Speech-timing and episodic analyses of the story of Cinderella: Implications for aphasia recovery

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Background – Our primary focus

A group of people who in the aphasiological/stroke literature have been described under different labels – some examples below:

"Post-stroke cognitive impairment" (Sun et al., 2014)

"Latent aphasia" (Boller & Vignolo, 1966; Heilburn, 1958; Pichot, 1955; Vallar et al., 1988)

"People who have become non aphasic" (Netos & Santos, 2012)

"Not aphasic by WAB" (Dalton & Richardson, 2015; Fromm et al., 2017)

The central question in this literature domain is the concept of pre-stroke "recovery" of verbal cognitive abilities, either implicitly or explicitly

Background – Measuring recovery as "speed/rate of information processing"

Range of measures:

- Self-perceptions of speed in real-life tasks (Gerritsen et al., 2003)

- Stop-watch in language tasks (Netos & Santos, 2012)

- Word fluency – standard, pen-and-paper (Kertesz, 1982)

- "Guestimate" – number and duration of pauses (Schlenck et al., 1989)

- **Speech rate of spoken narratives (words per minute)** (Fromm et al., 2017)

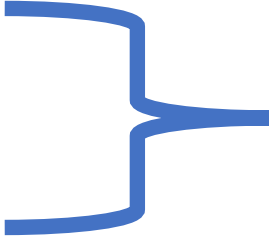# Background – Fromm et al. (2017) – Speech rate

Participants: Not aphasic by WAB (plus controls, plus anomic)

Measure: Speech rate of Cinderella narratives (as words per minute)

Main finding: Lower speech rate in not aphasic by WAB as compared to controls

Background – Speech rate and its components

Speech rate includes (among other behaviours):

1) Words → **information**

2) Revisions, e.g., "I gave, no, I was given …"

3) Fillers, e.g., "you know what I mean" → **editing**

4) Filled pauses/disfluencies, e.g., "hm", "erh"

5) Silent pauses → **formulation**

The bottom line: Speech rate is a coarse-grained, though useful, measure of information transmission rate

Background – Beyond speech rate, more fine-grained measures

Articulation rate includes:

1) **Words, i.e., information**
2) **Revisions**
3) **Fillers**
4) **Filled pauses/disfluencies**
5) Silent pauses

PURPOSE: To examine **overt information and editing** behaviours

Word rate includes:

1) **Words, i.e., information**
2) Revisions
3) Fillers
4) Filled pauses/disfluencies
5) Silent pauses

PURPOSE: To examine **pure information rate** without formulation and editing behaviours

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Background – Examining episodes as formulation

Episodes are the main sequences of events in the story of Cinderella (Stark, 2010)

The ordering of the episodes is fixed for certain events; however, it can also vary with regard to other episodes

Relevance to aphasia recovery: Anomia may prevent retrieval and realization of semantic memory content that would make an episode complete

Background – Research questions

1. If we were to "peel" speech rate and isolate some of its components, what can we learn about aphasia recovery, if we compared recovered and control participants?

2. How do people with different levels of language ability (recovered, controls, aphasia) cope with spoken narrative demands (episodic organisation)?

3. How do standard cognitive-linguistic measures (WAB AQ, verbal STM span) correlate with our measures of rate and episodic organisation?

Method - Participants

30 Participants from the AphasiaBank (MacWhinney et al., 2011)

Recovered: 10 people who had recovered from aphasia, i.e., ≥ 93.8 on AQ WAB

Aphasia: 10 people with aphasia, ≤ 93.8 (all "anomic")

Control: 10 neurotypical

Method – Speech-timing analyses

Cinderella narratives (first narration) analysed with Praat (Boersma & Weenink, 2016)

Semi-automated identification and segmentation of:

- silent pauses (≥ 200 ms) (Mack et al., 2016; Peach & Coelho, 2016; Salis, Martin et al., 2018)
- revisions
- disfluencies
- word segments

All these behaviours were coded and transcribed (where applicable)

Method – Episodic analyses

Episodic structure and terms (Stark, 2010)	Our codes	Summary of information conveyed
Setting/Orientation	RO	Cinderella's domestic situation
Episode 1	INV	Invitation to the Prince's ball
Episode 2a	PAL	Arrival of stepmother and stepsisters at the ball
Episode 2b	FAI	The miracle: Fairy godmother meets Cinderella
Episode 3	CAP	Cinderella's arrival and encounter with Prince
Episode 4	TLM	Clock strikes 12 and the magic wears off
Episode 5	SOL	Prince's search and shoe fittings
Coda	HAP	The marriage and the happily ever after

Method – Praat illustration
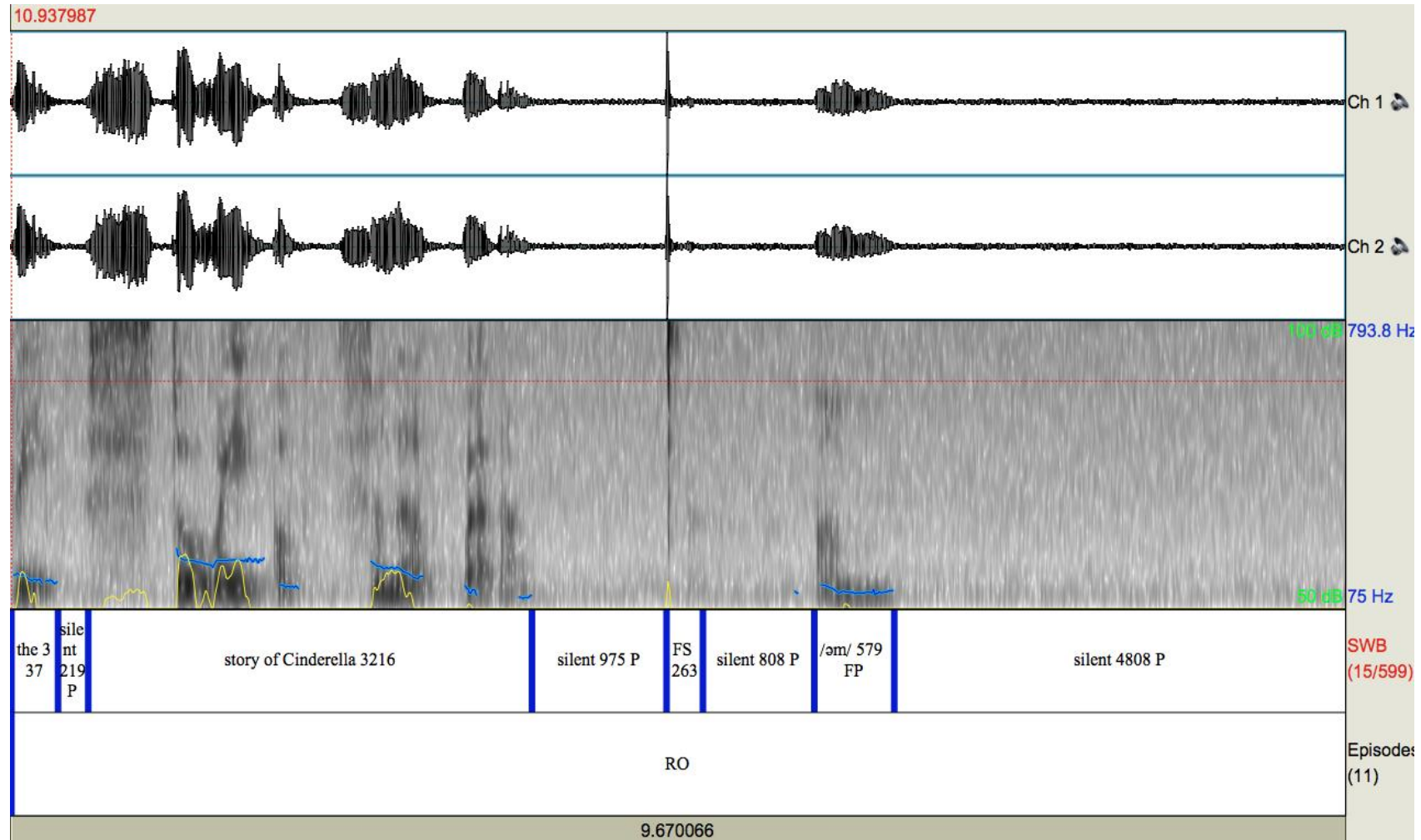
Method – Base measures

- **Total duration** of narratives (from speech onset after investigator's instructions to the very end of each narrative)

- **Durations** of:

word segments (either in isolation or connected)

silent pauses

filled pauses (e.g., "hm", "er")

fillers and revisions (e.g., "you know what I mean")

- **Number of words** per narrative

Method – Rate, speech-timing measures

Speech rate: ALL speech segments, **PLUS** filled pauses and revisions, **PLUS** silent pauses

Articulation rate: ALL speech segments, **PLUS** filled pauses and revisions, but **EXCLUDING** silent pauses

Word rate: ALL speech segments, **EXCLUDING** filled pauses, revisions, and silent pauses

Note: All these measures expressed as words per second

Method – Episodic structure measures

Episode Recurrence Index :

How often a previous episode recurs in a person's narrative

Episode Omission Index:

How many episodes are omitted from a person's narrative

Note: Both measures expressed as numbers of episodes

Results – Group characteristics

	Aphasia	Recovered	Controls	Statistical comparisons
Age	58.5	61.5	60.3	ns
Education	16.0	15.9	15.2	ns
Gender	7 female 3 male	7 female 3 male	6 female 4 male	ns
Time Post-onset	5.8	5.5	-	ns
STM (word span)	4	4	-	ns
Aphasia Quotient	87.2	97.2	-	$p < .001$

Results – Number of words (base measure)

K-W = 9.90, p = .01
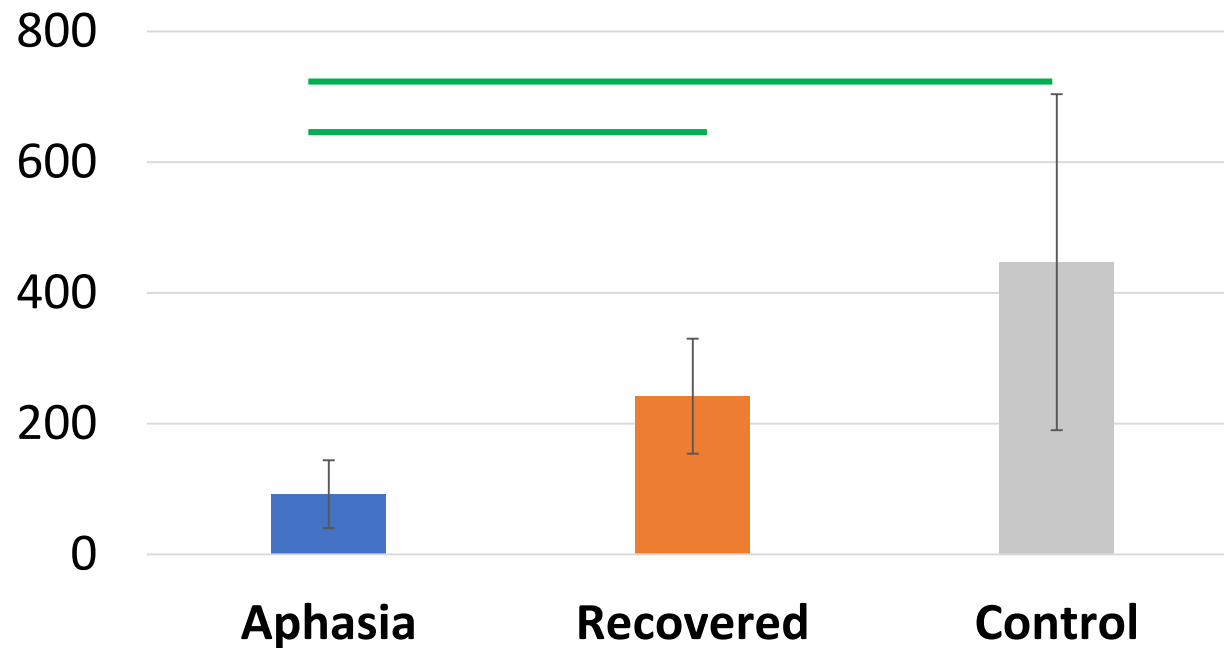
p < .01
(Holm-corrected)

Results - Pause duration (base measure)

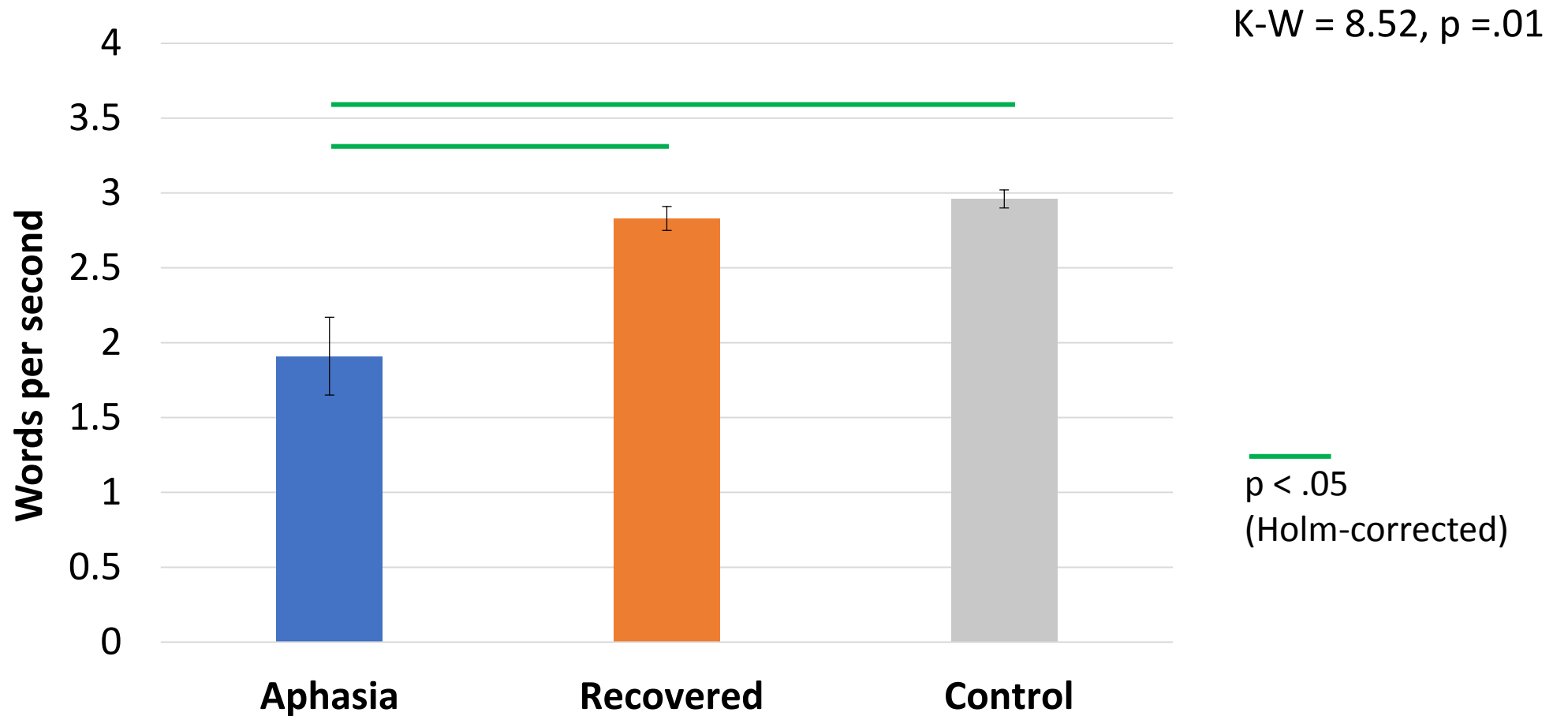K-W = 15.36, p = .00

p < .05
(Holm-corrected)
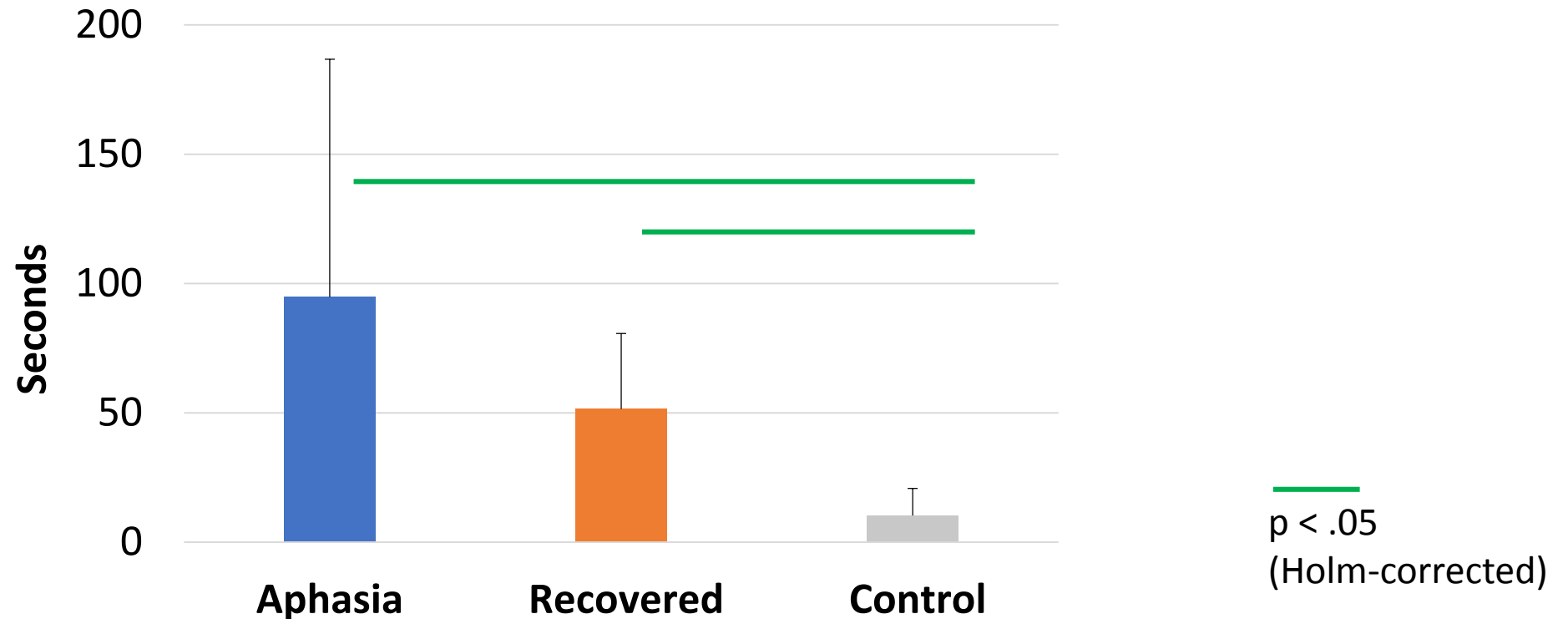
Note: Only pause duration significantly differed among groups; other base durational measures did not (e.g., total narrative duration)

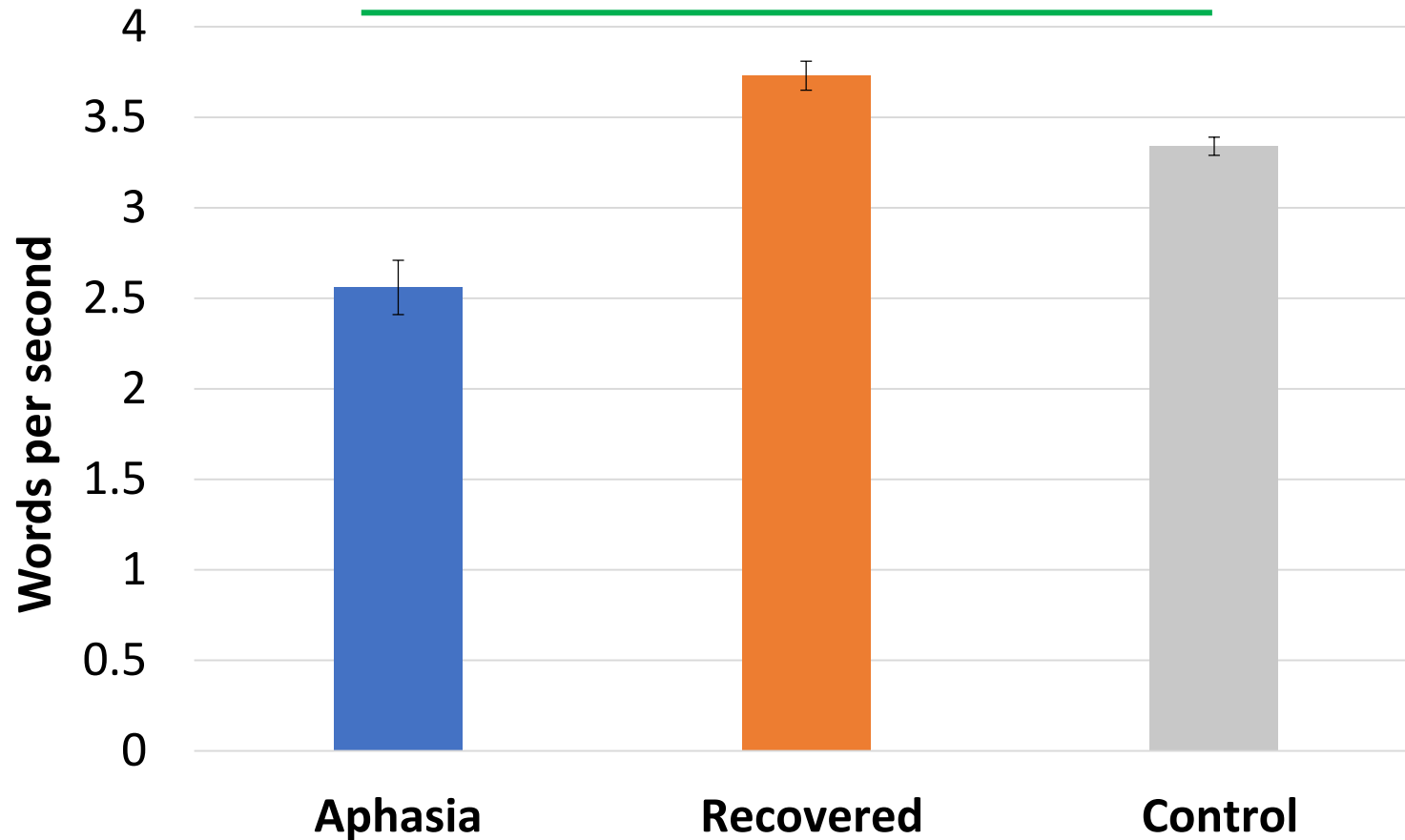# Results – <u>Speech</u> rate (i.e., information, editing, formulation)

K-W = 18.26, p = .00

p < .05
(Holm-corrected)
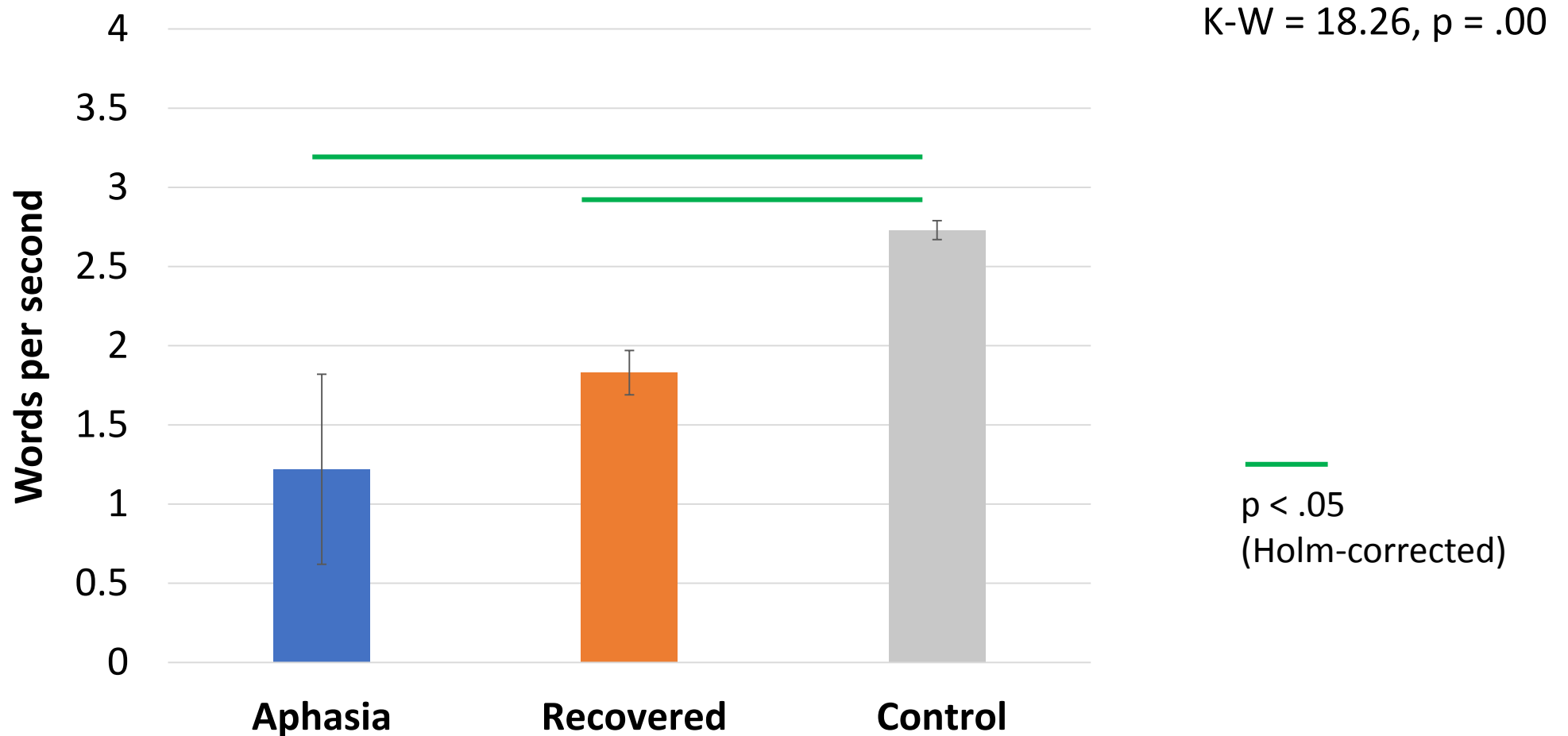
Results – <u>Articulation</u> rate (i.e., information, editing)

K-W = 8.52, p =.01

p < .05
(Holm-corrected)
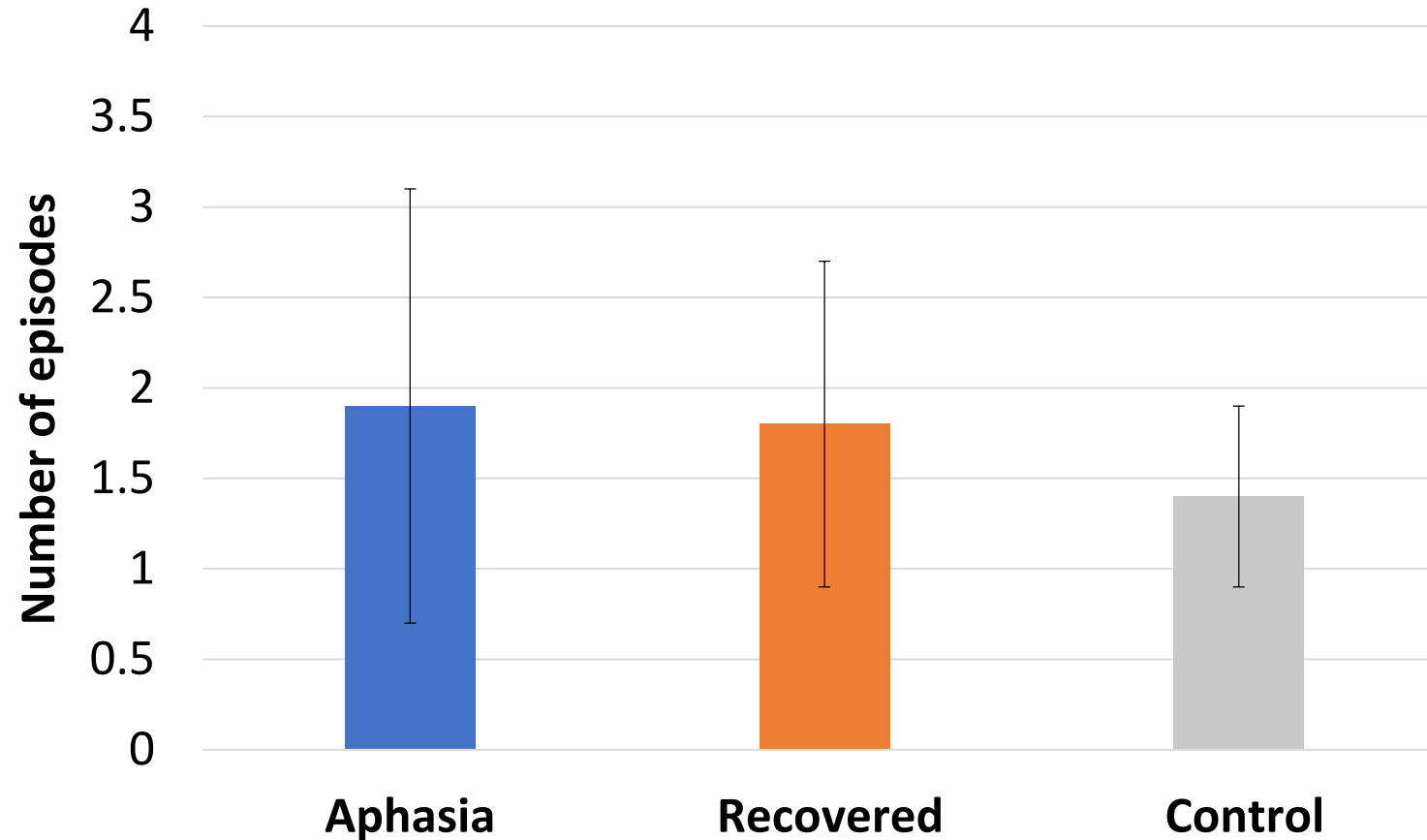
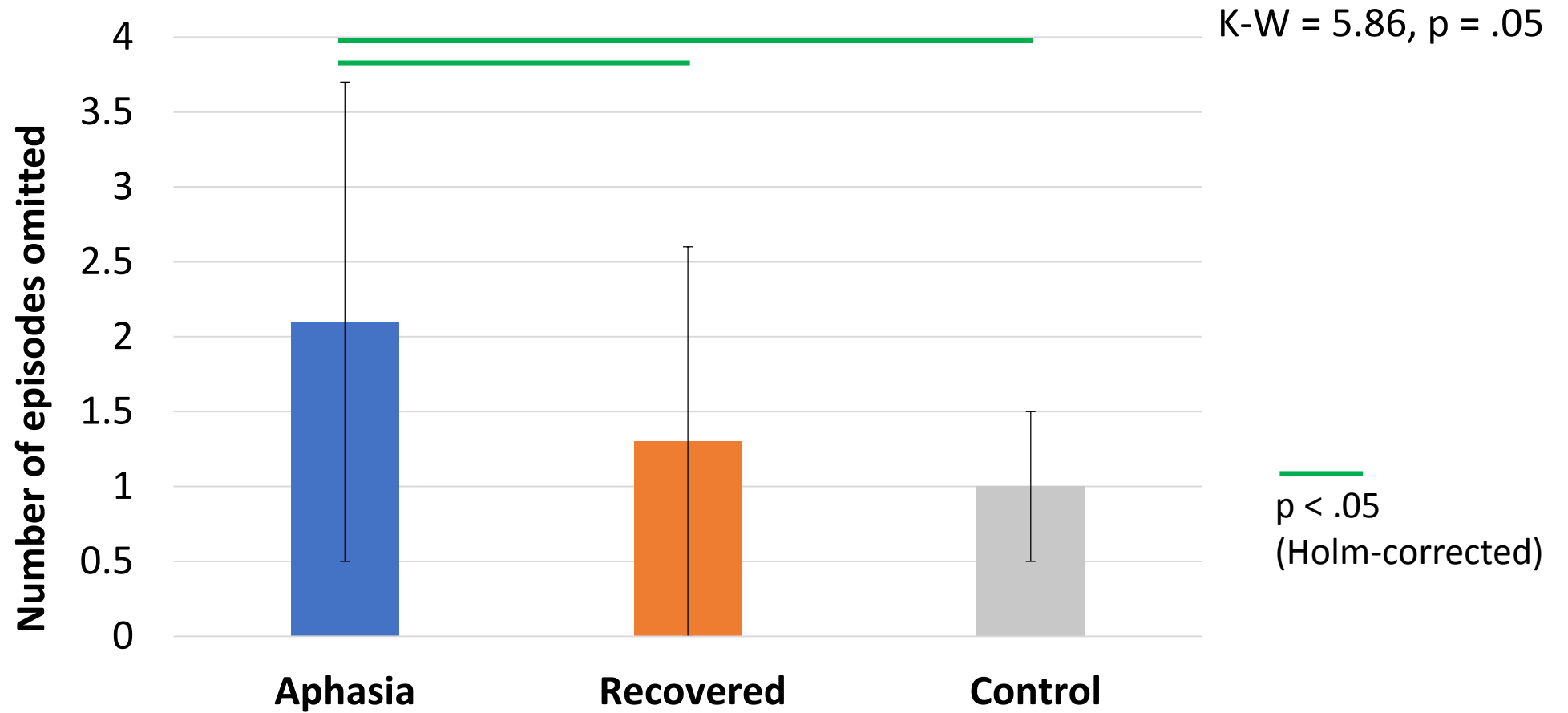# Results – <u>Word</u> rate (i.e., information only)

K-W = 8.77, p =.01

p < .05
(Holm-corrected)

Results – **Recurrence** Index

K-W = .98, p = .61

Results – Episode **Omission** Index

K-W = 5.86, p = .05

— p < .05
(Holm-corrected)

Results - Correlations

	Speech Rate	Articulation Rate	Word Rate	Episode Recurrence	Episode Omission
WAB AQ	.11	.05	-.03	.10	-.59*
STM	.29	.08	.01	.13	.61*

* p < .05

Summary of (some) measures

	Aphasia-Recovered	Aphasia-Controls	Recovered-Controls
Number of words	✓	✓	—
Pause durations	—	✓	✓
Speech rate	—	✓	✓
Articulation rate	✓	✓	—
Word rate	—	✓	—

Discussion – Recovered group differed from controls in formulation time, not information or editing time

- Speech rate differed between recovered and controls, a similar finding to Fromm et al. (2017)

- Pause durations differed between recovered and controls

- Articulation rate and word rate did not differ between recovered and controls

- Considered together, these findings indicate that the recovered group differed from controls in terms of **covert formulation time**

Discussion – What are the sources of the differences?

Processing speed impairment, even though the task was not "speeded"

Slower in "thinking for speaking" (Marshall & Cairns, 2005)

Executive functioning demands: Formulation, monitoring

Other reasons: Fewer main concepts, subtle TTR differences (Fromm et al., 2017)

Discussion – Recovered and controls similar in episodic structure

- Episode Recurrence and Episode Omission Indices similar between recovered and controls

- Overall, episodic structure was similar in recovered and controls

Discussion – Episodes in aphasia and controls

- PWA differed from controls only in terms of episode omissions, not in episode recurrence

- Memory and/or language? (Pritchard, Dipper & Salis, in preparation)

- Executive functioning deficit (Murray, 2017)

Discussion - Correlations

- Rate measures did not correlate, neither with AQ, nor with STM

- Different underlying constructs: Perhaps processing speed associated with formulation

- Episode omission correlated with AQ and STM

- Direction of correlations was different

Discussion – Overview of our protocol

- Captures standard levels of linguistic description in terms of accuracy
(Rochon et al., 2000; Saffran et al., 1989; Thompson, 1995)

- Also captures and integrates linguistic description, rate of production at the following levels:

- Episodes, the focus of today's presentation

- Sentences

- Words

- D(i/y)sfluencies, offering important insights into monitoring and editing mechanisms, especially when combined with rate measures

- More to be data to be extracted!

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