, the duration measures showed that people with anomic and latent aphasia had longer silent pause durations than the control group, even though total articulation and pure word duration were similar

Table 4. Discourse organization results.

Variables	Participant groups		
	Anomic aphasia	Latent aphasia	Controls
Percentage of formulation time			
Utterance continues episode	42.0% [39, 45]	33.8% [31, 37]	19.3% [18, 21]
Utterance introduces a new episode	44.7% [39, 50]	41.8% [37, 46]	27.2% [23, 32]
Total formulation duration (s)			
Utterance continues episode	4.04 [3.37, 4.72]	2.25 [1.90, 2.67]	0.81 [0.71, 0.91]
Utterance introduces a new episode	5.07 [3.91, 6.36]	3.40 [2.69, 4.19]	1.71 [1.35, 2.09]
Episode recurrence index	1.9 [1.2, 2.6]	1.8 [1.3, 2.4]	1.4 [1.1, 1.7]
Episode omission index	2.1 [1.3, 3.2]	1.3 [0.7, 2.2]	1.0 [0.7, 1.3]

Note. Figures are means, followed by the 95% confidence intervals.

Table 5. Discourse organization: Summary of differences and similarities between groups.

Variables	Participant groups		
	Latent aphasia vs. controls	Latent aphasia vs. anomic aphasia	Anomic aphasia vs. controls
Percentage of formulation time			
Utterance continues episode	✓	✓	✓
Utterance introduces a new episode	✓	x	✓
Episode recurrence index	x	x	x
Episode omission index	x	✓	✓

Note. ✓ denotes statistically significant difference; x denotes absence of significant difference.

across the three groups. These results are inconsistent with our prediction that people with anomic aphasia would have longer silent pause durations than the latent aphasia group. Taken together, the findings that the latent aphasia group produced fewer words and longer silent pause durations than neurotypical controls suggest that people with latent aphasia may have difficulty retrieving lexical items during narrative production. We return to this point below.

The rate measures indicate that the latent and anomic aphasia groups transmitted information more slowly than the control group. The latent aphasia group differed from controls in terms of speech rate, but their articulation and pure word rates were similar. This is consistent with the finding that silent pause duration was the only duration measure that differentiated the latent aphasia and control groups. The fact that the latent aphasia group differed from the anomic aphasia group with respect to articulation rate indicates that the anomic aphasia group's discourse contained more filled pauses than the latent aphasia group. This may contribute to speech samples from people with anomic aphasia sounding more disordered than samples from people with latent aphasia. Further work is needed to substantiate this claim.

Processing Speed as a Key Impairment in Latent Aphasia

The differences in speech rate and silent pause duration are consistent with a previous work by Neto and Santos (2012), who argued that latent aphasia can be explained by a processing speed impairment. A processing speed impairment might be observed as differences in measures of rate or duration. However, other than silent pause duration, rate measures were more likely to differentiate groups than duration measures. Thus, rate measures seem to be more sensitive to language impairments in latent aphasia than duration measures. Neto and Santos elicited only one duration measure, similar to the total duration measure we generated, to capture language production differences. The rate measures in this study provide a more precise and comprehensive view of real-time linguistic processing than the duration measures alone.

It is interesting that both speech rate and silent pause duration distinguished the latent aphasia group from the control group. Silent pauses are thought to reflect lexicosemantic and syntactic planning (e.g., Peach & Coelho, 2016), and speech rate is the only rate measure that includes silent pauses. Taken together, these results suggest a language planning deficit in people with latent aphasia. To our knowledge, this deficit has not been substantiated before in the latent aphasia literature. Fromm et al. (2017) reported that individuals with latent aphasia had a slower speech rate than controls. However, they did not calculate articulation rate or pure word rate and so could not determine whether planning deficits per se were the most likely cause of speech rate differences.

We have discussed three characteristics of the language deficits associated with latent aphasia: lexical retrieval difficulty, processing speed, and language planning. Each of these could be addressed by appealing to different theoretical frameworks. For example, there are models that account for deficits in lexical retrieval and sentence construction (e.g., Dipper, Black, & Bryan, 2005; N. Martin & Saffran, 1999; Whitworth, Webster, & Howard, 2014), whereas a planning deficit could be explained as a manifestation of executive functioning deficits (e.g., R. C. Martin & Allen, 2008; Murray, 2017; Penn, Frankel, Watermeyer, & Russell, 2010; Purdy, 2002). However, the processing speed theory proposed by Salthouse and colleagues (Kail & Salthouse, 1994; Salthouse, 1996) provides a parsimonious explanation of how these three characteristics relate to one another. Motivation for using this theory to explain our findings comes from Neto and Santos (2012), as well as related research in aphasiology (e.g., Bose, Wood, & Kiran, 2017; Kolk & Van Grunsven, 1985; Swinney, Zurif, Prather, & Love, 2000) and the wider stroke literature (Gerritsen et al., 2003; Winkens et al., 2006). Although Salthouse's account is not a neuropsychological account per se, it is nevertheless a cognitive theory with relevance to aphasia, including latent aphasia.

Salthouse (1996) postulated two mechanisms to account for a range of phenomena related to why processing fails or is more protracted: the limited time and simultaneity mechanisms. The limited time mechanism is only relevant when external limits are imposed on the time available for processing. As this study did not impose time limits, this mechanism is not directly relevant in our discussion. However, the simultaneity mechanism is. This mechanism posits that the products of earlier processing may be lost by the time later processing is completed. This means that relevant information from early processing may no longer be available when it is needed. As Salthouse argues, deficits could emerge because of discrepancies between the time course of information loss and the speed with which critical operations such as retrieval, encoding, elaboration, search, rehearsal, or integration can be executed. Furthermore, the simultaneity mechanism assumes that information decreases in availability (i.e., quantity or quality) over time because of decay or displacement (Salthouse, 1996). Another relevant aspect is that the decrease in information availability occurs regardless of the amount of time allowed for processing (Salthouse, 1996). This concept of processing speed as the general impairment underlying aphasia is very much in line with more specific linguistic accounts, which have been advanced to explain linguistic processes such as building syntactic representations (Swinney et al., 2000) and activation and retrieval of lexical representations (Gravier et al., 2018).

In discourse production, the type of information, which is (or should be) activated and needs to (or should) be processed simultaneously, stems from diverse sources such as verbal long-term memory, lexicosemantic, and syntactic processing. The reduced speech rate observed in people with latent aphasia could emerge due to an impaired ability to simultaneously process information and maintain activation from multiple domains. One consequence could be lexical retrieval difficulty if the speaker is unable to activate relevant representations quickly enough (or conversely, if lexical activation decays too quickly). This processing account of lexical retrieval is similar to the one Martin and colleagues have proposed (e.g., N. Martin & Saffran, 1999). One key difference is that their model focuses on activation of individual words, whereas we include activation of syntactic and discourse-level processes. People with latent aphasia often perform well on untimed confrontation naming tasks, possibly because their ability to process lexical information in relative isolation is sufficient for single-word naming tasks. The need to integrate multiple processing streams in a timely fashion may lead to lexical retrieval difficulty in discourse production.

The narratives of the latent aphasia group were similar in episodic organization, albeit shorter, relative to the narratives of neurotypical controls. Recall that there were no differences in episode omission or recurrence between these two groups. The latent aphasia group produced fewer words, and therefore, their narratives were impoverished in terms of lexical diversity and detailed information content, a finding also noted by Fromm et al. (2017) and Dalton and Richardson (2015). The increased silent pause duration in the latent aphasia group could be explained as a consequence of increasing the time allowed for processing in an effort to produce a more informative narrative. Recall, however, that within Salthouse's (1996) account, activated representations become less available over time (i.e., the activations decay or are displaced). During pauses, people with latent aphasia may have been attempting to search, retrieve, and integrate, among related operations, before producing the information. However, the deficient simultaneity mechanism did not allow that to happen.

A deficit in the simultaneity mechanism may also account for the finding that people with anomic aphasia omitted more episodes than the latent aphasia or neurotypical groups. Omission of episodes may reflect verbal long-term memory deficits, or it may be that people with anomic aphasia omit episodes when anomia prevents them from expressing key ideas in the episode. In general, people with aphasia have been noted to present with long-term, episodic memory deficits (e.g., Risse, Rubens, & Jordan, 1984), which may also be exacerbated by coexisting semantic memory deficits (e.g., Dalla Barba, Frasson, Mantovan, Gallo, & Denes, 1996; McCarthy & Warrington, 2016). Kintz, Wright, and Fergadiotis (2016) reported that people with aphasia produced fewer words associated with more abstract or less distinct semantic categories. Participants in this study had the opportunity to review the Cinderella story via a wordless picture book prior to generating the narrative, which minimizes the likely contribution of verbal long-term memory. Participants with anomic aphasia may have been unable to simultaneously and sufficiently activate both the long-term memory of an episode and relevant lexical items, resulting in omission of the episode from the narrative.

We also asked whether the percentage of formulation time was greater in utterances that introduce a new episode and whether the size of that effect would differ as a function of group. The rationale was that introducing a new episode requires retrieving details of the episode and relevant lexical items, as well as attentional processes such as switching costs. In turn, these cognitive demands would increase processing demands and thus the formulation time. The results were consistent with the predictions for the neurotypical and latent aphasia groups, but not for the people with anomic aphasia. People with latent aphasia showed greater formulation time than controls overall, but there was no evidence that the effect of introducing a new episode was greater in people with latent aphasia than neurotypical controls. Further research is required to fully understand why introducing a new episode is associated with increased formulation time in both neurotypical controls and people with latent aphasia.

Interestingly, the anomic aphasia group did not show a higher percentage of formulation time in utterances that introduced a new episode. This finding may reflect a more severe processing impairment in the anomic aphasia group. Speakers may abandon utterances or substitute more general words (e.g., *man* instead of *prince*) if it becomes clear that they will not be able to access the relevant information in a timely fashion. This strategy could result in similar formulation time in utterances that did and did not introduce new episodes for people with anomic aphasia. This account predicts that new utterances might contain less precise lexical items or other types of errors that index the increased processing demand. However, these types of data were not analyzed in the current study.

One way to explore the validity of the simultaneity mechanism in future research would be to compare speech and language rate measures in single versus dual tasks, similar to the study by Oomen and Postma (2001). These authors found that neurotypical adults produced more filled pauses and repetitions in storytelling when they had to engage in a tactile recognition task while telling a story than when they had to narrate a story without the second task. Another possibility would be to vary the linguistic and cognitive demands associated with narrative production (e.g., familiarity, concrete vs. abstract vocabulary) to determine whether increasing the demands affects the groups in different ways. Early research using temporal measures in spoken discourse with neurotypical individuals found that the more familiar a speaker becomes with the language material, the faster their delivery becomes (Goldman-Eisler, 1968).

Implications and Limitations

Our study has important implications for clinical practice and research. The first implication concerns how the concept of recovery is measured. Our findings, together with those of Neto and Santos (2012), suggest that temporal measures such as duration and rate in language tasks may be more sensitive than measures of accuracy, which are the prototypical measures used in stroke and aphasia recovery studies. Use of temporal measures in aphasia and stroke studies may discern the subtle processing speed deficits reported by people who appear to have recovered from aphasia. Importantly, tests such as the WAB-R may not be sensitive to the persistent deficits in individuals with latent aphasia because processing speed plays a very little role in WAB scoring rules. However, more modern aphasia tests, such as the Comprehensive Aphasia Test (Swinburn, Porter, & Howard, 2004), do consider processing time and so may be more sensitive to latent aphasia.

The second related implication concerns the duration and rate measures elicited with Praat, which is a freely available speech analysis software. Although many clinicians have the knowledge to carry out similar analyses, they may not have the time in routine clinical practice. However, speech rate could be calculated much more readily without the need of software, following orthographic transcription of a narrative. Thus, speech rate could be a way to identify latent aphasia, mindful that this measure, like other processing speed measures, may be prone to intraindividual variability (Evans, Hula, & Starns, 2018) and inherent measurement error or test–retest reliability (also cf. Boyle, 2014). At present, normative data do not exist for speech rate across different discourse samples. However, this study, along with the larger data set from Fromm et al. (2017), provides preliminary data regarding speech rates in the Cinderella story that might be indicative of latent aphasia.

One caveat regarding this study is that the type of discourse may have influenced the pattern of results. There is evidence that personal discourse generates different elements of narrative building devices and strategies than storytelling (Olness & Ulatowska, 2011). Thus, recounting an emotive, personal event might exhibit different temporal patterns than an innocuous fairy tale. Further work is needed to determine the extent to which the patterns reported here generalize to other types of discourse. However, if the processing speed explanation is correct, then differences in speech rate should be observed across most contexts.

This study focused on temporal and macrostructure levels of analysis. We did not study temporal patterns at sentence, phrase, or lexical levels that would provide insights on aspects of microstructure. Such temporal analyses are clearly needed in order to build a more insightful understanding of the range of deficits that may be present in aphasia as a whole, as it has been shown in other neurogenic clinical populations (e.g., traumatic brain injury; Peach & Coelho, 2016; primary progressive aphasia: Mack et al., 2015). We also did not discuss the individual differences. Like other aphasia subgroups, interindividual variability has been documented in latent aphasia (e.g., Vallar et al., 1988).

Furthermore, the people with anomic aphasia in this study had a slightly higher aphasia quotient than people with anomic aphasia in the WAB-R manual (Kertesz, 2006). Thus, participants in this study may have had relatively mild anomic aphasia. One implication is that this study may underestimate differences between the anomic and latent aphasia groups. People with more severe anomic aphasia might have, for example, a slower speech rate than people with latent aphasia. In terms of differentiating groups, however, it is important to know that speech rate might not differentiate latent aphasia from anomic aphasia but that it does differentiate people with latent aphasia from neurotypical controls. Finally, the sample size is a limitation of this study. The acoustic analyses involved in calculating articulation and pure word rates are laborious, making it challenging to code larger samples. The strong effect sizes for key findings such as speech rate, number of words, and silent pause duration, in combination with nonoverlapping confidence intervals, suggest that these results are reliable. That said, we recognize that larger sample sizes would be more sensitive to subtle differences between groups.

Conclusions

The purpose of this study was (a) to characterize temporal aspects of speech and language production in individuals with latent aphasia or, more precisely, not aphasic by WAB; (b) to determine whether speech production varies as a function of whether an utterance marks the transition to a new episode; and (c) to examine completeness of narrative production through analysis of episodes. We found that some, though not all, temporal measures, that is, speech rate and silent pause duration, distinguished people with latent aphasia from neurotypical controls. Moreover, our results suggest that introducing new episodes is associated with an increase in processing demands, which can be indexed as a greater percentage of formulation time for both neurotypical controls and people with latent aphasia. The results were interpreted as evidence that individuals with latent aphasia show persistent deficits in processing speed, which can be observed in measures of discourse production, such as narrative storytelling.

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Appendix A

AphasiaBank Participant Codes

Anomic aphasia	Latent aphasia	Controls
elman05a	adler03a	capilouto18a
elman10a	fridriksson07a	kempler01a
elman15a	fridriksson11a	msuc01a
scale17a	kurland04a	msuc04a
tap08a	scale16a	msuc07a
thompson13a	tcu09a	wright07a
whiteside13a	tucson18a	wright19a
williamson02a	whiteside17a	wright58a
williamson17a	williamson13a	wright64a
wright202a	wozniak06a	wright73a

Appendix B

Definitions of Codes

Codes	Definitions
Silent pauses	Periods of absence of acoustic signal greater than or equal to 200 ms.
Filled pauses	Phoneme vocalizations such as “uh,” “er,” “eh,” “uhm,” and “mm.”
Sighs	Audible, high-frequency sounds, which were judged to indicate affect.
Breaths	Incidences high-frequency sounds that were judged to indicate breathing.
False starts	Sound(s) that was not identified as word or filled pause but indicated articulatory movement. Typically, false starts were lip smacking behaviors.
Laughter	Sounds that were judged to indicate laughter.
Mazes	Verbal segments that were used in a nonpropositional function (e.g., “something or other,” “I’m not sure,” “I don’t know,” “like,” “OK,” “oh god”). If the maze was accompanied by other phrases in a clearly identified linguistic structure and conveyed propositional meaning, then the segment was not coded as a maze. For example, in the sentences “I’m not sure how many sisters there were” or “I don’t know what happened next,” the phrases “I’m not sure” and “I don’t know” were not counted as mazes. However, if these phrases were uttered on their own, then they would be mazes. Unintelligible segments were also logged as mazes but were excluded from word count.
Repetitions	Identical words or phrases that occurred sequentially two or more times. For example, “the, the” is one repetition, whereas “the, the, the” are two repetitions. Repetitions could be separated by a silent or a filled pause.
Revisions	Words or phrases that had a propositional function, and it was clear that the person revised a previously produced word or phrase. For example, in the phrase “the, the, this house,” “this” is a revision. Revisions could be separated by a silent or a filled pause. For example, in the phrases, “got all of [silent pause] cleaned the floor and stuff” the segment “cleaned the floor and stuff” is a revision.
Other	Words that did not relate to the story or were instances of anomia (e.g., “foot thing”). Isolated phonemes (e.g., “sh”) were also logged as other; such instances were not included in word counts.

Appendix C

Episode Coding Information

Episode codes	Stark's codes	Description notes
RO	Setting/orientation	Introduction of Cinderella story. Set up background of Cinderella's family and how she does all housework for her stepmother and stepsisters.
INV	Episode 1	Invitation to Prince's ball. Cinderella can't go to ball because she has to do housework. Stepmother and stepsisters leave for the ball and Cinderella is sad.
PAL	Episode 2a	Stepmother and stepsisters arrive at ball. Prince greets all guests. Guests are dancing and eating.
MAG	Episode 2b	Fairy godmother finds Cinderella crying and tells her she can go to the ball. Fairy godmother performs magic to make Cinderella a dress, glass slippers, and a coach to ride to the ball. Fairy godmother tells Cinderella she must be home by midnight. Cinderella leaves for the ball.
CAP	Episode 3	Cinderella arrives at palace. Prince sees her and wants to dance with her. Stepsisters and guests were all watching them.
TLM	Complication	Clock strikes midnight and Cinderella leaves, leaving behind one of her glass slippers. The prince finds it. Magic wears off on Cinderella, driver, and coach.
SOL	Solution	Prince searches for Cinderella. Stepsisters try to fit into the slipper but cannot. When Cinderella tries it on, it fits.
HAP	Coda	Prince and Cinderella get married and live happily ever after.

Appendix D

Information About Word Counting Rules

- Word count (as a unit) was based on lexical entries in a standard dictionary. For example, "Cinderella was a little girl" counted as five words.
- Compound nouns counted as one word (e.g., "stepmother," "godmother," "horseman").
- Contracted forms counted as two words (e.g., "didn't," "who's," "she'd").
- The contracted lexical verb "gonna" counted as one word.
- The preposition "o'" (e.g., "o' clock" was not counted as a separate word from the noun).
- Apart from unintelligible segments, which were coded as mazes (see Appendix B), all other mazes were included in word counts. Repetitions and revisions were also included.
- Paraphasias that were recognizable words were included in word counts. However, unintelligible paraphasias were excluded (e.g., "the xxx glass" consists of two words).
- Filled pauses were excluded from word counts.