Neuropsychologia 101 (2017) 115–120

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

The effect of cortical and subcortical lesions on spontaneous expression of memory-encoded and emotionally infused information: Evidence for a role of the ventral stream

Efthymia Efthymiopoulou[a], Dimitrios S. Kasselimis[a,*], Apostolia Ghika[a], Andreas Kyrozis[a], Christos Peppas[b], Ioannis Evdokimidis[a], Michael Petrides[c], Constantin Potagas[a]

[a] 1st Department of Neurology, School of Medicine, National & Kapodistrian University of Athens, Athens, Greece
[b] Department of Radiology, Therapeutic Center of Athens "Lefkos Stavros", Athens, Greece
[c] Montreal Neurological Institute and Hospital, McGill University, Montreal, Quebec, Canada

ARTICLE INFO

Keywords:
Aphasia
Extreme capsule
Ventral stream
Speech rate

ABSTRACT

The ventral stream of language processing has been implicated in the spontaneous expression of memory-encoded and emotionally infused information. The present study investigated whether left hemispheric lesions in post-stroke right-handed aphasic patients may be selectively associated with specific language functions. Speech rate was assessed with two tasks, one based on autobiographical memory of an emotionally infused event (stroke story narration) and the other based on information that is visually available at the time of speech generation ("cookie theft" picture description). CT and/or MRI scans were obtained for each patient and lesions located in 16 regions of the left hemisphere were identified and coded. The total number of cortical and subcortical areas affected served as a measure of lesion extent. While mean speech rates were similar across conditions, there were different patterns of association between each index and specific lesion sites. Non-parametric quantile regression statistical models constructed to assess dependence of both speech rate indices on each lesion locus indicated that the speech rate in the stroke story had significant inverse associations with total number of lesioned areas, as well as lesions in the inferior frontal gyrus and the external/extreme capsule region. The cookie theft speech rate had significant inverse associations with total number of lesioned areas as well as lesion in the inferior frontal gyrus, but not with the external/extreme capsule region. In sum, integrity of the extreme/external capsule region appears to be important selectively for the Stroke Story task, supporting the hypothesis that the ventral stream plays a central role in spontaneous expression of memory-encoded and emotionally infused information.

1. Introduction

Non-fluent aphasia is characterized by reduced rate of speech and reduced phrase length, phonemic paraphasias, impaired repetition and naming, but relatively preserved comprehension (Goodglass, 1993). It has historically been linked to a lesion located at the posterior part of the third frontal convolution in the left language dominant hemisphere (Broca, 1861; Geschwind, 1970). However, several studies have shown that non-fluent speech syndromes can occur as a result of lesions not necessarily located at the posterior inferior frontal gyrus (IFG) (Basso et al., 1985; Kasselimis et al., 2015; Mohr et al., 1978), and that the claim of a strict lesion-to-syndrome correspondence is an oversimplification (Kasselimis et al., 2017; Scwhartz, 1984; Willmes and Poeck, 1993). Contemporary research findings indicate that language is supported by a rather complex left-lateralized network involving cortical and subcortical areas (Friederici, 2011). It is thus tenable to argue that articulated speech is not affected solely by a lesion restricted to a single brain area.

This notion is strongly supported by the relevant literature. Several cortical and subcortical areas, including left, but also right hemisphere regions, are involved in word production (Indefrey and Levelt, 2004). Moreover pathways connecting posterior and anterior cortical areas are shown to play a significant role with regard to speech fluency. There are two such known pathways connecting temporal with frontal cortical areas for language processing, often referred to as the dorsal and the ventral streams (Hickok and Poeppel, 2004, 2007; Saur et al., 2008). The dorsal stream, traditionally considered to be the major language pathway, connects posterior temporal and inferior parietal areas with premotor cortex and prefrontal areas via the arcuate fasciculus and the superior longitudinal fasciculus, and the ventral pathway utilizes a

* Correspondence to: National and Kapodistrian University of Athens, Eginition Hospital, 74 Vas. Sofias Av., 11528 Athens, Greece.
E-mail address: dkasselimis@gmail.com (D.S. Kasselimis).

http://dx.doi.org/10.1016/j.neuropsychologia.2017.05.010
Received 17 September 2016; Received in revised form 3 May 2017; Accepted 7 May 2017
Available online 08 May 2017

relatively recently discovered pathway that links intermediate temporal with frontal areas via the lower part of the extreme capsule, the temporo-frontal extreme capsule fasciculus (Petrides, 2014; Petrides and Pandya, 2008; Saur et al., 2008).

Apart from the anatomo-clinical concerns discussed above, there is another methodological/clinical issue worth mentioning; that is, the method of eliciting a speech sample, which will be then used to evaluate a patient's linguistic competence on the basis of several indices, including speech rate. Research on aphasic discourse utilizes several genres/types (for an overview, see Müller et al., 2008), which may arguably present with different characteristics (Armstrong, 2000). Different patterns of language output emerging from different elicitation methods have been demonstrated in several studies. For example, an early study by Ulatowska et al. (1981) showed that both aphasic patients and healthy controls exhibit differences between their procedural and narrative discourses. Glosser et al. (1988) evaluated aphasic speech output derived from a narrative and a picture description task, and found significant differences between the two conditions (the latter characterized by exemplified verbal patterns with reduced contextual variations). The effect of discourse type on verbal production indices, such as lexical diversity, has been also demonstrated in non-pathological speech (Fergadiotis et al., 2011). The extent of verbal output may be also affected by the familiarity of the topic discussed by the patient (Williams et al., 1994). In summary, several authors acknowledge that the qualitative and quantitative characteristics of speech output may be influenced by the choice of elicitation technique (Armstrong, 2000; Linnik et al., 2016), and further stress the need for assessing verbal production across genres by utilizing several tasks (Armstrong et al., 2011).

The above brief review of the literature demonstrates that, although Broca's area in the inferior frontal gyrus has been considered to be the “speech center” throughout a large part of the history of aphasiology, contemporary research aims to elucidate the biological substrate of language mechanisms by examining relationships between several interconnected cortical and subcortical areas with specific linguistic functions, such as speech output, under different conditions, which, in turn, may affect the qualitative and quantitative aspects of verbal production. In this context, our goal in the present study is to investigate the effect of brain lesions on a quantitative measure of language output (i.e. the rate of speech) in patients with non-fluent aphasia resulting from left hemisphere stroke under two distinct conditions: a task in which speech output is guided by information generated from memory (narration of the patient's own stroke events) and a task in which speech is guided by information that is available to the patient at the time of narration (description of a picture). These two tasks are fundamental components of standard aphasia assessment (Goodglass and Kaplan, 1983), and, as described above, are thought to elicit quantitatively and qualitatively different verbal outputs. The Stroke story requires recollection of a personal experience and, therefore, assesses retrieval of both the content and timeline of life events, whereas picture description requires identification and verbalization of visual stimuli. Based on the existing literature, we expect to find associations between speech rate and lesion sites not necessarily restricted to the inferior frontal gyrus. Furthermore, we aim to explore whether specific lesion loci may demonstrate a differential effect on quantitative characteristics of speech elicited by different tasks.

2. Methods

The sample consisted of 41 right-handed patients (12 women) with left hemisphere stroke-induced aphasia, aged 24–86 years old (Mean: 60.41; SD: 14.72), with 2–20 years of formal schooling (Mean: 10.59; SD: 3.99). Mean time post stroke was 19.74 months. Individuals with psychiatric history or degenerative diseases were excluded. CT and/or MRI scans were obtained for each patient and lesions were identified and coded as located in 16 pre-determined left hemisphere regions, according to a previously reported methodology (Kasselimis et al., 2017). These 16 regions were: the inferior frontal gyrus (IFG), the middle frontal gyrus (MFG), the precentral gyrus (PrG), the inferior temporal gyrus (ITG), the middle temporal gyrus (MTG), the superior temporal gyrus (STG), the inferior parietal lobule (IPL, i.e. the angular and supramarginal gyri), the thalamus, the insula, the supplementary motor area (SMA), the internal capsule (IC), the head and tail of the caudate nucleus (CNH and CNT, respectively), the putamen, the globus pallidus (GP), and the external/extreme capsule (EC). The extreme capsule lies between the insula and the claustrum and immediately medial to the thin claustrum lies the external capsule. It is therefore practically impossible to distinguish these two fiber tracts in radiologic evaluations. The total number of affected cortical and subcortical regions (out of the 16 selected) served as an index of lesion extent (henceforth “lesion score”) (Buxbaum et al., 2004; Kasselimis et al., 2013).

The patients were assessed with a short form of the Boston Diagnostic Aphasia Examination (BDAE-SF; Goodglass and Kaplan, 1983), adapted in Greek (Tsapkini et al., 2010). Speech rate (SR) was defined as the total number of words divided by the total duration of speech. Speech rate in each one of the two tasks for each patient was calculated on the basis of a speech sample obtained during standard BDAE assessment. The two tasks were: (a) the stroke story that requires the patient to recount his/her stroke incident and (b) a task requiring the patient to describe in detail a picture depicting a “cookie theft” event. For the stroke story task, the question addressed to the patient was: *Can you please describe what happened the day you had your stroke?* For the picture description task, the question addressed to the patient was: *Can you please describe what you see in this picture?* There was no time restriction; the patients were free to talk as much as they needed. SR was calculated for each patient based on recorded speech samples during performance of the above two tasks (henceforth SRss and SRct for stroke story and cookie theft picture, respectively) (see Table 1 for individual data). Further neuropsychological testing included the Boston Naming Test (Kaplan et al., 1983) and the Peabody Picture Vocabulary Test – Revised (Dunn and Dunn, 1981), both standardized in Greek (Simos et al., 2011), the Comprehension of Instructions in Greek (Simos et al., 2014), the Controlled Oral Word Fluency (Kosmidis et al., 2004), and two standardized word and pseudoword reading fluency measures (Simos et al., 2013). For the patients’ performance on BDAE and neuropsychological tests, as well as the mean lesion score, see Table 2.

2.1. Analyses

Since the SR scores were not normally distributed, Quantile Regression was used to analyze the data. This is a non-parametric statistical procedure considered to provide more robust estimations with regard to extreme values compared to common regression models (Koenker and Hallock, 2001; STATA, 2012). First, we investigated the possible effects of several independent variables (i.e. lesion score, years of formal schooling, age, and time post-stroke onset) on SRss and SRct, in two preliminary analyses. Then, we conducted 16 similar analyses per speech rate measure, each one corresponding to a distinct cortical or subcortical region (see Methods). This resulted in a total of 32 statistical models in which SRss or SRct served as the dependent variable. Years of formal schooling, age, time post-stroke onset, and lesion score were entered as independent variables in order to assess the effect of each lesion locus controlling for the remaining affected brain areas. In order to reduce confounding, in each model where a specific region was entered, the lesion score did not include the particular area entered in the statistical model. Statistical analyses were carried out using STATA (STATA, 2012).