Original article

Proposing "Cued-Speech" as a new approach for Dyslexia

Proposta do uso do "Cued Speech" como nova forma de abordagem à Dislexia

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ABSTRACT

Cued Speech is a technique that allows visualizing the phonemes of spoken language. Its efficiency in making deaf children phonologically aware, mastering the alphabetic principle and learning to read and write fluently is already demonstrated. Dyslexic children share phonological unawareness with their deaf peers. In deaf children it is caused by the lack of access to spoken language, preventing the construction of phonological representations. In dyslexics, it is a cognitive deficit whose origin is yet to be completely solved. Brain-function mapping of dyslexics during decoding tasks shows an aberrant activation of right hemisphere STGp (posterior superior temporal gyrus) and inferior parietal right region, whereas non-impaired readers activate their left symmetric regions during the same task. Nevertheless, research shows that, after remediation programs, dyslexic children improve behaviourally and also reach a greater involvement of their left STGp in non-word reading. Programs focusing on phonological awareness training produce the best outcomes. This article proposes testing cued speech as a remediation tool, as it is totally driven to the construction of phonological representations and needs no special equipments, just the hands. Also, children can be trained at home, by their parents, on day-to-day situations, diminishing costs of the treatment and consequently disposing it to a greater number of children.

Key words: cued-speech, dyslexia, language, literacy, phonology.

RESUMO

"Cued Speech" é uma técnica que permite a visualização dos fonemas da língua falada. Já está demonstrada a sua eficácia em fazer com que crianças surdas atinjam a consciência fonológica, dominando o princípio alfabético e lendo e escrevendo fluentemente. Crianças disléxicas compartilham com seus colegas surdos a falta de consciência fonológica. Nas crianças surdas, ela é causada pela falta de exposição à língua falada, o que impede a construção de representações fonológicas. Já nas crianças disléxicas, é um déficit cognitivo de origem ainda não totalmente conhecida. O mapeamento da atividade cerebral de disléxicos durante atividades de decodificação mostram uma ativação anormal do giro temporal superior posterior do hemisfério direito e da região parietal inferior direita, enquanto leitores sem impedimentos ativam as regiões simetricamente opostas nas mesmas atividades. No entanto, pesquisas demonstram que após serem submetidas a programas de treinamento, as crianças disléxicas tanto melhoram na capacidade de leitura como atingem um maior envolvimento de seu giro temporal superior posterior esquerdo na leitura de pseudopalavras. Os programas que produzem os melhores resultados são aqueles dirigidos ao desenvolvimento da consciência fonológica. Este artigo propõe testar o uso do "cued speech" como uma ferramenta de treinamento, já que é um sistema completamente voltado para a construção de representações fonológicas e não requer nenhum equipamento especial, apenas as mãos. Além do que, a criança pode ser treinada em casa, por seus pais, nas situações do dia-a-dia, diminuindo os custos do tratamento e disponibilizando-o a um número maior de crianças.

Palavras-chave: Cued-speech, dislexia, linguagem, alfabetização, fonologia.

PHONOLOGICAL REPRESENTATIONS AND LITERACY

Learning to read and write fluently depends on the development of phonological awareness, which permits us to perceive speech as a chain of a limited number of sounds (the phonemes of the language) combined in different sequences. To become literate, children need to bring phonemes from the unconscious level (as they are in illiterate people) to the conscious level, where they can be manipulated and associated to graphic symbols – the graphemes. Each grapheme corresponds (more or less, depending on the language orthography) to an alphabet letter[11]. About 15% of the population presents difficulties reading and writing, from which about 85% suffers from dyslexia[21], a language deficit with no endogenous or exogenous apparent cause[13].

Children begin the literacy process with two lexicons in their vocabulary: the semantic lexicon, storing the meaning of all the words they know, and the phonological lexicon, storing the abstract form of these words. Learning to read means achieving an orthographic lexicon, i.e., to internally represent the written symbols representing the words of the language, and connect them to the semantic and phonological lexicons[13].

Three stages have been establised in the acquisition of literacy - the logographic, alphabetic and orthographic stages. In the logographic stage, the word is treated as any other object: its meaning is associated with global features such as colour, size, font used etc. To progress to the next – alphabetic - stage, the child needs to receive explicit instruction on how to associate phonemes to alphabet letters. Then the child learns to treat letters differently of other objects, creating abstract representations for them, which are associated to the phonemes. Children who reached this stage are able to read applying grapho-phonological rules to a printed word[11,13]. These rules allow assembling the phonological representations of the words and, consequently, accessing the semantic lexicon, just as it would happen through an auditory input[1,9]. The phonological access is important to beginner readers, since they acoustically recognize thousands of words and their meanings, but lack the orthographic representations for them (i.e., they have not yet built an orthographic lexicon). Moreover, grapho-phonological rules are a generative procedure that makes children independent readers: once they have mastered its principles they need no help to read regular words[1,9,11]. A refinement of this stage is to associate each phoneme not to a letter, but to a grapheme[13] - for example, in English the grapheme ‘sh’ is compounded by two letters, corresponding to the phoneme /š/ (an unvoiced postalveolar fricative). As long as they are exposed to more and more printed material, the young readers begin to construct an orthographic lexicon that enables them to recognize words directly from their written form (direct access)[1,9,13]. A positive feedback takes place: the more the child succeeds in identifying a word by the grapho-phonological rules, the more familiar the child will be to the written form of that word. Mental orthographic representations will occur and the most common words will be identified visually: the lexicon will be accessed directly from the written form[1,9,11]. Those three types of reading strategies progressively take precedence over each other[11,13], and the construction of the orthographic representations does not mean phonological assembly will be abandoned: each time one faces an unknown word, or a non-word (that is, a meaningless sequence of phonemes), phonological assembly will be used to read that material[1,9,11,13].

Obviously, if the child does not acquire the phonological awareness, there will be a disruption of the process at the alphabetic stage: it will not be entirely able to read through phonological assembly, with consequences to the construction of the orthographic lexicon. Indeed, not only dyslexic children have trouble to read the non-words but also the orthographic access are more developed in normal readers than in deficient ones[11].

Phonological and visual causes have been proposed to cause dyslexia. As major visual problems are excluded from the dyslexia definition, only subtle problems with little impact on everyday life could account for the problem. Of course visual stress (manifested as migraines, for example) and visual distortions or unstable visual images may disturb reading, and visual treatments may help in those cases[13], but nowadays the most widely accepted explanation is that dyslexia is a cognitive deficit specific to phonology: poor phonological representations difficult phonemic awareness and block the alphabetic stage of reading acquistion, disrupting the construction of the orthographic lexicon[11,12,13]. Research has demonstrated that proficiency in phonological analysis of words significantly differentiates dyslexics from controls and predicts future literacy skills[11,19,22].

Even a blind one, i.e., somebody in the very extreme of visual deficiency, can learn to read and write as long as he has intact phonological representations. The Braille method is also an alphabet that uses phoneme-grapheme correspondences, so the child will pass for the same logographic, alphabetic and orthographic stages in its literacy process[13.] But a deaf kid with intact vision will not be able to read and write efficiently. Without access to spoken language, there will be no development of phonological representations and alphabetic writing will be meaningless to him[11,13]. Nevertheless, as long as a deaf child gain visual access to phonemes by cued speech technique (that will be described in next sections), it will be able to construct visual representations to the phonemes and establish a phonologic and orthographic lexicon, reading as fluently as hearing children do[1,5,6,8,9,14]. This leads to the conclusions that (1) as long as the alphabet is composed by combinatorial units corresponding to the phonological units, the brain is capable of creating orthographical representations to the words, be it visual or tactile and (2) phonemes, that has traditionally been defined as the 'speech sounds', may have its definition enlarged[8] - they remain the smallest part that distinguish one word from another, but can be conveyed by other medias apart from acoustic: cued speech provides full access to the phonemes of a language in natural discourse through vision.

DYSLEXIA ETIOLOGY

Is dyslexia specific to the phonological system or is it secondary to a more basic auditory, visual or motor impairment? Researchers do not entirely agree in this point, and the biological basis of dyslexia are yet to be completely understood. Dyslexics has shown to be less sensitive than controls to dynamic (brief, rapidly changing) sensory stimuli, both in the auditory and visual modality[3,19]. The "magnocellular theory" postulates this is due to dysfunctions of the magnocellular pathway in their brains[12]. Indeed, not only the neurons of the magnocellular layeres of the lateral geniculate nucleous are on average 27% smaller in dylexic brains, but dyslexics also present a significant right-left assymetry in the cross-sectional neuronal areas in the medial geniculate nuclei (MGNs): dyslexic samples showed more small neurons and fewer large neurons in the left size. In dichotic listening studies, rapid acoustic stimuli show left hemisphere dominance and reduction of the rate of acoustic change diminishes lateralization, i.e., the analysis of fast temporal auditory transitions, critical for language, is specifically handled in the left hemisphere.[7] Deficits in detecting rapidly presented or rapidly changing acoustic stimuli has been argued to play a direct role in phonological development and in disorders due to fundamental disturbances in sound perception.[3,7,19]. Specifically, many of the acoustic temporo-spectral changes that are critical for identifying and discriminating phonemic segments within speech occur within tens of milliseconds, requiring a rate of acoustic processing that has been shown to be impaired in many dyslexic individuals[3,19]. Or, in the words of Sherman et al[17], though many consider dyslexia to be fundamentally a disorder of language, there is evidence that it is associated with perceptual abnormalities that could, by interfering with normal development, lead to higher-order defects, including linguistic anomalies. Nevertheless, Ramus attests that auditory disorders are restricted to a subset of dyslexics and are not necessary for a phonological deficit to arise, and the auditory disorders observed in dyslexics seems to be mostly unrelated to speech perception and phonological processing[13].

The magnocellular theory is not the only one available. There are three main theories to explain the causes of developmental dyslexia: (1) Phonological theory says the cognitive deficit is specific to phonology. (2) Magnocellular theory attests that magnocellular dysfunctions lead to deficits in detecting rapidly presented or rapidly changing acoustic and visual stimuli, interfering with phonological representations (as described above). (3) Cerebellar theory claims that cerebellum dysfunctions cause disturbed phonological representations, since the cerebellum plays a role in motor control (therefore in speech articulation) and in the automatization of overlearned taskes, such as driving, typing and reading[12]. To access these three leading theories of developmental dyslexia, Ramus et al conducted a case study where 16 dyslexic and 16 controls were administered psychometric, phonological, auditory, visual and cerebellar tests. Data revealed all 16 dyslexic suffered from phonological deficits, but only 10 suffered from auditory deficits, 4 from a motor deficit and 2 from a visual magnocellular deficit. According to this study, we conclude that phonological deficit does not depend on sensory or motor deficits to appear, and is sufficient to cause dyslexia. Overall, Ramus et al study supports phonological theory of dyslexia, acknowledging aggravations due to sensory and motor deficits, but denying they may be the primary cause of literacy problems[12]. As Ramus pointed out, there is a paradox about dyslexia research nowadays: the more clear it becomes that a significant proportion of dyslexics present sensory and/or motor deficits, the more clear it is that sensory and motor deficits will ultimately play only a limited role in a causal explanation of specific reading disability[13].

BRAIN MAPPING, REMEDIATION PROGRAMS AND BRAIN PLASTICITY

Unlike spoken language, written language is a cultural invention of only about 5000 years that might not have evolved under natural selection. Reading puts considerable demands on human cognitive system and reading skills are achieved by a whole network of brain areas, some of which seem rather specific and solely dedicated to the reading task. Understanding reading acquisition requires not only to answer what is the nature of the input necessary for learning to occur, but also how, under the influence of this input, the brain partly reshape itself into a proficient reading machine. Imaging studies of the brain at different stages of reading acquisition process is expected to reflect the emergence of new representations for alphabetic strings and orthographic lexical items. Brain-function mapping have been made in attempt to associate reading systems to brain areas. Alphabetic/orthographic representations, p. ex., have been reliably associated to the occiptal-temporal region of the left hemisphere[13].

A hierarchy has been pointed in this region, in that the more anterior they get, the more abstract they become: posterior areas seems to be related to processing of low-level visual features and letter-shapes, the mid-portion of the left fusiform gyrus would cope with representations of abstract letter strings of both words and non-words and anterior portion would be specific to words[13]. As reading skills increase, activation in those occipital-temporal areas also increases, which is consistent with progressive formation of alphabetic and orthographic representations. Those same areas are hypo-activated in both child and adult dyslexics during reading tasks[13], what does not necessarily mean a dysfunction in those areas cause dyslexia: this can be interpreted as an abnormal development of orthographic representations due to phonological deficit.

Temporo-pariental junction is also a major component of the reading system, including the posterior superior temporal gyrus (STGp), the angular gyrus and the supra-marginal gyrus, mainly in the left hemisphere. Decomposition of the region into functional regions has not yet been achieved, but it is assumed to be involved in the lexicon, in sublexical-phonology and in the computing of grapheme-phoneme correspondences. In reading, activation of occpito-temporal areas occurs before that of temporo-parietal junctions, as would be expected from the view that visual-alphabetic processing precedes phonological processing and lexical access. Children seem to activate the left STGp more than adults when reading, which again is consistent with the idea that children rely more on alphabetic and less in orthographic strategies. Dyslexic children and adults activate less this area than controls, consistent with their phonological deficits and difficulties in grapheme-phoneme association. Dyslexics compensate this hipo-activation by hyper-activating simetric right-hemisphere areas compared to controls. Another way of compensation for their orthographic phonological processing difficulties is the increased involvement of the inferior frontal gyrus bilaterally (this area of the left hemisphere – Broca's Area – is often involved in reading)[13].

Nevertheless, Simos et al[18] findings has pointed to a plastic reality where an intensive remediation program in reading is associated with dramatic changes in brain activation profiles in children with very severe reading difficulties. They obtained brain scans of eight dyslexic children and eight controls during a pseudo-word reading task. Non-impaired readers displayed predominant activation of the left STGp and the left inferior parietal region, whereas dyslexic had an aberrant profile of activation of the right STGp and the right inferior parietal region. After dyslexic children received a 80 hours training on phonologic processing and decoding skills for 1 to 2 hours/day during 8 weeks, not only they showed a marked improvement in phonologic decoding abilities, but also dramatic changes in brain activation profiles that rendered activation pattern virtually indistinguishable from that found in age-matched children who never experienced reading problems. The controls were also scanned after eight weeks but have not shown any systematic change in the activation profiles. That is, even if dyslexia has a demonstrable neurologic basis, there is a malleability of the phenotypic profile of the disorder. Instruction seems to play a significant role in the development of neural systems that are specialized for reading. Variations in normal development can be reversed by means of reading intervention targeting phonologic processing and decoding skills for a relatively short time. Neural systems are much more plastic than previously believed[18].

Two hypothesis were raised to explain the phenomenon: (1) compensatory hypothesis says that training establishes a new brain circuitry for reading, other than the one present in normal readers. (2) Normalization hypothesis points out that intervention may repair the aberrant brain circuitry for reading, establishing a circuit identical to the one typically established by non-impaired readers during reading acquisition[18]. But there is still not a clear answer to why dyslexic children do not establish the normal circuitry as naturally as non-impaired readers do[15].

Temple et al also observed similar results in brain activation profile after training, in a study where 20 dyslexic children were examined by fMRI before and after a remediation program focusing on auditory processing and oral language training. Oral language and reading performance improved after training, and there were activation in left temporo-parietal cortex and let inferior frontal gyrus, a pattern closer to that of normal reader children. A correlation was observed between oral language improvement and temporo-parietal cortex activation. Additional compensatory activation in right hemisphere frontal and temporal regions was also reported[20].

From all remediation strategies used so far, programs focusing on the development of phonemic awareness and decoding skills produced the best outcomes[11,22]. Torgesen developed a study to test the effectiveness of three different strategies in reading acquirence skills involving 180 children from 13 elementary schools, who were randomly enrolled to one of the four following conditions: (1) no treatment condition; (2) RCS (regular classroom support), i.e., the chikdren received individual tutoring in the activities and skills taught in their regular classroom reading programs; (3) EP (embedded phonics), i. e., they were trained to recognize small groups of whole words and the stimulation of phonological awareness was done in the context of the sight words being learned during the writing activities and (4) PASP (phonological awareness plus synthetic phonics), i. e., a program that provided explicit instruction in phonemic awareness by leading children to discover and label the articulatory gestures associated with each phoneme. The children were provided four, 20 minute instructional sessions per week, during five semesters, from the second semester of kindergarten to the second semesters (inclusive) of the second year of primary school. After analysis of instructional outcomes, the PASP group showed stronger skills than the EP group in phonological awareness, phonemic decoding and context-free word-reading. In the analysis involving all instructional conditions, the PASP children were also stronger on word-level reading skills than RCS and no treatment control children[22].

CUED SPEECH

Cued Speech was devised by Orin Cornett in 1966 to make spoken language fully accessible to the deaf, since it makes all phonemes distinguishable through vision. The system uses different hand shapes (cueing the consonants) plus different hand positions near the mouth (cueing the vowels). Phonemes not distinguishable on the mouth (/p/, /b/) are clarified by different manual cues, as long as the same cue is used to phonemes with clear different lip shapes (/t/, /m/). A combination of a manual configuration plus what is seen in the mouth cues a consonant-vowel cluster. That is, hand shape and hand position, in combination with the lip shapes of speech, makes every sound of speech clear. Cued speech is nothing more than a tool to overcome the ambiguity of lip reading[1,2,5,8,9]. In Brazilian Portuguese we have 8 hand shapes and 5 hand positions[10], as shown in the chart below.

The effectiveness of cued speech in making the phonemes visually accessible to the deaf children is well attested [1,2,5,6,8,9,14]. Consequently to this accessibility, not only these children become capable

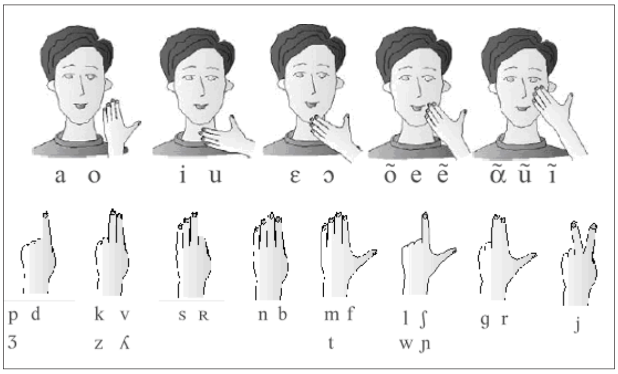

Fig.1.: Brazilian Portuguese Cues, adpted from Lúcio.

of visually understanding the language spoken around them, but are able to create phonological representations to the visual phonemes they have access to and to pass through all stages of reading acquisition exactly as hearing children do, becoming fluent readers.

THE AIM OF THIS PAPER: PROPOSING CUED SPEECH AS A REMEDIATION APPROACH TO DYSLEXICS

Why can cued speech be advantageous to dyslexics? What do they have in common with the deaf ones? And what are the characteristics of the system that make it a good choice as a remediation program to dyslexics, with advantages over the techniques used so far?

In previous sections we saw that dyslexics suffer from an inability to reach phonemic awareness. This is the same problem that deaf children have, except that in their case, they are prevented from creating phonological representations for not being exposed to spoken language. Cued speech was then devised to give visual access to spoken language, that is, it is totally driven to the construction of phonological representations, exactly what is missing in dyslexia. Of course, the simple fact of presenting the phonemes by a different media (visual instead of acoustic) would be no guarantee that a dyslexic one would acquire phonemic awareness. So, what data supports the idea that cued speech is a valid attempt to cope with the problem?

First, it was seen that dyslexics do respond to training, especially to the interventions that teach the alphabetic principle directly. Methods that draw attention to the mouth and the articulation of the sounds are a good training to develop phonemic awareness[11,22]. This is well attained by cued speech, since the cues are senseless without mouth shape. Second, many dyslexics have shown difficulties in coping with rapid changing sensory stimuli (visual and/or acoustic). If the phonemes are presented simultaneously visually and acoustically, this redundancy will reinforce the information being conveyed. Third, the simplicity of the system brings many beneficial features: (1) It is very simple and takes only about 15 hours to be learnt by hearing adults (fluency comes with practice), independently from cultural background. As it strictly respects language phonology, it is not the case to know how words are written, but how they sound. (2) The easiness is a stimulus to the parents to learn it and participate in their children therapy. (3) It represents simultaneously the consonant (hand shape) and the vowel (hand position), that is, manual cues copes with the sequence C+V (the most common syllable of Portuguese, an extra advantage to Portuguese speakers). Syllables with more complex structures such as CCV or CVC require and additional cue to identify the extra consonant[1,5,9]. This feature makes cued speech a good contributor to the acquisition of mechanisms of syllabic and phonemic segmentation, since associating manual and lip configuration is a good decodification exercise. Children are made aware of the sounds of their language and before long are able to break the code in its parts, recognizing sounds and syllables[5]. (4) It requires no special equipments, just the hands, diminishing costs of the treatment and consequently disposing it to a greater number of children.

Another point is that it is not the first time cued speech has been used to develop phonemic skills in hearing subjects with significant results, as the successful use of cued speech to improve discrimination of English vowels and diphthongs by Chinese hearing speakers reported by Chapman in his master thesis[4] and therapeutic application to correct misarticulation of /s/ and /z/ sounds in a 8-year-old boy with normal hearing[16].

LaSasso, who studies the development of reading in the deaf community, points it could be valuable to dyslexics if studies demonstrate that the deaf submitted to it are rising different brain areas to process phonological information than hearing readers do. She might be assuming that since the usual reading pathway is damaged in dyslexics brains, the way to surpass this should be making use of different areas to cope with the skill[6].

Nevertheless, even if research demonstrates the opposite, i. e., that hearing and deaf subjects use the same region to this skill (a result much more interesting, in my opinion, in which it demonstrates that a phoneme is an entity independent of the media by which it is conveyed), cued speech would probably prove to be useful anyway, since neuroimaging has shown that dyslexics normalize brain activation during reading skills after training, what means that, if they have a damaged reading pathway, it can be recovered.

For all these reasons, cued speech is a promising approach to dyslexia and if future research on the theme confirms all expectative, it might become a very popular remediation tool, effective, cheap and easily available for all dyslexic children.

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