Attentional Capacity in Children: Intervention Programs for Its Development

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The goal of this chapter is to offer a brief conceptual overview on the complex attentional mechanism and to present one of the psychoeducational intervention programs developed by the team conducting research on children's developmental psychology at the INCIHUSA-CONICET and the School of Psychology at Aconcagua University. All the intervention programs implemented by this team were designed with the purpose of optimizing and strengthening attentional resources and cognitive control processes in school children of the province of Mendoza.

The Attentional Mechanism: A Brief Conceptual Overview

Although at present there is no unified theory of children's attention, several authors agree to define it as a control mechanism which is responsible for the hierarchical organization of the processes involved in the development of information [1–3].

Posner [4] identifies three functional components of attention, namely alerting, orienting and, executive attentions. They are supported by separate neuroanatomical networks: the posterior attention network, the anterior attention network and the vigilance network [5, 6].

The vigilance or alerting network is the most basic element of attention, and it implies the arousal level of an organism. It allows the activation level needed to carry out any action, for stimulus receptivity and for response preparation, that is, for the attentional tone. In addition, it is the necessary prerequisite for cognitive functioning. The anatomical structures involved are the locus coeruleus, the right area of the frontal and parietal lobe and the cortex, and the neurotransmitter involved is noradrenaline [2, 4, 7].

The posterior attention network is responsible for the orientation and localization of visuo-spatial stimuli. It is involved in the visuo-perceptual and visuo-spatial recognition of objects (what and where they are) and in the execution of visuo-motor tasks. The anatomical structures associated with this network are the superior parietal lobe, the temporal-parietal junction, the superior colliculus, and frontal eye fields. Acetylcholine is the main neurotransmitter [2, 4, 8, 9].

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Finally, the anterior attentional network is associated with executive attention, the attentional control responsible for resolving conflicts between thoughts and feelings before producing a response. Volitional control, referred to by Norman and Shallice [10] as the supervisory attentional system (SAS), intervenes in this network to appropriately deal with various situations. The anatomical structures operating in this network are the lateral ventral prefrontal cortex, the basal ganglia and the anterior cingulate cortex (connected with structures involved in emotional processing) and the neurotransmitter involved is dopamine [2, 4]. The SAS becomes activated to face new tasks for which no solution is known, and therefore, it requires planning, making decisions, and inhibiting automatic responses [11].

Posner [4] suggested that SAS is involved in error detection. A behavioral indicator of error detection and correction is the reaction time after committing an error.

It could be said that the function of executive attention is deciding to which stimuli to direct perceptual resources. It intervenes, also establishing the activation or inhibition order of the processes which develop and organize information in accordance with the situational requirement. This function is closely related to the motivational and autoregulatory mechanisms [1, 3, 11, 12].

The development of attention is considered to be essential for the functioning of other cognitive processes. It is also an indicator which enables prediction of cognitive levels in childhood. It represents the gateway to the possibility of triggering a series of cognitive functions. It may be mentioned in this way memorization and retrieval of contents, the ability to plan, organize and monitor an action to check its adjustment to the task by inhibiting inappropriate and dominant responses. It intervenes also in the cognitive flexibility required to correct mistakes or generate new behaviors in response to contextual demands, and the completion of the action once the objectives have been accomplished, and in the evaluation of results [2, 9, 11, 13–16]. These cognitive functions are also referred to as executive functions or cognitive control functions, and they allow individuals to self-direct their behavior to achieve specific goals. Therefore, attention plays a key role in children's school performance because it participates in the selection of relevant information. Its role is also relevant in the maintenance of that information, allowing for the manipulation of mental representations by modulating the responses to the various stimuli [17]. A higher attentional capacity has been found to be associated to a better execution of tasks which involve cognitive control, both in children and adults [18–20].

Children's attention development is a gradual, developmental process which has been proved to become more organized, flexible, and independent from context over time [2, 21, 22].

The main contexts for child development, namely family and school, need to promote the continuous development of cognitive, emotional, and social competencies. They may enable the child to gradually strengthen and use the following functions: (1) attention control; (2) maintenance and manipulation of information to behave in accordance with that information; (3) regulate one's own behavior to act in a reflexive manner; (4) establish courses of action involving a certain degree of planning, organization, and monitoring of such actions; (5) identify a problematic situation and find possible solutions anticipating likely outcomes of the action; and (f6 decision-making.

School children need to use a higher or lower level of attentional control, which constitutes a fundamental requirement for cognitive functioning. The level of attention control depends on the interrelation between neuropsychological patterns, socio-psychological factors, and external physical conditions. They interact together and may enhance or hinder cognitive functioning.

In summary, attention plays a key role in children's school performance because it participates in the selection, integration, and understanding of a broad amount of information [23]. It is understood as an active, constructive mechanism, whose capacity may be modified through continued practice. Indeed, each subject may generate his or her own attentional potential, which depends on the interaction of cognitive, conative, and affective factors [24].

This demonstrates the relevance of additional research showing the effectiveness of different intervention strategies aiming to boost the functioning of different socio-cognitive-affective processes that have not yet achieved, for various reasons, an adequate level of development for a certain maturation stage.

Can Attentional Capacity Be Enhanced?

Various studies have shown that different types of intervention were effective when it came to improving performance levels in tasks requiring cognitive control in preschool children [25, 26] and school children [13, 27–30] living in socially vulnerable conditions.

Research conducted in cognitive neuroscience reveals that differences existing in the neural structures and circuits are related to differences in the development of cognitive and socio-emotional skills, which would lend support to initiatives aiming to provide targeted educational interventions [31].

All the programs that have proved to be effective involve stimulating attentional control, creativity, cognitive flexibility, self control, and discipline by means of repeated practice activities that present gradually, increasing levels of challenge for their resolution. Therefore, it may be advisable to use both programs stimulating cognitive control functions and programs promoting social and emotional development [27]. In that way, children with a poorer cognitive control performance could draw greater benefit from these activities, and the gap existing between them and those children showing a better cognitive performance can be narrowed. This is the basis for psycho-educational intervention programs.

Our research team has conducted several studies on the efficacy of various intervention programs targeted to school children raised in socially vulnerable families in the province of Mendoza, Argentina, by evaluating their social skills and cognitive control processes [13, 29, 30, 32, 33].

The first study included the participation of school children 7–8 years of age who were affected by attentional impairment in a computer-based intervention program, and revealed significant improvement in their sustained attention as compared with the control group [34]. A later study showed that sustained attention, working memory, and alternative thinking attained improved retrieval at earlier ages when the computer-based intervention program was used in combination with a program aimed at strengthening children's cognitive skills to solve interpersonal problems [13, 30].

This section will describe one of the programs used to stimulate and optimize school children's attentional control capacity.

Computer-Based Program to Optimize Children's Attention

For research conducted between 2004 and 2010, a computer program was used to improve focused and sustained attention in children previously identified as having lower attentional efficacy [35].

Attentional efficacy is defined as the child's ability to accurately discriminate among stimuli that are identical to a cue, among a group of similar stimuli, during a certain period of time. When it comes to performing a task involving the visual search for a key stimulus, apart from the ability to select the stimulus correctly, it is necessary to sustain the focus on that stimulus for the appropriate execution of the task. Then it should follow that attentional selectivity and sustenance operate simultaneously [9]. Reduced attentional efficacy can thus be defined as a reduced ability to effectively focus and sustain attention during the period required by the assigned task, with respect to what is expected for the child's developmental age.

The results of a study conducted in 2010 are summarized below (see Ison [29] for further information).

A group of 138 school children (22.8 %) with low attentional efficacy (67 boys and 71 girls), between the ages of 7 and 12 years (9.25 ± 1.52) were identified. Two groups were then formed: (1) a study group composed of 72 school children (34 boys and 38 girls), and (2) a control group,

formed from 66 school children (33 boys and 33 girls). The children were randomly assigned to each group by means of the following procedure: once the children with low attentional efficiency were identified, they were assigned a number which was written on a piece of paper; the paper was folded in four and placed in a box. The pieces of paper were then drawn one by one to form the study group and the control group. The same procedure was used in each of the school grades.

According to the postintervention results obtained through the Analysis of Univariate Variance (ANOVA) procedure, in the younger group (7–9 years of age) the effect of the gender variable was not significant ($F(1, 75)=1.50, p<0.224$); however, significant differences in attentional efficacy were found between the study group and the control group. The attentional efficacy of the study group was significantly higher than that observed in the control group ($F(1, 75)=9.61, p<0.003$). Similarly, in the older group (10–12 years of age), the gender variable did not have a significant effect ($F(1, 63)=0.08, p<0.777$). The results of the test showed a significant improvement of attentional performance in the study group in comparison with the control group ($F(1, 63)=7.59, p<0.008$).

The intervention program used was the Computer-Based Attention Test for Children designed to stimulate focused and sustained attention in children [35]. This test was developed at INCIHUSA-CONICET and was used during the research studies carried out between 2002 and 2010 [13, 29].

More recently, between 2012 and 2013, an updated version of the 2003 test was developed.

Brief Description of the Program

The program consists of three tests aimed at stimulating focused and sustained attention through visual search tasks. In addition, each test includes training sessions geared for helping children to understand instructions correctly and to become familiar with the program. At this stage, the expert can guide the child and explain to him or her everything that is required to complete the second phase, which is the training itself. During the training sessions, the expert explains the instructions of the task to the child and shows him or her what the task consists of on the computer screen. Then, the child is given time to practice until the expert can verify that the instructions have been completely understood. Following that, the child completes the task on his or her own.

Each test presents three levels of difficulty (low, medium, and high) and different numbers of stimuli for the child to work with, it also offers the chance to save that information and the reaction and total times. In relation to the latter, the expert may allot a certain time to each task. All these variables can be selected by the expert, who sets the test configuration for each particular case.

Examples of Test 1

The cue is presented on the left and random identical, similar, or different stimuli appear on the right. If the stimulus appearing on the right coincides with the cue, the child will click "sí" (yes) and immediately hear a sound every time the choice is correct followed by the "muy bien" (very good) phrase said by a bird. Then a new figure will appear (See Fig. 18.1a).

If that new figure is different from the cue, the child will click "no", and the sequence described above will ensue.

If the child makes the wrong choice, a different sound will signal the mistake and the bird will say "presta más atención" (pay more attention) (See Fig. 18.1b).

Examples of Test 2

This task consists of searching and selecting the stimulus that is identical to the cue which, in this case, appears as "buscado" (wanted). It presents two categories of stimuli: (1) a farm with animals, and (2) a city with cars.

The task consists of looking for similarities and identifying differences within a broad and varied stimulus field. The screen shows a farm with different animals among which one is the key stimulus. The child needs to click on the animal that is identical to the "buscado" (wanted) cue. A green tick will appear on the animal when the choice is correct, followed by the corresponding sound, and the bird will say "muy bien" (very good) (See Fig. 18.2a).

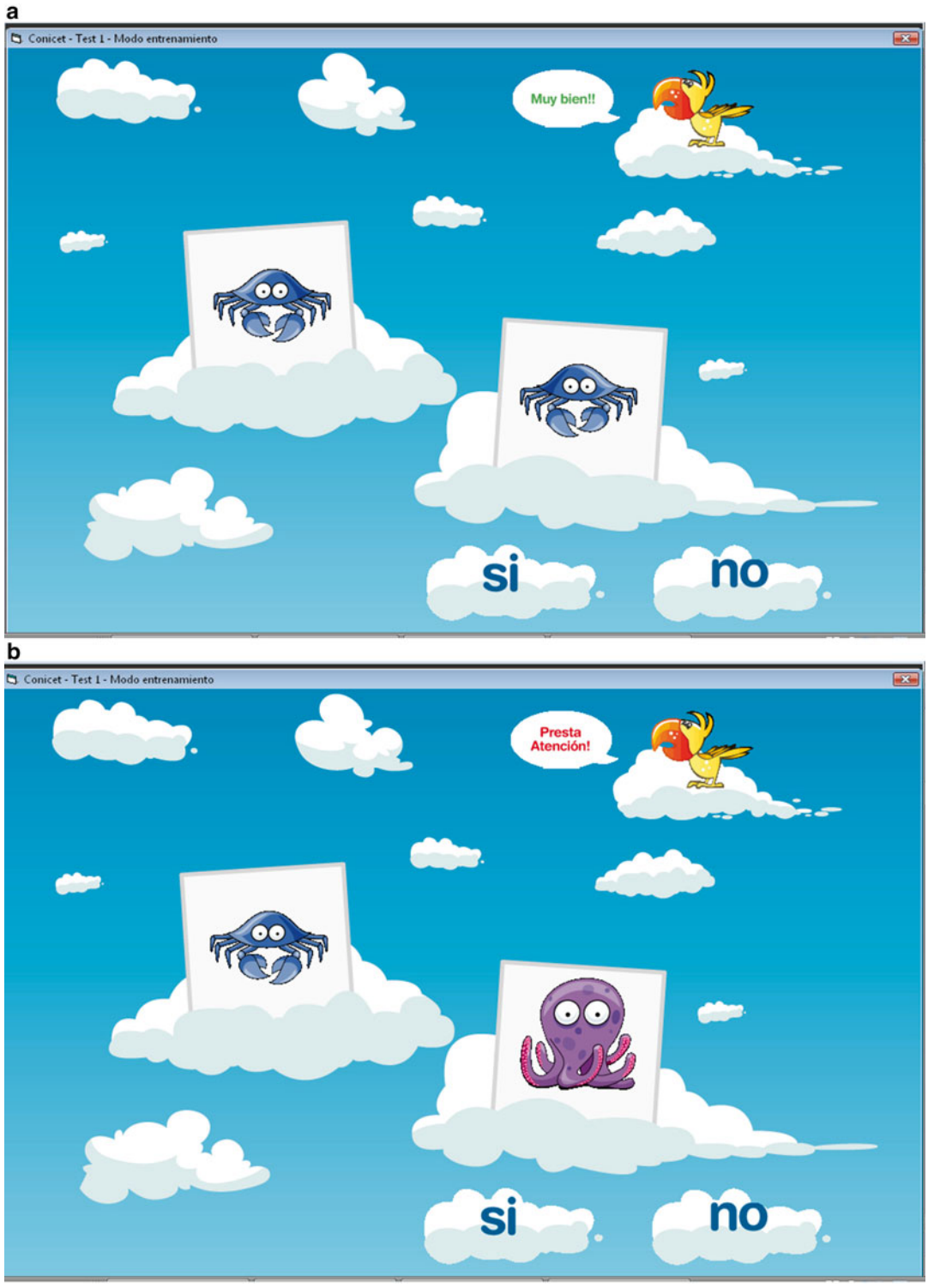

Fig. 18.1 (**a**) Attentional focus test when the correct stimulus has been chosen. (**b**) Attentional focus test when the incorrect stimulus has been chosen

Fig. 18.2 (**a**) Focused and sustained attention test, right choice. (**b**) Focused and sustained attention test, wrong choice

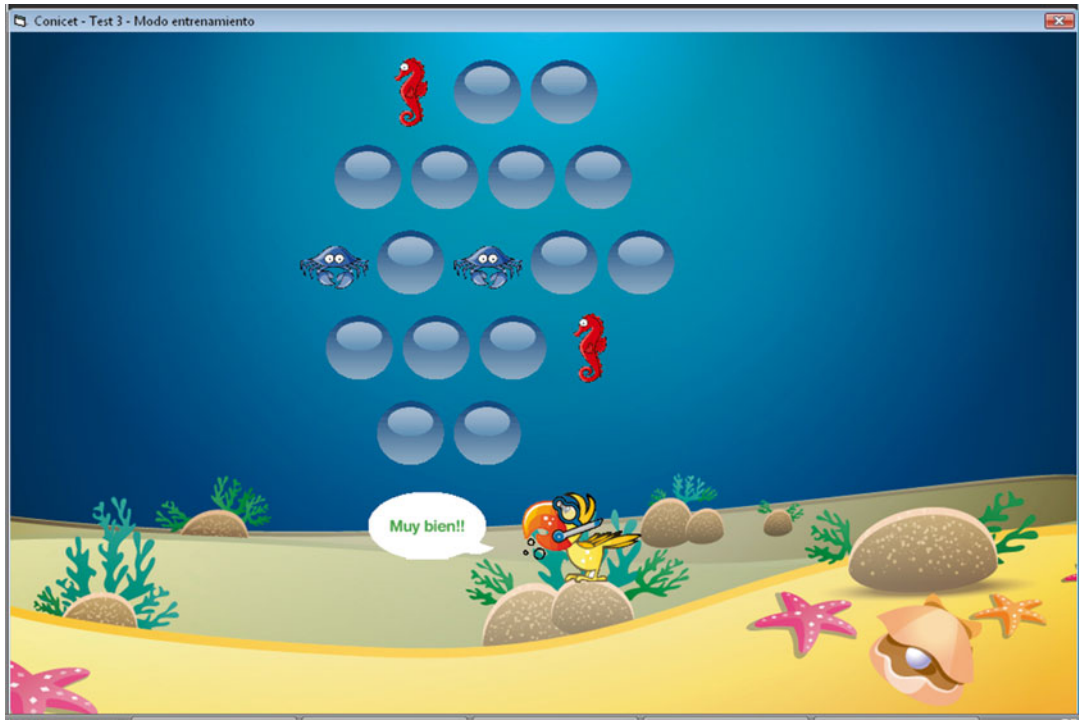

Fig. 18.3 Sustained attention and working memory test

If the child happens to select the wrong animal, a red cross will appear on the animal, followed by a sound that will indicate that the choice was incorrect, and the bird will say "presta atención" (pay attention) (See Fig. 18.2b).

Examples of Test 3

This test is based on the "memo test" game logic. A series of bubbles appear, and when children click on them, a stimulus pops up, sea animals in this particular case. And the task consists of finding the pair for each animal. If the correct pairs are found, the bird will say "muy bien" (very good), or else "presta atención" (pay attention). This is the most complex test because the child needs to remember where a certain stimulus is in order to find the corresponding pair, a task that requires not only concentration but also working memory. When both stimuli are matched, they will remain on display on the screen as the child looks for the other animal pairs (See Fig. 18.3).

For all tests, the program keeps record of the right and wrong choices and the omissions, as well as of the total time used to complete the task. It also keeps a record of the stimuli to which the child was exposed, the number of correct and wrong choices and omissions—stated in raw scores and percentages—and the total time needed for the completion of the task. Finally, a graph showing the performance of each child appears on the right. It shows the results of the tests (See Fig. 18.4).

Conclusions

Starting school poses new challenges for children, which involve developing a series of cognitive, emotional and social skills.

In order to adapt to the school context and achieve learning goals, school children need to deal with conflicts and organize their behavior

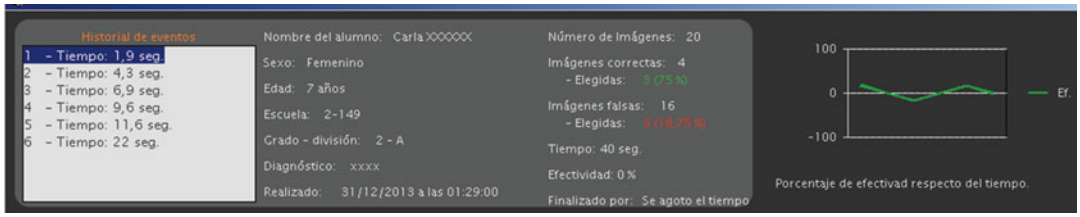

Fig. 18.4 Individual information record. The program records the child's personal data, in addition to information about the school, diagnosis, and date

according to working goals, plans, and rules. During the first years of school, children will only be able to achieve these goals under the teachers' guidance. However, they will gradually internalize cognitive strategies, routines, and habits that will enable them to gain autonomy when managing behavior and learning. In other words, they will need to begin to control their own behavior to better respond to contextual demands.

In this regard, attentional control has been found to be an important component of self-regulation [2].

The results obtained by our team show that intervention programs have greater effectiveness if applied to small groups of school children, and greater recovery of attention is achieved if stimulation starts at earlier ages. Additionally, greater effectiveness is attained if such programs are implemented systematically and sustained over time, with greater probabilities for them to help all children to develop cognitive and socioaffective skills that may enhance their educational opportunities.

If we consider executive attention to be a system involved in the voluntary control of actions, the benefits of attentional training could also extend to the cognitive and emotional regulation manifested in children's behavior [2, 27, 36].

Finally, the intervention program presented in this chapter finds its rationale in the interplay of the school child, the classroom context, and the child's family. Therefore, in addition to providing specific tools to effectively interact with children, the joint effort of parents and teachers promotes greater commitment to, and cooperation with, the teaching–learning process.

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