Alzheimer's & Dementia: Diagnosis, Assessment & Disease Monitoring 10 (2018) 31-40

Alzheimer's & Dementia

Cognitive & Behavioral Assessment

Analysis of macrolinguistic aspects of narratives from individuals with Alzheimer's disease, mild cognitive impairment, and no cognitive impairment

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Abstract

Introduction: The depiction of features in discourse production promotes accurate diagnosis and helps to establish the therapeutic intervention in cognitive impairment and dementia. We aimed to identify alterations in the macrolinguistic aspects of discourse using a new computational tool.
Methods: Sixty individuals, aged 60 years and older, were distributed in three different groups: mild Alzheimer's disease (mAD), amnestic mild cognitive impairment, and healthy controls. A narrative created by individuals was analyzed through the Coh-Metrix-Dementia program, extracting the features of interest automatically.
Results: mAD showed worse overall performance compared to the other groups: less informative discourse, greater impairment in global coherence, greater modalization, and inferior narrative structure. It was not possible to discriminate between amnestic mild cognitive impairment and healthy controls.
Discussion: Our results are in line with the literature, verifying a pathological change in the macrostructure of discourse in mAD.

Keywords: Mild cognitive impairment; Alzheimer disease; Aging; Narration; Language disorders; Communication; Diagnosis; Automatic data processing

1. Background

The progressive growth of the elderly is a well-established phenomenon in most populations, with a special burden in the demographic structure of developing countries such as Brazil. Considering that the incidence of dementia increases with age, this issue becomes a central health problem [1].

Alzheimer's disease (AD) is the most common type of dementia, characterized as an irreversible and progressive syndrome that compromises functional performance [2].

In that sense, language disorders gained an important role, as they can occur in the early stages of the disease and evolve throughout time [3,4]. Moreover, it is known that the architecture of language dysfunction seen in mild cognitive impairment (MCI) originates from primary language difficulties related to the decline in the semantic and pragmatic levels of processing [5]. Discourse analysis is a sensitive resource to recognize language difficulties in individuals in the early stages of disease [6]. Their discourse is described as disorganized, empty, presenting a large number of indefinite terms and phrases without meaning [7].

At the macrolinguistic level, it is important to highlight the impairment in the emission of relevant information and

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http://dx.doi.org/10.1016/j.dadm.2017.08.005

in connecting units of discourse content in a cohesive way with reference to the main theme [8,9].

Therefore, early identification of language traits can be of foremost importance in preclinical stages, MCI, and early AD if we take into consideration that a significant proportion of the elderly find themselves in this spectrum [10]. MCI cases worldwide represent 6.1%, with an incidence of 13.2/1000 subjects per year, among individuals aged 60 years or more [11]. Of particular interest is the fact that MCI cases can remain stable or restore its normal status over time, but approximately 50% of individuals develop dementia over a 5-year period [12]. Language deficits in MCI have been object of scrutiny in the literature, allowing well-known disturbances in tasks of fluency, naming, and semantic knowledge [13].

Specifically, when it comes to discourse, Cuetos et al. [14] reported a decrease in the content found in early AD stages. Drummond et al. [15] analyzed the narrative of individuals with AD, MCI, and healthy control (HC) from a cognitive standpoint. The HC and AD groups differed in all parameters, except for the time taken to execute the task and the number of words. The MCI had an intermediate performance between HC and AD. In addition, the MCI and HC differed from AD in relation to the overall coherence, cohesion, and type of discourse.

Discourse is recognized as a fundamental component in language assessments and should be considered for the identification of language disorders in dementias, as well as in the follow-up for these individuals [16]. Brandão [17] states that deficits in discourse indicate where failure occurs during processing. It is indispensable, therefore, to advance in the nature of such shortcomings and obtaining cognitive and discursive markers for the differential diagnosis of pathologies.

The well-rooted theory of Kintsch and van Dijk [18] supports the analysis model of microstructure and macrostructure to study the discourse of individuals with Alzheimer's disease [17,19].

Cinderella's storytelling has been used in aphasia studies [20] and is included in the assessments of subjects because of their penetration in Western culture, including Brazil.

Advances in new techniques of Natural Language Processing combined with Data Science techniques are expanding. Computational methods are applied in texts, seeking to identify signs of neurological or psychiatric impairments and automatically extract linguistic characteristics for recognition, classification, and description of diseases [21,22].

Among the obstacles in studies about discourse, transcription and analysis are vital and reports concerning computational analysis are scarce. Because they are laborious and difficult, research on a large scale becomes challenging and reinforces the benefits from the speed and systematic nature of computerized analyzes. Hence, searching for markers and performance profiles using unbiased techniques becomes fundamental and may guide clinical practice with greater objectivity and accuracy [23].

The Coh-Metrix tool [24] was developed at Memphis University to capture cohesion and difficulty of a text. This tool was adapted to Portuguese, so-called Coh-Metrix-Port [25]. The use of the tool for the dementia population motivated the creation of Coh-Metrix-Dementia [26], used in the present study. For that matter, Coh-Metrix-Dementia adds features to the existing 48 in Coh-Metrix-Port. New features include Latent Semantic Analysis, measures of lexical diversity, syntactic complexity, and semantic density.

By means of this technology, we aimed to verify if Cinderella's storytelling, a prototypic narrative very well known in Western culture [20], distinguished individuals with AD or MCI and HC; using both quantitative parameters, such as the occurrence frequency of distinguishing traits, and qualitative parameters, to verify the nature of macrostructural aspects.

The study was justified by the need to identify and characterize the differences between groups, different diagnoses, and the possibility of creating tools that facilitate the observation of results of clinical intervention in language in dementia.

The authors hypothesized that certain metrics could differentiate the three groups with being the worst performance for mild Alzheimer's disease (mAD), followed by amnestic mild cognitive impairment (aMCI) and HC, finding performance markers for each group.

2. Methods

Approval by the Ethics and Research Committee of the Medical School of the University of São Paulo (CAPPesq No. 1.192.984) was obtained, as well as Free and Informed Consent Term was signed by every individual.

The sample size consisted of 60 individuals divided into 3 groups: mAD group, aMCI group, and a healthy cognitive elderly control group.

The aMCI and mAD groups were recruited either from Universidade de São Paulo's outpatient clinics of cognitive neurology (GNCC), or from its dementia reference center (CEREDIC). All individuals had their diagnosis confirmed by a neurologist that was blind to the procedure, subsequently going through the proposed protocol. The MCI group was constituted only by amnestic, single or multiple domain, individuals. HC group was comprised by age- and education-matched community-dwelling volunteers and nonconsanguineous caregivers who fulfilled criteria for inclusion and exclusion.

2.1. Inclusion and exclusion criteria

Table 1 presents inclusion and exclusion criteria for all groups.

For the evaluation of discourse, a book with 22 sequenced scenes, portraying the Cinderella story without subtitles, was used. Evaluations were carried out individually by the same researcher (C.M.T.). Subjects were allowed to look

Table 1
Criteria for inclusion and exclusion of individuals in the study

Criteria	Healthy controls	Amnestic mild cognitive impairment	Mild Alzheimer's disease
Inclusion criteria			
Age	≥60 years. No maximum age limit	≥60 years. No maximum age limit	≥60 years. No maximum age limit
Education	≥3 years. No maximum educational level limit	≥3 years. No maximum educational level limit	≥3 years. No maximum educational level limit
Criteria MOANS [27]	Meet all requirements	Not a criterion for inclusion	Not a criterion for inclusion
Syndrome diagnosis of dementia—DSM-IV criteria [28]	Did not meet criteria for inclusion	Did not meet criteria for inclusion	Meet the criteria for dementia
Clinical Dementia Score (Clinical Dementia Rating) [29]	Stage 0 (healthy)	Stage 0.5 (dementia questionable)	Stage 1 (mild dementia)
NINCDS-ARDRA Criteria [30]	Not a criterion for inclusion	Not a criterion for inclusion	Probability criteria—probable AD
Criteria for consensus, Winblad 2004 [31]	Not a criterion for inclusion	Amnestic subtypes	Not a criterion for inclusion
Mini–Mental State Examination (Folstein et al., 1975) [32]	Acceptable performance for schooling	Not a criterion for inclusion	Not a criterion for inclusion
Verbal fluency test—semantic criterion—animals [33]	Acceptable performance for schooling	Not a criterion for inclusion	Not a criterion for inclusion
Neuropsychological assessment	Not applied—no criterion for inclusion	Defined the inclusion and subtype of MCI	Not applied—no criterion for inclusion
Exclusion criteria			
Cornell's Dementia Depression Scale [34]	Not applied to this group	Not applied to this group	Score equal to or greater than 7 (indicative of the presence of depressive symptoms)
Geriatric Depression Scale (Yesavage et al., 1983) [35]	A score equal to or greater than 5 (indicative of the presence of depressive symptoms)	A score equal to or greater than 5 (indicative of the presence of depressive symptoms)	Not applied to this group
Questionnaire on Cognitive Decline in the Elderly IQCODE [36]	Score lower than 3.41	Not a criterion for exclusion	Not a criterion for exclusion
History of previous psychiatric disorders (DSM-IV, 1994) [37]	Previous diagnostic	Previous diagnostic	Previous diagnostic
Visual acuity	Compatible with functionality and performance of the target task	Compatible with functionality and performance of the target task	Compatible with functionality and performance of the target task
Auditory acuity	Compatible with functionality and performance of the target task	Compatible with functionality and performance of the target task	Compatible with functionality and performance of the target task

through the book, which remained in front of them the whole time.

Subjects were instructed to narrate the story in their own words as if telling to someone who did not know it. There was no time limit. Discourse was recorded using the Canon SX 170 IS camera and transcribed manually using the principles of NURC/SP No. 338 EF and 331 D[2].

2.2. Data analysis

The SPSS 14.0 (Statistical Package for Social Sciences, version 14.0) was used for statistical analysis. The significance level of 5% ($P \leq .05$) was adopted for the interpretation of the results, and nonparametric Kruskal-Wallis test was used to compare performance among the three groups regarding the variables of interest, with Tukey's multiple comparisons when significant.

All collected discourses were transcribed, and then Coh-Metrix-Dementia was used to extract the metrics for computerized analysis. This program is able to display the value of 73 features in several linguistic aspects. There was a need to edit the transcripts, segmenting them into sentences to ensure better system performance. The Manual of Notes of Propositions on sentences of Transcribed Narratives was elaborated based on Saffran et al. [38].

The manual comprises 3 phases:

Phase 1—Removal of a set of words, called nonwords: neologisms, empty comments, false beginnings, direct discourse markers, repetitions, interruptions, alterations, elaborations, and coordinating and deictic conjunctions.
Phase 2—Segmentation of the text in sentences: after the words were removed, the text was segmented into sentences. Segmentation took into account syntactic and semantic characteristics.
Phase 3—Annotation of the narrative propositions from the sentences: marking of the defined narrative propositions in the sentences. The definition of the 28 propositions was made from the base story, selecting the main ideas that could tell the story.

In this study, experts participated in phases 1 and 2 were 4 professionals, and phase 3 was performed by 2 professionals. The professionals were divided into pairs for the annotation of a sample of each group. The Kappa index was calculated to verify the concordance between the judges, and the data were adjusted.

Both texts with the manual segmentation performed by the evaluators were analyzed by Coh-Metrix-Dementia for the extraction of metrics.

Table 2 presents the list with the 28 propositions defined for the narrative. The original story was taken into account, and the main ideas were then selected.

The 28 propositions were also grouped according to four major components of the narrative structure:

- Orientation: 1–7.
- Problem: 9, 12, 18, 22, 24.
- Development: 8, 10, 11, 13, 14, 15, 16, 17, 19, 20, 21, 23, 25, 26.
- Conclusion: 27, 28.

The total number of propositions reported in the discourse, the presence of modalization (comments on the content of the story and/or doubts or concerns about its production), and the presence of sentences that did not refer to any proposition defined by the evaluators were verified.

Using features provided by the tool and by manual marking, the macrostructural characteristics were extracted. The analyses of the macrostructural characteristics were carried out as follows: for the analysis of the informativity, the number of propositions of each text was verified; for the analysis of the global coherence, the amount of empty emissions, the total ideas density feature, and the latent semantic analysis feature were verified; and for the analysis of the modalization, the amount of modalizations was verified.

Table 2
List with the 28 propositions of the narrative

1. Cinderella's mother dies
2. Cinderella's father marries again
3. Cinderella and her father/her father's death
4. Rich girl
5. Envy (Stepmother and Daughters)
6. Cleaning the attic/Being a servant
7. Debauchery and wickedness
8. Invitation to the ball (dance)
9. They do not let Cinderella go to the dance
10. Animals help make the dress
11. Cinderella is happy with the dress
12. Stepmother's daughters tear Cinderella dress
13. Refuge in the forest/crying
14. Fairy godmother appears
15. Fairy godmother measuring Cinderella for new dress
16. Moment of transformation/pumpkin-carriage
17. Fairy godmother makes/gives a dress to Cinderella
18. Fairy Godmother warns Cinderella to return before midnight
19. Went to the dance
20. Prince meets Cinderella
21. Prince dances with Cinderella
22. Midnight/Cinderella loses shoe on ladder
23. Prince picks up shoe and looks for Cinderella
24. Stepmother holds Cinderella in the attic
25. The stepmother's daughter tries the shoe and does not fit
26. Animals free Cinderella
27. Cinderella tries the shoe and it fits
28. Marriage

The features stipulated by Coh-Metrix-Dementia that provides information about the macrostructure are presented in Table 3.

3. Results

The groups were matched for age, education, and, although not controlled, gender was balanced among groups. Coh-Metrix-Dementia was used to capture discourse features. Statistical analyses were performed to verify the features and metrics capable of differentiating the groups.

3.1. Informativity and narrative structure

Regarding the number of propositions reported in the discourse, mAD individuals presented lower numbers in relation to aMCI and HC, indicating less informative discourses. In the four items of the narrative structure, the performances of aMCI and HC were similar. The number of propositions in each item was superior to mAD.

Table 4 presents demographical and global cognitive results and the number of propositions and the structure of the narrative.

3.2. Global coherence and modalization

In the average features between adjacent sentences and mean of similarity between all sentence pairs in the text, a difference was found only between aMCI and mAD. The aMCI presented the lowest values in these measurements.

The mAD individuals presented the highest values in the metric standard deviation among sentences, among all sentence pairs. aMCI and HC presented similar performance. In the other features of the latent semantic analysis category, no differences were found between the groups.

The total idea density of the text showed that mAD individuals presented a lower total number of propositions. The aMCI and HC groups presented similar performance.

The mAD individuals presented greater production of empty sentences and modalizations than the individuals of the aMCI and HC.

Table 5 exhibits the results in relation to the amount of empty emissions, total idea density, results related to Latent Semantic Analysis, and quantity of modalizations.

4. Discussion

The purpose of this study was to verify the differences between mAD, aMCI, and HC in the task of producing narratives, exploring an innovative method of computational discourse analysis that could identify performance markers in macrostructural aspects and help differentiate individuals in each stage.

We did not differentiate multiple or single domain in our sample, as most language studies in the literature [39–41].

In relation to macrostructural aspects, informativity, global coherence, and modalization were analyzed.

Table 3
Features of Coh-Metrix-Dementia

Latent semantic analysis (LSA)	
Average between adjacent sentences	Mean of similarity between pairs of adjacent sentences present in the text
Standard deviation between adjacent sentences	Standard deviation of the similarity between the pairs of adjacent sentences present in the text
Average similarity between all sentence pairs in the text	Mean of similarity between all sentence pairs in the text, not just the adjacent pairs
Standard deviation between sentences, all sentence pairs	Standard deviation of similarity between all sentence pairs in text
Average between adjacent paragraphs	Average similarity between adjacent paragraphs in the text
Standard deviation between adjacent paragraphs	Standard deviation of similarity between adjacent paragraphs in the text
Mean givenness of sentences	Average similarity between each sentence and all the text that precedes it. Average givenness of each sentence of the text from the second sentence onward. If the text has only one sentence, the metric is set to 0.0. Givenness of a sentence is defined as the LSA similarity between the sentence and all the text that precedes it.
Standard deviation of sentences givenness	Standard deviation of the similarity between each sentence and all the text that precedes it. Standard deviation of the givenness of each sentence of the text from the second sentence onward. If the text has only one sentence, the metric is set to 0.0. The givenness of a sentence is defined as the LSA similarity between the sentence and all the text that precedes it.
Mean span of sentences	Mean span of each sentence of the text from the second onward. If the text has only one sentence, the metric is set to 0.0. The span of a sentence, as well as givenness, is a way of measuring the closeness between a sentence and the context that precedes it. The difference, in simple terms, is that span seeks to capture similarity not only with the explicit content presented earlier in the text but also with everything that can be inferred from that content.
Standard deviation of sentence span	The standard deviation of the span of each sentence of the text, from the second onward. If the text has only one sentence, the metric is set to 0.0.
Semantic density	
Total idea density	Number of propositions present in the text, per every 10 words. For the calculation of the propositions, empty or disfluent propositions are not taken into account, and the calculation is done on the revised text for better performance of the extraction tool.

4.1. Informativity and narrative structure

The informativity refers to the target propositions expected for the narrative. Twenty-eight propositions were defined in Cinderella's story. The results showed that the mAD individuals presented less propositions than the aMCI and HC individuals, indicating less informative discourses with less reference to what was expected for the narrative. These findings corroborate the literature that indicates alteration in the content of individuals with AD [14,19]. Rusted et al. [42] reported that a possible justification for the reduction in discourse content in Alzheimer's disease would be memory impairment and reduced ability to retrieve information. We minimize memory impact in discourse production since the Cinderella scenes were available for consultation during the task.

Fleming and Harris [43] found differences between individuals with MCI and healthy subjects regarding discourse length and quality, impaired in the former by the absence of central elements. The performance compromised in semantic activities may occur due to shortcomings in executive skills related to semantic processing, which is responsible for retrieving, maintaining, monitoring, and manipulating semantic representations.

The study by Lira [19] reported that the AD group presented half of the propositions in comparison to the total of the control group in a narrative task and linked this difficulty to a loss in content processing.

In the present study, the expected number of propositions was high, which may have contributed to the results found. The fact that no subject has produced a discourse with all the selected propositions should be emphasized. This was also found in Toledo [44] with normal individuals and corroborates the results of Alves and Souza [45], who evaluated the differences of priorities between examiner and subject in the construction of narratives.

Bschor et al. [8] studied the performance of groups of individuals with AD, MCI, and healthy subjects in the description of the Cookie Theft Picture. Individuals with AD presented discourses with lower relevant content than those of MCI and healthy subjects, who presented similar performance, as found in the present study.

The difficulties in the processing of content may be related to the deterioration in the "semantic database" or be interpreted as a failure to access the database, which would remain intact in relation to attentional and executive processes [46].

Another hypothesis that explains the amount of information produced by the individuals would be the context of the evaluation. In this hypothesis, the individuals produced less information because they assumed that the evaluator already knew the figure.

In the present study, the structure of the narrative by the division in orientation, problem, development, and outcome was analyzed. The problems in the mAD group were also reported by Ska and Duong [9], Lira [19], and Jerônimo [47]. The mAD individuals had greater difficulty in narratives, a tendency to present facts in isolation and to describe the scenes rather than establishing a relationship between elements.

Table 4
Demographical and global cognitive results and analysis of the amount of proposition and narrative structure

Item	Group			Kruskal-Wallis test (*P*)	Tukey multiple comparison test (*P*)	Results
	aMCI	mAD	HC			
Age						
Mean	73.3	78.2	74.8			
Median	73.0	78.0	72.0	.090	—	aMCI = mAD = HC
Standard deviation	5.9	5.1	11.3			
n	20	20	20			
Education (years)						
Mean	10.8	8.6	11.4			
Median	11.0	7.5	11.0	.131	—	aMCI = mAD = HC
Standard deviation	4.5	5.5	2.6			
n	20	20	20			
Mini–Mental State Examination						
Mean	28.25	22.95	29.30		(aMCI × mAD) (*P*) < .001*	
Median	28.50	21.50	30.00	<.001*	(aMCI × HC) (*P*) = .234	mAD < aMCI = HC
Standard deviation	1.12	3.17	0.92		(mAD × HC) (*P*) < .001*	
n	20	20	20			
Verbal Fluency—FAS						
Mean	34.45	19.20	35.60		(aMCI × mAD) (*P*) < .001*	
Median	31.00	18.00	32.50	<.001*	(aMCI × HC) (*P*) = .917	mAD < aMCI = HC
Standard deviation	9.75	7.94	9.66		(mAD × HC) (*P*) < .001*	
n	20	20	20			
Verbal Fluency—Verb						
Mean	13.10	6.05	13.75		(aMCI × mAD) (*P*) < .001*	
Median	13.00	5.00	12.50	<.001*	(aMCI × HC) (*P*) = .869	mAD < aMCI = HC
Standard deviation	4.01	3.25	4.78		(mAD × HC) (*P*) < .001*	
n	20	20	20			
Verbal Fluência—Animals						
Mean	14.50	7.90	14.90		(aMCI × mAD) (*P*) < .001*	
Median	14.00	8.00	14.00	<.001*	(aMCI × HC) (*P*) = .860	mAD < aMCI = HC
Standard deviation	2.59	2.13	2.51		(mAD × HC) (*P*) < .001*	
n	20	20	20			
Boston Naming Test						
Mean	42.40	22.45	49.30		(aMCI × mAD) (*P*) < .001*	
Median	43.00	23.00	49.50	<.001*	(aMCI × HC) (*P*) = .004*	mAD < aMCI < HC
Standard deviation	7.74	7.32	3.64		(mAD × HC) (*P*) < .001*	
n	20	20	20			
Camel and Cactus Test						
Mean	52.55	40.70	56.30		(aMCI × mAD) (*P*) < .001*	
Median	53.00	40.00	57.00	<.001*	(aMCI × HC) (*P*) = .029*	mAD < aMCI < HC
Standard deviation	3.43	6.44	2.74		(mAD × HC) (*P*) < .001*	
n	20	20	20			
Number of propositions						
Mean	14.25	5.50	17.15		(aMCI × mAD) (*P*) < .001*	
Median	15.50	4.00	18.00	<.001*	(aMCI × HC) (*P*) = .118	mAD < aMCI = HC
Standard deviation	4.94	5.34	3.07		(mAD × HC) (*P*) < .001*	
n	20	20	20			
Orientation						
Mean	3.90	1.90	4.85		(aMCI × HC) (*P*) = .432	
Median	4.00	1.00	4.00	.001*	(aMCI × mAD) (*P*) = .030*	mAD < aMCI = HC
Standard deviation	2.90	2.00	2.25		(mAD × HC) (*P*) = .001*	
n	20	20	20			
Problem						
Mean	3.30	1.30	4.15		(aMCI × HC) (*P*) = .201	
Median	3.00	1.00	4.00	<.001*	(aMCI × mAD) (*P*) < .001*	mAD < aMCI = GG
Standard deviation	1.78	1.63	1.18		(mAD × HC) (*P*) < .001*	
n	20	20	20			
Development						
Mean	8.35	2.45	9.70		(aMCI × HC) (*P*) = .324	
Median	9.00	2.00	9.00	<.001*	(aMCI × mAD) (*P*) < .001*	mAD < aMCI = HC
Standard deviation	3.38	2.67	2.75		(mAD × HC) (*P*) < .001*	
n	20	20	20			

(*Continued*)

Table 4
Demographical and global cognitive results and analysis of the amount of proposition and narrative structure (*Continued*)

Item	Group aMCI	mAD	HC	Kruskal-Wallis test (P)	Tukey multiple comparison test (P)	Results
Conclusion						
Mean	1.80	0.85	1.95		(aMCI × HC) (P) = .783	
Median	2.00	1.00	2.00	<.001*	(aMCI × mAD) (P) < .001*	mAD < aMCI = HC
Standard deviation	0.70	0.93	0.39		(mAD × HC) (P) < .001*	
n	20	20	20			

Abbreviations: aMCI, amnestic mild cognitive impairment; mAD, mild Alzheimer's disease; HC, healthy control.
*Statistical difference.

4.2. Global coherence and modalization

For the analysis of the global coherence, the empty emissions, the total idea density feature, and the latent semantic analysis feature were verified. Greater difficulty was found in the discourse of the mAD individuals. They also presented higher numbers of empty emissions without reference to the narrative, indicating greater difficulty to maintain the theme. The mAD presented lower values in the total idea density feature when compared with the other groups. This feature takes into account the ideas transmitted by the subject and how each transmitted information cell is related to the target propositions.

The features that analyze the similarity between sentences and their contribution to global coherence are highlighted. In the metric standard deviation between sentences, higher values in mAD among all pairs of sentences were found, indicating greater difficulty in keeping the

Table 5
Empty emissions analysis, total idea density analysis, latent semantic analysis, and number of modalizations

Item	Group aMCI	mAD	HC	Kruskal-Wallis test (P)	Tukey multiple comparison test (P)	Results
Empty emissions						
Mean	11.40	27.10	12.55		(aMCI × mAD) (P) = .002*	
Median	8.50	22.50	9.00	.001*	(aMCI × HC) (P) = .964	mAD > aMCI = HC
Standard deviation	8.57	19.55	11.99		(mAD × HC) (P) = .005*	
n	20	20	20			
Total idea density						
Mean	0.38	0.32	0.37		(HC × aMCI) (P) = .799	
Median	0.39	0.33	0.38	.003*	(HC × mAD) (P) = .006*	HC = aMCI > mAD
Standard deviation	0.05	0.06	0.04		(aMCI × mAD) (P) = .001*	
n	20	20	20			
Average between adjacent sentences						
Mean	0.26	0.33	0.29		(HC × aMCI) (P) = .631	HC = aMCI
Median	0.27	0.33	0.30	.009*	(HC × mAD) (P) = .186	HC = mAD
Standard deviation	0.06	0.11	0.05		(aMCI × GDA) (P) = .025*	aMCI < mAD
n	20	20	20			
Average similarity between all sentence pairs in the text						
Mean	0.22	0.28	0.24		(HC × aMCI) (P) = .427	HC = aMCI
Median	0.22	0.28	0.25	.022*	(HC × mAD) (P) = .171	HC = mAD
Standard deviation	0.05	0.09	0.04		(aMCI × mAD) (P) = .009*	aMCI < mAD
n	20	20	20			
Standard deviation between all pairs of sentences						
Mean	0.21	0.24	0.21		(HC × aMCI) (P) = .812	
Median	0.21	0.24	0.21	.022*	(HC × mAD) (P) = .017*	HC = aMCI < mAD
Standard deviation	0.03	0.05	0.02		(aMCI × mAD) (P) = .075	
n	20	20	20			
Modalizations						
Mean	0.90	5.90	0.40		(aMCI × mAD) (P) = .002*	
Median	0.00	2.50	0.00	<.001*	(aMCI × HC) (P) = .934	mAD > aMCI = HC
Standard deviation	1.25	7.62	0.99		(mAD × HC) (P) = .001*	
n	20	20	20			

Abbreviations: aMCI, amnestic mild cognitive impairment; mAD, mild Alzheimer's disease; *n*, number of individuals; HC, healthy control.
*Statistical difference.

theme throughout the discourse. The average metric between adjacent sentences and average similarity between all sentence pairs differentiated the aMCI from the mAD, which presented the highest values and shows more repetitive discourse without introducing new information. It was not possible to discriminate each group based on these features.

This study demonstrates an innovative method for the analysis of global coherence, using automatically extracted metrics and empty emission marking. The findings corroborate those of Brandão [17] and Brandão et al. [48], who reported greater impairment of individuals with AD in relation to global coherence.

Drummond et al. [15] also indicates deficiency of overall consistency in individuals with AD and similar performance of the control and MCI groups. The authors state that these difficulties are associated with the semantic-pragmatic and lexical components of language. The good performance of the MCI group can be explained by the lesser recruitment of episodic memory and the preservation of working memory [49], which could support the good performance of the aMCI group in the present study.

It is hypothesized that the executive functions are faulty or that the executive control of the work memory does not activate properly the relevant clues that would allow the retrieval of ideas related to the topic [48].

Jerônimo [47] verified differences in global coherence between control, MCI, and AD groups. The MCI and AD groups presented similar performance, differing from the control group, in disagreement with our results. The difficulties of global coherence were related to the executive and semantic-pragmatic components of language. Individuals present difficulties to create a macroplane, which contemplates the macrostructure of the text [17].

In this study, the mAD individuals found difficulty in the planning and organization of the ideas related to the topic, demonstrating compromise of the textual macroplane. According to Jerônimo [47], there are leaks and errors in the organization of ideas and an increase of empty sentences when individuals present deficits in the formulation of the macroplane for the production of the text, as also found in this study.

According to Nespoulous [50], the presence of modalizations indicates a disruption of the discursive macrostructure because the subject includes opinions and comments about his performance during the discourse. It was decided to maintain the analysis of the modalization at the macrostructural level because it can be characterized as a discursive incoherence. In the present study, it was found that there were a greater number of modulation in the mAD discourse, a fact also found by St-Pierre et al. [3].

In contrast, Lira [19] did not find higher frequency of modalization for the AD group. The presence of the modalizations indicates the difficulty of maintaining the central theme of the discourse, but it may indicate an effort of the subject to provide pragmatic aspects of interaction with the evaluator. Individuals with AD often inserted excerpts from personal narrative, associating something presented in the figure with an autobiographical personal experience. The introduction of irrelevant content and off-topic elements can occur because of the presence of problems in the semantic-pragmatic component of the language [15].

The use of computational mechanisms reduces the time and excessive work demanded from clinicians in relation to traditional manual analyses. It can be an ally in the discourse analysis of individuals with cognitive decline, contributing to diagnosis, longitudinal evaluations, and verification of intervention effects.

The use of Coh-Metrix-Dementia provides a large number of automatically extracted metrics quickly, which can aid in clinical practice.

This study explored a computerized tool to verify differences in the discourses of individuals from the three groups. Individuals from the mAD presented discourses with greater macrostructural impairment, that being a less informative discourse, poorer global coherence, and more modalizations. These differences were not found between the aMCI and HC groups for the proposed task when considering isolated metrics.

4.2.1. Limitations of the study

A larger number of subjects are recommended to replicate this sort of study, considering the training needs of the computational system and also because the discourse is considered a complex activity with great sociolinguistic variation that may interfere in the answers.

Another factor that could be emphasized would be the capture of discourses in a suitable environment, minimizing noise level for optimal acoustic analyzes, and to accurately measure nonlinguistic factors such as duration and location of pauses and disfluencies.

Finally, the study evaluated MCI as a whole, given the small number of amnestic single domain. The linguistic analysis of each subgroup could provide, however, valuable insights for the establishment of a possible continuum among these patients with single domains, multiple domains, and dementia.

Acknowledgments

The authors would like to thank Michael James Stablein of the University of Illinois Urbana-Champaign for his translation services and review of this work. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

The authors have declared that no conflict of interest exists.

RESEARCH IN CONTEXT

1 Systematic review: The authors reviewed the literature using traditional sources (PubMed, SciELO), abstracts, and presentations at conferences. The study of discourse has been increasingly researched; however, the use of computational tools for this purpose is still little investigated.

2 Interpretation: Our results showed the macrostructure impairment of individuals with AD and corroborate findings from the literature. The results confirm the importance of discourse evaluation and the benefit of computerized techniques for analysis.

3 Future directions: The computational tool can be used by clinicians to extract discourse characteristics. In future research, microstructural changes in the discourse of the evaluated individuals will be verified, and the segmentation form of the sentences will be adapted.

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