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Descriptive discourse in fluent aphasia: The predictive role of attention, phonology, lexical retrieval and semantics

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ABSTRACT

Aims: To study the relationship between cognitive and linguistic skills (as measured through standardized tasks) over spontaneous speech elicited during a picture description task.
Methods & procedures: 21 controls and 19 people with fluent aphasia matched by age and sex were evaluated using transcripts made from a picture description task coded using the CHAT format and analyzed using Computerized Language Analysis (CLAN). Indices obtained from the speech samples contained measures of lexical quantity and diversity, morphosyntactic complexity, informativeness, and speech fluency, along with different kinds of speech errors. We studied their correlations with attentional measures from Conners' Continuous Performance Test and with standardized measures of naming, pseudoword repetition and semantic non-verbal association. We further used stepwise linear regression to analyze the predictive value of standardized linguistic and cognitive skills over discursive indices.
Outcomes & results: Contrary to our initial hypothesis, there were no significant correlations between attentional scores and discourse variables in aphasic participants. Moreover, semantic association, along with naming, was the measure more related with discourse performance in people with fluent aphasia, but cognitive and linguistic standardized measures had overall little predictive power on most discourse indices. In the control group, there was a certain association of naming skills and attentional reaction time with discourse variables, but their predictive power was also low.
Conclusions & implications: The current results do not support a strong relationship between basic attentional skills and performance in descriptive discourse in fluent aphasia. Although some of the standardized tasks seem to bear some relationship with spontaneous speech, there is a high amount of interindividual variability in discourse that is not captured by classical cognitive tasks routinely used in assessment. Further work on the determinants of discourse performance in aphasia and on the clinical application of discourse analysis is warranted.

1. Introduction

Aphasia is a language disorder produced by brain injury. Despite the unquestionable importance of studying discourse production

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in people with aphasia (PWA), collecting and analyzing data in clinical settings has posed a significant challenge (MacWhinney et al., 2011; Pritchard et al., 2017; Stark et al., 2021). Therefore, clinical assessments are mainly based on standardized tests, but there is increasing interest to consider evidence from spoken discourse to address communication problems (Kiran et al., 2018; Stark et al., 2021; Richardson et al., 2021). Several studies have shown that performance in clinically standardized measures of linguistic processing, such as confrontation naming, predicts part of the performance for naturalistic connected speech in PWA (Herbert et al., 2008). But there are also substantial discrepancies between standardized confrontation naming tasks and the different indices that might quantify the diverse features of naturalistic speech production in aphasia (e.g. Fergadiotis & Wright, 2016; Mayer & Murray, 2003; see Mason & Nickels, 2022, for a systematic review).

Moreover, there is an increasing interest on how additional impairments in nonlinguistic cognitive functions, such as attention, might affect performance and communicative effectiveness in PWA (Murray, 2012; Pérez Naranjo et al., 2018; Villard & Kiran, 2017). Some researchers (Hula & McNeil, 2008; McNeil et al., 1991; McNeil & Pratt, 2001) have proposed a new perspective on aphasia, suggesting that it should be seen as a condition that affects the pool of resources involved in accessing linguistic knowledge, rather than as a linguistic impairment. This reframing highlights the close connection between attention and aphasia. Some other researchers, while accepting a close relationship between attention and aphasic symptoms, argue for a weaker view where attentional deficits can co-occur and influence linguistic difficulties in aphasia (Murray, 2012; Villard & Kiran, 2017). In this regard, several studies have shown that attentional difficulties might contribute to language processing problems, albeit in a limited manner. On one hand, not all PWA manifest significant clinical difficulties in the attentional domain (Lee et al., 2020; Marinelli et al., 2017; Murray, 2012; Schumacher et al., 2022). On the other hand, strong influences of attentional skills seem to be task specific, mainly affecting complex tasks which involve comparisons between linguistic or semantic features of stimuli (Pérez Naranjo et al., 2018), or rise only when the additional influence of linguistic disturbances is taken into account (Pérez Naranjo et, al.,2018; Faroqi-Shah & Gehman, 2021).

Most previous studies on the influence of attentional skills on language processing for PWA have not considered naturalistic scenarios which enable discourse assessment (see, however, Schumacher et al., 2019, or Alyahya et al., 2020, which included discourse samples of PWA along with performance in several linguistic and nonlinguistic tasks). Discourse can be defined as a complex unit of language that extends beyond the sentence level and involves the use of various linguistic structures, including phonology, lexicon, syntax, semantics, and discourse markers, to convey meaning in a specific context (Cavanaugh & Haley, 2020; Stemmer, 1999; Wright, 2011). Studies of discourse in aphasia have followed either a more structural or a more functionalist-oriented perspective. Studies based on a structural perspective tend to focus on measures of syntactic and lexical productivity during spontaneous speech in some specific context such as the description of a picture or a personal narrative. The functionalist perspective focuses on how meaning is organized and conveyed through the discourse and/or on the pragmatic-interactive level (Armstrong, 2000; Pritchard et al., 2017). Here we aimed to study both structural aspects of discourse, based on measures of lexical and syntactic productivity, and some functional aspects based on measures of discourse informativeness (Nicholas & Brookshire, 1993; 1995) (see below).

One of the most used methods to obtain representative speech samples in PWA is the description of images or pictures (Vandenborre et al., 2018). It offers several advantages over conversational analysis, such as obtaining an objective reference to the conversational topic (Fergadiotis et al., 2011) and memory and sustained attentional demands are minimized (McNeil et al., 2004).

In comparison to picture description, which gives rise to what we might call *expository* or *descriptive* discourse, storytelling narratives (i.e. telling past experiences, familiar tales or narrating stories based on sequences of pictures) tend to boost lexical productivity and propositional density (Alhaya et al., 2021; Stark, 2019). Increased linguistic productivity and informativeness might be advantageous for data collection. However, storytelling also entails high demands for memory and planning resources, and could be challenging for people with brain damage. For example, Stark (2019) points out that PWA produced fewer words per minute and a lower type-token ratio during narratives in comparison to other forms of discourse.

Hence, in the current study, we aimed to investigate the relationship between descriptive discourse and different measures of verbal and nonverbal cognitive skills in PWA. We focus on fluent aphasia as an initial approach, as we aimed to avoid PWA with frontal lesions which might implicate exaggerated attentional dysfunction as well as very reduced speech fluency which might preclude the possibility to obtain representative speech samples. We additionally contrasted the group of PWA with a neurotypical control group in order to ascertain whether the relationships between descriptive discourse and cognitive skills might differ between groups. In order to capture the multifaceted pattern of discourse we focused on different measures (Alyahya et al., 2020): (a) lexical quantity and diversity, such as type, token and type-token ratio of lexical items (Wright et al., 2003), (b) utterance length and complexity (Rochon et al., 2000) (c) quality and informativeness of the discourse, which included percentage of different kinds of paraphasias in PWA, as well as percentage of correct information units (Nicholas & Brookshire, 1993; Pritchard et al., 2017) and Main Concept Analysis (Nicholas & Brookshire, 1995), and (d) fluency, quantified as words per minute.

As clinical measures of cognitive linguistic skills we considered different tests assessing confrontation naming and pseudoword repetition. Because confrontation naming involves multiple stages of linguistic production ranging from semantic to lexical and phonological-articulatory production, we expected confrontation naming to have an important predictive value for all measures of descriptive discourse in PWA, including fluency, quantity and diversity of lexical items, utterance length and complexity, as well as quality of information. Notwithstanding, we also expected pseudoword repetition to tap into phonological production skills and thus to be a specifically good predictor of phonologically related paraphasias.

Along with confrontation naming, tapping onto multilevel lexical process, and pseudoword repetition, tapping into phonological processing, we considered a picture-based nonverbal semantic association task. PWA might show different ranges of impairment when semantic association skills are tested with nonverbal materials such as the Pyramid and Palm Trees or the Camel and Cactus tests (Fonseca et al., 2019; Hogrefe et al., 2021; Robson,Sage et al., 2012). Semantic impairment has risen as a significant factor when analyzing different dimensions of aphasic impairment using principal component analysis (Butler et al., 2014; Schumacher et al., 2019;

Alyahya et al., 2020). However, as happens with attention, nonverbal semantic difficulties might have limited explanatory power in explaining aphasic disturbances compared to other linguistic skills (Robson, Keidel et al., 2012). However, we reasoned that semantic skills would be good predictors of the quality and informativeness of discourse, as they allow retrieving and linking concepts. Thus we expected nonverbal semantic skills to be specifically related to semantic paraphasias and main concepts.

Following previous results (Pérez Naranjo et al., 2018), we expected attentional difficulties, and particularly intra-individual variability (Villard & Kiran, 2017), to be limited but significant predictors of descriptive discourse performance in PWA. Which specific features of discourse would be affected by attention is difficult to specify. In principle, semantic and pragmatic aspects of discourse production are clear candidates, as they depend on a controlled way of processing (Murray et al. 1998). In this regard, research on traumatic brain injury has shown how cognitive difficulties related to attention, processing speed, executive control and other cognitive functions influence high-level features of the discourse such as its pragmatic and semantic adequacy, despite the absence of aphasia (Hill et al., 2018; VanSolkema et al., 2020). In agreement with this view, Murray et al. (1998) reported that PWA had greater difficulty retrieving words and producing relevant and informative speech when their attention was divided between a picture description task and a simultaneous tone detection task than when they could focus their attention on the description task. Hence, we might expect reduced attentional skills to be related to a lower lexical productivity and informativeness of the discourse. Murray et al. (1998) also expected morphosyntactic aspects of speech production to be less affected by attention, given their supposed automaticity. However, their results also showed a decrease in the number of complex sentences and an increase of grammatical errors under the divided attention condition, suggesting that the planning and construction of sentences might recruit attentional resources, depending on its length and complexity. Taking into account these previous results, we expected attention to affect discourse production at several levels including lexical quantity and diversity, the quality of information provided and the length and complexity of utterances. Moreover, we expected that attentional skills would predict discourse variance above the variance explained through performance in classical clinical tests of language and semantic cognition.

The case of control participants is complex and more speculative. In principle, attentional resources might also constraint discourse performance. However, this relationship might be more difficult to detect, because attentional constraints might be evidenced mainly when task demands exceed attentional resources. Because the current study deals with a brain injured population, and because of its explorative nature, we opted for a picture description task minimizing attentional, executive and memory demands. Hence, discourse production demands are less likely to be above the capacity limits of attentional resources in control participants. Notwithstanding, and to the extent that some variability in attentional skills among our control participants are expected, we also anticipated attentional measures to capture some of the variability in discourse production of the neurotypical sample, but possibly to a lower extent than in PWA.

2. Methods

2.1. Participants

The current study uses speech samples, as well as language and cognitive assessments, from a group of 19 people with fluent post-stroke aphasia (10 males and 9 females, mean age 52,05 ± 3,45) and 21 neurotypical healthy controls (13 males and 8 females, mean age 54,48 ± 3,26).

This constitutes a subset of a previously reported sample of 21 people with aphasia and 24 neurotypical controls (Pérez Naranjo et al., 2018) with available speech samples obtained during a picture description task (see below). PWA were recruited from Speech

Table 1
Sociodemographic and clinical characteristics of PWA.

Participant	Sex	Age	Education	MPSO	Stroke type	Aphasia type	Severity (BDAE)
PWA1	M	46	Superior	19	Ischemic	anomic	mild
PWA2	F	22	Secondary	4	Hemorrhagic	anomic	mild-moderate
PWA3	F	32	Superior	5	Ischemic	transcortical sensory	mild-moderate
PWA4	F	79	Elementary	8	Ischemic	transcortical sensory	mild
PWA5	M	52	Superior	4	Ischemic	anomic	minimal
PWA6	M	55	Superior	63	Ischemic	anomic	minimal
PWA7	F	40	Secondary	9	Ischemic	anomic	minimal
PWA8	F	41	Elementary	10	Hemorrhagic	transcortical sensory	minimal
PWA9	F	40	Superior	5	Hemorrhagic	conduction	mild
PWA10	M	50	Secondary	6	Hemorrhagic	transcortical sensory	minimal
PWA11	M	44	Secondary	6	Ischemic	anomic	mild
PWA12	M	71	Elementary	3	Ischemic	transcortical sensory	mild-moderate
PWA13	M	72	Superior	23	Hemorrhagic	conduction	moderate
PWA14	F	59	Secondary	26	Ischemic	transcortical sensory	mild-moderate
PWA15	F	77	Elementary	2	Ischemic	Wernicke	mild-moderate
PWA16	M	48	Elementary	8	Ischemic	transcortical sensory	mild
PWA17	M	51	Secondary	7	Ischemic	anomic	mild
PWA18	M	50	Secondary	9	Hemorrhagic	anomic	mild-moderate
PWA19	F	60	Secondary	3	Hemorrhagic	Wernicke	mild-moderate

Note: BDAE: Boston Diagnostic Aphasia Examination; F: female; M: male; MPSO: Months Post Stroke Onset; PWA: person with aphasia.

and Language Therapy programs from CEADAC (Spanish National Reference centre for Brain Injury), Torrejóńs University Hospital and Medical Rehabilitation Center at Madrid (Spain) and were selected if they were native Spanish speakers, have suffered a single stroke of the Left Middle Cerebral Artery resulting in a fluent aphasia, CT scan or MRI did not show a lesion of the frontal lobes, have no premorbid history of neurological or mental impairments, and volunteer to participate.

A convenience neurotypical control sample composed of Spanish-speaking volunteers matched in age and educational level was recruited from the community through word of mouth. They had normal or corrected-to-normal visual and auditory perception, no history of neurological or psychiatric disorders, and no cognitive complaints, according to their self- report.

Each participant was audiotaped during a description task of the veterinary clinic sheet included in the pragmatic assessment part of the BLOC test (Puyuelo et al., 2002; see below) using an mp4 Philips recorder and performed a set of standardized clinical tests measuring verbal and nonverbal cognitive skills. Each participant performed the tests included in the study in a minimum of one session, up to a maximum of 4 sessions of 1 h within a maximum of 4 weeks.

Table 1 displays sociodemographic and clinical characteristics of aphasic participants. Levels of education are coded as follows: elementary includes primary and middle school, secondary includes upper secondary and vocational education, and superior entails undergraduate and postgraduate studies. Aphasia severity was based on criteria by the Boston Diagnostic Aphasia Examination (Goodglass et al., 2001).

2.2. Materials

2.2.1. Picture description task

For the picture description task, we chose the sheet of the Veterinary Clinic, taken from the Spanish BLOC—C test (Objective and Criterial Language Battery) (Puyuelo et al., 2002). This slide is part of the pragmatic skills subtest of the BLOC—C. It is a black and white picture showing the waiting room of a veterinary clinic. The image shows a substantial number of different people and animals performing different actions within the context of the veterinarian's waiting room. For example, a dog appears with a broken leg, or another one escapes from a child who tries to hold him. It is intended to allow the person to describe different events and actions in which the characters are involved, in a similar vein to the cookie-theft picture from the Boston Diagnostic Aphasia Examination (Goodglass et al., 2001), but with more characters and actions.

Participants were asked to describe all the people and animals in that scene, and what they were doing. Transcripts were made in CHAT code that belongs to the CLAN program and the international recommendations of the Aphasiabank to make transcripts (MacWhinney, 2000; MacWhinney et al., 2011). During transcription, utterances are segmented based on criteria derived from syntax, intonation, pauses, and semantics, in agreement with Berndt et al. (2000). Table 2 shows the different commands used for analysis. Speech errors were classified according to the CHAT userś manual (Mac Whinney, 2021) into phonological paraphasias, semantically related and unrelated paraphasias, and neologisms.

Transcripts were made by an experienced speech-language therapist (NP-N). Once the transcripts were made, 20% of the total of the sample of each PWA were subjected to an examination of inter-judge reliability. Four additional judges were recruited for the assessment of reliability: three speech-language therapists and a psychiatrist previously trained in the CHAT format. They received three sessions of approximately 2 h each. The first one focused on the conventions of the CHAT format. The second one focused on how to code the different types of errors in PWA. In the third one, an example from the database was used for them to practice. The three speech-language therapists received the sessions in group. Due to schedule reasons, the psychiatrist received the sessions individually. Inter-rater agreement was carried out on each transcript. It was carried out using the RELY command and obtaining inter-judge agreement from the utterances. The average inter-rater reliability for sentence error coding was greater than 95%, and for word error coding it was greater than 80%. This is above the 80% level traditionally considered the minimum level of acceptability (Kazdin, 1982). Intra-judge reliability was not calculated. In the case of discrepancies in the transcripts, agreements were reached until the minimum coincidence required in the study for each transcript was reached.

For each transcription, a set of different indices was derived to assess (a) lexical quantity and diversity of the speech sample, (b) sentence length and complexity, (c) quality and informativeness of the discourse, (d) speech fluency, as well as (e) different types of errors produced by PWA

Table 2
CLAN commands used for analysis.

CLAN command	Results
CHECK	Reviews the correct use of coding in CHAT
CODER	Codes the type and number of errors in speech
MLT	Counts utterances and words on a line
FREQ	Counts the frequencies of words used in selected files. It generates an alphabetical list of all the words used by all speakers in a transcript along with the frequency with which these words occur.
COMBO	Calculates the number of strings of given letters or words. It was used to count the number and coded speech errors
TIMEDUR	Calculates the total speaking time
CQPA	We used it to extract LME and embedding index.
EVAL	We used to calculate number of tokens, types of words and type-token ratio
RELY	Calculates inter-judge reliability

2.2.1.1. Measures of lexical quantity and diversity.

a) *Token*: the total number of words used by each participant was measured as a quantitative index of word production.

b) *Type*: the number of different words used

c) *Type-token ratio* (*TTR*) (Wright et al., 2003): It is defined as the relationship between the total number of different words and the total number of words in the sample and was considered a measure of lexical diversity

2.2.1.2. Measures of sentence length and complexity.

a) *Mean length of utterance (MLU)* was assessed as the number of total words per utterance across the speech sample for each participant.

b) *Embedding index*. This measure was quantified as the number of embedded clauses per sentence (Rochon et al., 2000)

2.2.1.3. Measures of quality and informativeness.

a) *Percentage of Correct Information Units (%CIUs)*. According to Nicholas and Brookshire (1993), Correct Information Units are words that are intelligible in context, accurate, relevant, and informative about the eliciting stimulus.%CIUS was calculated as the percentage of Correct Information Units with respect to total number of words (TNW).

b) *Main Concepts (MC)* (Nicholas & Brookshire, 1995). Each main concept represents a "key concept" (understood not only as specific lexical units, but as a unit with meaning) that is part of a discourse (Pritchard et al., 2017). In our experimental study, the list of Main Concepts was first obtained in a different control group of 10 subjects who were asked to describe the image clearly and objectively, with "key and complete concepts" in a concise and unequivocal way. These relevant concepts had to be coincident in the description of 33.3% of control subjects (Richardson & Dalton, 2015).

The following formula was applied to obtain the MC score (Kong, 2009): MC = (3 x AC) + (2 x AI) + (1 x I), where (AC) is Accurate and Complete, (AI) is Accurate and incomplete, and (I) is Inaccurate Complete or Incomplete concept.

2.2.1.4. Speech fluency. *Words per minute* were quantified as the total number of words divided by the total amount of time that the participant was speaking during picture description

2.2.1.5. Aphasic errors. Errors were classified in four different categories (phonemic paraphasias, semantically related paraphasias, unrelated paraphasias and neologisms) and quantified as percentages with regard to the total number of words used (Stark et al., 2019).

2.2.2. Standardized tasks

a) Phonological processing: As a measure of phonological skills we used the pseudoword repetition subtest taken from Spanish Test Barcelona (Peña Casanova, 2005) consisting of 8 items.
b) Confrontation naming. A composite score for confrontation naming was calculated by taking into account an object and an action naming task. We used the 15 item shortened version of the Boston Naming Test (BNT) for object naming (Kaplan et al., 1983; Goodglass & Kaplan, 2005). Because of time constraints and/or fatigue, 3 PWA and one control subject were not able to complete this task. Action naming was assessed using the action naming subtask of the Spanish BETA test battery (Cuetos & González-Nosti, 2009) consisting of 30 items. One person with aphasia could not complete this task. Individual performance in object and action naming was converted to z scores and a mean composite score was calculated for each participant.
c) Nonverbal Semantic processing: As a measure of nonverbal semantic skills we considered the Semantic Associates subtest of the BETA battery (Cuetos & González-Nosti, 2009). Similar to the Pyramid and Palm Trees Test (Howard & Patterson, 1992), the participant is asked to pair the picture of an object with another one semantically related among 4 possibilities, including a semantic and a visually similar distractor, for a total of 30 trials.
d) Attentional processing. We used the Conner's Continuous Performance Test II (C—CPT, Conners, 2002) as a standardized and comprehensive measure of basic attentional skills. The C—CPT consists of 360 trials where different letters appear visually, one at a time, on a computer's screen. Participants are required to respond by pressing the spacebar every time a stimulus appears, except when the letter "X" is displayed. The task includes 6 blocks, each consisting of 3 sub-blocks with different Inter-Stimulus Interval (ISI) of 1, 2 and 4 s, presented in different order for each block. Each stimulus is displayed for 250 ms, for a total time of 14 min to complete the task. Before the beginning of the task, a short practice block was carried out. All participants demonstrated enough capacity to adequately distinguish target and nontarget stimulus and to follow task instructions.

Table 3
Individual profiles of performance for clinical language tasks and picture description in PWA.

Participant	PwRep	BNT	AN	SA	Token	Type	TTR	MLU	Emb	%CIU	MC	wpm	%PhonP	%SemP	%UnrelP	%Neol
PWA1	4/8	n.a.	27/30	30/30	262	100	0.38	17.54	0.818	72.52	22	50.87	1.53	1.15	0.00	2.67
PWA2	8/8	15/15	30/30	30/30	355	112	0.32	21.41	0.750	72.65	21	90.53	0.54	0.00	0.27	0.54
PWA3	8/8	8/15	22/30	30/30	237	67	0.28	13.16	0.330	60.89	17	84.07	0.81	4.84	0.00	0.40
PWA4	7/8	n.a.	21/30	28/30	173	71	0.41	5.39	0.158	72.28	18	66.43	1.63	2.72	0.54	0.00
PWA5	3/8	12/15	24/30	30/30	419	95	0.23	21.26	0.000	59.41	21	66.82	0.23	1.81	0.00	0.23
PWA6	3/8	14/15	28/30	29/30	306	83	0.27	16.50	0.818	82.54	24	114.96	4.44	0.32	0.32	1.90
PWA7	3/8	11/15	16/30	29/30	191	82	0.43	4.50	0.242	81.25	21	32.99	2.60	3.65	0.00	2.08
PWA8	5/8	10/15	26/30	20/30	189	51	0.27	5.60	0.100	85.64	23	97.99	3.11	3.11	0.00	0.00
PWA9	0/8	8/15	23/30	30/30	284	89	0.31	10.62	0.214	61.36	25	70.74	5.42	4.07	0.34	2.03
PWA10	7/8	13/15	30/30	27/30	198	68	0.34	14.00	0.500	85.64	22	112.85	0.50	0.99	0.00	0.00
PWA11	4/8	12/15	28/30	29/30	265	95	0.36	9.00	0.400	88.73	26	120.61	2.55	0.73	0.00	0.36
PWA12	3/8	7/15	18/30	28/30	257	79	0.30	7.29	0.103	71.59	20	120.55	1.14	0.38	1.14	0.00
PWA13	0/8	3/15	12/30	28/30	244	69	0.28	6.74	0.000	74.62	19	67.53	5.00	7.69	1.92	1.92
PWA14	7/8	n.a.	30/30	30/30	216	84	0.39	11.89	1.000	82.59	22	82.96	0.45	0.00	0.00	0.00
PWA15	2/8	12/15	23/30	26/30	142	46	0.32	8.29	0.182	92.62	30	120.16	3.36	0.00	0.00	0.00
PWA16	8/8	13/15	30/30	30/30	240	80	0.33	11.10	0.154	76.49	20	72.13	2.39	2.79	0.40	0.00
PWA17	6/8	3/15	n.a.	26/30	265	84	0.32	6.59	0.107	81.30	30	76.64	0.00	0.81	0.81	0.00
PWA18	8/8	12/15	27/30	25/30	81	38	0.47	4.87	0.167	86.90	10	63.16	1.19	1.19	0.00	1.19
PWA19	2/8	3/15	21/30	30/30	363	103	0.28	8.77	0.056	72.12	19	100.51	8.44	3.07	1.79	1.79

Note: AN: Action Naming; BNT: Boston Naming Test; Emb: Embedding index; MC: Main Concepts; MLU: Mean Length of Utterance; n.a.: not available; PWA: Person With Aphasia; TTR: type-token ratio; wpm: words per minute;%CIU: percentage of correct information units;%Neol: percentage of neologisms;%PhonP: percentage of phonological paraphasias;%SemP: percentage of semantic paraphasias;% UnrelP: percentage of unrelated paraphasias.

According to factor analysis (Egeland & Kovalik-Gran, 2010a, 2010b), C—CPT scores might be grouped into at least four different dimensions of attention: focused attention, sustained attention, impulsivity, and vigilance. An important advantage of C—CPT is that those scores could be related to the distinct dimensions of attention considered in clinical models (Mirsky et al., 1991; Sohlberg & Mateer, 1987), although the more complex dimensions such as dividing and alternating attention are not considered.

Our previous results with an extended sample (Pérez Naranjo et al., 2018) showed primarily difficulties in focused attention, and particularly with indices of response variability in PWA. Moreover, these indices were related with performance in several language and semantic tasks. Hence, we selected the following C—CPT indices for the current study: omission errors (targets not responded), as an index of focused attention, commission errors (nontargets with responses), as an index of impulsivity, response time (RT), as an index of focused attention and speed, and, finally, RT standard error (RT SE) and RT variability as indices of intraindividual variability in attention. The RT SE index of C—CPT stands for standard error of response time across trials, and therefore indicates trial-by-trial variability in focused attention. RT variability measures variability of RT SE across subblocks (i.e., how variability itself changes across the task).

Data were analyzed using IBM SPSS Statistics for Windows, Version 28.0.1.1. Data normality was analyzed for PWA and neurotypical controls independently using the Shapiro-Wilk test. Then, between-group differences were assessed using Mann-Whitney U tests, followed by Spearman's Rho correlations between discourse and standardized measures for each group. The Holm-Bonferroni procedure was used to correct for multiple comparisons (Holm, 1979). Uncorrected p values are reported but statistical results surviving the multiple comparison corrections were marked where appropriate. When assessing between-group differences, the correction procedure was applied independently for C—CPT measures, standardized language tasks and discourse measures. When assessing correlations, the procedure was used to correct for multiple comparisons across each standardized measure and discourse variables. Finally, stepwise linear regression models were used to assess the predictive value of the set of standardized clinical tasks over discourse measures.

3. Results

3.1. Preliminary results

Table 3 shows individual performance of PWA in standardized language tasks and in measures of picture description. The normality of data distribution was assessed through the Shapiro–Wilk test for control participants and PWA separately. Many variables related to discourse measures were found to be normally distributed across both groups. However, some discourse variables such as embedding index, as well as some standardized tasks were found to distribute non normally across one or both of the groups. Taking this into account, differences between groups and the analysis of correlations between variables were approached through nonparametric statistics.

3.2. Differences between groups

Table 4 shows a summary of the comparison between groups with regard to age, education and gender, showing no significant differences.

Table 5 shows differences in performance for standardized tasks and connected speech measures. Paraphasic errors were excluded from this analysis due to a very low number of occurrences in neurotypical controls.

As expected, PWA showed overall lower scores on standardized language tasks. Discourse measures showed a mixed pattern: PWA surpassed the control group on total tokens, but also showed lower lexical diversity as measured by TTR, lower sentence complexity, a lower percentage of CIUs, and fewer words per minute. Finally, regarding C—CPT performance PWA showed higher RT SE.

3.3. Relationships between connected speech and cognitive measures

Spearman's correlation analyses were used to assess relationships between standardized tests (including C—CPT measures, phonological, naming and semantic association tests) and discourse measures in PWA and controls (see Table 6). Additional correlational analysis between error types of PWA and performance on standardized tests is shown in Table 7. Results showed little association between attentional scores and discourse performance in PWA, although there were significant correlations between RT and RT variability and some aspects of discourse performance in controls. Naming showed moderate to large correlations with many

Table 4
Comparison between groups in sociodemographic variables.

	Age mean (±SD)	Education elementary/secondary/superior	Sex F/M
Control group	54.48 (14.95)	10/4/7	13/8
PWA	52.05 (15.04)	5/8/6	9/10
	$t_{(38)} = 0.510$	$\chi^2_{(2)} = 2.984$	$\chi^2_{(1)} = 0.852$
	$p = .306$	$p = .225$	$p = .225$

Note: F: female, M: male; PWA: people with aphasia.

Table 5
Comparison between groups in C—CPT, standardized tasks and discourse measures.

Measure	Control group mean (±SD)	PWA mean (±SD)	Mann-Whitney U	p value
C-CPT indices				
Omission	12.24 (16.55)	17.63 (22.80)	180.5	.606
Commission	10.71 (7.38)	14 (7.16)	149.0	.170
RT	429.61 (78.69)	511.83 (140.31)	123.0	.038‡
RT SE	6.19 (3.86)	10.92 (9.43)	86.0	**.002***
RT variability	9.17 (7.45)	15.26 (14.99)	127.0	.05‡
Standardized language tests				
PwRep	7.67 (0.65)	4.63 (2.71)	69.5	**<0.001***
SA	29.71 (0.71)	28.15 (2.54)	111.0	**.006***
BNT	12.9 (2.05)	9.75 (3.99)	77.5	**.008***
AN	27.52 (3.11)	24.22 (5.23)	120.5	.052
Discourse measures				
Token	179.14 (41.13)	246.68 (79.79)	81.5	**<0.001***
Type	69.00 (14.31	78.74 (19.40)	130.0	.06
TTR	0.387 (0.03)	0.331 (0.06)	83.5	**.002***
MLU	15.07 (6.98)	10.76 (5.31)	118.5	.028‡
Emb	0.75 (0.60)	0.321 (0.30)	93.0	**.004***
%CIUs	85.68 (9.07)	76.90 (9.60)	89.0	**.003***
MC	23.71 (5.44)	21.58 (4.52)	156.5	.243
wpm	147.19 (28.37)	84.87 (25.44)	17.0	**<0.001***

Note: AN: Action Naming; BNT: Boston Naming Test; C—CPT: Conner's Continuous Performance Test II; Emb: Embbedding index; MC: Main Concepts; MLU: Mean Length of Utterance; PWA: People with aphasia; PwRep: Pseudoword Repetition; RT: Reaction time; RT SE: Standard error of Hit Reaction time; RT variability: Variability of Hit Reaction time across blocks; SA: Semantic Association.; TTR: type-token ratio; wpm= words per minute;%CIUs= percentage of correct information units; *difference remains significant after Holm-Bonferroni correction for multiple comparisons; ‡difference does not remains significant after correction for multiple comparisons.

aspects of discourse in controls, but its association to discourse performance in PWA was restricted to sentence length and complexity measures. In contrast, semantic association skills showed correlations with measures of lexical quantity and sentence length in PWA. With regard to aphasic errors, pseudoword repetition was associated with phonological paraphasias. Naming scores showed a trend to correlate with verbal (semantic and unrelated) paraphasias, although the correlation was not significant after correction for multiple comparisons.

Subsequently, stepwise multiple regression analyses were carried out to determine the relative contributions of cognitive measures to descriptive discourse performance in the picture description task, for each group separately. Variance Inflation Factor (VIF) was kept below 5. Results are summarized in Table 8. In PWA, semantic association was a predictor of lexical quantity (Type and Token), while confrontation naming and semantic association were predictors for MLU. Sentence complexity measured as the number of embeddings

Table 6
Correlations between discourse measures and standardized cognitive tasks.

	Quantity and diversity			Sentence complexity		Quality and informativeness		Fluency
	Token	**Type**	**TTR**	**MLU**	**Emb**	**%CIUs**	**MC**	**wpm**
PWA								
Naming	.025	.175	.211	**.624***	**.666***	.351	.202	.164
PwRep	−0.313	−0.175	.353	.133	.336	.157	−0.319	−0.107
SA	**.606***	**.700***	−0.124	**.663***	.281	**−0.612***	−0.158	−0.164
Omission	−0.275	−0.228	.004	−0.371	−0.118	−0.024	.024	.074
Commission	−0.591‡	−0.399	.332	−0.336	−0.024	.401	.075	.068
RT	.113	.002	−0.374	−0.172	−0.208	−0.346	−0.176	.211
RT SE	.008	.007	−0.163	−0.297	−0.078	.004	.186	.382
RT variability	−0.188	−0.157	.018	−0.456‡	−0.050	.205	.249	.307
Controls								
Naming	**.577***	**.569***	−0.056	**.715***	**.642***	.225	.453‡	.421
PwRep	.278	.243	−0.210	.533‡	.451‡	−0.007	−0.063	−0.199
SA	.200	.186	−0.133	.300	.249	.285	.251	.289
Omission	−0.326	−0.268	.395	−0.145	−0.014	−0.037	−0.119	−0.082
Commission	−0.206	−0.240	−0.017	.111	.054	−0.162	−0.264	.165
RT	−0.387	−0.394	−0.153	**−0.581***	−0.531‡	−0.179	−0.519‡	−0.308
RT SE	−0.309	−0.314	−0.074	−0.357	−0.372	−0.466‡	−0.520‡	−0.110
RT variability	−0.196	−0.145	.039	−0.391	−0.458‡	**−0.622***	−0.387	.025

Note: Emb: Embbedding index; MC: Main Concepts; MLU: Mean Length of Utterance; PWA: People with aphasia; PwRep: Pseudoword Repetition; RT: Reaction time in milliseconds; RT variability: Variability of Hit Reaction time; SA: Semantic Association; TTR: type-token ratio; wpm: words per minute;%CIUs: percentage of correct information units; *correlation remains significant after Holm-Bonferroni correction for multiple comparisons; ‡correlation does not remains significant after correction for multiple comparisons.

Table 7
Correlations between different types of errors in connected speech and standardized cognitive tasks.

	%PhonP	%SemP	%UnrelP	%Neol
Naming	−0.299	−0.528‡	−0.527‡	−0.137
PwRep	**−0.627***	−0.185	−0.305	−0.381
SA	−0.027	.094	.030	.380
Omission	.283	−0.102	.196	−0.170
Commission	−0.033	−0.037	−0.484‡	−0.333
RT	.188	.021	.395	−0.079
RT SE	.331	−0.185	.188	−0.171
RT variability	.342	−0.178	.157	−0.196

Note: PwRep: Pseudoword Repetition; RT: Reaction time in milliseconds; RT variability: Variability of Hit Reaction time; SA: Semantic Association;% UnrelP: percentage of semantically unrelated paraphasias over total number of words; %PhonP: percentage of phonological paraphasias over total number of words;%SemP= percentage of semantically related paraphasias over total number of words; *correlation remains significant after Holm-Bonferroni correction for multiple comparisons; ‡correlation does not remain significant after correction for multiple comparisons.

was also predicted by naming. Communication efficiency as measured by%CIUs showed a complex pattern where SA along RT has predictive power. No predictors emerged for TTR, MCs or fluency. With regard to the neurotypical control group, confrontation naming seemed the best predictor for lexical quantity, as well as for utterance length and complexity. Semantic association was related to lexical diversity. Finally, RT emerged as the best predictor for the MC analysis. No predictors emerged for%CIUs or speech fluency.

Table 9 shows the results of the multiple regression analyses for the different types of paraphasic errors produced by PWA during the picture description task. Pseudoword repetition predicted the percentage of phonological paraphasias and neologisms, although it explained more variance in the former than in the later. Verbal paraphasias (semantically and non-semantically related) were predicted by performance in naming tasks.

4. Discussion

The current study aimed to shed light onto how descriptive discourse in fluent aphasia relates to clinical standardized measures of linguistic and cognitive nonlinguistic skills. We also studied associations between descriptive discourse and standardized tasks on a control group. Measures of pseudoword repetition, confrontation naming and nonverbal semantic association skills were considered to reflect processing skills at the phonological, lexical and semantic level, respectively. Attentional indices of impulsivity, focused attention, response time and variability were taken from C—CPT-II (Conners, 2002). We expected confrontation naming to be an important predictor of different quantitative and qualitative aspects of discourse production. With regard to pseudoword repetition, we expected it to be related mainly to phonological errors, while semantic association performance might relate to the quality and informativeness of discourse. Finally, we expected attention, particularly focused attention and intraindividual variability, to contribute to explaining a portion of the variability in discourse performance.

In the following, we will first discuss some issues concerning the differences between PWA and the neurotypical control group on descriptive discourse and cognitive performance. Then we will move on to discuss our results on the relationship between the performance in standardized linguistic and nonlinguistic tasks and discourse production.

Table 8
Results of stepwise linear regression analyses for discourse measures.

Dependent variable	Adjusted R^2	F	df	P value	Predictor(s)	Change in R^2	Beta	p value
PWA								
Token	0.261	7.342	1,17	< 0.05	SA	0.302	0.549	**<0.05**
Type	0.480	17.606	1,17	<0.001	SA	0.509	0.713	**<0.001**
MLU	0.453	8.461	2,16	<0.01	Naming	0.297	0.498	**<0.05**
					SA	0.217	0.469	**<0.05**
Emb	0.406	13.278	1,17	<0.01	Naming	0.439	0.662	**<0.01**
%CIUs	0.443	8.154	2,16	<0.01	SA	0.301	−0.709	**<0.01**
					RT	0.204	−0.479	**<0.05**
Controls								
Token	0.324	10.603	1,19	<0.01	Naming	0.358	0.598	**<0.01**
Type	0.325	10.647	1,19	<0.01	Naming	0.359	0.599	**<0.01**
TTR	0.244	7.457	1,19	<0.05	SA	0.282	−0.531	**<0.05**
MLU	0.246	7.533	1,19	<0.05	Naming	0.284	0.533	**<0.05**
Emb	0.184	5.522	1,19	<0.05	Naming	0.225	0.475	**<0.05**
MC	0.200	5.989	1,19	<0.05	RT	0.240	−0.490	**<0.05**

Note: Emb: Embbedding index; MC: Main Concepts; MLU: Mean Length of Utterance; PWA: People with aphasia; SA: Semantic Association; TTR: type-token ratio;%CIUs= percentage of correct information units.

Table 9
Results of stepwise linear regression analyses for errors.

Dependent variable	Adjusted R^2	F	df	P value	Predictor	Change in R^2	Beta	p value
%PhonP	0.418	13.940	1,17	<0.01	PwRep	0.451	−0.671	**<0.01**
%SemP	0.308	9.002	1,17	<0.01	Naming	0.346	−0.588	**<0.01**
%UnrelP	0.510	19.762	1,17	<0.001	Naming	0.538	−0.733	**<0.001**
%Neol	0.242	6.751	1,17	<0.05	PwRep	0.284	−0.533	**<0.05**

Note. PwRep: Pseudoword Repetition; %PhonP= percentage of phonological paraphasias over total number of words;%SemP: percentage of Semantic paraphasias over total number of words;%UnrelP: percentage of semantically unrelated paraphasias over total number of words.

4.1. Differences between groups

As expected, PWA scored significantly lower in standardized tasks measuring phonological skills, lexical retrieval (confrontation naming) and semantic association. Significant differences in C—CPT performance between PWA and neurotypical controls were detected only in RT SE, with a more variable performance in PWA.

Differences between groups in the picture description task pointed to a higher word productivity in people with fluent aphasia (the total token count was higher than in neurotypical controls) but with less lexical diversity (lower TTR) and quality (%CIUs), apart from a slower speech rate and a lower complexity of utterances. In contrast, both groups seemed to convey a similar amount of communicative information as measured by the MC analysis. In a recent study by Boucher et al. (2022) PWA were found to show lower scores in most measures of discourse performance during a picture description task, including also lexical quantity. However, they included participants within 8–14 days post stroke and did not limit their study to fluent aphasics. Brisebois et al. (2022) have shown a longitudinal improvement of the discourse of aphasic participants both at the microlinguistic level as well as in its informativeness. A study with a similar sample to the current one (fluent aphasics in a stable phase), found a similar level of lexical productivity between PWA and controls in narratives elicited by pictures, but lower quality of information (Andreeta & Marini, 2015). Overall, our results suggest that people with fluent aphasia did not necessarily produce fewer words than neurotypical controls when describing a picture, and not necessarily produce less information. However, their descriptive discourse shows lower lexical diversity, lower sentence complexity and a slower speech rate which results in less effective communication. Information is also conveyed less efficiently with a higher quantity of words for conveying the same relevant data.

4.2. Relationships between connected speech and cognitive measures: lexical access, phonology and semantic association skills

Confrontation naming was the clinical standardized measure which better predicted many measures related to descriptive discourse production in controls. However, and in line with some previous results, scores on confrontation naming were only related to some measures of discourse but not others in PWA (Mason & Nickels, 2021). Particularly, when considering the different types of words produced during discourse, semantic association skills emerged as the best predictor for PWA, explaining around 50% of variance. This suggests that the disruption of brain networks related to semantic processing might significantly contribute to lexical retrieval difficulties during descriptive discourse, at least for people with fluent aphasia. Notwithstanding, naming was the main predictor of sentence length and complexity both for PWA and neurotypical controls, but it only explained around 30% of variance. Nonverbal semantic association skills also contribute to explain additional variance regarding MLU in PWA. Thus, all in all, the results suggest that standardized lexical retrieval tasks based on picture naming might provide important evidence with regard to the descriptive discourse performance of PWA, but it might not represent the wide range of deficits that might influence performance during discourse (Mayer & Murray, 2003; Fergadiotis & Wright, 2016). The multifaceted nature of lexical retrieval during spontaneous speech might thus not be completely captured simply by performance in picture naming; and caution should be taken to extrapolate directly to everyday language use from picture naming tasks. Our results also suggest that nonverbal semantic association skills could be an additional measure of interest in the assessment of aphasic participants.

Fergadiotis and Wright (2016) point out that naming was very weakly related to paraphasias produced during spontaneous speech, but they did not assess different types of errors separately. Our results suggest that we should differentially consider phonological and verbal paraphasias. As expected, phonological errors (phonemic paraphasias and neologisms) were related to pseudoword repetition skills. However, they were not related to confrontation naming scores. On the other side, the regression analysis showed that lexical errors such as semantic and unrelated paraphasias might be associated with confrontation naming. Semantic association skills did not relate to verbal paraphasias, either semantically related or unrelated, suggesting that the occurrence of these errors in our sample and during the picture description task is related to lexical retrieval difficulties more than to nonverbal semantic deficits (c.f. Lewis & Soares, 2000).Phonological errors in language production have been related to the dorsal route of language processing, while previous results relate semantically related and unrelated paraphasias to largely overlapping areas of the left ventral temporoparietal cortex (Schwartz et al., 2012; Stark et al., 2019). In any case, both phonological and lexical retrieval standardized tasks explained only around 30–40% of variance of spontaneous errors during connected speech (with the exception of unrelated errors, which were scarce among all participants). Therefore, and in line with conclusions by Fergadoitis & Wright (2015), care should be taken before we extrapolate the results of confrontation naming to predict the presence of errors in aphasic speech in natural contexts.

4.3. Relationships between connected speech and cognitive measures: attentional skills

Based on previous results (Pérez Naranjo et al., 2018), we also hypothesized that attentional skills, and particularly focused attention and attentional variability, would have an important influence on verbal performance during the picture description task for PWA. Although differences in attentional performance between groups were barely detected in other indices of attention such as commission and omission errors, differences in trial-to-trial response speed showed reliably an increased variability for PWA. Variability has been considered a hallmark of aphasia (McNeil et al., 1991; McNeil & Pratt, 2001; see also Villard & Kiran, 2017). Variability in attention might produce intermittent access to linguistic knowledge during sentence planning and lexical retrieval, thus exacerbating language production difficulties. However, and in clear contrast to our initial hypothesis, the results of the correlational analysis show no clear influence of basic attentional skills in discourse performance in PWA.

There are some issues to bear in mind before we dismiss the possible role of attention for language performance in PWA. First, one reason why the influence of attentional skills over discourse was so limited in the current study might be related to the picture-description task used. Some researchers have pointed out that different discourse elicitation tasks might tax in different ways our cognitive system (Fergadoitis et al., 2011; Stark, 2019). The current study uses a single picture description task, which minimizes memory and executive components of discourse elaboration by maintaining the relevant pictorial material disposable in every moment. This might have minimized attentional demands. Second, we only assessed a subset of basic attentional skills. Several complex components related to executive function were not specifically assessed (Diamond, 2013; Kuzmina & Weekes, 2017; Purdy, 2002). And, finally, only fluent aphasic participants with posterior lesions were included in the study.

Hence, future studies should consider in deeper detail the role of basic attentional skills along with more complex executive measures, and across a wider set of discourse types and a variety of aphasic profiles, to shed more light onto the relationship between attention and discourse in aphasia. Notwithstanding, our current results are in line with evidence showing that linguistic and nonverbal attentional deficits in aphasia are partially dissociable, constituting different domains of impairment (Alyahya et al., 2020; Schumacher et al., 2019), although both verbal and nonverbal deficits might be important contributors to everyday communicative performance and to the clinical response to therapy (Fridriksson et al., 2006; Lambon Ralph et al., 2010).

4.4. Relationships between connected speech and cognitive measures in the control group

Some discourse measures significantly correlate with attentional skills when considering the neurotypical control group. In particular, RT correlated with MLU in neurotypical control participants, and RT variability correlated with%CIUs. Multiple Regression analyses also showed that lower RT was associated with the production of MC in the control group. Hence, it might be too early to dismiss any influence of attentional skills related to discourse production, particularly those related to processing speed. Processing speed influences in lexical access (Facal et al., 2012; Faroqi-Shah & Gehman, 2021) have been documented in older adults during experimental tasks. In this case, the evidence suggests that the influence is detectable in spontaneous discourse.

Why does RT evidence a small influence on the neurotypical control group but none in PWA? This is difficult to answer. In fact, an opposite pattern could be expected a priori: the presence of disruptions in attentional processing for PWA might exacerbate discourse planning and lexical retrieval difficulties in some cases more than others, thus facilitating the detection of a relationship between attention and discourse. However, the presence of additional cognitive difficulties with lexical and semantic processing in PWA might exert a higher influence than attentional problems. In particular, semantic difficulties seem to damper lexical productivity, so that the impact of focused attention and variability is minimized. In the case of sentence length and complexity, lexical retrieval, and to some extent also semantic association skills, seem to constrain the capacity to build larger and complex utterances more than basic attentional difficulties. Note that, again, this does not mean that attention does not influence language production in PWA, simply that the basic attentional skills seem to have little influence under the current task demands. However, difficulties might be noticed as soon as attentional demands increase (Murray et al., 1998).

4.5. How predictive are standardized tasks for discourse performance?

In fact, the predictive value of the cognitive tasks used in the current study for discourse related measures tended to be low, with only around a 25–35% of variance explained in most cases. Moreover, none of the selected standardized tasks seemed to contribute to explain performance across several dimensions of descriptive discourse. For example, none of the selected variables contributed to explain lexical diversity (TTR) or differences in MC for aphasic participants, or%CIUs in neurotypical controls. This lack of predictive value has two implications. On one hand, it points out that discourse measures might provide additional ecological information in the clinical assessment of aphasia that is not provided by some usual standardized tasks. Thus, advances toward the facilitation of the use of discourse measures by clinicians are of invaluable interest (Pritchard et al., 2017; Stark, Bryant, Themistocleous, den Ouden, & Roberts, 2022). On the other side, further research would be necessary to better understand cognitive contributions to discourse performance. A possible candidate that has not been explored in the current study are high order executive functions related to planning and behavioral control, which might bear more importance as responses are less stereotyped and linguistic complexity increases (Bourginon, 2014; Wong & Law, 2022).

The only attentional measure that seemed to explain additional variance in discourse measures beyond phonological, lexical and semantic tasks was RT. In particular, RT seemed to be associated with informativeness. In the case of neurotypical controls, RT explained a little amount of variance related to the conveying of MC, with people showing faster responses, and thus a more efficient processing of information, also producing more relevant information in their discourse. In aphasic participants, better RTs are related to a better communicative efficiency in terms of%CIUs. However, the pattern of results here is complex, as it also involves a paradoxical effect where higher semantic association skills led to lower communicative efficiency in terms of%CIUs. As this pattern of result is complex and unanticipated, its explanation is merely speculative and should be confirmed with further research. We believe that the paradoxical negative effect of semantic association skills for communicative efficiency is related to the fact that PWA with less semantic difficulties produced more speech. The increase in lexical productivity might have facilitated off-topic commentaries that might be quantified as a reduction in communicative efficiency. However, once this negative effect is accounted for, RT seemed to have a positive albeit weak effect facilitating communicative efficiency.

4.6. Limitations

Some of the main limitations of the current study have been already pointed out. They are related to the sample, the discourse elicitation task, and the selection of cognitive variables. With regard to the sample, we initially selected a group of people with fluent aphasia, with the aim to reach speech samples of significant size to provide reliable results, and to avoid severe attentional deficits related to frontal lesions. Consequently, however, we are limited to generalize the current results to other aphasia types. A similar limitation arises when considering the picture description task: different types of discourse and elicitation tasks might be used to study the complexity of discourse.

It is worth considering another aspect of our sample. As shown in Table 1, our participants with aphasia had mild to moderate language impairments, rather than severe ones. It is possible that including a wider range of linguistic impairments could have facilitated the observation of a greater association with some of the predictors, including the attentional measures.

Finally, the current set of cognitive tasks is not exhaustive. In particular, additional measures of executive function might have provided more information on nonlinguistic cognitive influences over discourse production. Further research should explore the relationship between cognitive skills and discourse using a wider range of attention and executive function tasks in a more comprehensive manner, including more measures related to executive attention and different types of discourse.

5. Conclusions

Contrary to our initial hypotheses, we did not find attentional variables arising as important predictors of descriptive discourse performance for our PWA group, although processing speed was overall related to better performance in the control group with regard to Token, Type, MLU and MC.

On the other hand, the semantic non-verbal association task was the main predictor of lexical quantity indices, and also contributed to explain variability in sentence length for PWA. Confrontation naming was a predictor for verbal paraphasias and sentence length and complexity in participants with fluent aphasia. Finally, pseudoword repetition was a predictor for phonological errors in speech.

Finally, we have to note that the total amount of variance in the picture description task predicted by our standardized tasks was overall low. We might question whether additional cognitive measures (such as, for example, complex executive functions) would contribute to a better adjustment. But, in any case, the pattern of results suggests that ecological measures of discourse production in aphasia should be taken into account to get a better understanding of clinical problems. Therefore, it is of utmost interest to synthesize and standardize procedures to collect and analyze discourse samples in naturalistic situations which might be helpful in clinical practice.

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CRediT authorship contribution statement

Narcisa Pérez Naranjo: Conceptualization, Investigation, Data curation, Writing – original draft. **David del Río:** Conceptualization, Methodology, Supervision, Writing – original draft. **Silvia Nieva:** Methodology, Resources, Writing – review & editing. **Carlos González Alted:** Resources, Writing – review & editing.

Declaration of Competing Interest

No potential conflict of interest was reported by the authors

Appendix 1

This document contains example transcriptions from a representative control participant and a participant with aphasia, along with a short English description of the content and the types of errors and difficulties observed

TRANSCRIPTION AND CODING EXAMPLE FOR A CONTROL PARTICIPANT

1@Begin

2@Languages: spa

3@Participants: CONTR Participant, SLT SpeechLanguageTherapist

5 @ID: spa|corpus|CONTR|39;00|male|||Participant|||
6@ID: spa|Aphasia|SLT||female|||Investigator|||
8@Media: controlSMC_ID1, audio .
9@Time Duration: 1:35:00
10 *SLT: y me cuentas todo lo que veas .
11 *SLT: ahora .
12 *CONTR: ya .
15 *SLT: hmmm [= afirmativamente] .
16 *CONTR: pues hay mucha gente en una clínica veterinaria, e:n principio [//]
17 tenemos una depen, una especie de dependienta [//], donde: [///]
18 que está atendiendo a una señora que lleva a un gato, donde tiene
19 comida para perros y correas, que supongo que venderá algo .
39 *CONTR: luego sale la, la veterinaria [//] y tiene aquí a una señora que
40 está recibiendo a un perro, que tiene la pata escayolada, que se
41 deber haber pegado un golpe o algo (.) .
57 *CONTR: luego tenemos aquí dos señores, que tienen un perrito, que debe ser
58 la mascota. La señora está metiendo mano en su bolso para algo,
59 Otra señora que tiene una llave que le está diciendo que si ésta
60 llave es de alguien, supongo .
81 *CONTR: un niño que está agachado con una caja porque tendrá, ha
82 salido su tortuga [///], que estaría dentro de la caja .
92 *CONTR: y luego hay unas, un banco muy grande donde están esperando un niño
93 con un perrito .
102 *CONTR: luego otro señor que tiene ya un loro dentro una jaula o: (.) y
103 luego dos niñas que tienen un gatito .
113 *CONTR: luego hay un niño al que se le está escapando un perro y: y quiere
114 cogerlo [//] .
123 *CONTR: otra señora que está al lado de la puerta de entrada que está con un
124 niño con un cachorrito de perro que tiene la pata también vendada .
137 *CONTR: y luego hay un cuadro con un [//] perro y otro cuadro con dos gatos
138 que están comiendo leche de un [//] cuenco .
147 @End

Lines 16–19: The speaker is trying to explain the scene globally, as a first general visual impression, and then describe specifically the part where a lady with a cat is talking to a sales clerk at the counter. He starts the description of the picture from right to left.

Lines 39–41: The speaker explains the part of the image where the veterinarian is returning a dog to its owner.

Lines 57–60: The participant describes the scene where a lady is looking for the owner of the keys she has found. Next to her is a lady who seems to be looking for them in a purse. And next to her is a man holding a dog on a leash.

Lines 81–82: The participant describes a boy who has a turtle outside its box.

Lines 92–103: The participant describes a boy who is sitting next to the parrot's owner and who has a dog on a leash. Next to them are two girls also waiting in the waiting room with a kitten.

Lines 113–114: The participant describes a boy who has the dog on a leash and it escapes from him.

Lines 123–124: The participant describes a woman who is next to the entrance door with a child. She is holding a puppy dog with a bandaged paw.

Lines 137–138: The participant describes pictures hanging on the wall in the veterinary clinic.

TRANSCRIPTION AND CODING EXAMPLE FOR A PARTICIPANT WITH APHASIA

1@Begin
2@Languages: spa
3@Participants: APH ID5 Aphasic, SLT Investigator
4@ID: spa|corpus|APH|52;00|male|Anomic||Aphasic||ID.5|
6@ID: spa|Aphasia|SLT||female|||Investigator|||
7@Media: MNP_ID5, audio
8@Time Duration: 7:00:00
9 *APH: Ya mismo .
11 *SLT: venga, pues ya mismo .
14 *APH: bueno e:h, pues e:l chico, o: esta con tu madre, con su
15 madre [//] +/.
16%cod: $APH:S:r
22 *SLT: mmmhmhm↑ .
23 *APH: e:h (.) esperando al e:h veterinario para (.), porque: [///], el
24 e:l mmmm (.), e:l cachorro está: (.) e: m: con una (.) m:, pata

25 e: (.) rota .
36 *SLT: mmmhmhm↑ .
37 *SLT: ⟨muy bien⟩ [<] .
39 *APH: <por otra parte>[>], e:l [x 2] otro: hijo (.), perdona, el otro:
40 niño: eeeh (.) e:s e:h, como el: (.) está (.), e:h [x 2], está
41 (.), m: (..), e: (.), m: (.), s: (..) e:l [x 2] perro, eh, del
42 niño (.), s:e (.) escapa (.) de: [x 2] ést, del niño,
43 efectivamente, m:, porque, m: (.) está, e:h↑ (.), está [x 2] muy
44 a gusto [///], e:h (.) m: por conocer a: [x 2] al [//] cachorro .
45%cod: $APH:S:r
46 $APH:CIR
72 *SLT: mmmhmhm↑ .
73 *APH: por otra parte, e:[x 2] el en el (.) banco, tienen (.) dos u:
74 chicas, eh↑ con un gato (.) esperando también a que el veterinario
75 e: (.) lo vea, yo pienso que es solamente, m: co:n (.) la vacuna .
92 *SLT: ⟨Mhmhmh [= afirmando la descripción]⟩ [<] .
94 *APH: <*s*, o sea que: (..) eso no: +/
95 >[>][= como diciendo que tiene buen pronóstico el tema de la pata] .
99 *SLT: tiene buena pinta [= rien ambos] .
102 *APH: por otra parte: e: (.), un hombre e:, está esperando también al
103 veterinario a:, a ver [//] lo que s, lo que se, s: se pasa [//] con
104 e:l (..) loro,
105 e:h
106 que está e: en una m: (.), jaula, e: (.) co:n, no con redes sino
107 co:n (.) [= en voz baja se pregunta:" como se llama esto?"] .
108%cod: $APH:S:r
109 $APH:S:r:prep
126 *APH: cristal .
128 *SLT: Mhmhmh↑ .
130 *APH: a: [x 2] al, e: otro [///] e:h cliente, es un niño, que está junto
131 al, de e:l perro, al del loro [//], está: también esperando
132 al veterinario, y está, y el perro están atendiendo [//] a:, a:l está
133 atento efectivamente [///] al cachorro que está, que está: o que
134 estaba [///], o que está (.) [//] e: [x 3] m:, que está con (.),
135 con (.), con la: pata (.) vendada [//] .
136%cod: $APH:S:r
137 $APH:S:r:segm
138 $APH:CIR
168 *SLT: Mmmhm↑ .
170 *APH: luego, por otra parte (.), una señora, que: (.) no sé si se ha
171 encontrado unas llaves, que, e:h y: otra persona, perdona,
172 otra señora [//] que está (.) m: viendo, o:, a ver si, las
173 llaves, e: [x 3] es, está:n [//] en [x 2] el bolso o no↑, (.) +//.
174%cod: $APH:S:r
175 $APH:CIR
197 *APH: e:, no sé si eso es lo correcto (.), pero bueno
198 [= pensando en voz alta que no lo tiene claro] +// .
203 *SLT: +, pu de ser, puede se:r↑, que le esté preguntando que si son
204 suyas ?
211 *APH: y el (.) y el señor [//] que, está con ella, efectivamente tiene
212 un perro e:h↑, eh de caza, a lo mejor un [x 2] (.) un pointer [//]
213.
224 *APH: luego, al lado también, pero en otro lugar, e:h, está un chico, eh
225 ↑con una caja, e: y una:, tortuga, eh↑, esperando también al
226 veterinario[= tose] .
238 *APH: luego, e: el veterinario, bueno la: veterinaria [///], que
239 no es eso ?
240%cod: :S:r:der
246 *SLT: si: .
248 *APH: está (.) m: está: ha reconocido [///] al [x 2] perro de la:, e:,
249 señora (.) eh↑, que ha reconocido al perro de la señora (.) porque

250 está e:h, a:h, e:h, en la consulta [//] efectivamente, pero,
251 perdona, porque [///] el perro está:, que está perdona, que el perro
252 está[//], con una (.) m: una ven [x 2] venda [//], efectivamente, que
253 no sé si es porque está rota, o si es porque ha sido una herida .
254%cod: $APH:CIR
293 *SLT: mmmmm↑ .
294 *APH: y, de perdona, detrás [//] de donde está la veterinaria, tiene, e:
295 está la vendedora, la vendedora *o* +/.
308 *SLT: mmmmm↑ .
309 *APH: o: la asistente de la veterinaria [///].
314 *SLT: eso mejor sí .
317 *APH: y está e: con un gato y además no sé si e: está comprando la
318 comida o: si está charlando, solamente o:, no tiene:, no (.) no
319 sé +//.
320%cod: $APH:CIR
335 *APH: vale, muy bien, fenomenal .
339 @End

Lines 14–25: the speaker is trying to describe that there is a woman who is next to the entrance door with a child. She is holding a puppy dog with a bandaged paw. He starts the description of the picture from left to right.

Lines 39–44: The participant describes a child who has a dog that is running away from him because its leash is loose. He makes abundant pauses in speech with word finding difficulties due to the anomia, sometimes unable to find the target word.

Lines 73–94: The participant talks about the part of the picture where two girls are seen playing with their kitten.

Lines 102–126: The participant is describing a man who has a parrot in a cage.

Lines 130–135: The participant is trying to find the words to describe a boy who is sitting next to the parrot's owner and who has a dog on a leash. In his description he also mixes the image of the beginning of the woman with the puppy in the arms of the bandaged paw because the child is looking at her. His-narrative mixes both discursive topics in such a way that it does not seem clear which image is being referred to.

Lines 170–198: The participant describes a lady who is looking for the owner of the keys she has found. Next to her there is another lady who is looking for them in her purse.

Lines 211–212: The participant describes a man who is standing next to the lady with the handbag and has a dog that is sitting.

Lines 224–226: The participant describes a boy who has a turtle outside its box. He finds all relevant words even though it pauses.

Lines 238–253: The participant is trying to describe a scene where the veterinarian is carrying a dog with a leg in a cast and handing it to its owner. He uses a lot of crutches such as "excuse me" or "indeed" and repeats words or phrases very often, occasionally rephrasing.

Lines 294–319: The participant describes the scene of the lady in the store at the counter buying food for a cat that she is carrying in her arms. She is in a conversation with the sales clerk.

Appendix 2

The following table contains data on the inter-rater reliability agreement performed on a 20% of the transcription of each individual with aphasia

Appendix Table 1. Inter-rater reliability

PWA	Rater	% accordance in utterances	% accordance in words
1	1	100%	76%
2	1	91.60%	74.50%
3	1	88.23%	74.07%
4	1	100%	81.08%
5	1	100%	75.28%
6	2	100%	84.27%
7	2	100%	80.41%
8	2	96.77%	80.12%
9	2	94.44%	81.25%
10	2	100%	90.22%
11	3	100%	84.26%
12	3	100%	88.94%
13	3	95.65%	83.33%

(*continued on next page*)

(*continued*)

PWA	Rater	% accordance in utterances	% accordance in words
14	3	100%	83.14%
15	3	93.75%	85.03%
16	4	96.29%	98.60%
17	4	100.00%	82.44%
18	4	92.30%	82.19%
19	4	100.00%	83.17%
		Mean = 97.3%	Mean = 82.5%
		SD = 3.6%	SD = 5.8%

PWA: person with aphasia.

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