MIRRORING AS THE GREATEST DIFFICULTY IN LETTER RECOGNITION*

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1 Introduction

Morais (1997) highlights the contrast between the “irresistible force” of the oral language acquired by children with numerous types of cognitive pathology, and the “lamentable failures" in the learning of reading and writing by "clever, intelligent" children. “Recognizing these paradoxes is the best point of departure for effective reflection on the problems of learning to read and write”. (MORAIS, 1997, p. 44).

Pedagogical reflection is often blind to the paradoxes like that pointed out by the author, closing in on itself and resisting scientific advances that could be added to the existing theories in the attempt to change attitudes and find solutions to problems that are still perpetuated in the history of education, such as absolute and functional illiteracy. Nowadays, there is much discussion on the importance of teaching literacy and training proficient readers in a way that will guarantee for these individuals, the social use of writing in day-to-day practices outside the school. However, there appears to be a lack of interest in the initial phase of the training process. A person who is learning to read, in order to become proficient, needs to move beyond the initial stages of literacy that involve recognizing the lines that distinguish the letters and the correspondences between the graphemes and phonemes, both with the function of distinguishing meanings; he or she also needs to make these skills automatic, in terms of the process of reception (decodification) and production (codification), in order to advance in levels of literacy that will actually enable him or her to appropriate the benefits to be derived from mastering the skills of reading and writing.

The taboo that still surrounds the discussions on this initial stage of learning to read and write has placed a heavy burden on learners, who are often expected to behave like mature readers. In order to enrich the theoretical bases that exist in the area of reading and literacy, particularly in relation to this initial phase of the literacy process, this article gives a brief presentation of the initial results of an investigation on mirroring for letter recognition. It is essentially based on the neuroscientific discoveries by Dehaene (2007), who affirms that the biological and cultural aspects that define us as human beings are far more overlapping than the dualist trends shown by some scientific studies. An investigation is proposed, based on a syllabary that was designed based on the observation that mirrored graphemes present a higher level of difficulty than topologically similar graphemes, in the reading of a writing system.

2 Reading in its initial phase

At a time when education is available to all, illiteracy is being combated, and there is

* This article presents data relating to a study on neuronal recycling, which began at PhD level, under the supervision of Dr Emérita Leonor Scliar-Cabral (UFSC), based on contributions from Professor Dr. Régine Kolinsky (Université Libre de Bruxelles - ULB) and collaboration of Professor Dr. José Morais (ULB), Professor Dr. Paulo Ventura (Universidade de Lisboa – UL) and Professor Dr. Tânia Fernandes (UL).

unrestricted access to literacy education and a teaching that values the learner in his or her totality, there appears to be a discrepancy between the goals of these efforts and their actual results. Is not reading, after all, as simple as many of the institutionalized discourses would have one believe?

The initial phase of reading takes place before the child starts school, as it is in the social environment that the child first comes across different literacy practices. According to Paulo Freire (1994, p. 15), "all reading of the word presupposes a previous reading of the world, and all reading of the word involves reading the world, in such a way that reading the world and reading the word become a single, continuous in which you come and go". This phase, which takes place before formal contact with the written word, cannot be ignored, but given that this work deals with reading from a cognitive perspective, the initial phase is taken as that in which the formal leaning of the system of writing and language begins. This phase involves recognition of the graphic symbols (graphemes) that make up the system, in order to establish their relations with the phonemes of the language, so that it will be possible, in the future, to reach more complex levels of understanding, interpretation, resignification, etc.

There is no doubt that when it comes to reading, the aim is that the readers will reach more advanced levels. These levels become the pinnacle of all the efforts that have been made, over time, in the teaching of literacy. It is known, however, that many readers do not manage to achieve these advanced levels, for various different reasons, even though one would reasonably hope that they would do so after eight years of schooling, during which (one presumes) they had daily contact with reading.

Can this failure to learn to read be attributed to the fact that in many cases, those who train educators have not fully understood the proposals of literacy that have been widely publicized in the recent decades. Could the results observed – in a time when technological and scientific advances are creating ever more discomfort for those who are unsuccessful in an activity that is so essential in today's literacy-centered culture – be an indication that the problem does not lie in the lack of understanding of the theories, but in the theories themselves? There appears to be some truth in both cases.

On one hand, the educational theories proposed in recent decades point to unparalleled advances, particularly in relation to the historical, social and cultural concept of humankind, and his relationship with others and with his environment. This new understanding of the relationship between the educator and the educated, of the meanings developed in the school, and of the pedagogical praxis and the dialectic construction of knowledge, has moved away from the former concepts of teaching and learning that were mechanistic, decontextualized and unrelated to the social life. And in this sense, the fact that these concepts have still not been understood by the teaching profession involves a certain loss for the educational process.

On the other hand, perhaps the zeal with which these new concepts have been taken on board in educational circles in recent decades has had consequences that are no less alarming than the previous ones: the abandonment of educational practices that were heavily criticized, for a number of valid reasons, has led to a failure to consider extremely healthy aspects of the educational process. As Nunes and Kramer (1994) state, in a metaphor that is widely used in educational circles, the baby has been thrown out with the bathwater (!). While teachers learned what was inappropriate in the teaching and learning process, this did not mean they were clear as to what exactly they should do about it.

And when it comes to literacy, in its initial phase of systematized contact with the world of the written text, the problems were even more exacerbated. The old primers were criticized - and the discussion appears to be far from over - but faced with the new pedagogical trends from the whole theoretical construct brought by Piaget, Ferreiro, Vygotsky and others, and often, the insecurity over what to "put in the place" of the existing practices, teachers resorted to continuing with the former criticized practices, in an attitude that was, at

the very least, dissonant and contradictory.

The intention here is not to deny or detract from the value of all the concepts of education that have been constructed in recent decades, through the efforts of many educators who are fully committed to education in different aspects. After all, by valorizing the subject as a social and historical being and reviving the function of the school, education has begun to carve out its path, showing signs of a better future and of climbing back from the long period of lethargy in which it found itself.

The constructivist trends, however, defend the attitude of an experienced reader, for whom the process of decodification has already become automatic. And expecting a learner, who still has not mastered the written code, to behave like a mature reader is, at the very least, unproductive. The result is reflected in the dramatic results of the assessments. The students neither decodify nor guess. They simply simulate reading, feeling increasingly insecure and frustrated, and end up with a dislike of reading. Humanity took a long time to elaborate the systems of writing that exist today. Despite the phylogenetic and psychogenetic approaches to the development of writing, widely publicized in educational circles, in school, according to Kato (1998, p. 32), "[...] one does not expect the learner to develop gradually, but to behave like a fully literate person, right from the start of the literacy process".

Kato (1998) warns of the danger of taking as a point of departure the ideal reader, as this means committing the "grave error of assuming that it is possible to teach a child the strategies of a mature reader", affirming that educators

> [...] appear to believe that it is possible to avoid, at the start of literacy, separating the act of reading and writing words, and the text, which would be its natural place. But it should be remembered that in fact, this separation is linked to a stage of literacy that is characterized by a metalinguistic awareness of the word as an autonomous unit, but as a component of the text. The awareness of this unit causes the child to focus on this object, temporarily removing it from its context, which he recovers with greater or lesser speed. (KATO, 1998, p. 32-33).

Mary Kato was ten years ahead of the recent discoveries that confirm the existing problem of not making viable for the child in the initial stage of literacy this necessary and temporary isolation of the object of study from its natural context.

According to Dehaene (2007, p. 290), although there is often a discrepancy between the research carried out and actual practice in the classroom, the experiments described in the author's most recent work confirm that: in reading, "the brain does not move directly from the image to the meaning". The currently accepted educational theoretical premises, which attempt to revive only the historical and social dimension of the human being, end up denying his biological dimension, and often go against many scientific advances relating to man's biopsychological make up.

Writing systems, which vary from the written representation of meanings (as in Chinese writing) to the representation of phonemes (as in neo-latin languages), reflect the so-called two-way route of reading. On one hand, reading follows a phonological route, and on the other, it follows a lexical route. When reading, in the case of inexperienced readers, like children in the initial phase of literacy, their ability to coordinate the two seems unstable. It is only with experience that the two become integrated, to the point where they merge into "a single, integrated reading system", as Dehaene states (2007, p. 71).

> Without our even realizing it, a whole series of cerebral and mental operations is unleashed before a word is even decodified. It is dissected, then recomposed in the form of letters,

> bigrams, syllables, morphemes [...]
> The target of literacy education is clear, then: it is necessary to position this hierarchy in the brain, so that the child is able to recognize the letters and graphemes and transform them easily into acoustic images. All the other essential aspects of writing – learning to spell, enriching the vocabulary, shades of meaning, pleasure of style – directly depend on this ability. (DEHAENE, 2007, p. 290-291).[1]

It is clear, then, that failing to take into consideration the hierarchy of these cerebral operations is doing a disservice to the learner. If the aim is to show the reader the pleasures of reading and its benefits, the initial stages of letter recognition - decodification and codification – are the "key" to reading success, and it is necessary to provide the reader with this key. To use an analogy that is appropriate for the cyberculture in which humanity now lives, it is unfeasible to expect somebody to navigate independently through cyberspace without first learning how to handle the peripherals that are essential for this activity – e.g. the mouse and keyboard – and be able to recognize the different icons shown on the monitor, so that based on this recognition, he is able to understand what they mean in each context.

3 The hypothesis of neuronal recycling

According to Gibson *et al.* (1963), the distinctive features of the letters are first learned by the ability to distinguish objects, which is then transferred to writing, and from there it is a continual process, albeit slower with non-distinctive features between the letters. Currently, however, studies show that differences related to orientational aspects, specifically mirroring, are more difficult to learn, due to the way the neuronal system is organized.

> Illiterate adults have not mastered the discrimination between mirrored figures. In a "same-different" decision making task, these subjects have difficulty taking into account the visual indices relating to right-left orientation. From a functional point of view, the orientation of objects is not as relevant as their shape, i.e. a chair turned to one side remains the same when turned to the other side. (VERHAEGHE; KOLINSKY, 1991, p. 60).

The example of the chair used by Verhaeghe and Kolinsky (1991), clearly illustrates the paradox faced by the literacy student when he comes across the need to distinguish graphemes which are rotated, or mirrored. The brain is organized in such a way that it symmetrically interprets the information it receives, which causes humans to recognize themselves when looking in a mirror, for example. In reading, this orientational difference, generally irrelevant in daily life, becomes significant in many cases, requiring the learner to perform a neuronal reconversion, which Dehaene (2007) calls "recycling".

As Scliar-Cabral (2008) states, the lower the level of processing, the more automatic it should be during the learning, and the lower the number of features and units that make up the paradigm will be. This occurs so that the memory does not become overloaded, which is undesirable. An example of this is Chinese writing system; due to its mixed organization,

[1] "À notre insu, toute une série d'opérations cérébrales et mentales s'enchaînent avant qu'un mot ne soit décodé. Celui-ci est disséqué, puis recomposé en lettres, bigrammes, syllabes, morphèmes... [...]
Le but de l'enseignement de la lecture est donc clair : il faut mettre en place cette hiérarchie dans le cerveau, afin que l'enfant puisse reconnaître les lettres et les graphèmes et les transformer aisément en sons du langage. Tous les autres aspects essentiels de l'écrit – apprentissage de l'orthographe, enrichissement du vocabulaire, nuances de sens, plaisir du style – en dépendent directement.

with graphemes that correspond to morphemes and others that signal the pronunciation and ideographical units (although smaller in number), it has a very high number of possible combinations, making it highly complex (BOLTZ, 1996; TAYLOR, 1995).

Initially termed "neuronal reconversion" (DEHAENE, 2003), the hypothesis of neuronal recycling is based on the fact that the architecture of our brain, and our genetic envelope, limits the set of learnable, cultural objects. As for instance, the case of variations in writing systems between different cultures. Previously, it was believed that recognition of the Chinese writing system occurred in global fashion, with greater activation of the right hemisphere – responsible for holistic processing - as opposed to reading alphabetic systems, where there is greater activation of the left hemisphere. It was believed that cultural differences, therefore, would lead to the use of different brain circuits for reading, a hypothesis that was refuted by Dehaene (2005; 2007), who demonstrated that readers of both systems use the same brain circuit, involving the so-called region of the visual form of the word – the left ventral occipitotemporal region – in the left hemisphere, regardless of the cerebral lateral preference between right and left handed individuals, since all written forms share different features that reflect these restrictions of the visual circuits.

The brain is organized to interpret the information it receives in symmetrical form. Thus, when we look at a mirror, we recognize ourselves, despite the orientational difference, as mentioned above, and we are able to recognize, in the majority of day-to-day situations, that an object is the same regardless of its position: a cup is still a cup, whether its handle is turned to the left or to the right, for example. In relation to reading, this characteristic should be interpreted differently. It is in this aspect that the neurones need to recycle themselves, as what they have "learned" is of no use in this case. They will need to "relearn" to interpret the data they receive.

Since we are born, we go through a series of transformations, until the central nervous system is ready to be able to read, even though from the first months the child demonstrates some skills for linguistic analysis. During the first year of life, the maternal language has a strong influence on the specialization of the cerebral areas involved in language. At around five or six years of age, when the child begins learning to read, the more significant process of visual recognition and invariance are established. "It is likely that the ventral visual system is still in a period of intense plasticity when the functional specialization is far from being established [...]". This period, according to Dehaene (2007, p. 265), is extremely favorable for the appropriation of "new visual objects" like letters.

Dehaene (2007, p. 200) understands neuronal recycling as "[...] the partial or total invasion of cortical territories initially assigned to a different function, by a new cultural object"[2]. And this new cultural object is understood by the author, both in relation to the evolution of the species and in present-day terms. In relation to evolution, because there has been a change of specialization in the left ventral occipitotemporal region, previously focused on hunting and survival and now reading. In present-day terms, because for the purposes of reading, the subject needs to recycle his neurons in order to relearn what is or is not relevant in reading, as is the case with mirroring letters, unlike what occurs in other day-to-day instances.

The difficulty in learning something is directly related to the lesser or greater degree of difficulty in performing this recycling. In the case of the initial stage of reading, this difficulty is related, to some extent, for example to when the learner has to distinguish mirrored letters; there is a tendency for the left ventral occipitotemporal region to calculate an "invariance of rotation", as Dehaene states (2003), which is useful in day-to-day life, but which ends up

[2] Translation by Scliar-Cabral (2008, not published) from the original: "[...] l'a invasion partielle ou totale, par un objet culturel nouveau, de territoires corticaux initialement dévolus à une fonction différente".

causing problems in reading. This does not happen in other situations where it is necessary to distinguish between similar, non-mirrored letters.

As soon as a child has contact with the writing system, at the start of the process of becoming familiar with the letters of the system, it is common for him to go through a period known as the "mirroring stage"[3], in which it is very common to demonstrate a mirrored production of letters and/or words, as well as being unaware that the written production is inverted. In reading it is common, due to a result of this lack of awareness in relation to mirroring, for the child to invert mirrored letters. In so doing, the child is applying the symmetrization that is so useful to him in other instances of his life, like when he/ looks at himself in the mirror or recognizes objects in the world, even when they are in different positions. The subject, when dealt with in the literature, is done so in a very polemic way. Zorzi (2003, p. 132) comments that the problem behind the different points of view is related to "a lack of reliable, systematic information in relation to mirroring and its evolution in the process of children's learning, although there have been many publications in this regard". The author demonstrates the tendency to transform the phenomenon of mirroring into a pathology, such that it is frequently attributed to cases of dyslexia.

For Dehaene (2007), the stage of mirroring letters which, according to different studies, is normally transitory and is generally manifested in the first year of learning to read and write, is solid evidence in favor of the hypothesis of neuronal recycling. According to the author, mirrored writing reveals the obedience to the structural limitations imposed by evolution, which leads to symmetrization of the objects viewed. This characteristic is more specific than the identification of objects that occupy different spaces, or appear in one position or another (like a chair turned to the left, to the right, or even upside down, as mentioned by Verhaeghe and Kolinsky, 1991). It directly involves the question of change around one's own vertical axis: the mirroring of the self. Thus, even though the visual system is favorable for reading, in the words of Dehaene (2007, p. 346), "Symmetry, on the contrary, is a property that compromises reading"[4].

Thus, learning to read involves "unlearn" this general law of symmetry imposed by evolution. And it is with this dessymmetrization in mind that one should think of the process of teaching and learning the writing system, in the initial phase of literacy, when learners are experiencing difficulties involving letter recognition.

4 The methodological construct of the research

The purpose of this research, which is based on Dehaene's (2007) theory of neuronal recycling, is to investigate how the desymmetrization of graphemes occurs in the initial phase of reading, and whether mirroring presents greater difficulty than graphic similarity by topological variation of the graphemes.

The research subjects belonged to two categories: adult, illiterate subjects and pre-literate children. Distributed into three groups (G1, G2 and G3), the subjects were submitted to sessions of learning a writing system comprised of twelve graphemes corresponding to syllables (syllabary), developed specially for the research.

Based on the observation that an alphabetical system is more complex, in relation to reading, than a syllabary one, as the grapheme component corresponds to abstract units of language – phonemes – a syllabary was designed for the proposed investigation. i.e. a system in which the grapheme components correspond to syllabic units.

[3] Dehaene (2007) calls it the *"stade du miroir"*.

[4] Translation by the researcher, from the original: "La symétrie, em revanche, est um propriété qui gêne la lecture."

The subjects were divided into three research groups, in order to control the main variable: the mirroring of graphemes. The system of G1 consists of six pairs of mirrored graphemes. The system of G3 consists of six pairs of topologically similar graphemes, i.e. with small alterations in their features. The system of G2 is mixed, consisting of three mirrored pairs and three topologically similar pairs. According to the hypothesis of neuronal recycling and the necessary desymmetraziation in reading, when dealing with mirrored graphemes, it was expected that the G1 subjects would perform worse in the evaluating tests relating to the learning period of the syllabary than those of the G3, while the subjects of G2 would show an intermediary performance in reading the system.

The syllabary used in this research therefore consisted of eighteen symbols distributed in three separate systems, each containing twelve graphemes, as shown in the figure below:

Figure 1 – Grapheme constituents of the syllabary
Source: Garcia (2008).

Of the twelve graphemes of each of the three systems designed, six are root symbols (first column of the figure), which are repeated in the three systems, and on which the variations of the other six symbols are based. The first system (defined to be used with G1) consists of six mirrored pairs, based on the combination of root symbols and symbols in the second column. The third system (defined to be used with G3) consists of six pairs of symbols which have been topologically altered, produced based on the six root symbols and the six symbols in the third column, similar to them, with the addition of features and/or alterations to the relationships between the pairs. The second system (defined to be used with G2) is mixed, containing the root symbols associated with two types of combination: three mirrored symbols (second column) and three symbols with topological alterations (third column).

The definition of the sonorous counterparts of the twelve graphemes of each system was done in order to meet certain criteria, the main one being to control the number of repetitions of each syllable in the set of words formed and of the activities proposed during the learning sessions, to guarantee that each grapheme was presented to the subjects the same number of times. It was not intended that the selected syllables should form words in themselves, and a system of syllables in CV structure was sought (the canonic standard of Brazilian Portuguese) . The formation of nouns and frequently used words in the lexicon of the research population was also an important criterion, even though it was not possible to achieve this for all the words formed, due to the natural limitations imposed by the number of syllables in Portuguese, and their characteristics in word formation. Thus, the following set of syllables was chosen: /ma, gu, ga, ʎu, ʁa, sa, pĩ, ba, fũ, ʃu, mo, ʁu/.

Using the set of syllables selected, it was possible to form 28 words and 18 pseudowords. The words formed were: *pingo, galho, barra, sarro, moça, fungo, malho, gago,*

molho, funcho, ralho, fuma, mocho, marra, barro, funga, morra, churro, pinça, macho, bago, pinga, pimba, russa, raça, baixo, mago and *morro*. Some words were used in the learning sessions and in the evaluations; others were used only in the evaluations. The pseudowords, in turn, were defined exclusively for use in the evaluations, to ensure that the subjects were not using purely mnemonic strategies when reading. They are: *balho, chuma, fumba, chuga, pimo, gaça, gulho, moga, marro, mogo, pima, rago, funro, saba, pinra, rulho, funça* and *churra.*

The research design was defined so that all the subjects are submitted to four separate research stages: Pre-testing, learning sessions, intermediary testing and post-testing. All the stages are applied on an individual basis, over a period of three or four weeks, with one or two weeks for the pre-testing and two weeks for the learning sessions. Each session lasts between 30 minutes and two hours, with a total of approximately 14 hours of research with each subject.

The pre-testing phase has three to four sessions over one or two weeks, in which 12 tests are applied. Some of the tests actually consist of batteries of tests aimed at evaluating whether the subject is fit to take part in the research, as well as investigating data that enables them to be assigned to one of the three groups by means of an equalization by comparison of pairs. Others sought to cross different data with the learning of the syllabary, such as the possible development of phonological skills as a result of the learning, change of visual processing – from holistic to analytical – and a possible generalization of the dessimetrization in the recognition of the letters of the Roman alphabet system and geometric figures. The batteries of tests applied are presented below. The data resulting from their applications can be seen in Garcia (2008):

a) Mini-mental state;
b) Laterality test;
c) Snellen test for visual acuity;
d) Scliar-Cabral auditory discrimination test;
e) Test of reading letters, words and pseudowords;
f) Stroop test for reading interference;
g) Syllable and phoneme skills test;
h) Cooper test of processing visual forms;
i) Luminance test;
j) Image discrimination test;
k) Wechsler visual memory and digit span test; and
l) Ravens' colored progressive matrices test (RCPM).

In the learning phase of the syllabary, the subjects were submitted to six sessions over the two weeks, with the objective that they learn to relate the graphemes of the syllabary to their respective syllabary counterparts, based on the formation of at least twelve different words. The research predicts that the subjects will not be able to fully learn the relationships between the graphemes and their sonorous counterparts, but it is hoped that some level of learning will be achieved that will enable evaluation regarding to what is associated the difficulty in recognizing the different graphemes.

The intermediary testing was built into the research design to enable the learning development to be evaluated. Despite making the batteries of tests even more extensive, it seeks to give the investigation greater accuracy with regard to the development of the learning and the difficulties experienced by each group. The intermediary testing consists of the application of three tests: The test of learning the syllabary – the main test of the research – and two already applied in the pre-testing stage: The image discrimination test, and the luminance test, which seek to cross the learning with other skills, as mentioned above.

The post-testing has the objective of making it possible to check the data obtained before and after the syllabary learning period, as well as the final data with the intermediary tests, enabling the development of the learning process of the subjects and of the different research groups to be outlined. All the tests carried out in the post-testing are known to the subjects, and are applied in the following order:

a) Syllabary learning test;
b) Image discrimination test;
c) Luminance test;
d) Cooper's visual forms processing test;
e) Syllable and phoneme skills test.

The methodological research construct engendered was inspired by the project carried out by Kolinsky, of the Brussels Free University (ULB), which contributes to the definition of symbols of the syllabary, the research design, and the selection of the batteries of tests, some of which were adapted to computerized versions, using the program E-prime, by Ventura and collaborators of Lisbon University (UL). The complexity of the investigation led to our splitting the research into two separate periods. The objective of the first section, already concluded, was to determine the feasibility of the methodological proposal for the investigation, which was confirmed, after making some minor adjustments. The data presented in this article relate to this first period, in which the research was applied to nine subjects; five adults and four children. Based on the results obtained, the second phase of the research could then be initiated. Now in the execution phase, its aim is to collect statistically significant data regarding the hypothesis of neuronal recycling and the observation of mirroring with greater difficulty in the recognition of the letters.

5 The results obtained so far

The qualitative analysis of the data obtained so far points to a high level of difficulty in desymmetrizing in order to recognize the difference between mirrored graphemes in the initial phase of reading the syllabary, although the difficulty in identifying symbols which are topologically similar is also high.

Besides obtaining high success rates in the syllabary learning test, the research expects, among the difficulties found, to analyze which group presents a more concentrated level of errors in the identification of the graphemes: the group that had contact with a system of mirrored pairs, or the one that had contact with a system of topologically similar pairs. It would also be appropriate to analyze the occurrence of any advances in relation to the results of the intermediary and post-testing.

The results of the syllabary learning subtests show that the subjects of G1 (mirrored pairs) present higher levels of confusion between the pairs of graphemes studied than the subjects of G3 (typologically similar pairs), which confirms the hypothesis of neuronal recycling. The confusions experienced by the subjects of G3, however, were also high, which indicates that learning the system occurred at a basic level, preventing the desymmetrization from being analyzed at a deeper level, as would be desired. In the stage of the research described, there were no subjects distributed in G2.

Although the subjects had difficulty reading the words and pseudowords, tending to identify more the syllables in isolation, the subjects of G1 presented more concentrated errors, involving mirrored pairs, while the subjects of G3 presented errors involving topologically similar pairs, and also totally distinct pairs, to a much higher degree than the subjects of G1.[5]

The data indicate that a system made up solely of topologically similar graphemes is

[5] The detailed results of each test applied to one of the research groups can be seen in Garcia (2008).

more complex to learn, causing learners to commit more errors of confusion between the different graphemes of the system. On the other hand, the system made up of mirrored pairs proves less complex to learn, with the errors of confusion tending to be concentrated between the pairs with orientational difference, and not as widespread among the topologically distinct graphemes. In other words, even though the levels of errors are high in the different groups – which shows that the learning of both systems occurred at a primary level – the errors in G1 are more concentrated between the mirrored pairs, while in the G3 they were spread more between the different graphemes of the system, and not only between the topologically similar pairs. This data contradicts the statement of Dehaene (2007, p. 346) that symmetry is "a property that compromises reading".

In fact, the subjects of G1 need to familiarize themselves with a set of just six different graphical configurations and their mirrored counterparts. The subjects of G3, in turn, need to familiarize themselves with a set of twelve different graphical configurations, even though there were minimal distinctions for the different pairs. It can be inferred that once the symmetrization barrier has been broken, the subject needs to recognize a relatively smaller number of graphemes in the system of the G1 than in the G3. This optimization of the systems comprised of mirrored graphemes explains that the errors are restricted more to the mirrored pairs in the G1 – with the system containing a smaller graphical variation – and tend to be spread among the different symbols in the G3 system, in which there is greater graphical variation. The subjects of G3 who still have not sufficiently learned the relationships between the graphemes and syllables, are confused between the topologically similar pairs and the total different symbols.

Obviously, these data need to be corroborated with a larger population to confirm this conclusion, but we take the liberty of stating, by way of a research proposal, that if, as Dehaene (2007) affirms, the neurological system imposes a difficulty for grapheme recognition, due to the tendency to symmetrize, then the writing systems, made up of some mirrored symbols, prove to be intelligently constructed in such a way as to facilitate their learning, when the barrier of symmetrization is overcome, as they prevent the memory from becoming overloaded with too much separate, visual information.

6 Final considerations

The hypothesis of neuronal recycling presented by Dehaene (2007) is highly relevant in education, as it leads to a reconsideration of literacy teaching practices in the initial phase of literacy to be reconsidered, seeking to strengthen the relationship between the knowledge built in different areas in order to improve the quality of education and combat the high levels of illiteracy that still exist. Given that it is still recent, it lacks empirical research on teaching and learning that reflect on how to achieve the so-desired strengthening of the relationship between scientific practice and teaching practice, which justifies the research proposal described in this work.

As Rubem Alves (2004, p. 59) affirms, the objective is to reach the point of being able to say: "That which one day I did not know was taught to me; I learned with my body and forgot with my head. And the condition for which my hands know well is that the head does not think of what they are doing." In fact, the philosopher goes on to say, a pianist who needs to think about the keys on which he is placing his fingers when playing a piece of music will "stumble disastrously". (ALVES, 2004, p. 60). It is necessary to overcome these "stumbles" on the winding route, in the search for emancipation through literacy. And they need to be overcome not only by the future reader, but perhaps, in particular, by those assume the role of showing the way we should follow. Thus, perhaps the first step free of stumbling is to think of the human being in his totality, i.e. as a biological being; as man is a social, historical and

cultural being, then this is done out of a body that imposes certain limits and determined structures which, in turn, need to be respected, in order to make good use of them for the purpose of learning.

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