

# TEMPORAL PROCESSING, PHONOLOGY AND WRITING IN LEAD-CONTAMINATED CHILDREN

## *Processamento temporal, fonologia e escrita em crianças contaminadas por chumbo*

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### ABSTRACT

**Purpose:** analyze the impact of temporal auditory processing in writing and phonology of children with lead poisoning. **Method:** this study included 24 children, both genders, with a blood lead level equal or higher than 10µg/dL, without hearing impairment. Were assessments the spontaneous writing, immediate auditory memory, auditory discrimination, phonological awareness and auditory processing screening. Were assessments the spontaneous writing, immediate auditory memory, auditory discrimination, phonological awareness and auditory processing screening. Children were divided in two groups (GE – children with exchange of the consonant surd by sound in writing, GC – children without alterations in writing). **Results:** in GE, eight children (67%) had results abnormal in auditory discrimination and in PCF, the not expected performance in the AFT-R (subtest 1). In GC, only one child (8%) had results abnormal in auditory discrimination, and in PCF; the not expected performance in AFT-R (subtest 1). Fisher's Exact Test indicated significant difference between groups in the skills of auditory memory and auditory discrimination. **Conclusion:** there was no significant difference between performances in screening of temporal auditory processing in the groups. Children contaminated by lead and alterations in writing had worst performance in tests of phonological awareness, auditory discrimination, auditory memory.

**KEYWORDS:** Lead; Hearing; Child; Memory; Speech, Language and Hearing Sciences

### ■ INTRODUCTION

Auditory processing is defined as the set of specific hearing skills that the individual depends

to interpret what he hears, requiring the appropriate functioning of the peripheral and central hearing for development<sup>1</sup>. The difficulties in this process may contribute to learning difficulties<sup>2,3</sup>. They are characterized by alterations in oral communication, use of grammatical rules, grapheme inversions, alterations in laterality notion, agitation, hyperactivity or apathy, impaired auditory memory and difficulty in understanding the acoustic message in noisy environments, and may be associated with learning disabilities and limitations in reading comprehension<sup>4</sup>.

The temporal auditory processing is related to the perception of sound in a time period, defined as the ability to perceive/differentiate stimuli presented in a quick succession<sup>5-7</sup>. It is a prerequisite for the development of language skills and reading<sup>8,9</sup>.

Alterations in temporal auditory processing would be related to limitations in the ability to discriminate and classify quickly verbal auditory stimuli, resulting

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in difficulties at higher levels of processing linguistic information, such as verbal comprehension, reading and writing<sup>11,12</sup>.

The success of the early acquisition of reading and writing depends on different skills, including the skills of phonological processing: immediate memory or phonological working memory, lexical access and phonological awareness<sup>13</sup>.

When a stimulus is listening is necessary to represent acoustically and linguistically by the phonological coding occurs in the phonological component of working memory<sup>14</sup>. In tasks involving phonological working memory, such as repetition, immediate recollection of words and understanding of sentences occur temporal processing and storage of input<sup>15,16</sup>.

Are involved in the writing, the phonetic analysis, the correspondence between the knowledge of letters and speech sounds, and the comprehension of how the sound is produced in speech. Faults in this learning process can result in orthographic difficulties, as in cases of alterations involving the voiceless/voiced phonemes. These exchanges characterized by substitutions of phonemes may be due to the difficulty in understanding the distinction of voicing features, i.e., a failure in auditory discrimination<sup>17</sup>.

The skills of working memory and phonological awareness are interrelated and favor the initial acquisition of writing, influenced by stimuli from school education, being dependent on chronological age and maturity<sup>18</sup>.

The blood lead level in human is permitted until 10µg/dL<sup>19</sup>. The lead contamination can affect the development of the central nervous system, causing impairment in attention, concentration, memory, intelligence, learning, perceptual processes, psychomotor and interpersonal development<sup>20-22</sup>.

Considering the importance of auditory processing skills for the development of oral and written language and the influence of lead poisoning in some cognitive skills, this study purpose is to analyze the impact of temporal auditory processing and phonology in the writing of children with lead poisoning.

## ■ METHODS

This study includes 24 children, 8-15 years old of both genders. These children had blood samples collected to determine the level of lead in blood, and these examinations were conducted by the Secretaria Municipal de Saúde and performed by the Instituto Adolfo Lutz (IAL/SES-SP), Brazil.

Inclusion criteria were parental consent for evaluation and publication of results; blood lead level

equal or higher than 10 µg/dL, absence of hearing impairment (audiometry and tympanometry with normal results); alterations in writing characterized by difficulty on voicing features, i.e. by exchanging voiceless and voiced consonants.

According to these criteria, two groups were formed:

- SG (studied group): 12 children with exchanges between voiceless and voiced consonants on writing;
- GC (control group): 12 children without alterations in writing.

For written analysis, the child wrote a text of the theme provided by the evaluator. We analyzed the level of writing, orthographic errors, coherence and cohesion between paragraphs and vocabulary. We also evaluated the temporal auditory processing, immediate auditory memory, auditory discrimination and phonological awareness.

Temporal auditory processing was evaluated by means of a screening (Revised Auditory Fusion Test - AFT-R<sup>10</sup>, subtest 1). This test measures the time difference, in milliseconds (ms), that the listener is able to distinguish a short silent interval between two pure tones. Expected performance was defined as the perception of two tones occurred at an interval equal to or less than 60 ms and performance not expected when the perception occurred at an interval greater than 60 ms.

The immediate auditory memory was assessed by Auditory Sequential Memory subtest of the Illinois Test of Psycholinguistic Abilities – ITPA<sup>23</sup>, and we used the Auditory Discrimination Test to assess the auditory discrimination<sup>24</sup>. The results of both were analyzed according to the manual of each test and classified as normal immediate auditory memory, altered immediate auditory memory, normal auditory discrimination and altered auditory discrimination.

Phonological awareness was assessed by the Phonological Awareness Test (PCF)<sup>25</sup> which assesses children's ability to manipulate speech sounds. The results were compared based on normalized values to Brazilian population, which allowed the classification into normal phonological awareness and altered phonological awareness.

This study was approved by the Ethics Committee in Research of the Universidade de São Paulo, Faculdade de Odontologia de Bauru (protocol 04/2003).

The results were distributed in a database to perform the appropriated statistical analysis. Comparisons were made between the results through statistical analysis using the Mann-Whitney and Fisher's exact test.

## ■ RESULTS

Through descriptive analysis, it was observed that the average age of the sample was 10.3 years, being 12 (50%) female and 12 (50%) male.

The SG, composed of 12 subjects had average age of 9.6 years, being seven boys and five girls. In that group, eight subjects (67%) showed alterations in auditory discrimination, in the PCF and not expected performance in AFT-R (Subtest 1).

In GC, also consisting of 12 subjects, the average age was 11.0 years, with five boys and seven girls. Only one subject (8%) had alteration in auditory discrimination, in PCF and not expected performance in AFT-R (Subtest 1).

Table 1 presents the descriptive analysis of the items assessed in the total sample and in each group separately.

**Table 1 – Descriptive statistical analysis of the assessed items**

	Lead Poisoning (µg/dL)	Immediate Auditory Memory		Auditory Discrimination		Phonological Awareness		AFT-R	
		Normal	Altered	Normal	Altered	Normal	Altered	Expected Performance	Not expected Performance
SG	14,7	5	7	2	10	3	9	2	10
GC	16,3	10	2	10	2	7	5	2	10
TOTAL	15,7	15	9	12	12	10	14	4	20

When performing inductive statistical analysis of results (Table 2), using the Fisher's exact test, was observed significant difference between groups in auditory memory and auditory discrimination skills.

**Table 2 – Comparison between SG and GC assessed skills**

Skills	Value of p
Immediate auditory memory	<b>0,04469*</b>
Auditory discrimination	<b>0,00333*</b>
Phonological awareness	0,21376
AFT-R	0,19303

\*Statistically significant difference. Fisher's exact test.  
Value of p: ≤ 0.05

## ■ DISCUSSION

According to the literature, the child must adhere to the sequence of sounds as one prerequisite for the writing acquisition. The problems in auditory discrimination can be reflected in the writing, reading and in speaking<sup>26</sup>. In studied group (SG), 83.3% of the children had alteration in auditory discrimination and only 25% in the GC, being the difference between two groups statistically significant.

One study<sup>27</sup> showed that the incidence of voicing features exchanges in writing was higher in individuals with a history of alteration in oral language

development, i.e., children with sonority alteration would present difficulties related to phonemic differentiation of words. In this study, we found a higher number (75%) of alteration in phonological awareness skills in SG compared to GC (42%), but this difference was not statistically significant.

The literature<sup>28</sup> demonstrates that phonological awareness has moderate relationship with writing and low with reading. Other authors<sup>19</sup> found that performance on working memory, phonological awareness and writing level are interrelated and are related to chronological age, maturity and education.

With regard to immediate auditory memory, there was a significant difference in the performance of this skill in the assessed groups (58% with alteration in SG and 16% in GC), which indicates that alterations in immediate auditory memory and phonological awareness could be related to presence of auditory exchanges in writing.

In this study, 83.3% of SG children and 50% of GC showed no expected performance in AFT-R (Subtest 1), which did not allow to relate the findings in the writing with the performance of the auditory temporal processing, because there was no statistically significant difference between groups. This finding suggests that temporal processing screening, through the subtest 1 - AFT-R, was not sensitive to assert if the problems involving auditory processing can affect learning, both in phono-articulatory production areas and in reading and writing<sup>29,30</sup>.

Alteration in temporal processing is found in children with phonological disorders, because these

children may need more time to detect time intervals between auditory stimuli than children without phonological deviation<sup>29</sup>.

Alterations in the temporal ordering of sounds of different frequencies (high / low) and duration (short / long) occur in children with phonological awareness deficit<sup>30</sup>. The processing temporal does not seem to be influenced by age and grade level, which allows to infer that the temporal skills are developed at age seven, being little influenced by learning after this age<sup>31,32</sup>, and reaches its peak around twelve years<sup>33</sup>.

A study using the AFT-R test showed that the presence of reading and writing disorder in children results in detection thresholds at different intervals, and children with reading and writing disorder obtained average threshold in 89.5 ms, while children without reading and writing disorder obtained a 5.0 ms average in the results<sup>34</sup>. In this study, the threshold average of Subtest 1(AFT-R) was 112.9 ms for SG and 75 ms for the GC, showing a worse performance for the group with auditory exchanges in writing.

Whereas memory is a cognitive function closely related to language, is adversely affected by lead and other cognitive functions. A study that assessed 20 children with lead poisoning, aged three to six years, found immediate memory alteration in 65% of children<sup>35</sup>.

When assessing 25 school-age children (six to thirteen years) through the Academic Performance Test, one study found better performance children not contaminated by lead and worse performance in children with lead poisoning<sup>36</sup>.

## CONCLUSION

There was no significant difference between the temporal auditory processing in the assessed groups. Children contaminated by lead who showed alterations in writing (auditory exchanges) had worse performance on tests of phonological awareness, auditory discrimination and immediate auditory memory.

## RESUMO

**Objetivos:** analisar o impacto das habilidades do processamento auditivo temporal e da fonologia na escrita de crianças contaminadas por chumbo. **Método:** participaram deste estudo 24 crianças de ambos os gêneros, com nível de plumbemia igual ou superior a 10µg/dL, sem alterações auditivas. Foram avaliados escrita espontânea, memória auditiva imediata, discriminação auditiva, consciência fonológica e feita triagem do processamento auditivo temporal. As crianças foram divididas em dois grupos (GE – crianças com trocas de consoante surda por sonora na escrita; GC – crianças sem alterações na escrita). **Resultados:** no GE, 8 crianças (67%) apresentaram alteração de discriminação auditiva, na PCF e desempenho não esperado no AFT-R (Subteste 1). No GC, apenas 1 criança (8%) apresentou alteração de discriminação auditiva e na PCF e desempenho não esperado no AFT-R (Subteste 1). O Teste Exato de Fisher indicou diferença significativa entre os grupos nas habilidades de memória auditiva e discriminação auditiva. **Conclusão:** não houve diferença significativa entre o desempenho na triagem do processamento auditivo temporal nos grupos avaliados. As crianças contaminadas pelo chumbo que apresentaram alteração de escrita obtiveram pior desempenho nas provas de consciência fonológica, discriminação auditiva, memória auditiva imediata.

**DESCRITORES:** Chumbo; Audição; Criança; Memória; Fonoaudiologia



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