Cognitive Studies on Portuguese Sign Language (LGP): a work in progress

Estudos Cognitivos em Língua Gestual Portuguesa: estudo de arte

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Abstract

The main goal of present paper is to present the research lines that we are presently following in the study of Portuguese Sign Language (LGP), including the replication of previous studies in other sign languages (such as a working memory study) but also proposals that are, to our best knowledge, original (such as the study of time perception in deaf). We start by making a review of the theoretical framework that has supported several studies in other sign languages, particularly in American Sign Language (ASL), identifying then the need of replicating these studies for LGP. The status of our works is also presented.

Keywords: *Portuguese Sign Language (LGP), American Sign Language (ASL), Working Memory, sign languages, cognitive development, time perception, deafness.*

Resumo

O objectivo principal deste artigo foi apresentar um estudo que se encontra a decorrer, no ICS da UCP.

Neste trabalho, propomo-nos replicar estudos já feitos para outras línguas gestuais, nomeadamente, relativamente à memória de trabalho. As nossas propostas englobam também estudos originais, nomeadamente no que concerne a percepção do tempo nos surdos. Neste artigo fazemos uma breve revisão da literatura relativamente ao Estudo da Arte nas outras línguas gestuais, particularmente na ASL, identificando a necessidade de replicação desses trabalhos para a LGP. O Estado do desenvolvimento do nosso trabalho é também apresentado.

Palavra Chave: LGP – ASL – Mamória de Trabalho – Desenvolvimento cognitivo – Percepção do tempo pelos surdos

Deafness and cognitive development

There are no doubts that, although being the result of genetic programming, the development and maturation of the brain and related cognitive development, are crucially dependent of the interaction with the environment. As a key feature of this interaction are sensorial inputs, being now well known that sensorial deprivation may result in deficits in structural and functional organization. Congenital sensorial deprivation, as the one that results from congenital deafness or blindness, can then, theoretically, have a deleterious effect in that organization. Even when there are circumstances where these deficits can be corrected later in life, there is an increased probability of passing the critical period without stimulation.

We can identify two different kinds of questions when researching in deafness. The first concern is to know how deprivation of auditory sensorial inputs influences cortical and cognitive organization. The second, behind the scope of this article, and of greater relevance for intervention and rehabilitation, concerns the existence of a critical period for the auditory system. This second question, related with the existence of a critical period for the auditory system, gains even greater importance when considering that congenital deaf that are implanted as adults have worst auditory performances and little gains in what concerns their linguistic development. In fact, several studies seem to suggest that auditory performance of congenital deaf with cochlear implants is crucially dependent on the age of implantation.

The importance of Sign Language

Despite sensorial deprivation, auditory deficiency or deafness are multidimensional phenomena with

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several social, medical and educational features needing consideration. Therefore children with auditory impairment can follow various developmental pathways. Several factors can account for this variability. When taught sign language as a native language, deaf children are able to achieve linguistic milestones at a proper age. That is probably why one factor of good prognostic is when deaf children have deaf parents, and are immersed in that linguistic environment since birth.

However, sign languages and oral languages differ in several relevant features namely in the sensorial modality that it is used to convey the linguistic information. In sing languages we have the linguistic content that is understood as such by the brain, which conveyed to the brain through a different sensorial modality, that is a visuo-spatial modality instead of an auditory one. That poses a problem to the direct application of the classic working memory model to sign language.

Working Memory Model

The relation between memory, particularly working memory and oral language is well known, and has been extensively explored in numerous studies. In fact the working memory model postulates the existence of a mechanism specialised in processing phonological and linguistic information.

Working memory is an influential model that was first proposed in 1974 by Baddeley and Hitch in a seminal paper that points that *"despite more than a decade of research on the topic of short term memory we still know virtually nothing about its role in normal human information processing"* (p. 48). According to these authors the concept of short term memory should be replaced by one that of a working memory system. In this proposal we have a control system with limited storing and processing capacity, the central executive, and two subsidiary systems, one used for verbal material, the other one used for visuo-spatial material. In this initial paper the authors suggest that working memory plays an important role in several cognitive functions.

Phonological *loop* is the best studied component of the model and it is related with the processing of verbal and phonological material. Two components were proposed as part of the Phonological *loop*: a speech based store that keeps the mnesic trace and an articulatory control process. It is assumed that auditory information gains mandatory access to the store. This *loop* explains several experimental effects and its considerable explicative power, has lead people to reflect about the functional role of the phonological *Loop* in speech comprehension. Subsequently it was proposed that the phonological loop could play an important role in the long term learning of unfamiliar material (Baddeley, Papagno and Vallar, 1988). Its role in understanding the process of language acquisition was also studied (Gathercole and Baddeley, 1990), and relations with the acquisition of skill and knowledge in reading and mathematics are also found (Gathercole et al, 2006). The phonological *loop* seems to be a "Language Learning Device" to learn new words (Baddeley, Gathercole and Papagno, 1998) that crucially relies on the phonological store. It also seems to be related with a second language acquisition (Service, 1992). Some studies show that phonological working memory capacity, as measured by non word repetition, can influence the outcome of cochlear implantation, even more than implantation age (Willstedt-Svensson et al, 2004).

The proposal of a phonological loop to deal with verbal and phonological material is substantially validated. In fact, phonological loop explains several experimental effects: *phonological similarity* that shows that phonologically similar words are less remembered than dissimilar items (Conrad and Hull, 1964), strengthening the idea of a phonological coding. It also explains the *irrelevant speech effect*, that shows that irrelevant auditory material disrupts performance (Colle e Welsh, 1976) and reinforces the idea that auditory material gains automatic access to the phonological store, and the *word length effect* according to which, lists of longer words are less well remembered than lists of short words (Baddeley, Thomson and Buchanan, 1975), which is seen as evidence for an articulatory rehearsal process that seems to occur in real time. This word length effect can be prevented by *articulatory suppression* (Baddeley, Lewis and Vallar, 1984). *Articulatory suppression* is obtained when subjects perform an irrelevant mouth movement, while performing a span task. Articulatory suppression also prevents phonological similarity effect for visually presented material since it prevents sub-vocal recoding (Murray, 1986). In the phonological loop people seem to remember as many items as they can say in two seconds (Baddeley et al. 1975), which reinforces the idea that rehearsal occurs in real time.

The other subsidiary system, the visuo-spatial sketchpad, is less studied. The visuo-spatial sketchpad is seen as a store that, together with control proces-

ses, is responsible by registering the visuo-spatial information and keeping it trough a rehearsal process. More recently other component was added to the model, namely the episodic *buffer* (Baddeley, 2000), but the division between a verbal domain and a visuo-spatial domain seems to reflect a fundamental division in human cognition.

Working Memory Model and American Sign Language (ASL)

Wilson and Emmorey (1997) studied the working memory system of ASL signers considering the possible interference of the modality by which language reaches the brain: visual or auditory. As pointed by these authors many differences between verbal and visuo-spatial working memory have been attributed to differences between audition and vision. In fact, audition is more related with time, and vision is more related with space. As synthesized by the authors there are strong unidirectional associations between auditory items that are not found in visual working memory that may demand a nonlinear structure. That could imply that working memory for sign language may differ systematically from that for speech.

But the authors also stressed that there are several similarities between sign and speech, namely that signs are not holistic gestures but are constructed from a set of meaningless units, combined in a similar manner to that of the phonological level in spoken languages (Battison, 1978 in Wilson & Emmorey, 1997) and that there is a close relationship between perception and production, unlike what happens with the vast majority of visual stimuli that are usually used to evaluate working memory, and that allows rehearsal processes.

Based on these similarities, and in the growing evidence at the time that ASL-based memory code for temporary storage resembles the type of speech coding used by hearing subjects, the authors went further and directly explored the existence of a *"phonological" loop* for sign language.

They found a phonological similarity effect (using signs that were either similar or dissimilar in terms of handshape), replicating previous results. They also found a manual articulatory suppression effect (obtained by asking the subjects to open and close their fists, alternating the hands). They argue that suppression and similarity seem to derive from separate components of the system. For material that needs recoding (pictures of easily named objects) the similarity effect was eliminated by articulatory suppression. They obtained similarity effect when there was no hand motion, but hand motion suppressed the similarity effect, so it appears that an articulatory process in needed to recoding. They also found a "word" length effect; presenting short signs and long signs, and showing that memory performance is sensitive to the articulation time of the signs. On the other hand, they also found that suppression prevents the length effect. Synthesizing their findings about the effects, and the interactions between them, are analogous to what happens for oral language, reinforcing the hypothesis of a *"sign loop"*.

Working Memory Model and Portguguese Sign Language (LGP): A work in progress

The work of Wilson and Emmorey (1997) and posterior works seem to suggest that the *"phonological loop"* is a mechanism that is related to the processing of linguistic input, regardless of the modality of that input, suggesting that working memory system is a flexible one. Neuroscience data reinforces this similarity, for instance, recent neuroimaging studies had found an inner sign analogous to the inner speech and recent neurophysiologic evidence supports the notion of an amodal site for carrying phonological, syllable like representations in the temporal lobe that it's active when either speech or sign are processed in syllable tasks (cf. Ronnberg, 2003).

Deaf brain organization, in a similar manner to what happens in blind subjects, seems to display cross modal plasticity (in the case of the deaf it is when sign language activates areas of auditory cortex). In fact is today known from imaging studies that deaf subjects display auditory cortical activity when they are processing sign language gestures or other complex visual stimuli (Pettito et al 2000). Multisensorial convergence seems then to be a generalized feature of brain and cognition (Bavelier et al, 2006). Besides functional reorganization, auditory experience and/or exposure to sign language during human development seems to impact even anatomical organization. For instance volumetric analysis with MR shows that deaf people present a greater volume of grey matter in posterior left insular lobe. (Allen et al. 2008).

These results seem to point to a universal response of the brain and cognition to the learning of a sign language, namely ASL. In the case of working

memory, we can think that this similarity of ASL with spoken language reveals and underlying capacity of the human brain and cognition to deal with an alternative sensorial modality of linguistic input.

However, and more than in oral languages that are well established, there are significant differences between ASL and LGP.

ASL is the dominant language in the American deaf community, in some parts of Canada (Anglican) and in some regions of Mexico. The ASL is also used in other countries like the Filipinas, Malaysia, Hong Kong, Dominican Republic and Puerto Rico among others. Just like other sign languages its grammar and syntax is different from any other spoken language within its area of influence. The actual ASL has its origin in a confluence of various events and circumstances and has four great influences: Home signs; Martha's Vineyard sign language; Indians tribe sign language; and the Old French Sign Language. Thus ASL has a grammatical structure based in these four great influences.

Having completely different origins, the Portuguese Sign Language (LGP) has a distinctive grammatical structure from ASL. LGP is a language that is used by Portuguese Deaf people in their communication, being the most important window frame of their identity. Introduced in Portugal by professor Per Aron Borg, the great influence in LGP is Swedish Sign Language. It's possible that even before the arrival of Professor Borg in Portugal, it exist an Old Portuguese Sign Language developed in very little communities spread around the country, but no fonts confirm that hypothesis. Nowadays, the influence of Swedish Sign Language in LGP can only be seen in the hand configuration used in signs that describe the Portuguese manual alphabet, very identical to the Swedish one. Thus, other LGP linguistic parameters are distinctive from the Swedish Sign Language, probably as the result of the grouping of deaf children and youngsters in residential schools.

Another great difference between these two languages is their historical educational background. In 1880 in the Congress of Milan it was decided by majority that deaf should be taught orally, that sign language should be banished, and that deaf teachers should be replaced by hearing teachers. These recommendations had the opposition of two countries: the EUA and Sweden that kept sign language as the method of teaching the deaf.

As consequence, for over a century, Portugal, as several other countries, prohibited the use of sign language in deaf schools, and LGP developed outside school, namely in households, residential households and deaf associations.

Therefore, while ASL was developing inside deaf schools and in deaf communities, broadening its lexicon and refining its grammatical structures, LGP was only practiced in secrecy, becoming reduced to a daily basis communication, being held back in its developing. Although, in some periods in the USA, the use of ASL in schools had lost some importance, in the sixties, due to the linguistic investigations of William Stokoe, ASL reacquired and enlarged its statute as language for teaching the deaf students. In Portugal, only in the nineties LGP became regularly used as the language for educating deaf people and only in 1997 was recognized by law as a true language of deaf community.

Due to referred differences between the two languages (ASL and LGP), their distinctive historical background, and some other differences that seem to exist namely in terms of phonological and lexical variation.

As previously demonstrated younger sign languages (Aronoff *et al.*, 2008, Israel and Sandler, in press) appear to exhibit a greater amount of sublexical variation (e.g. handshape). Differences in social factors such as language age, size of the Deaf Community and prescriptive language norms seems to contribute to develop robust established lexical and sublexical categories and signs with less variation. Israel and Sandler study (in press) pointed out meaningful differences in phonological variations among categories in ASL, ISL (Israeli Sign Language) and ABSL (Al-Sayyid Bedouin Sign Language). ASL presented the less amount of variation, followed by ISL and ABSL showed the most variation. This study leads us to suggest that probably in LGP we will find a greater amount of variation, than in ASL. This is en important issue in order to design the linguistic Stimuli in our work.

Some pilot studies conducted by Mineiro *et al.* (2008) and Pereira *et al.* (in press) presented us some evidence about the variation of polissemic forms and the diachronic variation of forms in Portuguese sign language lexicon. These findings were consistent with the results of nominal criation in LPG found by Henriques (2006).

Although these are preliminary studies summed up to the fact that there is no established corpora for LGP, our feeling is that they are concrete differences in terms of lexical and sublexical variation between LGP and ASL. Further research in this domain is necessary to establish differences.

We consider that the studies made for ASL should be replicated for LGP, and it is proposed that the results of those studies may held some differences.

Presently, we are replicating the study of Wilson and Emorey (1997) on (because there is no established *corpora* for LGP there are few concrete data in several linguistic parameters) it was considered that the studies made for ASL should be replicated for LGP, and it is proposed that the results of those studies may held some differences.

We are presently replicating the study of Wilson and Emmorey (1997) on Working Memory because, although being a relatively old study, it relies on a well established model and holds important conclusions regarding the nature of the cognitive organization for sign language.

The materials are already constructed and implied the arrangement of several lists of similar items, dissimilar items, short signs, long signs and easily nameable pictures. Building these materials has proven to be a particularly difficult task. We have also introduced a *digit span* task. Because a consistent finding in working memory for sign language is that storage capacity is significantly lower for sign that for speech (Emmorey and Wilson, 2004), because Portuguese signs with all the required characteristics to build the list (and with additional semantic constraints) were hard to find, and based on the opinion of experienced deaf teachers, our lists had a maximum span of six items. However in some tasks, when we did the pre-validation of our material with elements of the deaf community we found, a ceiling effect.

We can speculate that this ceiling effect was found because probably there are differences in the relation between the articulation length of ASL and LGP and their correspondent oral languages that impact span, or in other linguistic features.

We are now increasing the maximum number of items in our lists in order to proceed to the applications in the experimental group. The experimental group, including only native speakers of LGP, is identified, and has already signed consent forms. Experimental results are due until the end of the current year.

Time Perception and Portuguese Sign Language (LGP): A relation to explore

It is interesting to notice that the span size difference between sign and speech that occurs in immediate serial recall doesn't occur for more complex tasks (Boutla et al., 2004 in Emmorey and Wilson, 2004). A possible explanation that is put forward is that sign languages rely in visual processing that occurs simultaneously and don't rely in temporally encoded distinctions (cf. Emmorey and Wilson, 2004). The different pattern that hearing and deaf subjects present in forward and backward digit span, with the backward digit span being more deleterious to hearing subjects is interpreted as reflecting the specialization of the *loop* in for the exact repetition of a sequence of items in a given order (Wilson and Emmorey, 1997) constituting one aspect in which the authors identified differences between the speech and the sign loop.

Taking into consideration these results, and beyond the replication studies in course for LGP, we are also exploring the hypothesis that these differences in the reliance in temporal sequences may have an impact in time perception.

Time perception and its measuring are basic components of cerebral function, and temporal processing is an integral part of many everyday goal oriented behaviours. The explanation for subjective time also assumes the existence of an internal-clock mechanism. Previous work has shown an association between the estimation of time and short term memory/ working memory (Coelho et al, 2004). We are presently adapting the tasks and procedures used in this study to LGP in order to address the relation between sign language (LGP), time perception and working memory.

Recognized as the official language of the Portuguese deaf community only in 1997, LGP is a language that presents a wide research field to which we expect to contribute in a productive manner.

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