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Neurocognitive Implications of Tangential Speech in Patients with Focal Brain Damage

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Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/intechopen.71904>

Abstract

There are no studies on the neurocognitive implications of tangential speech (TS). This research aims to take a step forward in the study of narrative processing, by evaluating TS in a sample that helps to detect this deficit when it is neurogenic and recently manifested. The relationship between TS, secondary to focal brain injury, and neuropsychological and neuroanatomical variables was explored. A comprehensive neuropsychological battery was administered to 175 volunteers: 95 alert inpatients, without aphasia, without psychiatric history and without TS history, and 80 healthy participants, without TS. Results: TS (prevalence 16%) was independent of type or site of injury. An adverse effect of TS on global neuropsychological performance was observed. This effect was significantly related to attentional errors along with prolonged processing times but not to correct responses. Reliability and validity indices for the present TS screening scale were provided. Conclusion: Present results support the hypothesis that this neurogenic inability to spontaneously find, organize and communicate verbal information, beyond single words, depends on extended brain networks involving processes such as sustained attention, complex-syntax comprehension, the (implicit) interpretation and spontaneous recall of a narrative, and emotional and behavioral alterations. Early TS detection is advisable for prevention and treatment at any age.

Keywords: communication disorders, language disorders, disconnected speech, focal cerebral lesions, goal-directed speech, mild cognitive impairment, narrative processing, sustained attention, time of day orientation

1. Introduction

The organization of spoken language involves the selection and maintenance of the topic of the conversation (with logical sense and pertinence) according to the context and the

listener. Ferstl et al. [1] affirm that language processing in context requires more than merely comprehending words and sentences: important processes such as inferences for bridging successive utterances, the use of background knowledge, discourse context and pragmatic interpretations need to be considered. Besides, the study of language processing in context also requires the analysis of its behavioral or expressive mechanisms, in particular, the presence of failures in goal-directed speech. Considering the method of analysis on these mechanisms, it is probable that the presence of failures in the quality and consistency of the discourse can be screened with a single (but comprehensive) measure, thus avoiding fragmentation into multiple variables, as previously considered in the field of communication disorders (see, e.g., [2]).

Currently, there is growing interest in the neurobiology of language beyond single words or short phrases [3–5] and, consequently, beyond aphasia. Aside from those basic studies, and going to the clinical practice, health professionals are often faced with patients (without aphasia) who cannot adequately explain a certain topic, for example, the reason for consultation. This may be a non-trivial problem. The impossibility of finding or pondering the proper verbal information to narrate an event (even when the most basic linguistic elements to construct the narrative are preserved) may be related to illness. The identification and causes of such impossibility require suitable evaluations as well as better definitions.

Excessive speech and incoherent or disorganized speech involve two different systems of classification. However, they are commonly linked. The terms logorrhoea; verbosity; tachyphemia; pressured speech; cluttered speech; disorders of speech, fluency, communication or language in general; circumstantial speech; tangential speech (TS); disconnected speech; flight of ideas; formal thought disorder; ‘word salad’; loss of goal; loss of topic; etc., are ambiguously defined in the literature. The definitions change notably throughout the different disciplines or authors involved. There are even some methodological problems to differentiate, for example, a lot of speech, which may be just a style of speech, from logorrhoea, which includes failures in the quality and consistency of speech; these problems may become evident when tests of fluency are used as indicators of logorrhoea [6].

In order to increase understanding on the matter, it is necessary to study each of those terms or constructs more systematically, from different perspectives. In particular, the use of comprehensive approaches in which pure language impairments are integrated with the rest of the cognitive functions is a necessary endeavor. Concurrently, and since the newest approaches in neuroimaging, for example, tend to study restricted language tasks and brain regions, the complement among different perspectives is for this reason doubly advisable.

There is a lack of study aimed at systematically analyzing TS in order to delimit and organize its conceptual and methodological basis. In this work, TS is attempted to be studied as pure language impairment because losing the focus or topic of the conversation has been found to be a common factor among several manifestations of irrelevant or incoherent speech. Besides, the concept of TS in itself links two attributes of the narrative: its content and quality (the ‘what’) with its organization and consistency (the ‘how’).

This study may represent the first attempt in the scope to generate hypotheses about a feature that usually has been explored as part of the larger attribute of pragmatics, with extremely variable conceptions and approaches.¹ Toward controlling this source of variability, and taking into account that discourse processing has been considered a typical skill associated with pragmatics, some of the measures which have been previously reported as valid indicators of discourse processing (see, e.g., [8–10]), were included in the present study approach.

The evaluation of spontaneous speech is a crucial step in any neuropsychological assessment to detect aphasia, but not to detect TS. Probably this is so because a simple easy-to-administer scale for measuring this comprehensive behavior has not been designed yet, particularly in clinical settings and for screening purposes. To design such a TS scale, the analysis (and eventual integration) of previous concepts on the matter is required.

Harvey and Bowie [11] described two types of disturbances in the production of goal-directed speech as common symptoms in schizophrenia: verbal underproductivity and disconnected speech. The first is characterized by a reduction in the amount of speech or in the breadth of information; the second, by illogical or tangential connections between words or sentences as a result of which the speaker often fails to return to the goal of the discourse.

In the field of brain injury, unlike the above described classification, disconnected or under-productive discourses could in principle suggest either delirium (involving disturbance/clouding of consciousness) or aphasia (involving lack/impairment of fluency or naming). Discarding delirium and aphasia such types of verbal symptoms may mimic psychiatric ones which, incidentally, have been considered for some authors manifestations of right hemisphere communication dysfunctions ([12–16], also see below).

Some of the neuropsychiatric constructs that have been cited together with TS are quite similar in many respects to TS, in particular when the attributes of coherence, consistency, stability and/or relevance are involved.

Tanner [17] stated that logorrhea is a garrulous and incoherent talking; the speech is rambling and has no point or conclusion; words are not connected semantically. The author also states that TS lacks of continuity and consistency and the train of thought wanders. Tangentiality is defined by Andreasen [2] as replying in an irrelevant manner; it refers only to immediate replies to questions (stimulus-response mode) and not to transitions in spontaneous speech. Tangentiality is theoretically distinguished from several other disorders such as: derailment, in which the errors are similar to tangentiality but they occur in the spontaneous conversational mode; poverty of content of speech, where the speech is adequate in amount but conveys little information; distractible speech, where inappropriate changes of topic only occur in response to external environmental stimuli; circumstantial speech, where the speech is indirect or delayed in reaching the goal, but the goal is eventually reached, etc. [2].

¹A similar methodological heterogeneity has been described for TS, within the perspective of discourse analysis [7].

In the present work, and trying to achieve a unified construct, previous studies on TS as well as on disconnected speech, logorrhoea, circumstantial speech and any other dysfunction which affect the quality and consistency of information in the topic of the discourse were reviewed.

Disconnected speech, logorrhoea and TS have been associated with psychiatric and/or cognitive disorders not neurologically lateralized [17–27], including schizophrenia,² dementia, mania, autism, semantic pragmatic disorder, attention-deficit hyperactivity disorder and traumatic brain injury.

Concerning the neuroanatomical bases of disconnected speech, logorrhoea and TS, ambiguous findings have been reported when using the lesion-based approach. As a rule, these reports do not clearly demonstrate the double dissociation between, for example, the left and the right hemispheres, and the frontal lobe and the rest of the lobes [12, 28–34]. Considering just TS, and excluding subcortical structures, Marini [33] supports the hypothesis that there is a major involvement of frontal right hemispheric areas to the process of organization of information in a narrative discourse: the individuals with right hemisphere damage produced descriptions with normal levels of microlinguistic processing but with more tangential errors and conceptually incongruent utterances, that is, with more impairments in macrolinguistic processing. Within this framework, the right hemisphere has been associated with the ability to correctly communicate prosodic, discourse and pragmatic aspects of language, including topic maintenance [29]. On the contrary, the involvement of the left hemisphere on TS has rarely been reported. Ferstl et al. [35] state that damage to frontal areas has been associated with nonaphasic language disturbances in which word and sentence level processes remain largely intact but text level processes are impaired. These authors studied several sites of lesions, including non-frontal ones, and analyzed text comprehension in nonaphasic patients. Ferstl et al. [35] observed that patients with left-frontal or bilateral frontal lesions cannot make use of instructions which require a change of perspective for recalling a story; besides, left-frontal damage leads to an impairment of goal-directed text-processing skills. Despite such specific finding, and under the lesion-based approach, the involvement of the left hemisphere and the non-frontal lobes on TS is scarce or unclear.

The dissociation between the left and the right hemisphere has been more frequently studied, and the results are contradictory, when the so-called pragmatic and/or emotional abilities of the right hemisphere (considered as a whole) were analyzed [10, 14, 36–39]. Taking into account these specific abilities of the right hemisphere, the quality and consistency of information in the topic of the discourse has always been an essential feature

²In the field of schizophrenia, Holshausen et al. [23] exclude the indicator of poverty of content [2] from the concept of disconnected speech. However, in the present study it is assumed that if a patient speaks fluently but he/she conveys little information, then such information is irrelevant; additionally, if the information conveyed is superficial or indirect, as in the case of circumstantial speech, such information is also irrelevant. Holshausen et al. [23] did include the indicator of circumstantial speech [2] within the concept of disconnected speech. However, the supposed property of circumstantial speech by which the goal of the conversation is 'eventually reached' [2] is not here assumed as a true event; instead, the degree by which that goal is actually reached is analyzed.

to be analyzed. However, the presence of failures in the processing of this feature, along with its neurological, cognitive and behavioral implications has not been elucidated yet. Neuropsychologically speaking, and as stated by Zanini et al. [39], the strong dichotomy of denotative versus connotative language, as processed by the left versus right hemispheres, respectively, has been recently challenged. Interestingly, some of the supposed abilities of the right hemisphere are nowadays separately analyzed in studies of social cognition, emotional connotation, valence, neuropragmatics, mentalizing, communication and narrative processing, among other processes [1, 3–5, 8, 40–48]. Such studies usually describe extended brain networks and bilateral involvement in their communication or language models.

The influence of the left hemisphere and the non-frontal lobes on TS might be indirectly inferred from those studies which, to date, have mainly involved healthy participants (HP) and language comprehension tasks. Nevertheless, when a language expression task (i.e., narrative production) was additionally evaluated in two neurofunctional studies with healthy participants [8, 40], Awad et al. [40] observed a common bilateral functional system, predominantly left lateralized, for both narrative comprehension and production. This functional system was most apparent in the left anterior temporal neocortex and the left temporal-occipital-parietal junction. As well, while the left and right hippocampus and adjacent inferior temporal cortex were active during speech comprehension, activity was reduced during speech production. AbdulSabur et al. [8] observed that the language system was integrated with regions that support other cognitive and sensorimotor domains, that is, they observed that, in addition to traditional language areas (e.g., left inferior frontal and posterior middle temporal gyri), both narrative production and comprehension engaged regions associated with mentalizing and situation model construction, as well as premotor areas. These authors reported strong associations between language areas and the superior and middle temporal gyri during both tasks. However, only during narrative production were the language-related regions connected to cortical and subcortical motor regions. AbdulSabur et al. [8] reported marked bilateral involvement for narrative comprehension alone (including right hemisphere homologs of perisylvian language areas), and predominantly left lateralized (and anterior) involvement for narrative production alone.

Complementary research exploring the relationship between patients with focal brain lesions and language expression tasks, excluding aphasia, is necessary. TS has been poorly studied in patients with focal brain lesions, especially in patients with left hemisphere damage and in patients differentiated by frontal and non-frontal lobe damage. A comprehensive neuropsychological study of goal-directed speech is necessary in the scope, not only to help elucidate the TS neuroanatomical correlates but also the TS cognitive and behavioral nature. This research aims to take a step forward in the study of narrative processing, by evaluating TS in a sample that helps detect this deficit when it is neurogenic and recently manifested. Due to the lack of clear antecedents on the matter, the main objective for the present study was to explore the relationship between TS, secondary to focal brain injury, and neuropsychological and neuroanatomical variables.

The present study is part of a bigger research project which aims at developing efficient tests, that is, brief and/or easy to apply neuropsychological techniques without neglecting the goals of accuracy and validity (see, e.g., [49–51]). Since theory and validity are interlaced, it is expected that the present data are not only useful to hypothesize about the bases of TS, but also to explore the viability, validity and reliability of the present scale to assess TS in a natural situation, by the bedside of the patient.

In summary, the present study aimed to explore, in patients with focal brain injuries, if TS is associated with cognitive, emotional or behavioral impairments and with specific sites of brain injury. Complementarily, the present study aimed to explore if a hypothetical pattern of neuropsychological and/or neuroanatomical impairments can be identified for TS as well as if reliability and validity indices can be obtained for the present TS screening scale.

In view of the reviewed, and in an attempt to delimit the conceptual definition of TS, only communication dysfunctions which affect the quality and consistency of information in the topic of the discourse, without affecting the most basic resources to carry out such discourse, were considered. More specifically, when: (a) the deficit was secondary to brain injury, (b) the patient was alert, without aphasia, without psychiatric history and without TS history and (c) according to the conditions which were expressed in the first paragraph of this work, the topic of the conversation was missing (i.e., the topic was irrelevant to the interview situation, or it was not well preserved or focused during the interaction) the resulting speech was defined as tangential.

In view of the exploratory nature of the study, a comprehensive neuropsychological battery was administered because all the battery tests and subtests were in principle considered potential factors for explaining TS. However, and bearing in mind that the tasks of narrative comprehension, memory and production have been previously recognized as valid measures of discourse processing (DP) [8–10], they were specially evaluated. Considering that tests of fluency have been used as indicators of logorrhoea [6], and that logorrhoea includes failures in the quality and consistency of speech, the performance in tasks of spoken and written verbal fluency were also evaluated.

2. Material and methods

2.1. Material

The battery of Neuropsychological Tests Abbreviated and Adapted for Spanish Speakers, a valid and reliable instrument developed to detect dementia, aging and cognitive impairment, including the probable site of brain impairment, was administered [52–55]. Sixty-seven indicators of 25 basic subtests were analyzed. The present battery assessed the task completion time [i.e., the processing time (T)] in several subtests as well as: (1) spontaneous speech (in its aphasic manifestations); (2) personal orientation; (3) time and place orientation, and errors (E) in time orientation; (4) phonemic discrimination (letter 'A') by auditory

cancelation (verbal auditory selective and sustained attention: omission and commission E); (5) figure discrimination (triangle) by visual cancelation [nonverbal visual selective and sustained attention: correct responses (CR) as well as errors and time (E&T)]; (6) direct and reverse serial order (months forward and backwards: E&T); (7) spatial memory (five hidden objects: accuracy (remembered objects and places) as well as four different types of E); (8) copy of alternating or repetitive graph series; (9) copy and naming (written response) of simple figures; (10) constructional praxia (cube and clock drawing in response to commands: CR and T); (11) syntax-complex verbal comprehension; (12) verbal auditory attention span (digits: forward and backwards); (13) writing abilities such as writing one verbal automatism (the name), writing by copying and by dictation and writing-legibility; (14) written verbal fluency [quantity: number of words, quality: syntactic complexity, legibility: overall score and legibility regardless of quantity (average score per word)]; (15) written arithmetic operations; (16) mental calculations (subtracting serial sevens: CR and T); (17) oral verbal fluency (number of words beginning with 'F'); (18) reading (a story): oral expression and abstraction/comprehension; (19) visual memory: face recognition; (20) visual memory: retrieval of a complex figure; (21) graphesthesia; (22) finger recognition; (23) a delayed story recall (spontaneous and cued, using two indicators: the interviewer's global impression during administration, and a standardized and detailed scoring of 25 passages after administration); (24) the paired-associate word learning, which included three trials and a delayed recall of easy and hard pairs and (25) semantic verbal memory/naming by picture confrontation. [Note: In general, accuracy (CR) was assessed unless otherwise indicated by E, T, and/or E&T.] The tasks of the battery related with DP were complex verbal comprehension (i.e., syntax-complex verbal comprehension and story comprehension) in addition to storytelling [i.e., a delayed story recall (spontaneous and cued)]. The tasks of the battery related with fluency were written verbal fluency (quantity: number of words) and oral verbal fluency (number of words beginning with 'F'). Details of test administration and scores are explained elsewhere [49–56].

The emergence of the following disorders as a consequence of brain injury as reported by the caregiver during the initial interview were also registered (scale range: 0–3): sensory deficits; motor deficits; perceptual-cognitive disorders (i.e., difficulty in recognizing known persons, places, moments or objects, independently of sensory acuity); sleeping disorders (i.e., insomnia, somnolence during the day, etc.); language disorders (i.e., paraphasias, anomies, echolalia, intrusions, reduced verbal comprehension or fluency, dysarthria, etc.); behavioral disorders (i.e., abnormal responses, anxiety, irritability, depression, lack of sphincter control, difficulty in organizing action, changes of personality, etc.); and thought disturbances (i.e., hallucinations, delusions, loss of sense of reality, dissociative symptoms, etc.). The presence of seizures was also registered.

Some complementary behavioral observations, which are usually evaluated during the administration of the comprehensive battery were also analyzed: the behavioral observations computed in this study were: degree of cooperation (0–3, i.e., absent: 0, very poor: 1, poor: 2, good: 3); emotional state (–1 to 1, i.e., inhibited: –1, normal: 0, excited: 1); disability awareness (0–3,

i.e., null: 0, bad: 1, regular: 2, good: 3); language speed (−1 to 1, i.e., slow: −1, normal: 0, rapid: +1); voice volume (0–4, i.e., whispered: 0, hypophonic: 1, low: 2, normal: 3, hyperphonic: 4) and prosody (0–3, i.e., total or severe dysprosody: 0, moderate prosody: 1, slight prosody: 2, normal expression or prosody: 3). The presence of emotional lability, aggression, hallucinations, delusions and verbal perseverations (including words and/or thoughts) was also registered.

2.2. Subjects and procedures

Data were obtained from a sample of 175 Argentine Spanish-speaking right-handed volunteers. Clinical data were obtained from a sample of 95 patients who were consecutively recruited from the Neurological and Neurosurgery Service of the Cordoba Hospital, a public hospital for adults. Demographically matched healthy participants (HP) were recruited from cultural, recreational and retirement centers in the province of Cordoba. HP were included if they were independent and adapted to daily life demands, without any known neurological or psychiatric disease. HP were excluded if they had: (i) TS or any type of language impairment, (ii) symptoms of neurological or psychiatric disorders, (iii) risk of neurological damage by disease or accident, (iv) any kind of medical condition which could affect neuropsychological performance or (v) sensorial or motor difficulties which could prevent them from carrying out the tests fluently. The recruitment method is better described elsewhere [49–51, 54, 57]. Patients were included if they had focal brain lesions confirmed by MRI and complementary diagnostic studies, and if they were preoperative inpatients. Patients were excluded if they: (i) had multiple or diffuse brain damage, (ii) had any other (previous or simultaneous) associated neurological disease, (iii) had history of psychiatric disorders, (iv) had history of TS, (v) were treated with psychotropic medication, (vi) had aphasia, hemianopia, hemineglect, hemihypesthesia or minimum signs of clouding of consciousness, according to the coincident report among the physician (before administering the battery), the caregiver (during the initial interview), as well as the neuropsychologist (during the administration of the battery). The data collected during the initial interview with the caregivers was taken as evidence of the premorbid condition. The comprehensive neuropsychological battery was administered and scored blindly to neuroanatomical data and the TS scale, which was applied by other member of the research team.

Patients grouped by TS were compared on their demographic variables as well as on type and site/side of lesion, disease duration (reported in months), risk factors (malnutrition, frequent contact with toxic agents, hypertension, heart disease, obesity, diabetes, genetic component of the illness, alcohol or drug consumption, etc.), and the presence of brachial and crural hemiparesis. Regarding the sites of lesion, they were divided into anterior hemisphere (frontal) lesions (A) versus posterior hemisphere (temporal, parietal or occipital) lesions (P). Lesions located in inferior structures (such as thalamus, basal ganglia, internal capsule, etc.) were classified as subcortical (SC) lesions; and lesions located in the frontal lobe and any of the posterior lobes, or in regions located between the frontal lobe and the posterior lobes, were classified as antero-posterior (AP) ones. As well, lesions were divided into left (L), right (R) and bilateral (B), according the injured hemisphere.

The emergence of TS was registered as a feature of spontaneous speech, different from the aphasia symptoms usually assessed by this item. In the item of spontaneous speech, the patients' ability to describe their own disease is explored. The interviewer's question in the TS item was: *'Tell me what happened to you and why you are here. (When did the problem start? How was it...?)'*

If the topic of the conversation was missing at any moment of the interaction, and digressive responses were maintained irreversibly, without spontaneous recovering, throughout the three successive statements, the resulting speech was empirically defined as tangential. TS was coded as present. Subsequently, the interviewer gave a prompt. (In order to corroborate the interviewees' own ability to get back to the point, interviewers did not have to give indications or ask questions which facilitate the recall of the topic of the conversation.) If TS was repeated three times (maximum four prompts), the interview was finished.

The following scale was applied:

0 = Empty talk; pointless speech (the thread of the conversation is missing); inconsistency with the context and with a line of communication; disconnected from the listener; permanent irrelevant comments. The discourse is impaired. Topic recovering is 0%.

1 = Speech disconnected from the goal of the conversation, or difficult to insert into a coherent line of communication, most of the time or in most of the expressions; interviewee may or may not get back to the point by means of an interviewer's prompt such as 'and so?' The discourse is relatively or mostly impaired. Topic recovering is >0% and ≤50%.

2 = Speech that may drift into nonessential details without straying too far from the main topic of conversation. Although it has a fluctuating direction (sometimes it approaches the topic and sometimes it scatters for no apparent reason), the interviewee can usually get back to the point at the request of the interviewer. The discourse is rarely impaired. Topic recovering is >50%.

3 = Correct or normal speech in its logical sense and adequacy to the context. If at times it deviates a bit from the topic, involving marginal comments, the main idea or gestalt returns spontaneously. The discourse is not impaired.

The interviewee's verbatim response was recorded (hand-written format) and the interviewer's prompts or questions were registered with a vertical line. Transcripts were reanalyzed by a second rater to assess inter-rater reliability. In order to carry out this study, transcripts were rated blindly by two trained neuropsychologists, members of the research team. [Note: As the prompts for TS cannot be changed, each TS prompt was binary-coded as 0 (disagreement) or 1 (agreement). The reason for that was to avoid magnifying the correlation by reevaluating only those patients within the range of TS. If all the indications were reassessed with a value of 0 (100% disagreement), the patient's score (initially <3) was increased by one point. If no prompt was provided in the first instance, and in the second evaluation, it was thought that the interviewee should have received at least one prompt, the patient's score (initially = 3) was decreased in one point].

2.3. Ethical statements

This study was performed pursuant to the ethical standards established in the 1964 Declaration of Helsinki. The participants or the patient's caregivers gave their written informed consent and the approval of the Research and Ethics Committee of the Cordoba Hospital was obtained. The neuropsychological evaluation did not pose any risk to the participants who, in all cases, were alert, and willing to perform the complete battery of tests, independently of their relative capacity or willingness to perform some of the subtests in particular. Participants did not receive any payment for their contribution.

2.4. Statistical analysis

Demographic data were analyzed by ANOVA for Age (TS as grouping variable) or by Chi square (χ^2) for education (three levels: 1st level: primary school, 2nd level: high-school and 3rd level: college or superior) and gender (two levels: men and women).

If the obtained number of TS cases was so small that the presence of empty cells and/or lack of variance could be observed, the original scale of TS was planned to be recoded. Under this condition, and unless otherwise indicated, the groups representing TS were patients without TS (non-TSP), patients with TS (TSP), as well as HP.

The effect of TS on neuropsychological performance was analyzed. With this purpose, a representative measure of the performance in the comprehensive battery was searched by multiplying the errors and times by (-1), and by studying the internal consistency of all the individual indicators through the Cronbach alpha coefficient. If the Cronbach alpha coefficient was satisfactory (0.70 or greater), the individual indicators were added thus obtaining a representative measure of the general neuropsychological performance (GNP). This variable was analyzed by ANOVA with TS as grouping variable and the Bonferroni post-hoc test for pairwise comparisons.³ The possibility of selecting representative measures of both CR and E&T was also analyzed. If that possibility was viable, a bivariate MANOVA with TS as grouping variable and CR and E&T as univariate dependent variables was carried out, using the Bonferroni post-hoc test for pairwise comparisons. The possibility of selecting a representative measure of DP was also analyzed. If that possibility was viable, the individual indicators of the tasks of the battery related with DP were added, and this variable was analyzed by ANOVA with TS as grouping variable and the Bonferroni post-hoc test for pairwise comparisons. If the ANOVA indicates both a significant main effect of TS, and significant pairwise comparisons among the three groups, the association between TS and DP was also analyzed as a way to contribute to the study of the validity of the TS scale (see below). With this purpose, the association by cross tabulation was studied and the percentile partition with the highest χ^2 was reported.

³ANOVA is a statistical dependency test. Each significant difference implicates a significant correlation between the independent and dependent variables. In this work no causal relationship between TS and the neuropsychological performance was assumed. The relationship between both variables was studied by ANOVA and, whenever a significant effect was reported, a double implication between the two variables was implicit. Such relationship was always emphasized in the text.

The indicators of number of words in the tasks of either spoken or written verbal fluency were analyzed by ANOVA, using the Bonferroni post-hoc test for pairwise comparisons.

The relationship between TS and the report of the caregiver during the initial interview, on the one hand, and the complementary behavioral observations during the administration of the battery, on the other hand, were studied through the Spearman's rank-order coefficient (r) for ordinal scales or by χ^2 for dichotomous ones.

2.4.1. *Complementary statistical information*

Additional data were searched with the purpose of discovering the nature of the cognitive impairments associated with TS. Explicitly, if TSP impairment was verified for GNP in general, and for CR or E&T in particular, further analyses on the individual indicators of the GNP component that produced a significant difference between TSP and both non-TSP and HP were performed, thus trying to see the qualitative pattern of TS impairments. MANOVA with TS as grouping variable and the individual indicators of the pertinent GNP components as dependent variables was performed, using Bonferroni post-hoc test for pairwise comparisons. Similarly, if the representative measure of DP produced a significant difference between TSP and both non-TSP and HP, further analyses on its individual indicators were also performed with the same purpose. MANOVA with TS as grouping variable and the individual indicators of DP as dependent variables was performed, using Bonferroni post-hoc test for pairwise comparisons.

In order to outline a hypothetical pattern of cognitive impairments associated with TS all the statistical analyses, including the complementary ones, were taken into account. If some of those cognitive impairments were coincident with measures which have been previously reported as valid indicators of DP, that coincidence was taken as evidence of the validity of the present TS scale. Additionally, inter-rater reliability was analyzed by the intra-class correlation coefficient (ICC). The difference between both evaluations was analyzed by the Wilcoxon paired-sample test.

3. Results

3.1. Main outcomes

A total of 15 cases with a value different from 3 in the TS scale were observed. Only one case was observed with a score of 0 and four cases with a score of 2. Due to such small number of cases, and in order to get better inferences, TS was recoded using 0 when the symptom was absent (non-TSP) and 1 (TSP) when the symptom was present (prevalence 16%).

Table 1 shows that TSP, non-TSP and HP did not differ in their demographic data.

Table 2 shows that there were no significant differences on type of lesion between non-TSP and TSP. Malignant tumors represented the most frequent type of lesion. By grouping the cells with fewer cases (i.e., the cells with the rest of the lesions), a non-significant difference

Group	Age (mean ± SD)	Education (three-level frequency)	Gender (men frequency)	N
non-TSP	41.90 ± 14.50	42 32 6	49	80
TSP	42.26 ± 14.23	6 8 1	8	15
HP	44.40 ± 16.85	34 40 6	40	80
Total	43.07 ± 15.56	82 80 13	97	175
	F(2, 172) = 0.53 p = 0.57	$\chi^2 = 2.11$; df: 4 p = 0.71	$\chi^2 = 2.08$; df: 2 p = 0.35	

Table 1. Demographic data.

between non-TSP and TSP was also observed when malignant tumors were compared with the rest of the lesions ($\chi^2 = 0.02$; df: 1; $p = 0.87$).

Non-significant differences were observed between non-TSP and TSP when A versus P lesions, excluding other lesions, were compared [non-TSP: A = 53% (A lesions/A + P lesions): (31/59), P = 47% (P lesions/A + P lesions): (28/59); TSP: A = 45% (5/11), P = 55% (6/11) ($\chi^2 = 0.19$; df: 1; $p = 0.67$)], or when R versus L lesions, excluding other lesions, were compared [non-TSP: R = 59% (R lesions/R + L lesions): (34/58), L = 41% (L lesions/R + L lesions): (24/58); TSP: R = 56% (5/9), L = 44% (4/9) ($\chi^2 = 0.03$; df: 1; $p = 0.86$)]. Non-significant differences were observed between non-TSP and TSP when specific site lesions [i.e., A, P, AP, SC ($\chi^2 = 2.89$; df: 3; $p = 0.41$); L, R, B ($\chi^2 = 0.97$; df: 2; $p = 0.61$)] were compared, or even when specific lobe lesions were compared ($\chi^2 = 8.48$; df: 9; $p = 0.49$) (percentages not shown, but available upon request).

Lesion	Group	
Type	Non-TSP	TSP
AVM	8	2
BEN TU	18	4
MAL TU	25	5
ISQ STR	6	1
HEM STR	4	1
TBI	6	2
OTHER	13	0
Total	80	15
$\chi^2 = 3.27$; df: 6; $p = 0.77$		

AVM: arteriovenous malformation, BEN TU: benign tumor, MAL TU: malignant tumor, ISQ STR: ischemic stroke, HEM STR: hemorrhagic stroke, TBI: traumatic brain injury, OTHER [name (N)]: subdural hematoma (1), aneurysm (2), mesial temporal sclerosis (4), abscess (2) and cyst (4).

Table 2. Classification of the focal cerebral lesions based on their type.

Both groups of patients did not differ on disease duration [(mean \pm SD): non-TSP: 29.04 ± 65.25 , TSP: 35.66 ± 79.31 [$F(1, 93) = 0.12$, $p = 0.73$], in the number of any additional risk for cognitive impairment [non-TSP: 1.15 ± 1.03 , TSP: 1.4 ± 1.06 [$F(1, 93) = 0.74$, $p = 0.39$], or in the presence of hemiparesis [brachial: non-TSP: 31% (partial/total count) (25/80), TSP: 27% (4/15): ($\chi^2 = 0.12$, $df = 1$, $p = 0.72$); crural: non-TSP: 31% (25/80), TSP: 20% (3/15) ($\chi^2 = 0.77$; $df = 1$, $p = 0.38$)].

The Cronbach alpha coefficient for all the indicators of the comprehensive battery considered as a whole (representing GNP) was 0.94. The Cronbach alpha coefficients for CR and E&T were 0.92 and 0.77, respectively. Therefore, GNP, on the one hand, in addition to CR and E&T, on the other hand, were analyzed. The Cronbach alpha coefficient for all the indicators of DP was 0.70; therefore, a representative measure of DP was also analyzed. (Note: In all the significant differences reported from now on, TSP was always more impaired than non-TSP, and both groups of patients were more impaired than HP).

The ANOVA with TS as grouping variable and GNP as dependent variable (see **Figure 1**) indicated a main effect of TS ($F(2, 172) = 25.55$, $p < 0.0001$) with significant pairwise comparisons (Bonferroni post-hoc tests: non-TSP vs. TSP: $p = 0.0017$; HP vs. either non-TSP or TSP: $p < 0.0001$).

The bivariate MANOVA with TS as grouping variable and CR and E&T as univariate dependent variables (see **Figure 2**) indicated that CR and E&T produced significant effect on GNP (Wilks lambda = 0.73, $F(4, 342) = 14.77$, $p < 0.0001$) and that a main effect of TS was produced on the two components of performance (univariate effect of CR: $F(2, 172) = 12.32$, $p < 0.0001$, univariate effect of E&T: $F(2, 172) = 28.35$, $p < 0.0001$). However, non-TSP and TSP did not differ in CR but they did differ in E&T when pairwise comparisons were analyzed (Bonferroni post-hoc tests: non-TSP vs. TSP in CR: $p = 0.2439$, non-TSP vs. TSP in E&T: $p < 0.0001$; HP vs.

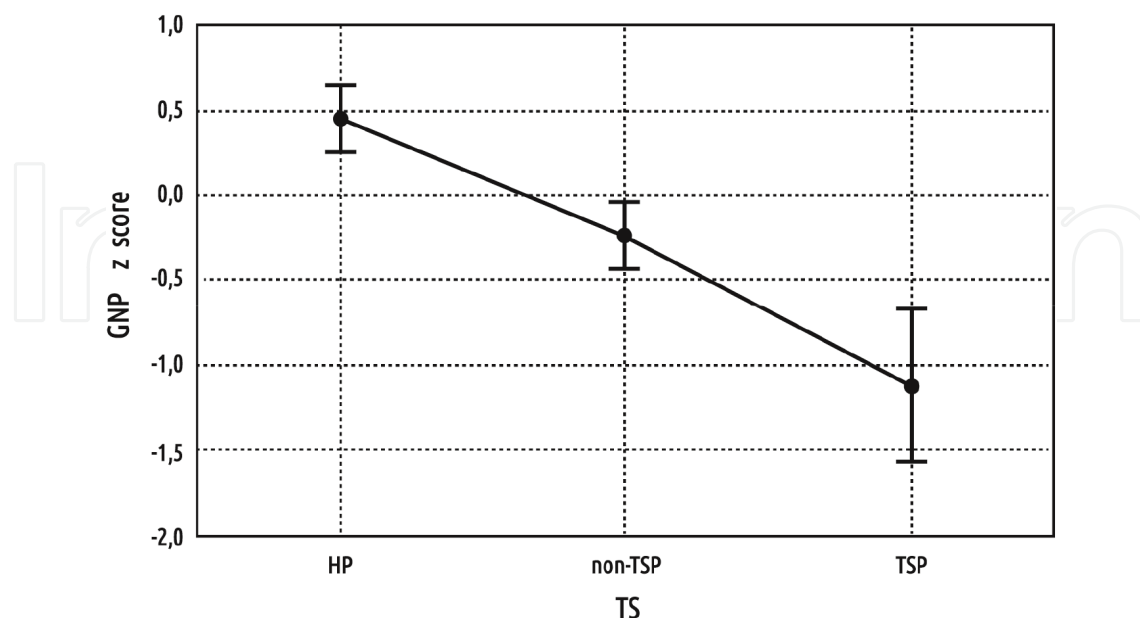


Figure 1. GNP (total score) as a function of TS (HP, non-TSP and TSP). LS means effective hypothesis decomposition. Vertical bars denote 0.95 confidence intervals.

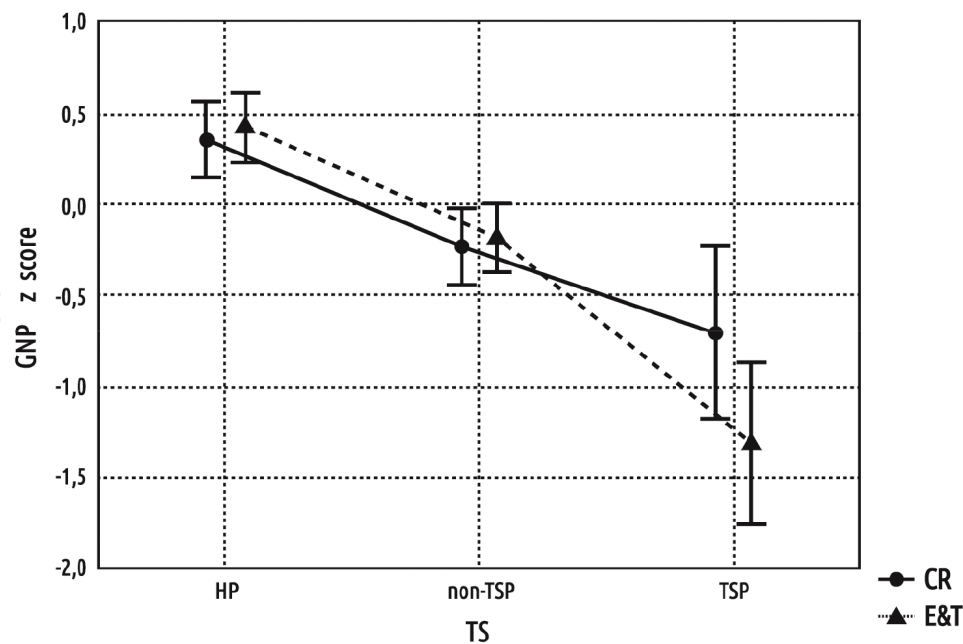


Figure 2. CR and E&T (total score) as a function of TS (HP, non-TSP and TSP). LS means effective hypothesis decomposition. Vertical bars denote 0.95 confidence intervals. E&T were multiplied by (-1).

either non-TSP or TSP: $p < 0.0003$ in any of the univariate measures). (Note: Since CR and E&T have different units of measurement, z-scores were used to show GNP results, which were identical to the results obtained with the raw scores).

The ANOVA with TS as grouping variable and the representative measure of DP as dependent variable indicated a main effect of TS ($F(2, 172) = 34.61, p < 0.0001$), with significant pairwise comparisons among the three groups using Bonferroni post-hoc test: that is, difference between non-TSP and TSP: $p = 0.002$, difference between HP and either non-TSP or TSP: $p < 0.0001$. A significant association between TS and DP was demonstrated (see **Table 3**): By taking the 25th percentile (P25) of the whole sample as cutoff point, 95% of the HP and 63% of the non-TSP had a score greater than the P25, while 80% of the TSP had a score equal or less than the P25.

The ANOVA with TS as grouping variable and the number of words in written verbal fluency as dependent variable indicated a main effect of TS ($F(2, 172) = 12.63, p < 0.0001$),

Group	≤ Percentile 25	> Percentile 25	Total
HP	4	76	80
Non-TSP	30	50	80
TSP	12	3	15

$\chi^2 = 46.24$; df: 2; $p < 0.0001$ (25th percentile = 36.00)

Table 3. Distribution of frequencies according to 25th percentile on the representative measure of DP.

with non-significant pairwise comparisons between non-TSP and TSP (Bonferroni post-hoc test: $p = 1$); significant pairwise comparisons between HP and either non-TSP or TSP were observed (Bonferroni post-hoc tests: $p < 0.003$). The ANOVA with TS as grouping variable and the number of words in oral verbal fluency as dependent variable indicated a main effect of TS ($F(2, 172) = 25.02$, $p < 0.0001$), with non-significant pairwise comparisons between non-TSP and TSP (Bonferroni post-hoc test: $p = 0.621$); significant pairwise comparisons between HP and either non-TSP or TSP were observed (Bonferroni post-hoc tests: $p < 0.0001$).

Regarding the report of the caregiver during the initial interview, the r (rank-biserial) between TS and: (a) sensory deficits, (b) motor deficits, (c) sleeping disorders, (d) perceptual disorders, (e) language disorders, (f) behavioral disorders and (g) thought disturbances were: 0.06, -0.14, 0.07, 0.08, 0.00, 0.29 and 0.43, respectively, the last two coefficients being statistically significant. The association between TS and the presence of seizures was non-significant: non-TSP: 51% (41/80), TSP: 33% (5/15) ($\chi^2 = 1.62$, $df = 1$, $p = 0.20$).

Regarding the complementary behavioral observations registered during the administration of the neuropsychological battery, the r (rank-biserial) between TS and: (a) degree of cooperation, (b) emotional state, (c) language speed, (d) disability awareness, (e) voice volume and (f) prosody were: -0.36, 0.23, 0.32, -0.19, 0.14 and 0.08, respectively. Of these, the first three coefficients were statistically significant. A non-significant association with the presence of emotional lability was observed: non-TSP: 6% (5/80), TSP: 20% (3/15) ($\chi^2 = 3.09$, $df = 1$, $p = 0.08$). A non-significant association with the presence of verbal perseverations was also observed: non-TSP: 8% (6/80), TSP: 13% (2/15) ($\chi^2 = 0.56$, $df = 1$, $p = 0.46$). There were no patients who showed aggression, hallucinations or delusions, during the administration of the battery.

3.2. Complementary statistical information

Since the GNP component that produced a significant difference between TSP and both non-TSP and HP in pairwise comparisons was E&T, its individual indicators were analyzed. The MANOVA with TS as grouping variable and the E&T indicators as dependent variables indicated that all the dependent variables produced a significant effect on the multivariate measure of performance (Wilks lambda = 0.38, $F(34, 312) = 5.75$, $p < 0.0001$). A main effect of TS was observed in all the components of the model except for E in time orientation to year as well as two types of E in hidden objects (all significant univariate effects: $F(2, 172) \geq 3.11$, $p < 0.05$; all non-significant univariate effects: $F(2, 172) \leq 1.41$, $p \geq 0.2466$). Significant differences between non-TSP and TSP according to Bonferroni post-hoc test involved E in verbal auditory sustained attention [omission E ($p = 0.004$) and commission E ($p = 0.0002$)], T in nonverbal visual sustained attention ($p < 0.0001$), as well as E in the time of day ($p = 0.0003$). The two groups of patients did not differ in the rest of the indicators (Bonferroni post-hoc tests: non-TSP vs. TSP all $p \geq 0.0627$). [Note: Considering pairwise comparisons, when a significant difference between non-TSP and TSP was observed, a significant difference between TSP and HP was also observed with $p < 0.0001$; besides, by taking the P25 of the whole sample as cutoff point for these significant indicators, 93% of the HP (74/80) and 68% of the non-TSP (54/80) had a score greater

than the P25, while 80% of the TSP (12/15) has a score equal or less than the P25 (results available upon request).] As shown, the presence of TS for the E&T indicators (individually considered) appeared as a rather nonspecific factor in terms of the stimuli involved, that is, TS was not related to a certain modality of cognitive impairment such as the verbal or the nonverbal one.

Additionally, and given that the representative measure of DP also produced a significant difference between TSP and both non-TSP and HP, its individual indicators were analyzed. The MANOVA with TS as grouping variable and the indicators of DP as dependent variables indicated that all the dependent variables produced a significant effect on the multivariate measure of performance (Wilks Lambda = 0.52, $F(12, 334) = 10.71$, $p < 0.0001$). A main effect of TS was produced on all the components of the model except for the interviewer's global impression during administration of the cued story recall (all significant univariate effects: $F(2, 172) \geq 8.78$, $p < 0.0002$; the non-significant univariate effect: $F(2, 172) = 1.48$, $p = 0.2305$). When pairwise comparisons were analyzed, non-TSP and TSP did not differ in the standardized and detailed scoring of the 25 passages after administration of the cued story recall (Bonferroni post-hoc test: $p = 0.3179$) but they did differ in the rest of the components (Bonferroni post-hoc tests: non-TSP vs. TSP all $p \leq 0.0220$). Considering HP, significant differences between HP and TSP were observed in any of the univariate measures, excluding cued recall (Bonferroni post-hoc tests: HP vs. TSP all $p < 0.0001$). Therefore, not all the indicators of DP, individually considered, produced significant differences between non-TSP and TSP as it can be inferred from the cued recall in its both indicators. [Note: all univariate results described in the present study were confirmed with nonparametric tests (results available upon request)].

Regarding inter-rater reliability, the ICC was 0.86 without difference between both raters according to the Wilcoxon paired-sample test ($z = 0.00$, $N = 95$, $p = 1$). [Note: the ICC for the dichotomized TS scale was 0.79 [Wilcoxon paired-sample test ($z = 0.40$, $N = 95$, $p = 0.685$)].

4. Conclusion

Present results support the hypothesis that the emergence of TS (with a prevalence of 16% in this sample) not only may be a consequence of focal brain lesions, of any type or site, but also is associated with cognitive impairment. TSP showed, as a whole, an impaired GNP relative to non-TSP and HP. The implication of TS on cognition was more related to E&T, rather than to CR, that is, although both CR and E&T contributed with the differences observed in GNP, when the two components of performance were differentiated, E&T were significantly associated with TS whereas CR were not. Alternatively, the tasks of the battery related with DP were significantly associated with TS whereas the tasks related with verbal fluency were not. More detailed analyses carried out to discover the cognitive nature of the TS correlates, indicated that the effect of TS on E&T involved tasks of different modality such as verbal and nonverbal sustained attention and attention (orientation)

to the time of day. On the contrary, the effect of TS on the tasks related to DP involved, specifically, complex verbal comprehension and the spontaneous, implicit and delayed recall of a story, excluding cued recall. The association between TS and recognized measures of discourse processing (such as narrative comprehension, memory and production [8–10]) provided support for the viability and validity of the present screening scale to assess TS. A satisfactory inter-rater reliability for the TS scale was also observed. Additionally, TS was associated with emotional and behavioral alterations in the clinical sample: significant correlations were observed between TS and the emergence of behavioral and thought disturbances, as reported by the caregiver during the initial interview, as well as between TS and the complementary behavioral observations of emotional excitement, rapid speech and diminished cooperation, as reported by the neuropsychologist during the battery administration. Regarding intervening clinical variables, and aside from the type and site of injury (see above), TS was independent of demographic variables, presence of neurological risks and disease duration.

5. Discussion

In the most recent research on verbal communication, AbdulSabur et al. [8] and Awad et al. [40] analyzed the processes involved in sharing knowledge through narrative processing, and described extended brain networks and bilateral involvement in their neurofunctional studies with healthy participants. Consistent with this view, Jouen et al. [5] observed in a combined fMRI and DTI study with healthy participants that understanding sentences and pictures revealed bilateral involvement and a common fronto-temporo-parietal network for both modalities. This semantic network was not limited to sensorimotor systems but extended to the highest levels of cognition, including autobiographical memory, scene analysis, mental model formation, reasoning and theory of mind. Present results agree with those studies since no focal brain lesions were identified for TS. To be precise, present results agree with the hypothesis that this neurogenic inability to spontaneously find, organize and communicate verbal information for a specific topic, and beyond single words, may be caused by several sites of brain damage or, most probably, by aberrant interactions within extended brain networks.

In trying to understand how TS is integrated with the rest of the cognitive functions, present results indicated that TSP showed an overall impaired cognitive performance relative to non-TSP; however, the contribution of the GNP components of E&T and CR showed distinctive patterns: the relative weight of E&T was superior to that observed in CR, thus finally producing a significant effect only on E&T. More thorough analyses carried out to discover the nature of the cognitive impairments associated with TS provided illustrative results: by considering just those individual indicators of E&T related to sustained attention, which were significantly associated with TS, it can be noticed that one task involved verbal auditory stimuli and the other task involved nonverbal visual stimuli; besides, one

task involved number of errors and the other task involved the time for solving the task. Therefore, neither the type of stimulus nor the type of failure seemed to be relevant to this finding. Additionally, and bearing in mind that tests of sustained attention are characterized by being monotonous and simple, some interviewees may be tempted to think that such type of tasks can be carried out with minimal effort, which may increase E&T. Nevertheless, such type of tasks only increased E&T in TSP regarding non-TSP. The errors in the time of day were also significantly associated with TS. Given that these errors not only involve other type of stimulus, but they also may be seen as a failure of sustained attention,⁴ the nature of the significant TS impairments in E&T (and sustained attention) as a whole appeared to be independent of the type of the stimulus. In this context, it can be speculated that TS impairments in E&T may have insidiously influenced all type of tasks, although only some of those tasks showed significant impairments. (In passing, and methodologically speaking, present results highlight the need of assessing the presence and magnitude of the E&T; otherwise, valuable information can be lost. Likewise, an increased time to respond correctly, which may sometimes be a subtle difficulty (see, e.g., [58]) could represent relevant data to be assessed, as indicated by the results obtained in the E&T in general, and in the T of nonverbal sustained attention, in particular).

On the other hand, the individual indicators of DP that produced a significant difference between non-TSP and TSP were: (a) syntax-complex verbal comprehension; (b) reading a story: abstraction/comprehension and (c) a delayed (and spontaneous) story recall. So, it can be stated that TS was also associated with high-level and/or complex linguistic tasks involving processes such as verbal comprehension, attention and memory. Regarding this finding, it can be relatively understood that if patients have problems to narrate an event (e.g., the reason for consultation), they can also have problems to narrate other event (e.g., the story involved in DP). The nature of the cognitive demands involved in this particular task of story recall, however, provide additional information in relation to the factors which were combined with the narration itself: specifically, the items (b) and (c) involved implicit attention and memory, that is, those tasks were intentionally designed to be effortlessly or automatically carried out by leaving them unprompted. For example, the comprehension and recall of a story were both included as components to a series of reading tasks, in which the command was just 'read' (neither 'think about what you read' nor 'remember what you read'). Therefore the cognitive demands of interpreting and later recalling a story required that the information be spontaneously registered and organized by the interviewee. By integrating these findings with those described above concerning sustained attention, it can be observed that most of the individual tasks associated with TS required a high degree of spontaneous (unassisted/self-controlled) organization. If failures in cognitive engagement interfere with such organization, then the appearance of irrelevant commentaries or task-unrelated thoughts (mind-wandering) could be favored. In this way, it is probable that E&T increase and the final performance (GNP) decrease. In other words, the process that goes

⁴If the time of day is seen as the target stimulus, and the ability to maintain focused awareness on it during continuous period is seen as the attention task condition, then paying attention to the time of day is a form of sustained attention.

from 'knowing the correct response', as inferred from CR, to the final result can be delayed or obstructed with errors.

Franklin et al. [59] assessed lapses of attention (mind-wandering) with experience-sampling thought probes during a standard implicit learning, in a serial reaction time task. Their results revealed an adverse effect of mind-wandering on implicit learning. Such results would be in agreement with the present ones because TSP, who had lower scores on tasks of sustained attention, also showed an impaired implicit learning in story recall with regard to non-TSP.

It is currently accepted that when automatic tasks are carried out, other cognitive and emotional associations are more prone to be spontaneously processed in the form of, for example, mind-wandering (see [59–61]). Since in the present study, TS was associated with automatic and complex linguistic tasks, it can be hypothesized that TS is an exacerbated manifestation of mind-wandering linked to high-level and verbal cognitive impairment. As verbal language interacts with the rest of the cognitive and behavioral functions thus helping to voluntarily organize thoughts and actions of any kind, dysfunctions in this domain can seriously affect many other skills [62]. What is more, the left inferior frontal gyrus involved in inner speech [63], which is an essential part of the executive-control language network, has been related to the monitoring of self-generated thoughts and divergent thinking [60].

In addition, and considering just the two groups of patients, TS was associated with emotional and behavioral alterations. Although there were no patients who showed aggression, hallucinations or delusions during the administration of the battery, there was an association between TS and either the behavioral and thought disturbances as perceived by the caregiver⁵ or the presence of diminished cooperation, emotional excitement and rapid speech as registered by the neuropsychologist.

Within this context, it is worth mentioning that, although language speed was found to be higher in TSP than in non-TSP, both groups of patients did not differ in spoken and written verbal fluency tests. This finding suggests that the clinical interpretation of rapid speech in TSP was probably produced by the presence of many irrelevant words during a certain period of observation. Furthermore, the interaction of TS with diminished cooperation, or emotional excitement, may have as well affected the outcome: the process of selecting (finding and pondering) the correct verbal information to be expressed, necessarily involves an inhibitory adjustment, as only some parts of the total thoughts linked to the target topic will be expressed. If the emotional balance between excitatory and inhibitory mechanisms is affected, the cognitive organization which goes from nonspecific/divergent utterances to specific/convergent ones may be obstructed. Alternatively, tests of fluency, unlike spontaneous speech, are required to follow certain constraints, which may have prevented TSP from communicating irrelevant information (compared with the relevant one) during such tasks. So, it seems

⁵When the semantics and syntax in a sentence do not represent a problem, as in the case of nonaphasic patients, that is, when the ability to use, understand or connect words is not impaired, then impairments in the semantics and (high-level) 'syntax' in a narrative, can be interpreted as a manifestation of thought (see, e.g., [17]).

that both the type of task constraints and the cognitive engagement to effectively prioritize between competing internal and external demands [64] were implicated in TS.

The interaction among emotional, behavioral and verbal language functions may have also influenced present anatomical results. The ability to deliberately stop intrusive thoughts and pay attention to the context, the relevant goal and the interviewer's signals (verbal and nonverbal) pertains to the more encompassing function of communication and social interaction. Kuhlen et al. [65] affirm that, for successful communication, conversational partners need to estimate each other's current knowledge state. These authors observed that nonverbal facial and bodily cues can reveal relevant information for such knowledge and also proposed that an integrative account of the mirroring and mentalizing networks can explain their results. Accordingly, Prochnow et al. [66] found that both supra- and subliminal emotional facial expressions shared a widespread network of brain areas, many of which have been implicated in empathy and social encounters. Since emotional and behavioral disturbances were observed in TSP, including nonverbal social processes, a disruption of distributed brain networks concerning such processes is conceivable for these patients.

The psychiatric and/or cognitive disorders that have been linked to TS also involve complex brain functions and networks. For example, and considering the implications for understanding the functional neuroanatomy of bipolar disorder, Satzer and Bond [67] observed in their review about mania and focal brain lesions that mania occurs most commonly with lesions affecting frontal, temporal and limbic-brain areas: bilateral prefrontal emotion-modulating regions and a probable imbalance between left-sided excitatory and right-sided limbic-brain inhibitory lesions have been proposed to understand the pathophysiology of mania. Considering the functional relationship between language and mood disorders, Cuesta and Peralta [68] observed that disorganization was the main language dimension accounting for the broader construct of formal thought disorder [2], which is usually studied in patients with psychiatric disorders.⁶ Taken together, these studies underline a relationship among disorganization of language, emotional disturbances and a disruption of distributed brain networks, agreeing with the present anatomical results.

Another psychiatric disorder that has been linked to TS is schizophrenia. Under this background, and also related to the concepts of disorganization of language and formal thought disorder, Holshausen et al. [23] hypothesize that executive functioning may play a role in maintaining the topic of conversation, planning upcoming speech and inhibiting inappropriate or unrelated discourse. (The authors also suggest employing a neurocognitive battery to elucidate this question in further studies.) Given that, in the present study, TSP and non-TSP showed differences in global cognition, and that global cognition and executive functioning are closely related [49, 56], it cannot be discarded that TSP showed impairment

⁶A radical difference between the psychiatric approach and the present one is that the construct of formal thought disorder and, particularly, its subcomponent of disconnected or disorganized speech include incoherence below the level of the sentence. These two different levels of analysis may lead to discover different levels of linguistic impairment.

in executive function compared with non-TSP. In line with this notion, Barbey et al. [9] suggest that core elements of discourse processing emerge from a distributed network of brain regions that support specific competencies for executive, social and emotional processes (see also [69–73]).

On the other hand, sustained attention [69], discourse abilities [8] and internally oriented mental processes such as: autobiographical memory; theory of mind; self-referential processing; future thinking and scene construction [60, 74], that is, the retrieval and integration of elements of previous experiences into a coherent event [74], have been related to the default mode network. Since all these cognitive processes are comprised in the spontaneous (self-referential) speech by which patients describe their own disease, the link between TS and the default mode network cannot be discarded either.

In summary, this work highlights the importance of studying a single and comprehensive item, that is, spontaneous speech, thus emphasizing the registration of one of its pathological expressions. As demonstrated here, TS was related to illness, to a neurogenic cognitive and behavioral disorder which, apparently, comprised a distributed brain network. Understanding the psychobiological correlates of TS may result in better strategies for interpreting such a disorder, in particular, to avoid errors in clinical practice. Since TS may be a non-trivial feature, its early detection is advisable for prevention and treatment: in the same way as finding and organizing words are essential points to be analyzed in the aphasic component of spontaneous speech, finding and organizing topics are essential points to be analyzed in the discourse component of spontaneous speech. People who show the failures associated with TS, even if those failures are subtle or insidious (like an increase in the frequency of apparently harmless lapses, interruptions of sustained attention, increased time to respond correctly, difficulty understanding or expressing complex texts, inability to (implicitly) attend and recall recent conversations, along with emotional and behavioral changes), may be suffering of a neurogenic disorder, with implications in global cognition and high-level language processing. If those failures are not early detected and treated, they may evolve to a more serious condition.

The combination of failures in selective and sustained attention along with the special characteristics of the language impairments observed in this study, allowed to outline a hypothetical pattern of cognitive symptoms associated with TS to be verified in further research. The association between TS and recognized measures of discourse processing, namely, complex verbal comprehension and story recall/storytelling, provided support for the viability and validity of the present TS screening scale, which was also reliable between raters.

By using efficient scales, aphasia and TS could be simultaneously screened during the first step of the doctor-patient interview. In this work, one complex function was assessed with a simple but carefully designed scale, which facilitates both saving time and controlling intervening variables during the interview interaction. The property of saving time during neuropsychological language evaluations is valuable, particularly in public hospitals. Additionally,

the structure of evaluation proposed here for TS might serve as a model to be totally or partially applied to other conversational items, or even to other scientific disciplines interested in discourse processing and cognition. Since aging is a factor associated with cognitive impairment and cognitive impairment is a factor associated with TS, the presence of TS in the elderly must not be ignored.

Acknowledgements

This study was supported by funds from the National Council of Scientific and Technological Research in Argentina (CONICET), from which Vigliecca is an employee. I am grateful to Silvia Molina and Marisa Peñalva for their participation in the study and to the doctors of the Neurosurgery Service of the Cordoba Hospital.

Conflict of interest

The author declares no conflicts of interest in this paper.

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