USE OF COMPUTATIONAL INTELLIGENCE AND VISION IN THE STUDY OF SELECTIVE ATTENTION OF CONGENITAL BLIND CHILDREN

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Abstract: The test Cognitive Assessment System (CAS) of Das and Naglieri was translated and adapted by Laboratory of Neuropsychology at *Instituto Benjamin Constant* for the cognition study in congenital blind children to understand the peculiarities of cognitive development in the absence of vision. Our emphasis is Expressive Attention subtest, showing its adaptation and manual implementation for the visually impaired. This subtest assesses selective attention and may identify if the child has difficulty in cognitive process. The sample consisted of 64 congenital blind students of Benjamin Constant Specialized School, where 21 performed the test. Data obtained during the application were grouped and analyzed by artificial intelligence laboratory Orange Canvas, which helped define the attention profiles of the sample. It can be created, in the future, new pedagogical techniques for a better development of their cognition. It was also presented here the automated adaptation which was developed by the Group for Information Technology Applied to Education Electronic Computer Center, Rio de Janeiro Federal University based on system technology "Geometrix". The proposal is that this software evaluates the attention of visually impaired people more quickly and efficiently, being more reliable to the original subtest, and also makes the statistical analysis of data, generating profiles.

1 INTRODUCTION

Currently, the study of cognition in congenital blind children is a topic not much discussed in scientific research in Brazil. However, the study of this area is very important to understand the possible differences of cognition of the visually impaired.

According to Seminério (1984), the human species has two morphogenetic channels through which human beings are capable of developing the structured processes of their knowledge, which are: the visual-motor channel and the phonetic-audio channel. Each of these channels has an afferent-perceptual way (vision and hearing) and an efferent-motor way (motor action and motor production of the phonemes of speech) that are interconnected and communicate through feedback. According to this theory, it is inferred that the visually impaired have a predominance of phonetic-audio channels and, therefore, have their cognition different from sighted people, as well as a different way to structure their cognitive processes.

The education given to the visually impaired in all grade levels uses teaching techniques based on cognition of sighted children. Thus, visually impaired children are not stimulated properly, which could affect their cognitive development. The

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Laboratory of Neuropsychology at the *Instituto Benjamin Constant* translated and adapted the battery of neuropsychological tests the CAS (Cognitive Assessment System) with the purpose of studying the cognition of the blind in order to understand these differences and create, in the future, new techniques for teaching them.

The Cognitve Assessment System (CAS) was developed by Das and Naglieri (1997) based on PASS-Luria theory, which states that cognitive processes can be measured in the following different instances: planning, attention, simultaneous processing, and successive processing. The CAS has several subtests designed to measure these cognitive processes and to correlate them to problems that may affect cognition, such as mental retardation, learning disabilities, Attention Deficit Disorder (ADHD), planning problems, emotional problems, serious head injury or even if the child is gifted.

In this work we demonstrate the adaptation and implementation of the Expressive Attention subtest in order to assess the cognitive process of attention in congenital blind children. This subtest assesses selective attention, i.e. "the ability to selectively focus on one stimulus while inhibiting conflicting responses to stimuli presented over time" (DAS & NAGLIERI, 1997). Likewise, when choosing to pay attention to some stimulus over another, this process of selective attention is also being used (Cohen, 2003; Duncan, 1999). This process of attention is evaluated through the Stroop effect in the subtest, which refers to the dominance that reading has on the designation of colours in literate people. According to Sternberg (2008), if the reading becomes an automatic process, it is not in our conscious control, and for this reason we have this difficulty to stop reading the written word and concentrate on identifying the ink colour.

During the implementation of the subtest there were taken notes on the answering sheet, and the data obtained was used for statistical analysis by intelligence laboratory Orange Canvas. This software implements functionalities, so that the execution time is not crucial; it is a machine learning and data mining. Through this program, the central object library (core objects) and the sets of programming instructions designed to perform a specific task (routines), was made a cluster of data inherent to the adapted subtest and prognosis obtained by children behavioral analysis. This cluster helped us to define the profiles of attention of the sample.

In manual adjustment of Expressive Attention subtest, it was not possible to place the stimuli (the Braille and textures) simultaneously. With the purpose of adapting this subtest in a more reliable way, with simultaneous stimuli, the software EXACT (Expressive Attention) is being finalized by GINAPE/NCE-UFRJ to solve this problem and to make the application faster and efficient. This software is based on the technology of "Geometrix" developed in Python (it is an interpreted language which does not need to compile the code to be executed), used to teach geometric concepts interactively to the blind student. This software captures through a webcam the finger movements of the blind student on a board with coordinates (X, Y) - in which he produces the figures with his finger around the figure rubbery - and shows on the computer screenplay what the student drew, and also informs with a synthesized voice what has been drawn.

The software "EXAT" will be using these Geometrix principles adapted to the needs of the Expressive Attention subtest, which are interaction, recognition of colours by texture and the immediate return to the child. It is being proposed the automation of the entire manual process of Expressive Attention subtest to the visually impaired. When the blind child puts his finger on the texture, the system through the webcam will recognize the texture and will inform with synthesized voice the name of the conflicting texture. We believe that we will obtain a more precise simultaneity of conflicting stimuli in this subtest, which will help to assess the selective attention of these children.

2 OBJECTIVE

The objective of this work is to define the profile of attention from the sample of students at *Instituto Benjamin Constant* (congenital blind children) using the Expressive Attention subtest of the battery of neuropsychological tests of Cognitve Assessment System (CAS). From the definition of these profiles and the description of their specific characteristics, it is intended, in the future, to create neuropedagogical techniques for a better learning of visually impaired children and a better use of their cognition.

The proposed solution is to use the Orange Canvas program to define the profiles of students in the subtest adapted manually. Also, it is being completed this subtest automation in order to make it easer to use, to provide a more precise simultaneity of stimuli (with more reliability to the original), and to make statistical analysis defining the profiles without using other tools.

The intention of this article is to show the importance of studying cognition in visually impaired and, likewise, to show how computer technology can help these studies: by prognosis definition with Orange Canvas and by convenience for the application of subtest after its automation using software EXAT. With this test's automatization it will be possible to evaluate children who not yet dominate the Braille system and then produce an immediate prognostic and the guiding for specific interventions.

3 METHODS

3.1 Participants

The sample consisted of 64 congenital blind children. But only 21 of these children performed the subtests, 10 male and 11 female. They are aged between 8 and 13 years old, students from kindergarten to the 6th grade of elementary school and attending the Specialized School of *Instituto Benjamin Constant* in Rio de Janeiro/Brazil. Figure 1 is a conceptual map of the sample data. According to the school information sheet for each child, they belong to lower social class. Among children who could not attend the test, 18 were excluded because they could not read Braille, 20 were excluded because they were over the age established for application of the test, and five were excluded for non-attendance.

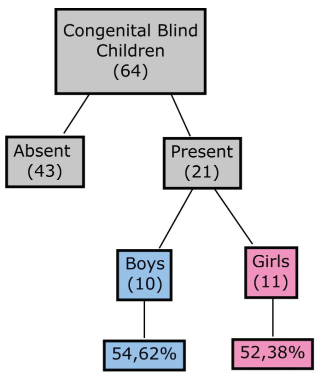


Figure 1: Sample Data.

3.2 Material

The Expressive Attention subtest for children aged between 8 and 17 years old was translated into Portuguese and adapted for blind children, changing from visual stimuli to tactile stimuli.

The original subtest is a variation of the Stroop test and consists of three parts. In the first part there are two sheets of paper with the names of the colours blue, yellow, green and red repeating themselves without an order. The first sheet is a small example with only two lines where the name of four colours is written in each one. This example enables the child to practice the task before doing it. In the second sheet, there are eight lines with five names of colours in each one.

In the second part there are two sheets with several rectangles painted with the colours blue, yellow, green and red repeating themselves, also without an order. The first sheet is the example with only two lines with four coloured rectangles in each. In the second sheet there are eight lines with five rectangles in each one.

In the third part there are two sheets with the names of the colours blue, yellow, green and red written in coloured ink. However, the ink colour is different from the colour name written. For example, the word blue written in green ink. The first sheet is the example that has two lines with four words in each one. The second sheet has eight lines with four words in each one.

The first stage of adaptation was the translation into Portuguese. Then, the colours, because they are visual stimuli, were replaced for textures. The blue colour changed to SANDPAPER, the yellow changed to FABRIC, the red changed to LACE, and the green changed to FELT. The writing in ink was replaced by Braille.

In the first part of the test, the names of colours written in ink were replaced by textures names written in Braille on a board of size 47.5 cm x 36 cm. The board sample was slightly smaller because it had fewer words, size 28 cm x 29 cm. Braille is written in a material called thermoform (PVC film), this page of thermoform stays in front of another sheet of paper on which is written the names of the textures in ink (to help the applicator to correct the test).

The second and third parts of the test which were in one sheet in the original test, had to be divided into two boards of size 59 cm x 33 cm. This adjustment was due to the size of the rectangles with the textures that had to be large to fit inside the Braille writing. The textures of the second board were made with thermoform. However, the rectangles with the textures in thermoform were glued on the board of paper above the coloured rectangles in ink. Below the rectangles, it is written the name of their texture to help the applicator to correct the test.

The adaptation of the third part is very similar to the second, the difference is that within the rectangles with the textures in thermoform, it is written in Braille the name of another conflicting texture. For example, in a rectangle with the texture of lace, it will be written sandpaper in Braille in the middle of this rectangle.

After the adjustment, we applied the pilot test to check whether the adjustment was appropriate for the children. Then we verified that children were confusing two textures that had been very similar: they mistook the lace with the fabric. Thus, we changed the type of lace, redid the thermoform and reapplied the test. This second model was adequate and was considered the definitive one.

3.3 Procedures

Implementation of Expressive Attention subtest in children was done in individual booths at the Laboratory of Neuropsychology at *Instituto Benjamin Constant*. The applicator conducted the child to one of these booths, seated her on the chair and asked some questions like her name, age, and school grade. Then the applicator explained in a playful and detailed way what she was doing there and how she would perform the test. The child is told that it is a game and has to be done as quickly as possible.

- Step 1: The initial board named Example D (relating to children of 8-17 years old, the object of this study) is presented to the child. This board has two lines containing the name in ink and in Braille (thermoform) of the textures of sandpaper, fabric, felt and lace. The second line was made to physically explain how it will be the sequence of stimulus boards and contains the same words of the first line, but in different order. For ages 8-17 years old the board stimulus starts in Item 4. This board is presented with eight lines, each line contains five stimulus words in Braille and in ink. The child should read the words from left to right until the end, going to the next line and so on until the end, at the best time possible. The applicator should take note on the answer sheet if the child read the word correctly and what was the time spent.
- Step 2: It is presented to the child the board of Example E containing four textures that correspond to the four stimuli words, seeking for tactile recognition by the congenital blind children. Then, there are presented the boards of Item 5, containing four lines each. The blind child must make the recognition of each tactile stimulus and say its name in sequence from left to right, going to the next line until the end of the board, in the shortest time possible. The applicator should take note on the answer sheet if the child correctly recognized the textures and what was the time spent.
- Step 3: It is presented the board of Example F which is similar to that of Example E, the difference is that now it is written in Braille the name of a conflicting texture. Then, there are presented the boards of Item 6, in the same prototypical example, but with four lines each. The child should read the Braille silently and then recognizing tactually the texture stimuli (conflicting) and say only the name of the texture stimuli. The applicator should get the child's hand and join her in reading the Braille, and then direct her hand to the texture. During the test, the applicator should take note on the answer sheet when the child says the correct name of the texture stimulus and what was the time spent on activity.

The score and time of each item are noted in the answer sheet. At the time of application, there are also noted some observations of the applicator, for example, if the child is distracted or tired.

3.4 Automation Proposal

Compared to the manual process of Expressive Attention subtest described above, the automated result of this work, to be reliable to the original test, requires more time, the researcher's interventions during the application and requires immediate response from the blind student for the test sequence, that does not happen on the subtest adapted. In order to solve this issue we decided to seek for a tool that would make the application of the test faster and with results consistent with the objective of the original test, then we turned to NCE/UFRJ (Electronic Computer Center, Federal University of Rio de Janeiro - Brazil) to ask for a solution for our needs. There was nominated a student of Master who developed the Geometrix system to assist blind students in the acquisition of some geometric concepts using a Webcam, a wooden board with the X, Y coordinates in self-relief and figures made of rubberized material. This system recognizes geometric shapes produced by the blind, bordered on the board, and report to them the properties of the polygon created.

Based on this architecture there was the idea of adapting this technology for the Expressive Attention subtest, preserving the same procedures described above in Steps 1, 2 and 3, and only in the test application there will be technology interventions, where the student will be placed in an individual booth with a computer, a webcam and the board with textures (described in item 3). By touching the texture, the system we call “EXAT" (an allusion to the name of origin) will capture through the Webcam the location of the finger of the student, identifying the texture and informing him the name of the texture (colour adjusted), thereby, the system will store in "EXAT" database these markings, generating the profile results at the end of the application of subtest. The student will be able to reveal the result of each test through a gestual marking of the reply that also will be interpreted by the system of computational vision.

However, for the accomplishment of automatized stage 3, a new stimulus board was formed; this board possess, as in the original subtest, all the stimulus congregated in it (the division in two boards was not necessary anymore), since the rectangles with the textures do not need to be big because they do not present the writing in Braille. So, the board had eight lines with five textured rectangles in each line. The textures continue being done using thermoform material (PVC film) and, below each texture, it was placed a colored rectangle there. Actually, the computer recognizes the colors when the child presses the rectangle and states the name of a conflicting texture.

Therefore, it is expected that with the automation of Expressive Attention subtest that the application time becomes faster, the intervention of the applicator happens only when really needed, the interaction with students take place simultaneously, and that the results are produced by the system at the end of the application, making the automated subtest as similar as possible compared to the original test.

Finally, it is believed that this technology becomes a tool that opens new horizons of research, contributing then to new tests adapted very closely to those applied to seeing people. We emphasize that the results produced by this system have not yet been concluded, as we reported earlier it is being finalized by the trainees of NCE/UFRJ with conclusion expected to be in August 2010.

3.4.1 Prototype

The EXAT software prototype, implemented based on the detailed information above, can bring truth to the subtest “Expressive Attention”, once it keeps the stimulus’ simultaneity.

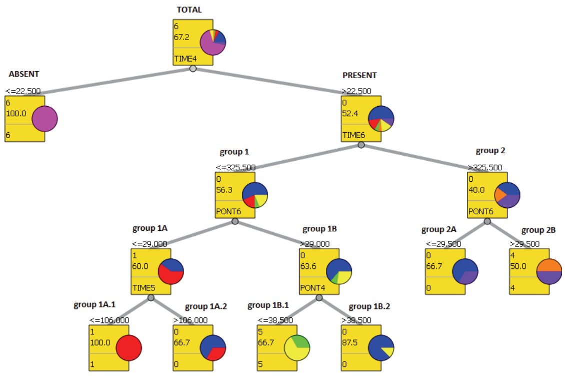
- The computer vision creates a new property for the thermoform: the sound. Therefore, it gives a label where there is none; translating it to an accessible language. By that, the trace of the child’s finger, through the webcam, allows it to use a spoken label for virtual objects.
- In order to begin receiving an explanation about the task, the child has to press a key. For him/her to listen to the explanation one more time, it’s possible to press the key as many times as needed. The EXAT sums up the number of times that the explanation was given and calculates the reaction time of the child (since the first explanation, until the test has begun).
- This software calculates the time transition from previous position to the current one (Δt). As per this data, the prognosis would be more objectively classified in order to be used as counterproof for previous prognosis that could not be reevaluated by the manual adaptation, since there are no records of it.

4 RESULTS

The analysis consisted in the grouping of the raw scores of items 4, 5, 5.1, 6 and 6.1, the times of those items and the forecasts produced by the researcher during the implementation phase of the subtest, with the help of statistical program Orange Canvas. Such predictions were categorized into the following levels: standard (0), lack of concentration (1), fatigue (2), difficulty in understanding (3), difficulty in identifying the textures (4), impatience (5), did not attend (6); which received numbers for statistical purposes.

By using the Orange Canvas program, it was verified that there was a correlation between the variables inherent of the subtest and the forecasts, where their veracity was checked. Through Classification Tree Graph tool, a diagram was drawn to the forecasts and their correlation with all the aforementioned variables. Of the 64 participants in the sample, 43 were grouped for not having conducted the test and 21 others who conducted the test were in a group that split into two subgroups: group 1 and group 2. It was found that from the 21 participants, 16 are in the same classification (group 1) in which there were 9 participant classified as standard, three classified as poor concentration, one classified as tiredness and three classified as impatience, all of them having time of item 4 $\geq$ 22.500 and time of item 6 $\leq$ 325 500. This first group is divided into two other subgroups: group 1A and group 1B. It was found that the group 1A had two classified as standard and three classified as poor concentration, all with scores of item 6 $\leq$ 29

000, time of item 4 ≥ 22.500 and time of item 6 ≤ 325 500. In group 1B there were seven classified as standard, one classified as fatigue and three classified as impatience, all with a score of item 6 ≥ 29 000, time of item 4 ≥ 22 500 and time of item 6 ≤ 325 500. Group 1A is divided into two other subgroups: group 1A.1 and 1A.2 group. In group 1A.1 there were two classified as lack of concentration with a score of ≤ 29 000 on item 6, time of item 4 ≥ 22 500, time of item 5 ≤ 106 000 and time of item 6 ≤ 325 500. In group 1A.2 there were two classified as standard and one classified as lack of concentration, all with scores of item 6 ≤ 29 000, time of item 4 ≥ 22 500, time of item 5 ≥ 106 000 and time of item 6 <= 325 500 . Returning to the group 1B, it was also divided into two subgroups: group 1B.1 and 1B.2. In group 1B.1 there was one classified as a lack of concentration and two classified as impatience, all with scores in item 4 ≤ 38 500, scores in item 6 ≥ 29 000, time of item 4 ≥ 22 500 and time of item 6 ≤ 325 500. In the group 1B.2 there were seven classified as standard and one classified as impatience with score in item 4 ≥ 4 38 500, score in item 6 ≥ 29 000, time of item 4 ≥ 22 500 and time of item 6 ≤ 325 500.



Legend of the prognostic
Blue = standard (0)
Red = lack of concentration (1)
Green = fatigue (2)
Purple = difficulty of understanding (3)
Orange = difficulty in identifying the textures (4)
Yellow = impatience (5)
Pink = not done the test (6)

Figure 2: Classification Tree Graph.

Of the 21 participants, 16 were from group 1 and the other five participants were from group 2, in which there were two participants classified as standard, one classified as difficulty in identifying the textures and two classified as difficulty of understanding. All these participants grouped with time of item 4 ≥ 22 500 and time of item 6 ≥ 325 500. The group 2 was also divided into two subgroups: group 2A and group 2B. In group 2A there were two classified as standard and one classified as difficulty of understanding, all with scores of item 6 ≤ 29 500, time of item 4 ≥ 22 500 and time of item 6 ≥ 325 500. In group 2B there was one classified as difficulty of identifying the textures and one classified as difficulty in understanding, all with a score of item 6 ≥ 29 500, time of item 4 ≥ 22 500 and time of item 6 ≥ 325 500.

5 DISCUSSION

- The standard prognosis was indicated by the applicator to the children who have not presented difficulty in understanding and performing the activity; and which had not clearly demonstrated any evidence of dispersal during the test application. These same children, in the analysis done by the Orange Canvas intelligence laboratory, were present in all subgroups, which means that the applicator was unable to set a correct prognosis of the standard attention.
- Lack of concentration was predicted to children who were easily dispersed with stimuli from the environment, such as sounds from the street or sounds made by other children. Children who wanted to talk with the applicator were also included in the prognosis of lack of concentration. In the analysis made by Orange, these children were, first, grouped in the same group (1A) and then divided into two subgroups by their score. But as they got close, the analysis done by the Orange confirms the prognosis made by the applicator.
- The fatigue was predicted to the children that were lying on the table during the implementation of subtest and yawned a lot. During application, there was only one child with this prognosis; therefore, the analysis made by the Orange can not be assessed for this outcome specifically. We suggest the application in a larger sample, so there might arise more prognostics in this category and maybe can be reassessed. However, prognosis fatigue and impatience were grouped together in Group 1B, which shows that these two types of prognosis can be evaluated as the same kind of lack of attention.
- The prognosis impatience was indicated by the applicator to children who kept asking to leave and to those who were watching the clock too much during application. Just like the prognosis of lack of concentration, the children with prognosis of impatience primarily stayed in the same group (1B)

and then subdivided into two other groups due to differences in scoring. Analysis of Orange confirms the prognosis made by the applicator.

- The difficulty of understanding was predicted to children who had difficulty in understanding what should be done during the activity. The Orange analysed these students as similar, placing them in the same group (2) which confirms the prognosis made by the applicator.
- The difficulty in identifying the textures was predicted to children who were confused to differentiate the textures, changing one by another, or confusing their names. Like fatigue, there was only one child classified with this prognosis, which complicates our assessment of Orange analysis in this specific prognosis. However, it can be observed that children who obtained the prognosis of difficulty of understanding and difficulty of identifying the textures were grouped together in Group 2B with a high score. This indicates that the difficulties which the applicator predicted, in fact, appeared as an increased attention on these students in perform the activity, achieving a higher score. This finding originated from the analysis of the computational intelligence of the system had a great relevance for the experiment. An interesting aspect of the analysis'result is that, not only it confirms the classification of the profiles, but also the computational intelligence has indicated a new interpretation for the profiles of difficulty of understanding and difficulty on identifying textures; what was originally indicated as an understanding problem, later was disclosed (by the analysis) as a peculiar process of learning which has shown good results from the participants.

The prognosis of lack of concentration, fatigue and impatience were separated from the prognosis of difficulty of understanding and difficulty of identifying the textures, leaving the first ones with a lower score; this corroborates the hypothesis presented here that the difficulties of understanding and identification texture caused an increase in the attention of these students.

Therefore, the intelligence laboratory Orange Canvas proves to be an important tool to help define the profiles of the attention of visually impaired children by grouping the data obtained in the responses of children in the subtest, and by the prognosis inferred by the applicator. This success in defining profiles of attention by the Orange suggests that adaptation automated which we are doing may contain in itself this statistical analysis, with no need to pass the data obtained during application to another software.

6 CONCLUSIONS

The cognition of the visually impaired, although not being an area very studied in scientific research in Brazil has proved to be a promising area. Thus, from results obtained with the analysis of the intelligence laboratory Orange Canvas Expressive Attention and the automation of the Expressive Attention subtest, it is concluded that computer technology can bring many benefits in research on these studies. The speed and convenience that this technology can offer us in gathering and processing the data means that it may become a very useful tool for conducting such activities. Moreover, contribution of information technology for the present study may facilitate other works, for example, the development of new pedagogical techniques made specifically for the cognition of blind children.

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