

Neurocognition of Prosody

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Prosody can help allocate the precise implication to phrases/sentences like ‘can of soda’ (linguistic aspect) or assist a listener comprehend how a speaker feels (emotional aspect). This essay will delve into the linguistic aspects of prosody. Important neurological and behavioural research regarding linguistic prosody will be addressed as well as its relevance to the field of prosody. Furthermore, this essay will try to look into critical questions regarding possible future research.

Preceding to the introduction of ‘functional imaging’, an investigation into the ‘biology of language’ hinged on exploring the structure and conduct of big clusters of individuals with principal brain damage. The introduction of ‘functional imaging, magnetic and electrical recording’ in this area has permitted corresponding viewpoints on the association of evidence for theories on linguistic prosody [1]. The primary goal of research in language ‘perception’ is to explain by what means the auditory input is characterised ‘phonetically’ and is interpreted as speech. Specific brain areas are considered as dedicated for ‘auditory processing’ [1]. These areas, situated ‘bilaterally’ in the temporal lobe are ‘transverse temporal gyrus’; understood to be the location of the prime ‘auditory cortex’, and auditory association cortexes [1].

Apart from phonological understanding, ‘word comprehension’ involves gaining access to semantic information. One of the key objectives of imaging research is to understand how semantic knowledge is accessed and manipulated during language comprehension [1]. In an initial study by, words were visually displayed to participants, who completed one of two tasks: in the compound the task they mediated whether the word was ‘abstract or concrete’, and in the easier task they mediated if the word was displayed in ‘upper- or lower-case’ [2]. The results indicated that an area in the ‘left inferior frontal gyrus’ (IFG) presented more ‘neural activity’ in the compound task than the easy task. Moreover, the recurrent performance of the compound task lead to a diminished ‘neural activity’ in the left IFG region (referred to as repetition suppression), but the recurrent performance of the easier task did not bring about ‘repetition suppression’ [2]. The suppression found only for the compound task indicates that this suppression points out to easier ‘semantic processing’ associated with repetition instead of easier ‘phonological processing’ [2]. A later study by largely replicated the findings [3]. This shows the clear involvement of the left inferior frontal gyrus (IFG) in semantic processing of language.

Limited fMRI studies have inspected how access and assortment of semantic implications happen during ‘sentence processing’. In one such study by, participants in one of the two tasks, either they heard sentences that had limited ‘ambiguous words’ (e.g., ‘The shell was fired towards the tank’) or sentences with fewer lexical vagueness (‘Her secrets were written in her diary’) [4]. Two experiments were conducted, each with an independent task: in one, participants vigorously attended to the sentences being aware that they had to answer a question based on them [4]. In the other, they inactively attended to the sentences. In the first task, there was more ‘inferior frontal gyrus’ activity for the high-ambiguity sentences than the low ambiguity sentences. However, in the second task, there were differences in the activation of the ‘inferior frontal sulcus’ and the ‘left middle temporal gyrus’ but nothing in the ‘inferior frontal gyrus’ [4].

The fMRI studies reviewed until now show that the left inferior frontal gyrus (IFG) is a central region for semantic processing. However, the study by has revealed that apart from the left inferior frontal gyrus the inferior frontal sulcus and the left medial temporal gyrus is also involved in the semantic processing of sentences [4]. Apart from these regions, there are accounts in the literature for multiple regions of the brain being involved in semantic processing [1]. A study by showed that the left superior temporal gyrus, the middle temporal gyrus, and the left superior frontal gyri displayed diminished when repeated words in context are presented for the same task [5]. Another study by discovered higher neural activity bilaterally in superior and middle frontal gyrus, and in the medial frontal gyrus during ‘semantic processing compared to phonetic tasks’ [3]. All these studies when considered together have revealed that both phonetic and semantic prosody processing involves a complex network of neurons and spatially involves many regions of the brain and is not localised to either a particular hemisphere or a specific lobe.

Until now, the essay reviewed fMRI studies on the phonological and semantic aspects of linguistic prosody. Now, the studies conducted through analysing event-related potentials (ERP) will be looked into. Initially studying linguistic prosody via ERP seemed excessively complicated [6]. However, a study in 2003 by revealed that the N100 (Negative peak at 100 ms) is related to ‘word segmentation’ process [7]. The study was conducted to determine whether ‘word onsets’ in consecutive sentences would bring out the early sensory components of ERP for non-native

speakers [7]. In the study, it was found that there were larger N100 peaks for 'word onsets' in all sentence conditions [7].

'Word onsets' in consecutive sentences vary in terms of pitch, frequency and length depending on whether the syllables in the word are 'stressed or unstressed' [6]. Therefore, examination of the N100 for 'word onsets' on 'stressed and unstressed syllables' revealed that there were larger N100 peaks for stressed syllables as compared to unstressed syllables [6,7]. It was concluded that non-native speakers don't use 'acoustic differences' in speech conception the same way as native speakers do [6,7]. This study revealed the key role of N100 being responsible for 'word segmentation' which is critical in linguistic prosody as it is the starting point to interpreting speech.

When the words at the end of the sentence violate the semantic expectations of the sentence, (eg. John killed a table.) there is an ERP component caused at the 200 ms range which is individualistic and distinct to the N400 peak [6]. This 200 ms component later was termed as the 'Phonological mapping negativity' (PMN) [6]. A review paper by and other papers by revealed that the N400 is generally responsible for 'semantic violations' in sentences [6]. This reveals that depending on the influence of context on the listener, it is possible for the 'phonological mapping negativity' to partake in a lexical interpretation of the sentence before it is completed, and before the N400 component peaks as well [6,8-10].

'Syntactic parsing' is the process in which a sentence is identified and a 'syntactic structure' (eg. Active or passive voice) is determined [11]. The 'left anterior negativity' (LAN) is shown to be responsible for 'syntactic violations' in sentences [6]. Usually, when 'word category' (He argued on Newton's of laws motion) violations and/or 'number agreement' ('The children plays in the garden') between subject and verb violations take place, the LAN is stimulated [6]. However, only the 'word category' violation has shown to produce an 'early LAN' or 'ELAN' (100-300 ms) which is been connected to neural activity in the 'anterior temporal lobe' [6]. 'ELAN' is shown to activate regardless of the extent of violations in sentences. This would indicate that the 'ELAN' is an autonomous entity independent of sentence processing strategies [12]. This shows that 'LAN' is responsible for processing both the 'word category' and 'number agreement' between subject and verb in a sentence.

The P600 (500-1000 ms) is shown to be responsible for a measured analysis and integration of syntax [13]. P600 has shown to activate for a diversity of language abnormalities like, (a) sentences that need a reanalysis if the structure due to intricate ambiguities and (b) most kinds of 'morpho-syntactic violations' (eg. John killed a table.) (similar to phonological mapping negativity) [14,15]. (Kaan, 2000) established that sentence that has a complex structure without any violation or ambiguity may still invoke a P600. Put together, these findings lead to conclude that the P600 is generally activated for the processing of the structure of sentences [6]. conducted a study on the role of the P600 and its subcomponents [16]. The results of the study lead to the authors to conclude that the subcomponents of the P600 are responsible for identifying syntactic issues, followed by solving them. Apart from that, the P600 appears to be responsible for 'secondary checking processes, and phonological revisions' [16]. Through all the ERP analysing studies, the semantic and syntactic processing aspects of linguistic prosody have been reviewed.

The following paragraph will delve into the aspect of transcranial magnetic stimulation (TMS) studies in patients with Aphasia. One

of the first studies in this area examined four aphasic patients and used '1-Hz rTMS' (repetitive transcranial magnetic stimulation) to exam four individual regions in the 'right hemisphere' [17]. The directed regions were 'anterior inferior frontal gyrus, posterior inferior frontal gyrus, mouth area of primary motor cortex and posterior superior temporal gyrus' [17]. There was an increment in 'naming accuracy' only when the 'anterior inferior frontal gyrus' was 'stimulated' [17]. In another study by the patients were administered 20 min of '1-Hz rTMS' every day for a span of 2 weeks [18]. Results indicated a significant increment on the 'naming accuracy' after the 10th session and this development was seen for at least the following two months [18-20].

In terms of possible future research, with regard to ERP research, a key aspect to be looked into would be to determine a method to go past classic "violation paradigms" to study language processing and devise a more effective paradigm that can be applied in real life conversations. With regard to fMRI research, a key area to delve into would be how bodily gestures influence 'neural processing' of language. This could involve understanding the effects of the combination of speech and bodily gestures on language processing [1].

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