An Abstract of Thesis for Ph.D at

BABES-BOLYAI University

An Intervention Program for Improving Writing and Information Retrieval among Students with Ambidexterity

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May 2016

Content

Abstract

This thesis deals with 1% of the population who is defined as ambidextrous ("mixed handed") and are often not evaluated professionally. They are characterized by low writing pace and slow information retrieval as well as slow sequence memorizing. Their slow functioning relatively to the norm creates an increasing gap in their academic achievements. Identifying the source of the problem is usually not identified, appropriate and focused intervention is not given and thus the problem that should help them deal with their difficulties.

This study refers to a unique intervention program called ATP (ambidexterity training program), which was developed by the researcher in order to enable the improvement of basic required skills in students with ambidexterity. The intervention program included **drawing**, meant to strengthen the middle-line crossing, **writing** sequences of the Hebrew alphabet (for older students also English alphabet) and number sequences in order to improve the verbal fluency, and **copying** a paragraph (30 words) in order to improve writing pace. The current study examined the effect of the ATP on 30 students with ambidexterity (7-16) from three diffrent schools who had been characterize with these slow skills through routine training twice a week during 34 meetings. Additionally, it was examined the effects on perception, cognitive impact, motor abilities and behavior among these learning disabilities participants.

The findings showed that there was significant improvement among all participants in writing pace and verbal fluency skills, whereas in most of them there was improvement only in naming skill and information retrieval. Because the naming skill and the information retrieval skill involved deep processing, it was required longer training. Additionally, it was established effects on participant's perception, cognitive impact, motor abilities and behavior.

This study raised awareness of the importance of accurate dominance identifying among pedagogical evaluators, occupational therapists and psychologists**.** Moreover, raising professional's awareness that learning disabilities in general and ambidexterity specifically are not chronicle diseases but a result of a "different brain" which functions relatively slowly in certain domains and requires strengthening weak skills through more practice that should change brain connections and working memory.

Introduction

Ambidexterity is addressed as an innate phenomenon (Mori, Iteya & Gabbard, 2006) which reflects imbalance in synchronization between brain hemispheres (Yancoseck, 2010). An ambidextrous person is someone who is able to use his or her right and left hands equally well, especially in the case of tasks that require fine manipulation or detail (Rodriguez, 2010). Studies show that ambidexterity is a "warning sign" for potential brain damage and tendency towards learning disabilities and organizational problems.

The concept of handedness comes from the observation that most humans exhibit a preference for one hand over the other, with 90% of the population showing a rightward preference (Corballis, 2003). Evidence supports this “hand-specialization hypothesis” as one of the possible origins of handedness. Children with inconsistent hand preference show inferior coordination compared to those of the same age with a definite handedness (Mori, Iteya & Gabbard, 2006). It has also been observed that these differences may persist until adulthood.

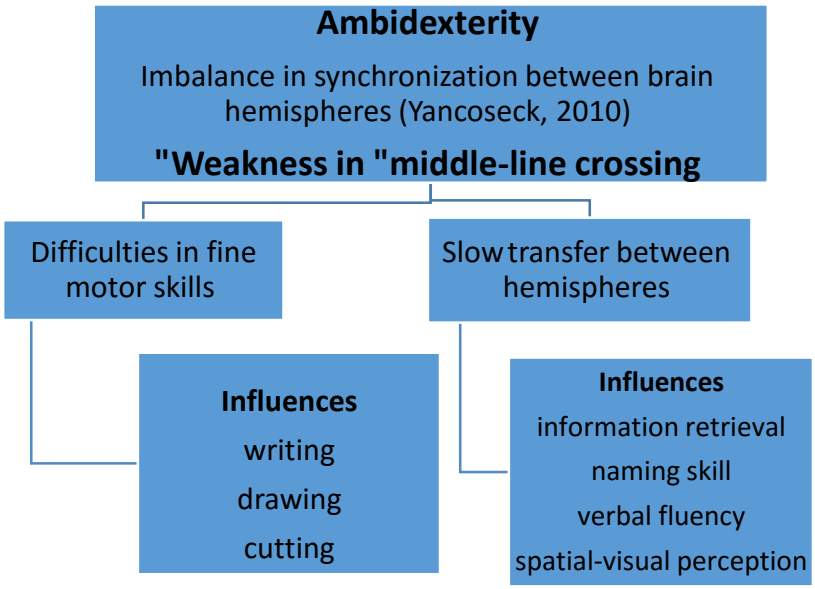
Moreover, it has been found that information transfer is done more efficiently among dexterous children. Recent evidence presents a link between mixed handedness and more efficient inter hemispheric communication when compared to either right- or left-handedness (Davidson & Tremblay, 2013). In addition, the examination of the hemispheric differences found a significant correlation between neurophysiology and handedness. Meaning, the maturity of dominant hemisphere is connected to effective electric transfer between the hemispheres which supports normal learning activities.

Research depicts aspects of handedness as a proxy for how the brain functions, yet it is not a perfect measurement. It is possible that ambidextrous people have an atypical brain lateralization, and that the brain circuitry and function is likely to differ from the normal pattern seen in right-handed individuals (Rodriguez, 2010).

One of the characteristics of learning disabilities is a weakness in "middle-line crossing". It is well known that the human brain acts in cross checking that expresses the integration between the hemispheres in the brain. This cross checking process evolves until age 4-4.5 through flipping, creeping, sitting and walking. The cooperation between the two sides of the body is necessary for completing physical

activities. Thus, it depicts aspects of handedness as a proxy for how the brain functions (Rodriguez, 2010). The ambidexterity phenomenon is defined as brain asymmetry that reflects imbalance in synchronization between brain hemispheres (Yancoseck, 2010) and results in learning disabilities. The main cause of learning disabilities among the ambidextrous is weakness in "middle-line crossing". Therefore, the required intervention program should include activities that improve the cooperation between the hemispheres.

Diagram no. 1: The impact of "middle-line crossing" weakness on ambidexterity



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Rational

This study investigates a unique intervention program called A.T.P (Ambidexterity Training Program), which was developed by the researcher in order to enable the improvement of basic required skills in students with ambidexterity. The intervention program included drawing, meant to strengthen the middle-line crossing; writing sequences of the Hebrew alphabet (and for older students also English alphabet) and number sequences in order to improve the verbal fluency; and copying a paragraph (30 words) in order to improve the writing pace. The study examined the effect of A.T.P on students with ambidexterity (ages 7-16) who had been characterized with these slow skills, through routine training twice a week in 34 meetings. It established effects on perception, cognitive impact, motor abilities and behavior among the learning disabled (LD) participants.

During my work as a Didactic Evaluator and a therapist for the past decade, I came across the phenomenon of ambidexterity (or mixed handedness) which indicated imbalance in synchronization between brain hemispheres (Yancoseck, 2010).

Ambidexterity causes slow writing pace, a gap between oral and written expression and lower spatial-visual perception (Rodriguez, 2010). Further, the capability to cope with skills that requires automation (like the alphabet or multiplication table), the ability to solve mathematical problems, speech fluency and difficulty in sequence memorizing are inferior among members of this population. However, the assumption was that professional intervention could improve these skills.

The researcher's personal interest in this topic began after studying a certain Cards-Test which checked hand dominance and speed. The test revealed ambidexterity, a phenomenon that was quite common in the family, as one of the researcher's children as well as father suffered from stuttering, which later turned out to be related to ambidexterity. Another child suffered from slow writing pace and information retrieval difficulty.

Additionally, the researcher's personal and professional connection to this research include an M.Ed. in Linguistic Education in a multi-cultural society; a B.Ed.in Special Education, Grammar and Literature; a didactic evaluator certification; and experience in teaching high school population at risk. The researcher runs a private clinic for learning disability diagnosis and emotional treatment.

These experiences served as motivation to further study this subject, since according to personal experience ambidexterity was diagnosed by observation, and many children who had not been diagnosed by professional therapists might be harmed. In other words, if the source of their difficulties is ambidexterity and it will not be discovered, it will be impossible to give them suitable treatment. This fact supports the common practice among therapists in which they particularly examine the child's relatives and provide the child with specific skills which can help with school requirements, for example writing and cutting.

Since it is such a central issue, and since the source of the problem is usually not identified, the focused intervention is often not suitable. Thus, the problem remains and there is not significant improvement. These conclusions have convinced

the researcher of the necessity of accurately identifying ambidextrous population, in order to create a suitable intervention program that would minimize the gap in their academic achievements.

This study can contribute to the field by raising professionals' awareness for L.D in general and students with ambidexterity in particular. This information led professionals to understand that low pace writing is not a chronic disease, and that our brain flexibility\plasticity may be improved through routine training. Training may therefore prevent a permanent writing disability, as written expression is an essential linguistic skill which enables data processing in one's brain and should therefore be developed.

An additional problem is that therapists who meet young children (4-9 years old) tend to focus on the dominant hand choice and on the frequent tasks in school. Nevertheless, according to researcher's experience, adults reported about their difficulties in later age, and there is no reference to the source of their problems. Furthermore, therapists are not aware of the implication of ambidexterity in academic functions.

Therapists must know the potential repercussions of training activity, since contemporary pedagogy talks about the flexible brain and about the significance of training. In this context, it is recommended to integrate the approaches - as there is convincing evidence that ambidexterity often shows anomalies of cerebral localization - and to raise awareness to the influence of each intervention program.

This would serve not only as an antiquarian interest, because outside the West, most societies and cultures continue to practice forced retraining of left-handers and children with ambidexterity. As the experiences recounted in these pages suggest, such practices are not only discriminatory, but they may also have deleterious consequences on the physical and emotional development of the students with ambidexterity, who constitute 1% of the world's population.

This evidence relates to my argument that finding the source of the problem in childhood (or earlier age) will prevent mental health problems in adolescence. That is to say, using additional diagnostic tools is necessary because in many cases the diagnostic questionnaire does not clearly expose the ambidexterity phenomenon, and

children might be trapped in a subsequent regressive vicious cycle in their school behavior.

Gap in knowledge

It is important to emphasize that the gap in knowledge is manifested in the following domains: a) Assessment tools – there is a low correlation between the outcomes of Oldfield Questionnaire, MacManus test and the Card Test (Galifret-Zazzo, 1965); b) In many incidents the questionnaire does not show what the dominant hand is despite its dominance in various activities; c) The findings do not report a connection between ambidexterity and difficulties in information retrieval.

Research Aims

This research shows the connection between ambidexterity and slow writing speed, slow oral fluency, slow speech, low automation and naming ability, which also result in inferior written expression ability.

Additionally, it raises awareness among the professionals of the fact that the writing hand is not necessarily the dominant hand in other activities.

- Finding the source of learning difficulties which will later enable designing a therapeutic program.
- Improvement of the inferior skills by routine practice
- Prevention of a permanent writing disability, as written expression is an essential linguistic skill which enables data processing in one's brain and should therefore be developed.
- Preventing emotional difficulties which accompany learning disabilities and turning helpless learners into active and capable ones.
- Bridging the gap between the theoretical knowledge about this problem and the practical ways of dealing with it.
- Providing findings which may help teachers and health professionals to identify children who are particularly at risk of developing certain problems.

Research Questions:

1. Is there a connection between ambidexterity and retrieval difficulties**?**
2. Will the intervention program improve writing pace, verbal fluency, naming skill and information retrieval?
3. Will the intervention program change student's perception, cognitive impact, behavior and motor abilities?

Key Concepts: Ambidexterity, Writing skill, Information Retrieval, Brain plasticity, Training.

Chapter I- **Old and new theories regarding Ambidexterity**

The theory of an ambidexterity shows that ambidexterity can be a "warning sign" for potential brain damage and a tendency for learning disabilities and organizational problems. It was first defined by the psychiatrist and neurologist Dr. Samuel Orton (1879-1948), who noticed frequent reading and writing difficulties among ambidextrous people. Orton coined the terms which refer to preliminary symptoms: difficulty in identifying spoken words, delayed and unclear speech, and motor writing difficulties. Orton observed reading and writing disorders in ambidextrous and found that most of them had a tendency to reverse letters and transpose their order, which he named the “Strephosymbolia” condition (Rodriguez, 2010).

Research has shown that an ambidextrous person is someone who is able to use his or her right and left hands equally well, especially with regard to tasks that require fine manipulation or detail (Rodriguez, 2010). That is to say that these people are mixed-handed or are able to distribute their actions between both hands in order to carry out various activities such as hand writing, throwing a ball or opening a can. Nevertheless, there are people who have the tendency for a dominant hand, who were trained to write with the other.

1.1 Traditional approach to Ambidexterity

In ancient times, a person was said to be "naturally" right handed or left handed or occasionally ambidextrous (Pronko & Bowles, 2013). The hand dominance was considered to be set biographically – following the parental tendencies. Through the years handedness tendencies were such that hand dominance was considered hereditary. Specialists in this field have noticed the difficulty of explaining "stubborn" or "fixed" left handedness in any other way (Domellöf, & Rönnqvist, 2011).

One theory about the earliest human communities claims that before a child could contribute by, for example, hunting, he had to master the manufacturing of tools and their accurate use to catch prey (Lillehammer, 2010). If there is no tendency towards single-handedness, then both hands must acquire these skills. It was assumed that it takes longer for both hands to learn coordinated and skillful tasks to the same level of expertise as only one hand. The ambidextrous child would theoretically take

longer to develop the same coordination milestones as their left and right-handed counterparts. If ambidexterity was prevalent it would, therefore, lead to a greater period of dependence for young humans and subsequently place a greater burden on the population. Single handedness would therefore reduce the period of dependence of human children, who would then be able to contribute to the community at a much earlier age.

Furthermore, if an individual is truly ambidextrous, in the face of an emergency or danger he must perform a complicated calculation of which limb to use to defend himself, to avert danger or escape. The ambidextrous must therefore essentially calculate which arm to use, as they are located differently in space (Pronko & Bowles, 2013).

Since the ambidextrous uses both limbs equally from birth, neither arm would acquire the same skill level or strength as a single predominating hand. Hence the ambidextrous would be a less effective hunter than the undexterous. Evidence shows that adaptations occur when the dominant hand functions more efficiently and therefore has greater durability. This does not occur if there is no preferential use of one hand (Lillehammer, 2010).

The belief is certainly wide-spread that handedness is a fixed and definite trait. Traditionally, being left handed has been seen as a problem, and a number of books have been written to assist parents and teachers of children who are left handed (Geoffrey et al., 2012). Furthermore, many have the impression that training imposes an artificial or unnatural dominance on "natural" left handedness. The common viewpoint is that many naturally left-handed people become right- handed for some activities through the training they receive.

The old ideas of "persuading" all children to use their right hands to write, even restraining and punishing them to assure compliance, has been left in the past, but more discrete techniques, such as demonstrating with the right hand and taking the pen or pencil from the child's left hand demonstrating again, and then returning the instrument to the child's right hand, persist with very serious consequences for the child's health (Geoffrey et al., 2012).

I.2 Contemporary Approach to Ambidexterity

Over the past forty years, scientific researches has found that being right handed and being left handed both mean that one has a lateralized brain, and that the

only difference between those with a right hand preference and a left hand preference is the specialisms that each hemisphere display (Uzoigwe, 2013). On the other hand, those who are mixed handed and who have no strong hand preference have a symmetrical brain that operates in a completely different manner. Research has shown this can cause mixed handers to consistently underperform. Since 2008, primary school teachers have recognized that approximately 25% of children arrive at school unaware of whether they are right or left handed, and as teachers have never been trained to resolve this issue, difficulties have arisen in basic skills such as scribbling, coloring, tracing, drawing and writing. The children are, however, even at the age of 4, skilled in keyboarding and the use of mobile phones (Uzoigwe, 2013).

In extant literature handedness remains an enigmatic phenomenon (Uzoigwe, 2013). There is no definitive explanation as to why mankind should have single rather than dual handedness. Intuitively it would seem advantageous in almost every context to have the benefit of equally dexterous hands. Either in warfare or in hunting, using two hands equally effectively would appear to be a favorable adaptation over single dexterity. No satisfactory explanation has been offered as to why and how singlehandedness evolved.

The right handed individual, however, reaches for the spear by his right hand and uses his left hand to help stand. There are still cognitive processes but they are less protracted. Hence in the undexterous individual, the use of the dominant hand can become a reflex which obviates the need for the delay engendered by executive cognitive evaluation of a situation (Domellöf et al., 2011).

In contemporary society this cognitive delay may manifest itself as a higher accident rate amongst mixed handed or ambidextrous individuals. There is strong evidence to suggest that those who display mixed-handedness suffer from more accidents in every environment examined including the home, playing sport and on the road (Domellöf et al., 2011). Mixed-handed people were observed to be over 6 times more likely to suffer from accidents which required medical care, compared to their dextral counterparts. Interestingly, it was found that only mixed handedness predicted accident frequency – footedness, ear dominance and eye dominance did not (Coren, 1981). Re-analysis of these studies was performed, dichotomizing participants into one of three categories of handedness: left, right or mixed/ambidextrous. The ambidextrous were found to suffer the most from accidents, compared to the single handed (Domellöf et al., 2011).

Hemispheric asymmetry

Hemispheric asymmetry indicates the existence of developmental influences that affect one hemisphere more than the other (Boleset al., 2008). Recent evidence shows that asymmetry may exist because of a relationship between a mental process' degree of lateralization and how well it functions.

Following the extensive research on hemispheric involvement in language processing, this chapter discusses the relationship between hemispheres. It has well been established in research that the right hemisphere is responsible for the creative facets of language, and new language connections that are necessary for understanding new expressions. However, the left hemisphere has been shown to be responsible for the organization knowledge, the specialized system and language processing. However, only in the language domain importance of an efficient relationship between a non-specialized system and creative processing has been found (Faust, 2012).

This process occurs in the corpus callosum, which performs as an intercom between the hemispheres and allows (for most of the population) the existence of a dialogue between them (Kenett, Anaki & Faust, 2015). According to the theory of Takeuchi et al. (2011), there is a positive relationship and efficient integration of information between white matter pathways and creativity ability. At the same time, according to Fink et al. (2014), there is a positive relationship between gray matter density in right hemisphere parietal and occipital brain regions and various facets of verbal creativity ability.

It has been found that when a person has to cope with understanding a concept combination that he never met, he has to activate his creative thinking with areas in the right brain that are local against the active language areas in the left side around a field called "Upper Back Temporal Bend". Nevertheless, this activity occurred in several fields in the brain and the web activity and its structure is changed (Kenett, Anaki & Faust, 2015). In other words, the language activity is not limited to one field in the brain, but includes two fields in the cerebral cortex: Broca's area, responsible for speech production, and varenica area, responsible for speaking and writing language understanding (Aziz-Zadeh et al., 2013). Therefore, collaboration between

expert specialized and non-expert non-specialized neural networks supported efficient creative problem solving and creative language processing (Kenett, Anaki & Faust, 2015).

According to recent evidence, the relationship between handedness and hemispheric lateralization couples to functionally lateralized parts of the visual cortex and shows a cerebral lateralization and handedness (Willems et al., 2010). Meaning, the left-hemisphere dominance for language is a main example of the functional specialization of the cerebral hemispheres. Furthermore, the degree of left-hemisphere dominance for language depends on hand preference. Nevertheless, the hemispheric specialization is not fixed, and varies considerably across individuals, even in areas engaged relatively early in the visual system (Willems et al., 2007).

The individual differences present in the relationships between the hemispheres are a result of maturation of the corpus or of developmental limits encountered at different ages of childhood (Boles et al., 2008).

The discussion of lateral asymmetry shows that good readers show greater right over left field superiority than poor readers (Marcel et al., 1974). The possible causal factors are that good and poor readers of the same age differ in the degree of lateralization in terms of cerebral hemispheric specialization of language functions. In other words, the poor readers were more lateralized than the good readers on the visual half-field presentation (Yeni-Komshian et al., 1975). There is also superior linguistic function in the right cerebral hemisphere of less lateralized individuals. In addition, boys showed greater asymmetry than girls (Krause et al., 2013). Moreover, the poor readers either suffer from some form of degraded processing in the right hemisphere or in the transmission from the right to the left hemisphere (Krause et al., 2013).

One conclusion is that when the relationship between a non-specialized system and creative processing is weak, like in the ambidexterity phenomenon which is accompanied by weak integration, the language domain may be inferior, and it likely that achievement of verbal skills might be slow or absent. This conclusion is supported by Rodriguez' (2010) theory about ambidextrous learners that displayed poor performance in language skills and had weaker speaking ability than their peers. Furthermore, the capability to understand unconventional connection language, like

metaphor, might be difficult due to the difficulty to use flexible thinking that is required in these verbal compositions.

I hold that strengthening this interaction may allow effective processing of both conventional and unconventional stimuli, support creativity in language and create creativity competence (Kenett, Anaki & Faust, 2015) which is necessary for learners with disabilities who are characterized as learners with inflexible thinking. Additionally, this expert system may cope with difficulties, and find unconventional solutions and creative problem solving tasks as a result of creating new unusual verbal combinations due to more flexible and non-specialized system (Wiley and Jolly, 2003

Aspects of handedness

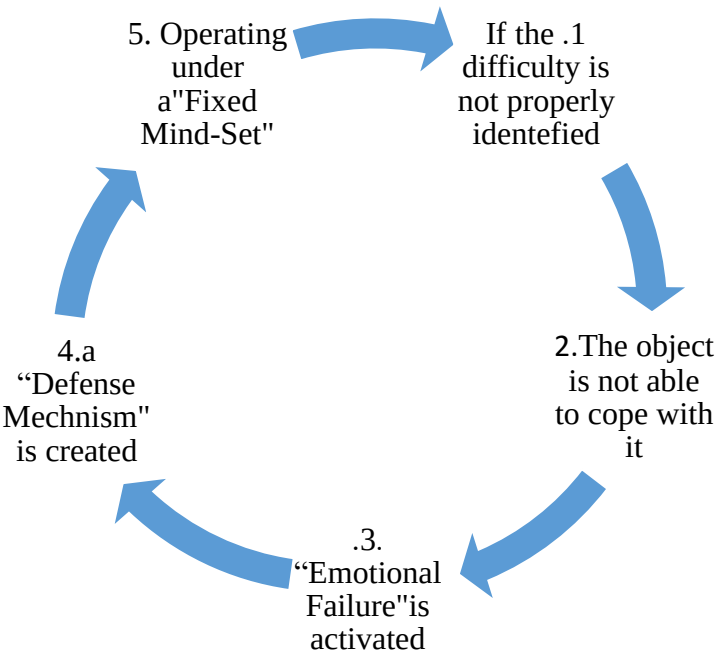
As noted in recent evidence, lateral performance is important for cognition and language (Pe'rez-Garcia et al, 2014). It turns out that lateral preference refers to the tendency to use one side of the body over the other and it is possible thanks to coordinated movements of hands, legs, eyes and ears. It is well known that functional lateralization occurs when there is organ combination and its representation is in the cerebral hemispheres.

Handedness has been related to multiple virtues but it has to do with the phenomenon of mixed handedness that has been associated with increased risk for language delay, learning difficulties and mental health problems (Pe'rez-Garcia et al, 2014). Mixed-handed people tend to use both hands in an unsystematic way for various tasks. This happens as result of absence of hand preference.

As mentioned, research depicts aspects of handedness as a proxy for how the brain functions, yet it is not a perfect measurement. A more accurate method would be to use fMRI [functional Magnetic Resonance Imaging] scanning, but this is not possible in a large-scale study. It is possible that ambidextrous have an atypical brain lateralization and that the brain circuitry and function is likely to differ from the normal pattern seen in right-handed individuals (Rodriguez, 2010). The conclusion might be that the right hemisphere, in this case, might not function in the same way for ambidextrous individuals as it does for right-handed individuals. Moreover, that could explain the association with ADHD, as one study has shown (Rodriguez, 2010). Those with ADHD have difficulties processing information, which is normally

processed in the right hemisphere of the brain. However, the results should not be taken to mean that all children who are mixed-handed will have problems at school or develop ADHD.

I hypothesize that in some cases ADHD development is a result of the learning disabilities these students have. According to my professional experience, if the difficulty is not properly identified and the object is not able to cope it, an "Emotional Failure" is activated. If the object does not understand this emotional source, a "Defense Mechanism" which then a *"Fixed mind-set"* is operated, e.g. "*I hate school*" or "*I have difficulties with paying attention*". It is well known that the popular treatment is providing medical aid in order to improve academic achievements. Thus, the learner cannot do without the pills and nobody understands why learning improvement does not occur. I believe that finding the source can prevent unnecessary distress. The student with learning disability has to cope with various challenges. Therefore, our responsibility as therapists, is to relieve the burden through accurate diagnosis and suitable intervention programs which will match the findings. I hold that identifying the ambidextrous students can prevent an "Emotional Failure" and its consequences (as will be shown in the following diagram).



Nevertheless, researchers are not sure what is behind this link, though they suggest that differences in the brain between ambidextrous individuals and those who have a dominant hand may play a role (Rodriguez, 2010). In fact, scientists are not sure why some people can use both hands equally well (with no dominant hand), a skill also known as mixed-handedness. They also warn us that since the phenomenon is rare, with just one out of every 100 people being mixed-handed, studies only focused on a small group of individuals.

Evidence supports this “hand-specialization hypothesis” as one of the possible origins of handedness. Children with inconsistent hand preference show inferior coordination compared to those of the same age with a definite handedness (Mori Iteya, Gabbard, 2006). It has also been observed that these differences may persist until adulthood. Lateralized adults show faster and more coordinated hand–arm action than those showing less side bias. Indeed, the belief is certainly widespread that handedness is a fixed and definite trait.

I.3 Writing Skills

The literature widely suggests that the skill of writing is one of the most complicated human activities, as it includes cognitive, perception and motor aspects (Hammill & Poplin, 1978). In this type of cases, each hemisphere acts separately and there is no synchronization between them. As a result, the writing skill, which depends on hand-eye cooperation, is impaired in ambidextrous children. When the eye and hand do not receive orders from (and do not report back to) the same hemisphere, the writing skill might be damaged (Modlinger, 1981). Therefore, treatment may need to focus on improving the "middle-line crossing" (Ding, 2004).

I.4 Information Retrieval

Hulme et al. (1991) claim that speed of speech is a measure of how quickly words can be encoded and rehearsed within the phonological loop. Another component referred to is the use of long-term memory representations of the phonological forms of the words that have to be recalled. In arithmetical skills the discussion regarded the ability to store number facts, as poorer fact retrieval also correlated with slower counting and weak access to lexical items.

I.5 Training

Previous studies have shown that the goal of cognitive training is to improve a targeted cognitive function (working memory, attention, language and visual processing), if possible to the optimal degree, but also that the outcome may be different between individuals (Cohen Kadosh, 2013). As is turns out, the goal of most interventions for LD population is a shift in neural activation from the right brain hemisphere to the left. Nonetheless, among LD learners this shift may be impaired, and they may overcome this impairment through lessening the dependency on the weak hemisphere or the less active hemisphere (Horowitz et al., 2014).

As noted in recent studies, an intervention program based on training led to an improvement in working memory and speed of processing (Horowitz et al., 2014). Training influences executive-function pathways in the brain as a result of greater activity of the error-detection system.

It is important to mention that cognitive training alone has been shown to induce a certain amount of change in task performance and in the neural levels (Krafnick et al., 2011). Successful cognitive training takes place when the intervention training is carried out during the sensitive periods of **brain plasticity** (Papanicolaou et al., 2001). It can be concluded that brain plasticity is expressed in organizational change in the region responsible for function, or through transfer to another hemisphere during long or short periods as a result of local damage or training.

Chapter II- **Research Methodology**

II.1 The Research Paradigm

The research uses “mixed methods”, an approach which combines quantitative and qualitative research methods in the same study (Venkatesh, Brown & Bala, 2012). Since the writing speed, oral fluency, pace of speech, low automation and naming ability have quantitative outcomes, quantitative research is appropriate. The interview part allows the researcher to understand the experience of the students and the significance that they attribute to the intervention program.

II.2 Research Population: 30 Ambidextrous students, ages 7-16 from 3 different schools: 10 students (14-16) from Boarding school, 8 young students (8-11) from Democratic school and 12 young students (7-11) from Elementary school; 19 male

and 11 female. 22 participants write with their right hand and 8 write with their left hand.

II.3 The Research tools

1. Three valid and reliable tests meant to **identify** 30 ambidextrous students: Oldfield questionnaire (1970), McManus Test (1988) and The Cards Test (1966).

2. Four valid and reliable tests meant for **checking** the initial performance in four skills: Naming test (Kave, 2005), Fluency, Automation (Ben Dror-Shani, 2006) and Writing Pace (DST, 2011).

3. The **implementation** of an intervention program (ATP) meant to improve the four weak skills and to prevent negative approach due to learning disabilities.

4. **Mid-checking** (after 18 meetings) of the impact of the intervention program and **post-checking** at the end of the program.

5. 25 In-depth interviews for **reporting** the student's difficulties before identifying the source of the difficulty, and the student's perceptions at the end of the intervention program.

II.4 Research Design

The ATP (Ambidexterity Training Program)

This unique program was developed by the researcher and is based on personal professional experience.
The goal of the program was to improve four skills - writing pace, verbal fluency, naming and aoutomation retrieval – by a 15 minute routine training, conducted twice a week (34 meetings in total). Another goal was preventing permanent slow writing pace and information retrieval and improving oral fluency.
The program was executed using the following activities:
1. **Drawing** for 3-5 minutes, meant to improve middle-line crossing and the motor abilities.

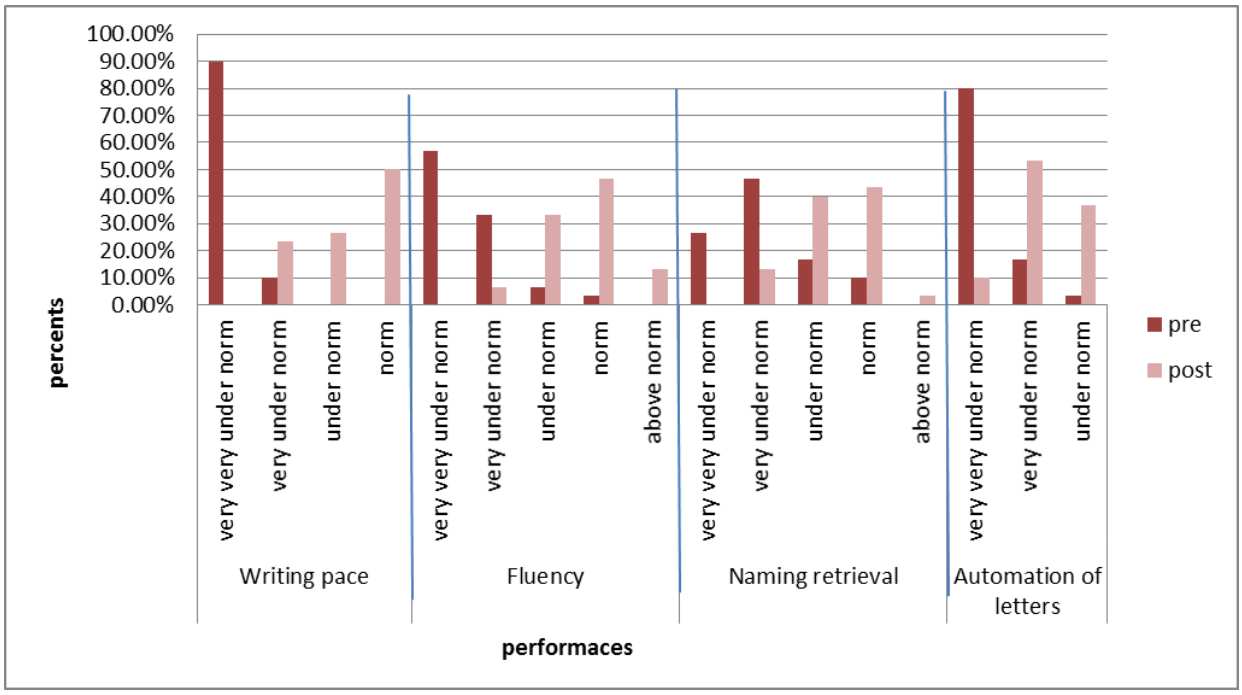
2. **Writing** sequences, i.e. Hebrew alphabet (for older students also English alphabet) and number sequences, for 3-5 minutes, meant to improve verbal fluency.

3. **Copying** a paragraph (30 words) for 3-5 minutes, meant to improve writing pace (addendum 1)

Chapter III- **Findings**

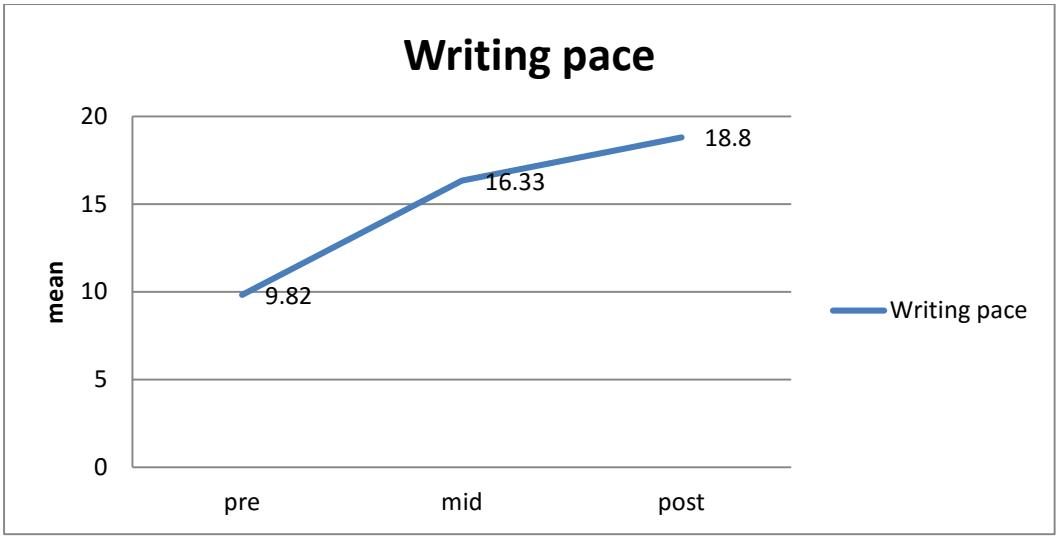
There was significant improvement among all participants in writing pace and verbal fluency skills, and less improvement only in the naming skill and information retrieval. The intervention program contributed in the following measures:

Diagram no. 1: Sum changes of the skills before the intervention program and after it (pre- and post-intervention).



Writing pace: The findings indicate that there was a high rate improvement, from 90% deficiency in the pre-intervention stage to 10% in the mid-intervention stage, and 0% in the post-intervention stage. There was an increase in writing pace rate (words per minute) in norm range level: from 0% in the pre-intervention stage to 13% in the mid-intervention stage, and to 50% in the post-intervention stage. These changes were significant ($\chi 2=78.84$, $p<0.01$).

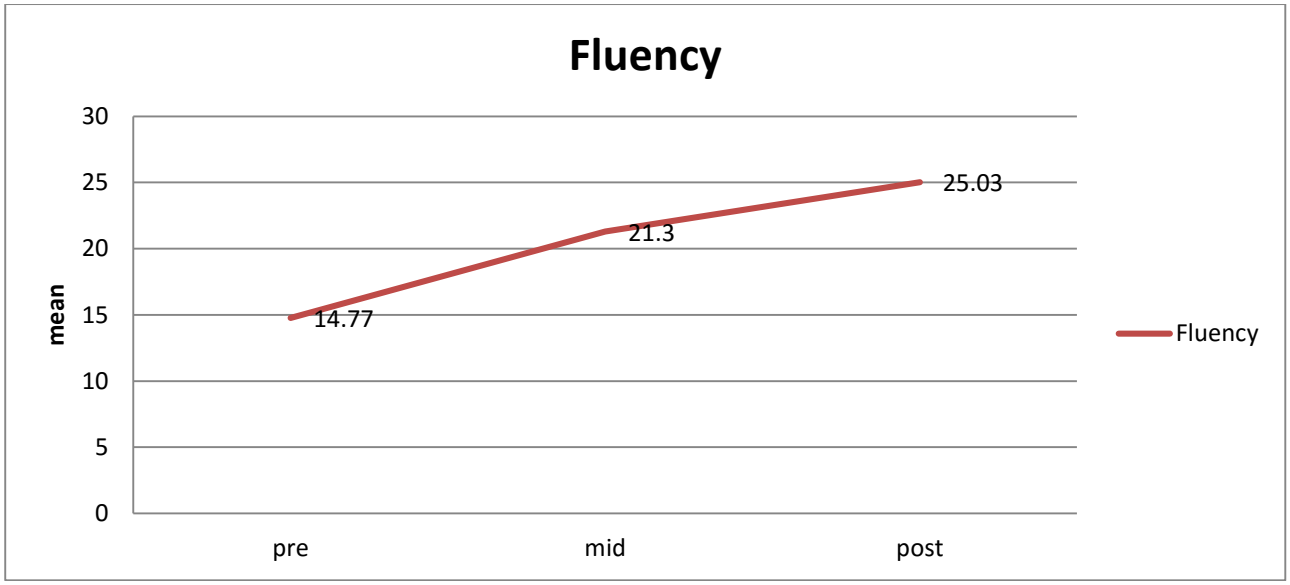
Graff no. 1: Writing pace data: The influence of different stages of the intervention on this skill



The gruff shows that the significant improvement occurred during the first stage. In another word, after 18 meetings occurred a step increase and progressive changes. **Verbal fluency**: the findings indicate that there was a significant decrease in the rate of the verbal fluency (words per minute) in the following levels: *Very very under norm* **(deficiency)**: from 57% in pre-intervention stage to 0% in the middle stage and post-intervention stage. *Very under norm* **(difficulty)**: from 33% in pre-intervention stage to 20% in the middle stage, and to 7% in the post-intervention stage.

There was a significant increase of verbal fluency (words per minute) in the middle stage compared to the pre-intervention stage. Additionally, there was significant increase of verbal fluency (words per minute) in the post-intervention stage compared to the middle stage and as compared to the pre-intervention stage. The verbal fluency increased from 15 words per minute in the pre-intervention stage to 21 words per minute in the middle stage, and to 25 words per minute in the post-intervention stage ($F=76.31$, $p<0.01$).

Graff No. 2: Fluency data: The influence of different stages of the intervention on this skill



Naming retrieval: the findings indicate that there was a significant decrease in the rate of naming retrieval (no. of words) in the following levels: *Very very under norm* (**deficiency)**: from 27% in the pre-intervention program stage to 0% after the intervention program. *Very under norm* **(difficulty)**: from 47% in pre-intervention program stage to 7% after the intervention program.

There was significant increase of naming retrieval (no. of words) in the post-intervention stage compared to the pre-intervention stage ($t=-8.09$, $p<0.01$).

The automaton process: the findings indicate that there was a significant decrease in the rate of the automation of letter (words per minute) in *very very under norm*, (deficiency), from 80% in the pre-intervention stage to 10% in the post-intervention stage. There was significant decrease in the required time for letter retrieval (words per minute) in the post-intervention stage compared to the pre-intervention stage. Meaning, the letter retrieval time decreased from 43 minutes in the initial stage to 34 minutes in the final stage ($t=7.99$, $p<0.01$) (Table 8).

According to the in-depth interviews, there were significant changes in the perception, cognitive impact, behavior and motor abilities of the participants. In addition, the data offers some insights concerning the relationships between training and the improvement of weak cognitive skills, and an accurate identification of the source of difficulty. According to the data collected most participants were diagnosed yet did

not know how to improve their weak skills. A 16 year old participant is recorded to have said: If I had known the source of my writing difficulties at a young age I could have practiced my writing skill and my understanding would have improved." Participants reported that the improvement increased their confidence in their academic abilities and brought significant change in their motor abilities. Likewise, their ability to concentrate improved due to the writing exercises during the lesson compared to their past performance.

Diagram no. 2: Automation of letters (words per minute) - comparison between Pre-intervention, Mid-intervention and Post intervention (measures of central tendency and measures of variability)

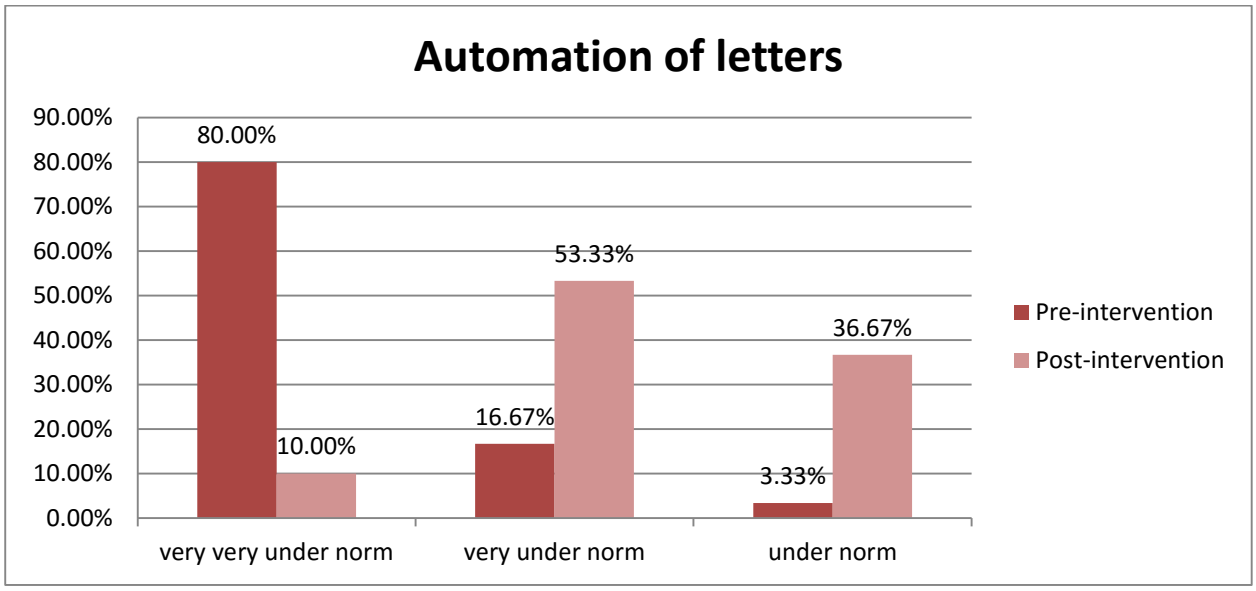


Table no. 1: The difference between the means of the different skills (pre- and post-intervention).

p.val	t-value (df=29)	Upper	Lower	Std Deviation	Mean	N	
.745	.328	.48193	-.34860	1.11211	.06667	30	Delta Writing pace vs Delta Fluency
.000	7.215	1.45460	.81207	.86037	1.13333	30	Delta Writing pace vs delta Automation letters
.000	4.267	1.33136	.46864	1.15520	.90000	30	Delta Writing pace vs delta Naming
.000	5.573	1.45809	.67524	1.04826	1.06667	30	Delta Fluency vs delta Automation letters
.000	4.205	1.23864	.42803	1.08543	.83333	30	Delta Fluency vs delta Naming
.214	-1.270	.14243	-.60909	1.00630	-.23333	30	Delta Automation letters vs delta Naming

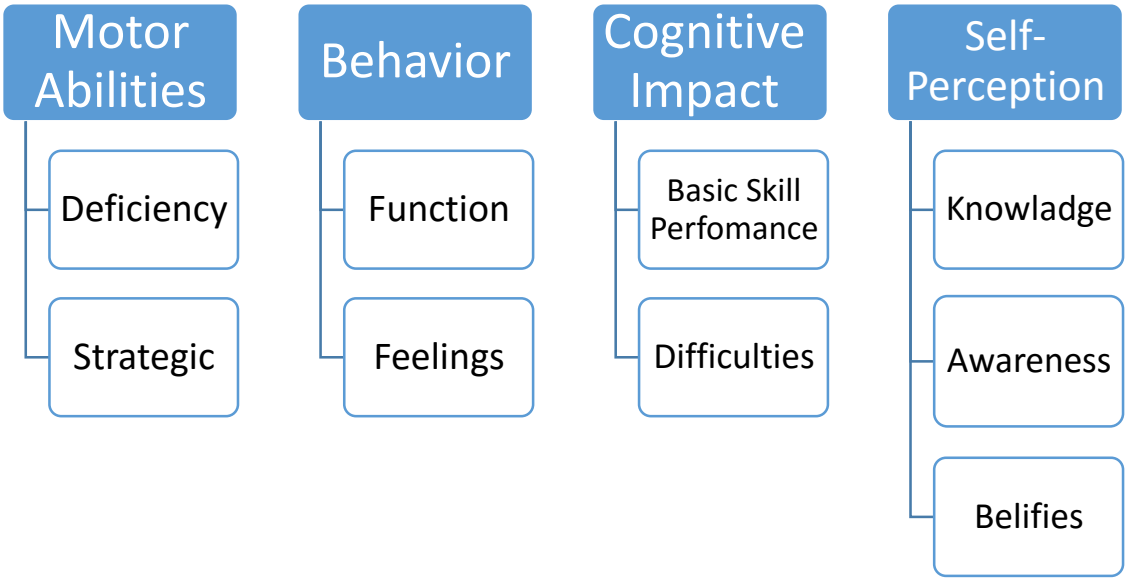
It was found that the difference between the writing pace and fluency is not significant statistically, and both of them had similar improvement in the outcomes in pre- and post-intervention.

The improvement that was measured in the writing pace and fluency is statistically higher ($p<0.01$) than the improvement that was measured in naming and automation retrieval skills.

There was no significant improvement in naming against the improvement that was measured in automation retrieval.

Qualitative paradigm - An in-depth interviews **data\ outcomes**

Diagram no. 13: Qualitative research findings- the main themes and categories given by the respondents



The study shows that the learning process in the intervention program A.T.P led to changes in four live fields among the participants: conceptions, cognitive impact, motor abilities and behavior. This was observable from the in-depth interview done after 34 meetings of practice and analysis, through comparison between the stage before the practice and after it.

It turns out that before the practice the results of learning difficulties were negative conceptions in three categories: knowledge, awareness and believing. Most

participants did not have any previous knowledge about the phenomenon "ambidexterity" in spite of a diagnosis done in childhood, but several of them knew that it exists in their family. Most of the participants knew that they have a problem ("I knew that I am Hyperactive"; "I'm a problematic boy") but did not understand the reason or the source of that behavior. The negative feelings of strangeness, unusualness and irregularity were a result of unawareness to the phenomenon and the causes for their learning disabilities. Furthermore, this caused a sensation of disbelief in the possibility that there could be a change and that the writing skill ability would become as expected.

Chapter IV- **Discussion**

The findings show that the incidences of improvement in a sample of ambidextrous students occurred in favor of the intervention program, conducted during 34 meetings (twice a week), and included training of drawing, copying and sequences. The increased writing pace, verbal frequency, naming retrieval and automation relate to the theory about cognitive training for children with developmental reading disabilities (Wolf et al., 2000). Furthermore, the data in this study correlates with earlier studies which emphasized how a child's cognitive potential can be increased and may even cross the limits that were at first imposed by the learning difficulties.

As previously mentioned, all participants showed improvement in all the skills except for automation. In other words, the deficiency in the third following skills: writing pace, verbal fluency and naming, disappeared in all 30 participants. Furthermore, their performance increased to norm or to over the norm. Only in information retrieval did several participants maintain deficiency, and most of them improved from "deficiency" to "difficult": 90% of participants showed deficiency in the writing pace and 50% had norm pace after the intervention program. The improvement in writing pace and fluency was significant (<0.01) compared to the improvement in naming skill and automation retrieval.

Conclusion

The results demonstrate different effects of the ATP on the skills which were examined, and on the processing pace in all students with ambidexterity. The findings suggest that the intervention program can lead to improvement by creating new neural

connections, made possible due to brain plasticity. It appears that consistent practice during regular meetings can lead to significant improvement; during the first 18 meetings of the intervention program there had been significant improvement in the writing pace and verbal fluency, whereas the other skills, which required deeper processing, improved after a longer period (34 meetings). The naming skill and the information retrieval skill involve deep processing, therefore require longer training.

The improvement in automation retrieval was limited to "very under norm" and "under norm", as none of the participants achieved performance within the range of the norm. I posit that these findings strengthen the research claim regarding the connection between ambidexterity and difficulties in information retrieval. A possible conclusion is that practice could improve these skills, yet it could never change or fix it. The learning disabled who has this retrieval deficiency is required to cope with it throughout his or her academic life.

Observing the gap between the improvement pace in the four skills (writing and fluency compared to naming and automation retrieval), it could be concluded that a training program which includes motor activity task (like drawing, copying and sequence writing) might lead to faster changes in the brain compared to verbal activity (like naming retrieval and automation) or visual tasks. Activity skills which were required in the intervention program included motor activity, causing the working memory to work faster. Naming retrieval and automation are deep processes which require longer training in order to improve. There is evidence that the motor cortex and spinal cord control the remarkable ability to change structure and function through endurance training (Adkins et al., 2006). Furthermore, the claim that the writing skill requires various cognitive processes, such as working memory, knowledge in long-term memory, or metacognitive processes such as self-regulation and metacognitive knowledge (MacArthur, Graham et al., 2008) can explain the improvement of the writing pace and the fluency as a result of intensive training and combining kinesthetic tasks.

Contribution to knowledge

The main contribution of this study has to do with unique and original intervention program, which enables the improvement of several basic inferior skills which are necessary for the learning processes. Furthermore, the program could

prevent a permanent writing disability, as written expression is an essential linguistic skill which enables data processing in one's brain and should therefore be appropriately developed. It could also prevent emotional difficulties which accompany learning disabilities and may turn helpless learners into active and capable ones. In other words, it could help learners avoid getting trapped in a regressive vicious cycle in their school behavior and change their perception about studying and academics.

It is important to mention that the ATP program is universal, as it may be conducted in any country, culture and language. The important stage is the accurate identification of students with ambidexterity, and designing a therapeutic program accordingly. Additional, this study may raise awareness among professionals to the fact that the writing hand is not necessarily the dominant hand in other activities. It is reasonable to suppose that this program may help teachers and health professionals to identify children who are particularly at risk of developing certain problems and to be exposed to the opportunity to make a change in the regions of the brain.

Further contribution involves the verbal retrieval capability, according to the belief that word recognition is facilitated by semantic knowledge (Kenett et al., 2015). In this study the participants were exposed to several different texts in order to increase word recognition by semantic knowledge, creating relationships through semantic associations. It appears that relationship-creating within semantic associations helps build a better basis for comprehension, and gives all learners an early set toward the multiple-layered structure of written language and the many connections among words.

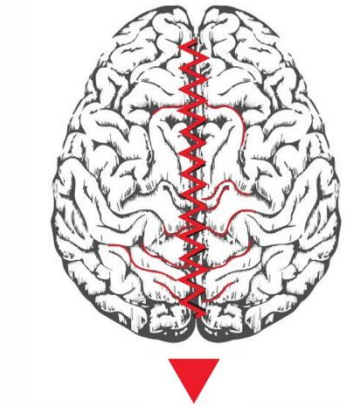
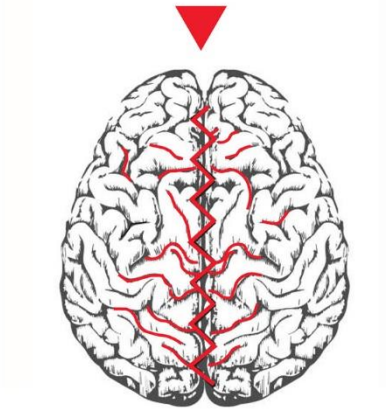
Regarding the correct retrieval of items, is has been found that the retrieval capability is more difficult after a longer break than after a shorter one (Karpicke & Roediger, 2007), and as the number of times an item is correctly retrieved increases, the difficulty of each next correct retrieval decreases. These data suggest that consistent training that includes a short break, e.g. twice a week during several months or intensive daily training during 1-2 months, should be applied in cognitive training.

Model:

Recommended Identifying and Treatment for Ambidexterity

Hypothetical Representation of

Identifying Ambidexterity or Imbalance by Hand Speed (Card Test)

Before A.T.P Imbalance in synchronization between the hemispheres Ambidexterity 	After A.T.P Better connection to balance A T P - Ambidexterity Training Program 
Slow Writing Pace	Improvement or Normal Writing Pace
Slow Verbal Fluency	Improvement or Normal Verbal fluency
Slow Naming Skill	Improvement in Naming Skill, but still low from Norm
Slow Information Retrieval	Improvement in Information Retrieval, but still low from Norm

Limitations of the research

The present study has several limitations. First, the sample size was relatively small and restricted to 30 students of a wide range – from 7 to 16 years old - thus the results cannot determine whether age-linked or handedness variables can define other subgroups. As previously underscored, all the participants have been diagnosed with learning disabilities, therefore further research would be helpful to examine these relationships in larger samples of adults, adolescents, and children. However, it is recommended to observe participants without learning disabilities as well.

Additionally, the sample here was restricted mostly to right-handed participants that did not know that the non-writing hand was their speedy hand. Further research should check more left-handed participants or maybe equal groups of right-handed and left-handed participants, and see which group might be in risk of being ambidextrous.

It is important to emphasize that because ambidexterity is a rare phenomenon, the groups are not equal in size. It is possible to choose more groups from different areas of the country and to compare them according to age, socio-demographic characteristics or type of schooling.

Another effect of the sample size is the reference to the participants' gender. The subjects in this research were chosen according to their hand speed. Thus, these results could not determine whether gender-linked or handedness variables may define other subgroups.

It is also important to acknowledge that during the experiment the participants have been challenged as they trained in order to improve their writing pace. The achievement itself enabled accurate measure, and participation increased their motivation to go on training although it required a considerable effort. It is possible that individual training without a watching instructor and the presence of peer-members will be less effective, since subjects cannot estimate their progress if they do it on their own (it requires accurate measurement using a stopwatch).

As mentioned, the researcher singularly conducted all the training and it is possible that personal beliefs and charisma influenced the participants' performance. That is to say, these results are not guaranteed in other situations or with other conductors, therefore the effectiveness of the intervention program might be limited.

Finally, although this field of study has accurate anatomical landmarks and structure function relevance, the reference to carefully defined anatomical regions cannot confirm that this training directly produces structural changes. Furthermore, because of significant neural plasticity, it is unclear whether the improvements are the results of training among students with ambidexterity.

Future Research

Many studies repeatedly report a need to learn more about what type of damage and/or developmental delays may cause atypical handedness, or if early brain damages cause ambidexterity related to genetic factors and associated with a preterm birth (Domellöf et al., 2011). Therefore, it is recommended to create a parallel use of relevant brain imaging techniques such as MRI (both structural and functional, if possible) and diffusion tensor imaging (DTI) in order to further explore the possibility that an intervention program may be associated with changes to the developing brain.

With regards to this study, it would be possible to check the brain structure before the intervention program and after it.

Some researchers have suggested that mixed-handedness indicates that the pattern of dominance has not been typically seen in most people (Vlachos et al., 2013). Many cases showed that it is less clear that one hemisphere is dominant over the other. The results of this study should, therefore, trigger further research into the important question of whether identifying misbalanced handedness might influence several cognitive functions. Additionally, the claim that only genes or environmental factors (Vlachos et al., 2013) might determine the possibility to change or to improve academic functions should be reexamined. This study showed that it is possible to change inferior skills. The findings may help teachers and health professionals identify children who are particularly at risk of developing these problems. This might be due to lack of attention and accuracy of determining and classifying handedness.

Future models of ambidexterity may posit that it is possible to strengthen inefficient cooperation between the hemispheres through motor exercises that relate to the integration of motor functions, linguistic variables, attention, and motor skill learning that depend on the frontal lobe. Therapists could also apply different activities which could help improve neural system disorders. This restricted intervention program suggests that other populations can also benefit from motor activities in spaciousness.

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Appendices

Addendum 1- an example of daily practice