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Number of ideas in spontaneous speech predicts cognitive impairment and frailty in community-dwelling older adults nine years later

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ABSTRACT

Objective: To investigate the associations between linguistic parameters in spontaneous speech at baseline and cognitive impairment and frailty nine years later.

Methods: A prospective analysis was carried out on data of the Frailty in Brazilian Older People Study (FIBRA) Study, a population-based study on frailty. From a probabilistic sample of 384 individuals aged 65 and older at baseline (2008–2009), 124 aged 73 years and older at follow-up were selected, as they had scored above the cutoff values of cognitive screening for dementia adjusted by years of schooling at baseline and had answered to the question *What is healthy aging* and had no frailty at baseline. Verbal responses were submitted to content analysis and had its ideas and words counted. Number of ideas corresponded to the frequency of meaning categories and number of words to all identified significant textual elements in the text constituted by the sample answers to that question.

Results: Multivariate logistic regression analyses, controlling for the effects of age, sex, and education, showed that individuals with a high number of ideas at baseline had lower chance of having cognitive impairment (*OR* = 0.39; 95% CI 0.22 – 0.69) and frailty (*OR* 0.66; 95% CI 0.44 – 0.99) nine years later than those with low number of ideas.

Conclusions: Higher number of ideas, but not number of words, in spontaneous speech seems to be associated to a more positive prognosis in mental and physical health nine years later. Linguistic markers may be used to predict cognitive impairment and frailty in older individuals.

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Introduction

Linguistic abilities may be among those least affected by aging. Older adults are known to maintain vocabulary, syntax and semantic knowledge, comprehension, and fluency skills (Alwin & McCammon, 2001; Verhaeghen, 2003). Therefore, low scores in linguistic parameters have been used as markers of neurological diseases, such as dementia due to Alzheimer's or vascular disease (Eyigoz et al., 2020). Most frequently, language abilities are assessed in clinical settings with structured vocabulary, naming, and verbal fluency tests. In the latter, individuals are required to say different examples of a given category or to say words that begin with a certain letter or phoneme for 1 min. However, it may be advantageous to evaluate language abilities in samples of spontaneous speech, when participants are asked to answer to open questions, write autobiographical essays, create narratives, or describe a picture (Beltrami et al., 2018; Shao et al., 2014; Shibata et al., 2018; Sutin et al., 2019). Tasks involving spontaneous speech may be more ecological, i.e. closer to those performed at daily life or in the natural environment than others performed at research laboratories or clinics of primary health care (Murphy et al., 2017). Therefore, they probably can generate higher adherence, especially among those with lower levels of education, and may be considered as representative of everyday performance. However, language investigations based on oral or written spontaneous narratives are less frequent in the clinic or research than those based on standardized language tests.

The number of ideas and the number of words are among possible measures to be extracted from samples of spontaneous speech. Number of ideas is an indicator of the complexity of oral or written language. Density of ideas reflects the extension to which an individual connects propositions, arguments, and modifiers (Brown et al., 2008; Chand et al., 2012; Kintsch & Keenan, 1973). Number and density of ideas and number of words can be interpreted as measures of verbal fluency. They can be counted in written language according to the presence of spaces between textual elements, or, in oral language, according to the informative aspects, such as intonation, stress, and pauses. They can exhibit increasing levels of structuration, since personal narratives triggered by a photo or a scent, until autobiographic reports organized by themes or chronology.

In the *Nun Study*, a longitudinal epidemiological study including 681 religious women, the content of autobiographical essays written by them in their youth was used as a predictor of cognitive status in adulthood and old age. Low number or low density of ideas predicted cognitive impairment

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compatible with Alzheimer's disease (Kemper et al., 2001a, 2001b; Snowdon & Nun Study, 2003). This pioneer study had its results confirmed by the *Precursors Study*, which compared the levels of complexity of ideas in samples of spontaneous textual behavior from young candidates for a medical course to data on their cognition as they aged (Engelman et al., 2010). Therefore, measures derived from spontaneous speech can potentially predict mild cognitive impairment and Alzheimer's disease (Engelman et al., 2010; Jarrod et al., 2010; Kemper et al., 2001a; Roark et al., 2011; Snowdon & Nun Study, 2003). Less is known about the possibility of linguistic markers to predict outcomes in physical status such as frailty.

Frailty is defined as a geriatric syndrome that involves impairment in several physiological systems due to lower homeostatic reserve, predisposing to functional impairment, falls, hospitalization, and death (Fried et al., 2001). Although the mechanisms underlying the association between cognitive impairment and frailty are unclear, clinicians and researchers alike observe bidirectional associations between frailty and cognitive impairment (Allegri et al., 2008; Robertson et al., 2013; Rogers et al., 2017). Meta-analytic evidence from cohort studies has confirmed these associations (Borges et al., 2019; Xu et al., 2015). Exploring the mechanisms that subside the association between frailty and cognitive functions is important to better deliver preventive and treatment options.

Previously, most evidence regarding cognitive impairment and frailty came from global cognitive screening instruments rather than tests that assess specific cognitive functions (Bartoli et al., 2020). Studies on different cognitive domains revealed that the executive functions showed consistent associations with frailty, especially for the cognitive subdomains of mental flexibility (Dutzi et al., 2017; Shimada et al., 2013) and self-monitoring (Amanzio et al., 2017). In addition, it is important to emphasize that, to date, there is still a significant gap in the literature about the direction of the association between frailty and cognitive impairment, as most studies have assumed that physical frailty may lead to cognitive impairment. If we assume that cognitive impairment may also lead to frailty, as shown by Ottenbacher et al. (2009), we realize there is scarce evidence regarding which cognitive domains may lead to frailty over time. To our knowledge, previous studies have not investigated whether measures of verbal behavior, such as number of ideas or number of words in spontaneous speech, may herald future frailty.

This study aimed to investigate associations between the content, i.e. the number of ideas and the number of words, observed in spontaneous speech of a sample of community-dwelling older Brazilians born between 25 December 1917 and 19 February 1944, without cognitive impairment or physical frailty at baseline (2008–2009), and the levels of cognitive impairment and frailty observed nine-year later (2016–2017).

Methods

Study design and participants

A longitudinal analysis was carried out on the database of the FIBRA Study, a population-based study on frailty, involving a probabilistic sample of community-dwelling Brazilian older adults from Ermelino Matarazzo, a subdistrict of the City of São Paulo, aged 65 and older at baseline (2008–2009). At baseline, the sample from Ermelino Matarazzo comprised 384 older adults, constituted by census samples of men and women 65 years of age or older (Neri et al., 2013). First, a probabilistic sample representative of the male and female population aged 65 to 69, 70 to 74, 75 to 79, and 80 years and older was calculated. The sampling unity was the urban census tracts defined as the smallest demographic unit established by the Brazilian Institute of Demography and Statistic. The number of unities to be selected at random was dependent of the population sample size. We selected 62 urban census tracts in Ermelino Matarazzo or other cities of the FIBRA Study with population of less than 500,000 inhabitants, to a sample error of 5%. Recruitment for the present follow-up study (2016–2017) was based on addresses' lists available in baseline databanks. The recruiters made three attempts to locate each one of the individuals (Figure 1). The inclusion criteria were the following: being aged 65 or older; having permanent residence in the subdistrict and domicile; having sensorial, comprehension, communication, and orientation abilities that allow effective participation; not having terminal disease, sequelae of stroke, aphasia, or Parkinson's disease in advanced stage and cancer (with exception of skin cancer); capacity of independent and semi-dependent walking, and not being bedridden or wheelchair dependent. The interviews had an average duration of 90 min.

The protocol of the FIBRA Study included measures of cognition and frailty in the first of two modules of its interview. All the samples were submitted to these measures. Part of the cognitive assessment consisted of a screening for dementia by the Mini Mental State Examination (MMSE; Folstein et al., 1975). Participants with an MMSE score lower than the cutoff value established for their educational level were excluded at the end of the first module. So, those who scored below the cutoff point on the MMSE (Brucki et al., 2003) adjusted for schooling (17 for illiterate individuals; 22 for those with one to four years; 24 for those with five to eight years; and 26 for those with nine or more years of schooling) were excluded ($n = 83$). By this reason, they did not answer the question *What is healthy aging?* used in language fluency content analysis. Eighty-three among the 384 baseline participants were excluded based on the cognitive criterion, and 301 older adults became eligible to the follow-up (2016–2017). Detailed information about baseline sample selection and main results are found elsewhere (Neri et al., 2013).

The follow-up recruitment and data collection procedures were performed at the houses of the participants, in sessions with an average duration of 60 min. The same inclusion criteria were adopted, but the study recruited family, friendship, or neighbor members to act as proxies, mediating the interaction between the interviewers and the participants. There were 109 losses due to no localization in the available addresses and 47 due to absence of data records of cognitive and/or frailty assessment at the follow-up. Sixty-five participants of the baseline study had died before the follow-up. Thus, the sample of the follow-up and to this study became composed of 127 older adults. As the design of present study determined that the participants should not have frailty at baseline, their data records were examined. Three participants had frailty at baseline and were excluded. The final follow-up sample in this study constituted of 124 older adults aged 73 years and older, without cognitive deficit suggestive of dementia and/or frailty, and with a response to the question on healthy aging at baseline (see Figure 1).

The baseline and follow-up projects were approved by the State University of Campinas' Research Ethics Committee (Certificates for Ethical Appreciation/C.E.A.E. Nº. 0151.1.146.000-07 and 49987615.3.0000.5404) and by the School of Arts,

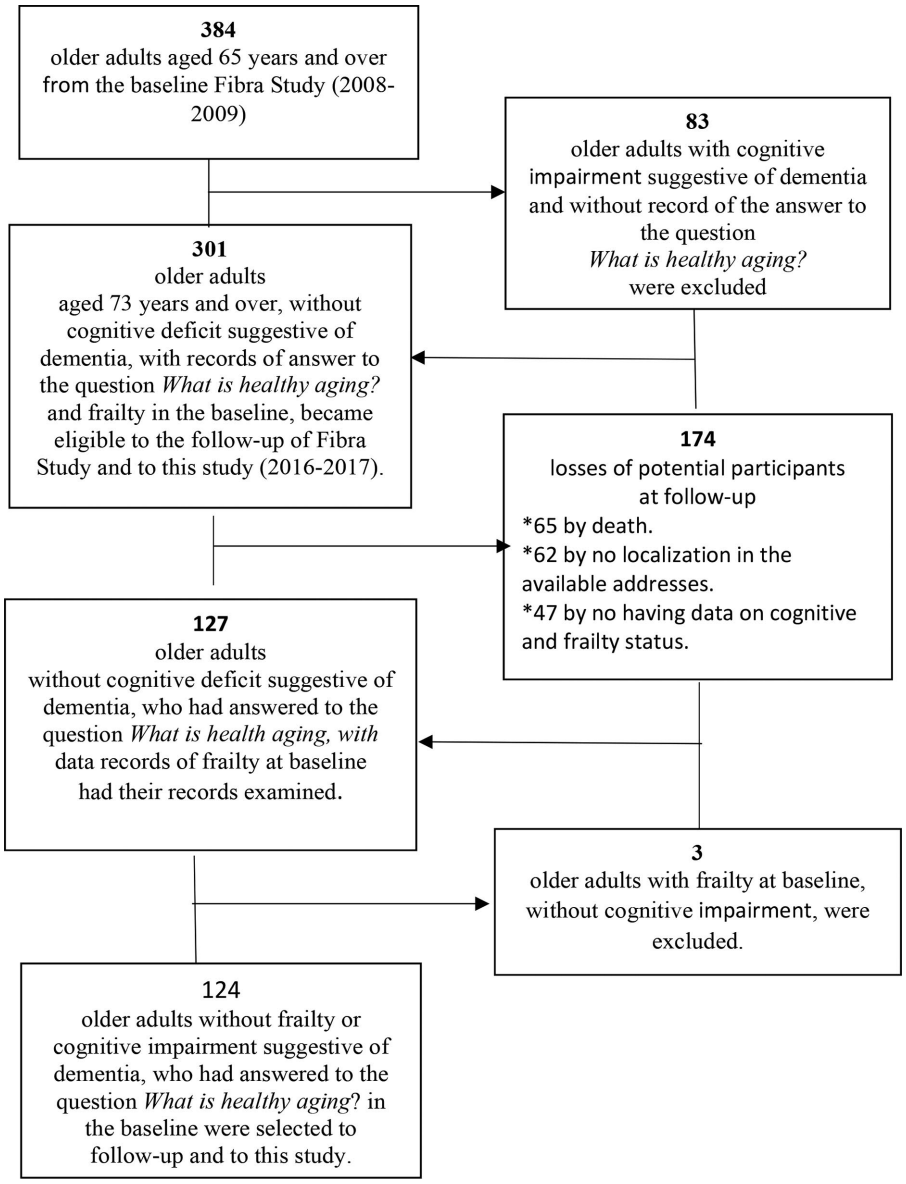

Figure 1. FIBRA Study participants' selection flowchart.

Sciences and Humanities of the University of São Paulo Research Ethical Committee (C.E.A.E. Nº. 92684517.5.1001.5404). In both baseline and follow-up, the participants signed an informed consent form before the interview. The proxies were also informed about the objectives, procedures, rights and duties, and signed a term of informed consent.

Variables and measures

Meanings attributed to the concept of healthy aging

The oral answers of the participants to the question *What is healthy aging?* were literally registered by the interviewers, transposed to the databank, and submitted to thematic and categorial analysis of content, defined as a categorical and inferential technique of analysis of communication that relies on systematic and objective procedures of description, classification, quantification, and qualification of messages (Bardin, 1979).

Number of ideas and number of words

The text constituted of the participants' answers to the concept of *healthy aging* and was submitted to the counting of ideas and words. Number of ideas was considered as the frequency of occurrences of specific categories identified in the response of each participant. Moreover, the number of words resulted from the counting of relevant textual elements separated by spaces, from each transcribed oral response (Brown et al., 2008; Chand et al., 2012).

Cognitive status

The MMSE was used to estimate global cognitive function (Folstein et al., 1975). The identification of cognitive impairment suggestive of dementia at baseline and follow-up was attributed to each participant when their MMSE score (from 0 to 30) was below the education-adjusted cutoff scores obtained from healthy control participants of a clinical study. The cutoff scores were calculated by subtracting one standard deviation from the mean score for each education range, and they were as follows: 17 points for illiterate individuals or for individuals without formal education; 22 for those with one to four years of education; 24 for those with five to eight years of education; and 26 for those with nine or more years of education (Brucki et al., 2003).

Frailty

The baseline study adopted the Fried and coworkers' phenotypic protocol of frailty (Fried et al., 2001), which contains three

self-report (loss of weight, fatigue, and physical inactivity) and two objective items (low muscle strength and low walking speed). At the follow-up, a correspondent valid self-report instrument built by Nunes et al. (2015) was employed. Participants were inquired about unintentional weight loss in the past year. In case of a positive answer, they were asked about the expected loss in kilograms. The answer was considered positive for frailty if the loss was greater than 4.5 kg or 5% of body weight. Fatigue was measured by two self-report items obtained from the Center for Epidemiologic Studies Depression Scale (CES-D) (Radloff, 1977) with four possibilities of response (always; most of the time; few times; never or rarely). Responses were considered positive for frailty if the participant answered "always" or "most of the time" to either or both questions. Handgrip strength, walking speed, and physical activity were assessed by dichotomous questions (yes x no) presented to the participant, asking for information about the occurrence of losses of strength, gait speed, and physical activity during the past year. Participants who fulfilled three or more criteria were categorized as frail; those who scored positively in one or two, as pre-frail; and those who did not score in any criteria, as non-frail or robust. As the self-report measure is a screening instrument, "process of frailty" was included as a category encompassing those that scored to pre-frailty and to frailty. These criteria generated good to acceptable psychometric evidence: $\alpha = 0.77$ and 0.72 of internal consistency to decreased walking speed and decreased physical strength, respectively. The sensitivity and specificity for identifying pre-frail individuals were 89.7% and 24.3%, respectively, while those for identifying frail individuals were 63.2% and 71.6%, respectively; 89.7% of the individuals from both the evaluations were identified in the "process of frailty" category.

Sociodemographic variables

Age, sex, and education were covariates; age was computed based on date of birth reported, and education was determined by the answer to the question "what grade did you study to?" converted to number of years of formal education.

Data analysis

This study included a combination of qualitative and quantitative strategies. The first was used to analyze the content and the number of verbal emissions in response to the question "What is healthy aging?" and the latter for comparative and association analyses between the categories of meaning derived from content analysis, and frailty and cognitive impairment.

The content analysis was based on a previously theory-based model of 4 themes and 16 categories (Mantovani et al., 2015; Neri et al., 2013), which was reduced to 11. The responses of the participants were divided into six blocks for the performance of the content analysis, done by three trained researchers who first worked independently and then together, observing an exigence of 100% of inter-examiners agreement.

A complete statement including one or more meanings was considered as the unit of analysis, regardless of the number of words or its grammatical quality, if it was understandable and relevant to the question. One category was defined as a class of meanings that shared at least one element in common, thus distinguishing it from other classes of meaning. The task of categorization was considered as the classification of elements comprising a whole, through differentiation and regrouping, according to previously defined criteria (Bardin, 1979).

Mann–Whitney and Kruskal–Wallis and Dunn's tests were used to compare the values of the distributions of numeric variables for two and for three or more groups. Univariate and multivariate logistic regression analyses were used to verify the associations of number of ideas, number of words and meaning categories at baseline with cognitive status and frailty at follow-up. Records of age (time between birth date and interview date), sex (self-identification as male or female), and number of years of education (as a response to the question "how many years of education do you have?") were used as covariates of adjustment to the analyses. These covariates were chosen due to high association with both frailty and cognitive impairment (Hoogendijk et al., 2019; Livingston et al., 2020).

The results of the statistical tests were considered significant if p-values were < 0.05. Data analysis was performed using Stata software version 15.0.

Results

At baseline, 63.7% of participants were women. Of the total 124 participants of this study, 14.2% had never been to school; 65.4% had between one and four years of schooling; 17.3%, between five and eight years; and 3.1%, nine or more years of education. The mean years of schooling were 3.5 (±2.01), and the mean age was 70.5 (±2.71). At baseline, 8.2% of the participants were classified as cognitively impaired—they were 38.0% at follow-up. At baseline, 8.2% of older adults were classified as frail—they were 22.1% in the follow-up.

Table 1 shows the observed themes from content analysis of participants' response to the question "*What is healthy old age?*" and categories and respective frequencies at baseline. The most mentioned theme was health and functionality, followed by psychological well-being, interpersonal relationships, and material resources. As to the frequency of categories, the highest frequency was for physical health, satisfaction and pleasure, activity, and independence and autonomy, while cognition and religiosity and spirituality were the least mentioned.

Data from all 124 participants who had records for the variables of interest in the baseline and follow-up studies were submitted to comparative analysis. The dependent variables were cognitive impairment and frailty assessed at follow-up, and the independent variables were the number of words, and the number of ideas and age, assessed at baseline. Results indicated that older adults with cognitive impairment at follow-up had a significantly lower number of ideas and words expressed in their answer and were significantly older than those without cognitive impairment. Frail and pre-frail individuals at follow-up had a lower number of ideas compared to non-frail counterparts (Figures 2 and 3).

The univariate logistic regression analysis, which considered MMSE scores as a dependent variable, showed that both markers of linguistic ability could be regarded as associated with absence of cognitive impairment at the follow-up. The multivariate analysis maintained this association ($OR = 0.39$; 95% CI 0.22–0.69), showing that older individuals with a higher number of ideas at the baseline had a lower chance of scoring for cognitive impairment at follow-up nine years later (Table 2). Likewise, a higher number of ideas at the baseline was associated with absence of cognitive impairment in the follow-up ($OR = 0.66$; 95% CI 0.44–0.99) (Table 3). The oldest participants

Table 1. Definitions and examples, raw and percentual frequencies[a] of mentions to the categories drawn from content analysis of the participants' responses to the question "*What is healthy old age?*" at baseline ($n = 124$).

Theme 1. Health and functionality	*n*	%
1.1. *Physical health*. Health status translated into medical diagnoses; signs and symptoms; healthy lifestyles. *Exs: Not feeling pain and not getting sick often. Caring for myself, special care like going to a doctor. Not drinking too much, not smoking and living a peaceful life.*	99	48.8
1.2. *Activity*. Vital involvement, social participation, productivity, energy. Exs: *Being willing and having the strength to work. Being able to shower, performing activities independently, going to family parties. Someone who can live, have friends, go to parties, have leisure time, and have the right to live.*	52	26.6
1.3. *Independence and autonomy.* Physical and mental ability that enables control over the environment; self-governance, self-determination. *Exs: It's hard to stay in bed and depend on others. Being independent, having* energy, *doing what you want without help, traveling, going out.*	48	22.6
1.4. *Cognition*. Basic cognitive functions are preserved, enabling problem-solving, discernment, reasoning, judgment, and autonomy. *Exs: Being able to think and perform tasks. I can't remember things already, I wouldn't like to lose all my memories, just a little—I wouldn't like to suffer or make people suffer.*	4	2.0
Theme 2.Psychological well-being		
2.1. *Satisfaction and pleasure.* Results from the sense that one has a good and happy life, in agreement with personal and social values and expectations. *Exs: Being happy with what I find on my way. Feeling at peace and happy, having a family. Being at ease in life, feeling happy, getting along with those close to you, not hurting others, paying off your debts.*	60	41.0
2.2. *Religion and spirituality*. What is sacred and transcendent as a source of existential meaning and a sense of belonging, and as resources for challenging times. *Exs: First and foremost, serving God, loving others as love myself, and fighting for life. I ask God not to lose my memory. Working while it's God's will.*	11	7.7
2.3. *Emotion-based coping*. Dealing with stressful situations through cognitive-emotional strategies that protect self-esteem and save personal resources. *Exs: Not losing your head over small things. Being at peace with yourself and in your life. When you are healthy and have some comfort, but if this is not the case, you must go on living.*	45	31.5
2.4. *Self-development.* Investments in self-knowledge and self-acceptance, seeking personal excellence, a sense of purpose and self-realization. *Exs: Being content with yourself, not aiming higher than you can reach. Someone who lives and does not complain… Learning how to deal with new difficulties. Knowing your children are well, living their lives relatively well, as well as your grandchildren, a mother's happiness is to see the family well.*	27	18.8
Theme 3. Interpersonal relationships		
3.1. *Family relationships.* Family as a source of acknowledgement, value, respect, protection, affection, safety, support, and satisfaction. *Exs: The family in united and husband and wife always understand each other. Being supported by the grandchildren and family. Not having problems with family.*	27	20.3
3.2. *Social relationships.* The group as a source of acknowledgement, belonging, value, protection, affection, safety and satisfaction. *Exs: Living well… Going out, loving, getting along with friends, drinking with everyone. It's to have good friendships and a normal relationship with everyone.*	31	34.8
3.3. *Social support.* Relationships where affection, material assets, information, instrumental support and informational support are given and received. *Exs: Having someone to talk to… Being able to help people. Having someone who cares for us, being able to care. People who support me, friends, people who worry about me and care for me.*	32	35.9
Theme 4. Material resources		
Possession of money, goods, and opportunities that facilitate the achievement of well-being, according to individual and social values. *Exs: Having money to go to the doctor, to eat, to buy medicine. Having a good salary to have a healthy life, otherwise you are always worried.*	25	100.0

[a]The calculation of the percentual frequencies considered each theme as 100%.

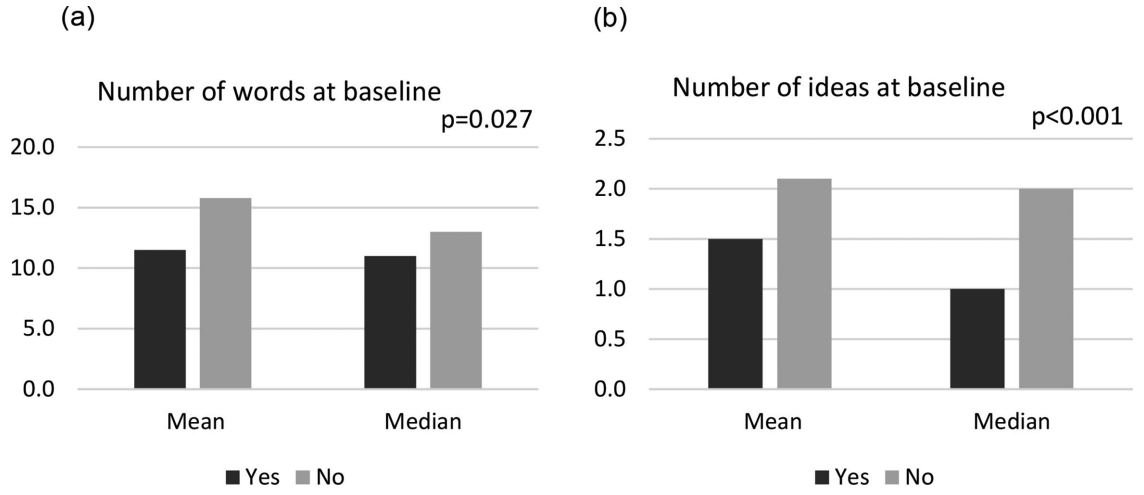

Figure 2. Cognitive impairment at follow-up (yes/no) and its association with the number of words (a) and ideas (b) at baseline. *p*-value referring to the Mann–Whitney test for comparing values between two groups.

at the baseline had a higher chance of being frail in the follow-up ($OR = 6.90$; 95% CI 1.44–3.36).

Discussion

We performed a study to investigate the associations between verbal behavior in spontaneous speech (number of ideas and number of words) obtained at baseline (2008–2009) and measures of cognitive status and frailty obtained at follow-up (2016–2017). At follow-up, participants with cognitive impairment were significantly older, had a significantly lower number of ideas and words and scored for more criteria of frailty than those without cognitive impairment. Also, at follow-up, frail individuals were older and had lower MMSE scores than pre-frail and non-frail ones. Higher number of ideas at baseline appeared to be a protective factor against cognitive impairment and frailty at follow-up.

Table 2. Results from the logistic regression analysis of the associations between cognitive impairment at the follow-up, and indicators of verbal fluency in spontaneous speech and socio-demographic variables at baseline ($n = 124$).

		Univariate logistic regression analysis			Multivariate logistic regression analysis[a]		
Variable	Category	*OR*[b]	95% CI	*p*-value	*OR*[b]	95% CI	*p*-value
No. of words	Continuous variable	0.94	0.89–0.99	0.031			
No. of ideas	Continuous variable	0.39	0.22–0.69	0.001	0.39	0.22–0.69	0.001
Age	65–69 years[c]	1.00	–	–			
	70–79 years	2.18	0.95–5.04	0.068			
	≥80 years	2.55	0.53–2.18	0.241			
Sex	Female[c]	1.00	–	–			
	Male	0.86	0.38–1.96	0.725			
No. of years of education	Continuous variable	1.06	0.92–1.22	0.362			

[a]Adjusted by age, sex, and education.
[b]OR (*Odds Ratio*): Risk ratio for cognitive deficit suggestive of dementia in the follow-up ($n = 32$ with; $n = 92$ without). 95% CI: 95% confidence interval for risk ratio.
[c]Reference category used for comparison. Stepwise criterion of selection of variables.

Table 3. Results from the logistic regression analysis of the associations between frailty at follow-up, and indicators of verbal fluency in spontaneous speech and socio-demographic variables at baseline ($n = 124$).

		Univariate logistic regression analysis			Multivariate logistic regression analysis[a]		
Variable	Category	*OR*[b]	95% CI	*p*-value	*OR*[b]	95% CI	*p*-value
No. of words	Continuous variable	0.98	0.95–1.01	0.396			
No. of ideas	Continuous variable	0.60	0.40–0.89	0.012	0.66	0.44–0.99	0.046
Age	65–69 years[c]	1.00	–		1.00	–	
	70–79 years	1.51	0.75–3.05	0.247	1.47	0.72–2.97	
	≥80 years	9.21	1.98–42.8	0.005	6.90	1.44–33.0	0.016
Gender	Female[c]	1.00	–				
	Male	0.74	0.37–1.47	0.388			
No. years of education	Continuous variable	0.98	0.95–1.01	0.396			

[a]Adjusted by age, sex, and education.
[b]OR (*Odds Ratio*): Risk ratio for frailty ($n = 27$ frail; $n = 68$ pre-frail; $n = 29$ robust or not frail). 95% CI: 95% confidence interval for risk ratio.
[c]Reference category used for comparison. Stepwise criterion of selection of variables.

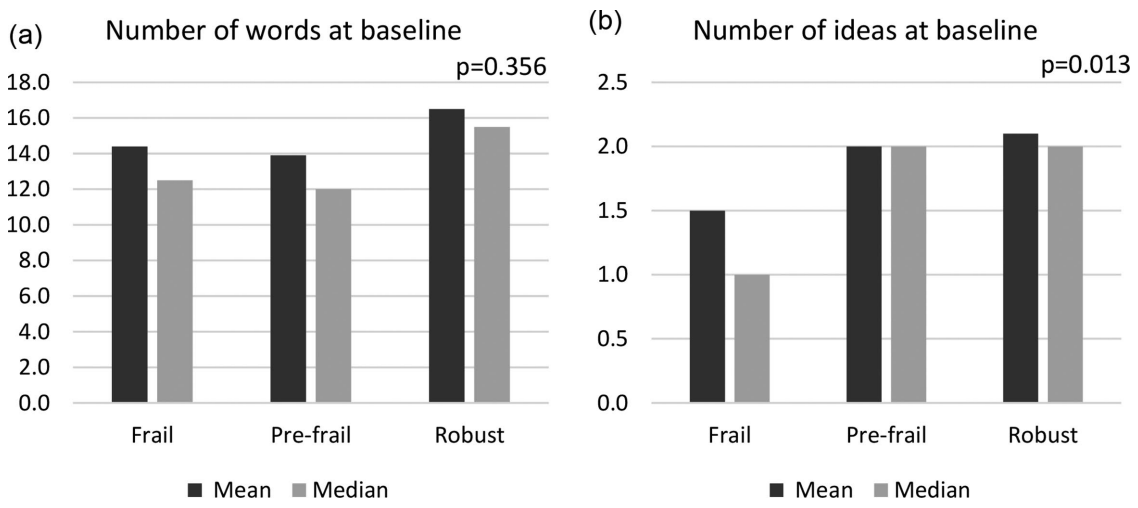

Figure 3. Frailty status (frail, pre-frail, and robust) at follow-up and its association with the number of words (a) and (b) ideas at baseline (frail individuals were different from pre-frail and robust ones). *p*-value referring to the Kruskal–Wallis test for comparing values between three groups, followed by Dunn's multiple comparisons test to number of ideas ($p < 0.05$ – Robust ≠ Pre-frail, Robust ≠ Frail).

Our results were comparable to others generated by studies involving linguistic ability and cognition. The *Nun Study* analyzed the content of 678 autobiographical essays written by religious women when they were between 18 and 32 years of age, entering an American congregation (Kemper et al., 2001a). When they turned between 75 and 107 years old, the surviving women were submitted to physical and cognitive tests. The neurological structures of the brain of women who had died were analyzed. Those who scored for low grammatical complexity and low density of ideas in the initial measurements were the ones who showed the highest risk of low performance in cognitive tests and Alzheimer's disease in advanced age. There was a relationship between low linguistic ability in youth and severity of Alzheimer's disease in advanced age, as suggested by clinical tests and confirmed by post mortem examinations of brain structures. On the other hand, nuns with high linguistic ability during youth had a good cognitive performance in old age, even when typical neuropathological markers of Alzheimer's disease were present (Kemper et al., 2001a; Snowdon & Nun Study, 2003). The authors concluded that the low density of ideas during youth reveals limitations in neurocognitive development, which may function as a risk factor for cognitive decline associated with age, mortality from all causes, and Alzheimer's disease in advanced age.

Engelman and colleagues performed a replication of the *Nun Study*, with data selected from the Johns Hopkins *Precursors Study* database (Engelman et al., 2010). It included annual records originated from questionnaires completed by all students who entered medical school between 1948 and 1964. The autobiographical essays were analyzed in terms of verbal fluency and other attributes. Researchers observed that participants with Alzheimer's disease in old age obtained

lower scores for density of ideas in their youth than healthy participants, and high density of ideas during youth protected them against the risk of developing Alzheimer's disease in old age. Findings were explained according to the concept of cognitive reserve.

Present findings support the studies revisited above, although in a very different sociocultural context and within a shorter time span. Results suggest that even in a sample of older adults with limited educational background, higher linguistic abilities may be used as a measure of cognitive reserve, which may herald a more positive prognosis a few years ahead.

Previous studies compared neuropsychological test scores to the evaluation of spontaneous speech. Shibata and colleagues found a moderate correlation (0.475) between scores obtained by older individuals in spontaneous speech and in the MMSE (Shibata et al., 2018). Beltrami and colleagues investigated whether there were differences between performance in conventional tests of verbal fluency and in spontaneous speech in 96 individuals aged 50 to 75 years to identify early cognitive impairment (Beltrami et al., 2018). They found that neuropsychological tests and a number of features regarding lexical, acoustic, and syntactic aspects of spontaneous speech could significantly differentiate between mild cognitive impairment, early dementia, and control participants. In the study conducted by Smolík and colleagues, propositional density was lower in samples of oral production from patients with mild cognitive impairment than from control participants (Smolík et al., 2016). Density of ideas was associated with verbal fluency measured by conventional tests and with education. These findings suggest that the detailed analyses of spontaneous speech may be useful to identify pathological ageing in addition to standardized cognitive tests.

Although risk ratios cannot be translated as indicators of causal relations, the great majority of studies show frailty as a condition that precedes cognitive deficit (Duarte et al., 2018; Ma et al., 2019; Yassuda et al., 2012), while a minority shows the contrary, that is, cognition preceding frailty (Ávila-Funes et al., 2009; Han et al., 2014; Ottenbacher et al., 2005; Raji et al., 2010; Rosado-Artalejo et al., 2017). Fewer studies, such as the one conducted by Godin et al. (2017), found bi-directional relationships between frailty and cognitive deficit in samples derived from the two-wave Survey of Health, Aging and Retirement in Europe (SHARE; $n = 11.491$). In the final model of simultaneous path analyses, the authors observed direct associations between age and frailty, age and cognitive deficit, educational level and cognitive deficit, isolatedly or in interaction at the follow-up. The associations of age, sex, social vulnerability, and level of education with frailty and cognitive deficit at follow-up were both mediated by frailty and cognitive deficit at baseline, alone or in reciprocal interaction.

These data are suggestive that frailty and cognitive impairment may mutually affect each other, due to the influence of multimorbidities and basic pathophysiological problems that tend to increase and accumulate with age, as well as due to the accumulated influence of negative or stressful social circumstances. Pathophysiological shared pathways between frailty and cognitive impairment are still debatable, but cardiovascular risk factors and the impaired motor conduction, especially in frontostriatal connections, seen in most neurodegenerative dementias are possible mechanisms (Borges et al., 2019).

Methodological aspects of the present study impose limitations to our results. One refers to the use of separate measures for number of ideas and words, instead of selecting density of ideas, a possibly more robust variable in theory. In fact, this choice was intentional because the notion of idea was matched to the idea of category of meaning, that is, a psychological analysis of content was performed, rather than a linguistic analysis. Another limitation resulted from the restricted sample size, with the lack of audio or audio video recordings of the participant's oral statements, a procedure that could have benefited the validity of the textual records, as well as its comprehension, by the access to other instances of verbal behavior, such as laughs, hesitations, whispers, silences, gestures, and facial expressions. Furthermore, results were adjusted by age and education, and other variables may have influenced the observed associations. As we considered a follow-up nine years later compared with baseline data, several participants were not found or were deceased. A supplementary table is provided showing that older participants (80 years and more) were most of the group not found to the follow-up, and almost 50% of those participants with cognitive impairment at baseline died after nine years. These data must be considered with our findings and are plausible regarding both prognosis and attrition rate as we studied people with 80 years or older and those with cognitive impairment. Finally, our sample consisted of people with low education, which limits the extrapolation of our findings to people with high education and different interpretive capacity of our protocol on verbal fluency.

Future studies may explore the validity of data regarding number of ideas in spontaneous speech compared to the simultaneous application of typical structural evaluations of neuropsychological tests. Additionally, different verbal tasks must be tested, in view of their viability, adequacy to the cognitive, educational, and cultural level of older individuals, and similarity to natural situations. Investigating the nature of multiple relationships between physical frailty, cognitive global status, and parameters in spontaneous or structured speech, in adult and aged people with different levels of cognitive deficit should cover an important gap in the knowledge of clinicians and researchers regarding these complex relationships.

Conclusions

A higher number of ideas in spontaneous speech produced by aged individuals at baseline showed negative associations with cognitive impairment and frailty assessed at follow-up, nine years later. Although the data do not allow to draw any cause-and-effect conclusion, they are suggestive that number of ideas derived from the response to an open question of interest to older speakers can provide clues to the understanding of the cognitive performance in advanced age.

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Author's contributions

ALN, IA, MSY, FSAB, and DA contributed to the conception, design, data analysis, and report of the present study. TFMG and CNAV organized and analyzed the qualitative data. TFMG wrote the first version of the manuscript, which was reviewed by all the authors, who approved the submitted version.

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