Dissertation for obtaining the Certificate of Capacity in Speech Therapy

Effects of audiophonic loop training with Forbrain headphones on reading accuracy and speed as well as on working memory and verbal short-term memory in dyslexic patients: Multiple case studies

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INTRODUCTION

Dyslexia, or specific written language disorder (TSLE), is defined by impaired reading and spelling, without however affecting the patient's level of intelligence (American Psychiatric Association, 2015). The reading difficulties generally encountered by dyslexic patients relate to reading speed and accuracy. Deciphering is not automated, which induces slow and not very fluid reading, but also the production of phonological errors (Habib & Joly-Pottuz, 2008).

Working memory is a cognitive function that provides access to learning and reasoning (Villemonteix, 2018). Generally, working memory abilities in people with dyslexia are deficient. This disorder therefore causes additional difficulties in learning and automating reading in children with this disorder.

The Forbrain headset is a tool that allows you to hear yourself speak. It is used, according to its affiliate program, by approximately 2000 speech therapists and audiologists worldwide. This helmet is based on the principles of the audiophonic loop but it is equipped with a technology allowing a modified auditory feedback. Forbrain therefore adjusts the frequencies of its user's speech in order to challenge its audiophonic loop. It seems that the use of these headphones under certain conditions improves the level of reading in children with learning difficulties (Torabi and al., 2018).

We would therefore like to test whether wearing Forbrain can influence reading accuracy and speed in two dyslexic children, as well as their working memory capacities. The work we are doing is a multiple case study in which two young dyslexics will wear the Forbrain helmet and carry out the

study protocol of Torabi et al. (2018) to which we have made some adaptations. Two other dyslexic children will carry out this same training but will not wear Forbrain.

First, we will carry out a study of the recent literature on dyslexia. Then, we will present the working memory model of Baddeley and Hitch (1974) as well as the deficits of this memory within the TSLE. Then, we will study the process of the audiophonic loop and its interest for reading aloud in order to introduce the Forbrain helmet and the studies that have already been carried out using this tool. In a second step, we will present our protocol and the progress of our case study. We will present the results obtained and finally discuss the strengths of our study but also its limits and prospects.

DISCUSSION

The objective of this thesis was to analyze and observe the effects of the Forbrain headset on reading speed and accuracy, as well as working memory and verbal short-term memory capacities in two dyslexic patients. To carry out this study, we proposed a protocol adapted from that of Torabi et al. (2018), and the same training was performed with two other dyslexic patients who did not wear the Forbrain headset.

I. The materials used, strengths and limitations

A) Pre- and post-protocol reading evaluation tests

The meaningless reading texts recruited for our study are widely used today by speech therapists to assess language disorders and are considered as reference tests for the diagnosis of dyslexia (Mathis et al., 2018). The standardization of each test allowed us to place the patients' level in relation to that of children of the same school level. However, the standardization proposed by Alouette (Lefavrais, 1967) in five classes is less precise than that of Evalouette (Launay et al., 2018) which divides the population into seven classes. The scores of control subjects were therefore analyzed with less precision than those of tested subjects.

Moreover, at the beginning of this study, we preferred to avoid a retest effect that could distort our results and that is why we chose to use two distinct meaningless texts. However, the use of two different tests among our subjects constitutes a methodological bias. Since the test material was not identical for all subjects, we were not able to compare the scores of the tested subjects with those of the control subjects as much as we would have liked. The evolution of reading accuracy, expressed in percentages for the two texts, allowed us to compare it in a graph. However, this can only be interpreted for informational purposes. We could not analyze the reading speed scores between the four subjects. Indeed, the calculation to obtain the speed index is different between the tests and the time allocated for each reading is not identical. These two arguments therefore did not allow us to carry out a relevant comparative analysis.

If a new study on the Forbrain headset were to be conducted, it would seem interesting and essential to standardize the pre- and post-therapeutic tests in order to evaluate the results obtained more rigorously.

B) The modified protocol of Torabi et al. (2018)

We made several modifications to the protocol that only concern the nature of the activities. These changes were chosen to adapt to the individual needs and speech therapy of the patients. We were able to perform the same task for all the young patients, but by specializing in the sounds or

semantic fields to work on. These adaptations have made the rather strict framework of the protocol more flexible and have integrated our study into the continuity of speech therapy care initiated by Madame Morille.

However, the modifications made constitute a methodological bias since the protocols carried out for the four subjects differ. Comparative analyses between subjects cannot, therefore, demonstrate as much rigor as if all patients had exactly the same speech therapy treatment. But we want to emphasize that we allowed these adaptations because this clinical report is based on a multiple case study. In this context, we are mainly interested in the results for each patient.

C) The satisfaction survey

We designed the questionnaire at the end of the study to bring a qualitative dimension to our quantitative results. Each question addressed one of the main criteria of the study: reading speed, reading accuracy, memory in a broad sense, and memorization strategies. The questions were, therefore, very general. The suggested prompts in parentheses, especially for the question of reading accuracy, could have been the subject of additional questions. These could have been simpler to process for children who may have difficulty synthesizing their ideas. Similarly, the QRU format did not allow them to express their feelings freely. However, it was interesting to note that the patients themselves commented on their observations.

II- Profiles of study participants: similarities and differences

For our study, we wanted to have profiles of children that were as similar as possible in terms of age, school level, and degree of severity of difficulties. This homogenization of profiles makes it possible to carry out more interesting and relevant comparative analyses.

Among the four subjects, three were 11 years old at the beginning of the study and were in sixth grade. The last one was 12 years old and was in fifth grade. The profiles of the adolescents were, therefore, generally similar in terms of their age and school level.

In addition, one girl and three boys were recruited to participate in this study. We could not obtain a sample that was fair in terms of gender, but we did not use this criterion for selecting subjects. Indeed, given the small number of participants, we did not expect to observe a gender effect on the results obtained for the use of the Forbrain headset.

Finally, the degree of severity of difficulties cannot logically be strictly identical between two dyslexic patients. Comparing the results obtained between different subjects, therefore, makes less sense than analyzing the pre- and post-protocol scores for each young patient. This individualized approach is also the one we adopt in the context of speech therapy care. In our study, subject D has a more severe dyslexia than the other three young patients, and his results are significantly lower than those of subjects A, B, and C. His identification of written words is not automated, which slows down his reading out loud and makes it very costly. In addition, this young patient has behavioral disorders

that affect his learning and exacerbate his difficulties. We, therefore, need to nuance our analyses since this control subject is much more in difficulty than the tested subjects. At the end of the study, we found that subject D reads very few additional words in three minutes. But clinically, he takes much more pleasure in reading and is very proud of his progress, which is a real success for us.

III- Analysis of results and hypothesis verification

A) Results obtained in reading speed and accuracy

Reading speed

We can see that the speed index increased for each subject, although this evolution is not homogeneous. The results of subjects A and C show the most significant improvements. In fact, the increase in reading speed is very significant for subject A since he almost doubled the number of words read in two minutes. Subject C also read many more words during the post-test phase compared to the pre-test. The speed indices of subjects B and D indicate a much less significant increase, as they each read about ten more words during their second test. Therefore, the results of patients who trained with the Forbrain headset (subjects A and B) are not homogeneous since the subject B's score increase is very low. These results have been challenging for us, given those obtained by Gomez Guillermo's study (2018). Indeed, at the end of his protocol, reading speed had been significantly improved in all subjects wearing the headset compared to children in the control group. However, it should be noted that his work focused on primary school students learning to read. Therefore, it appears that wearing the Forbrain headset facilitates reading automatization, but in the context of a TSLE, it does not significantly improve reading speed.

Reading accuracy

We can observe that the reading accuracy index increased for subjects A and B and decreased for subjects C and D. However, these negative evolutions do not indicate a regression in the reading skills of the subjects. Indeed, the children read more words in the allotted time, so due to their difficulties, they made proportionally more errors.

Improvements in reading accuracy indices for the tested subjects are to be considered on a case-by-case basis. For subject A, the score increase is not sufficient to place him outside the pathological zone. Still, we observed that subject A had significantly accelerated his reading speed during the study. Therefore, this child now reads more words and makes fewer mistakes than before. However, the number of errors produced is still higher than that of children in his age group. For subject B, the improvement in reading accuracy is more significant, and the score obtained during the second reading allows him to reach the normal zone for sixth-grade students.

B) Results obtained in working memory and verbal short-term memory

Working memory

We can see that the span for each subject increased by at least one point during the second testing phase. Therefore, the working memory capacities have improved for each of them. Control subject D even has the most significant improvement, with two additional span points.

Verbal short-term memory

Finally, we can observe that the evolutions of the forward spans of the four subjects are not uniform. Control participants and subject B increased their span by one point and reached the norm for their age group. However, subject A obtained the same score in both testing phases and did not normalize his results. Thus, we cannot establish a significant effect of the Forbrain headset or the Torabi et al. (2018) adapted training on verbal short-term memory capacities.

C) Satisfaction Survey Results

We have noticed that the subject's responses to the satisfaction survey did not always correspond to the results they obtained at the end of the protocol. When the answers were surprising compared to the quantitative results, the subjects seemed not to have noticed their progress. For example, the responses of subject C may seem very modest to us given the results he obtained at the end of the protocol. On the one hand, he did not realize his progress in reading speed, and on the other hand, he stated that he had developed "a little" strategies to memorize better, although he had developed three different strategies. His answers seem to go hand in hand with his comment, "it was good to succeed," which suggests a low self-confidence in the context of his school learning. It appears that subjects do not always realize their ability to improve. We wonder about the origin of this low self-confidence. Does it come from adolescence and the internal upheavals it induces, or from the psychological impact that a specific learning disorder diagnosis and the difficulties it implies can have?

Moreover, if we examine some questionnaires in detail, we can make assumptions about the state of mind of the young person at the time of completing them. Indeed, subject A responds "a lot" to three out of four questions when asked if he has the impression of having improved a particular criterion. He also answers affirmatively to the fourth question by choosing "a little." We can assume that either subject A is entirely satisfied with the protocol, or he does not want to disappoint us and prefers to give us the answers he thinks we expect. It would have been relevant to ask this young person to justify each of his answers to establish if they were consistent with his answer choices. Finally, subject D answered "I have no opinion" to the third and fourth questions, which led to the fact that he could not answer the fifth question. We wonder about the possibility that the introspection required to answer the survey may be too costly for this young person. It would have been interesting to ask these questions orally and more informally to better understand his feelings.

IV- Limits and Perspectives

A) Remarks and Proposals on the Study Results

Reading Speed

At the end of the protocol, we observe that all patients have increased their reading speed. This means that they decode words more quickly. However, the results obtained on the post-tests are not

standardized. Only subject C, who is a control subject, obtains a score that approaches the average for young people of his age. Therefore, the use of the Forbrain headset does not seem to be the origin of the improvement in the reading speed index for subjects A and B.

However, we can hypothesize that the adapted protocol of Torabi et al. (2018) allowed for a positive influence on reading speed in our four participants. It would be interesting to carry out a new, larger-scale study using the same protocol to test whether these observations are generalizable.

Working Memory

In the same way, we cannot attribute the observed improvement in working memory capacity to the Forbrain headset. However, we can hypothesize that the adapted protocol used by Torabi et al. (2018) may have increased the span of the subjects in our study. It would also be interesting to conduct a larger study to verify if this hypothesis generalizes. Furthermore, given the improvement in working memory capacity for the four subjects, new lines of inquiry emerge. Indeed, we have seen that a working memory deficit in dyslexics results from a failure to access phonological representations (Alegria & Mousty, 2004). Since the working memory capacities of our subjects are now normalized, it would have been relevant to test the phonological abilities of the patients to see if they improved in parallel. To do this, metaphonology tests such as spoonerisms and sound suppression tasks, as proposed by the Evaléo 6-15 assessment battery (Launay et al., 2018), should have been administered during pre- and post-tests. However, due to time constraints, we could not analyze all this data in this study.

Reading accuracy

Finally, this study has yielded encouraging results regarding the effect of the Forbrain headset on reading accuracy for the two subjects who used it. Since the increase in indices for these two patients was not uniform, it would be interesting to conduct an additional study. This study would recruit more participants and divide them into two groups: test and control. Patients of different ages should also be recruited, and the protocols should be strictly identical between all subjects, if possible. In this way, we could statistically analyze whether the effect of the Forbrain headset observed here on reading accuracy is generalizable to a larger population.

B) Comments and suggestions on study parameters

Frequency of using the headset

Furthermore, the study patients wore the Forbrain headset for 30 minutes during 20 sessions that took place once or twice a week. Given the results obtained in this study, we wonder about the effect that more frequent use of the Forbrain headset could have on reading accuracy. This tool could, for example, be used daily at home for reading aloud, for pleasure or for homework. According to the recommendations of the Forbrain website and our observations, using the headset for periods of 30 minutes seems sufficient. Indeed, longer use could tire the user.

Attraction to using the headset

During the protocol, we observed that the tested subjects enjoyed wearing the headset and hearing themselves speak thanks to the microphone and bone conduction headphones. This tool seemed motivating for these dyslexic patients who have been coming to speech therapy sessions to rehabilitate their disorders for several years. The use of the Forbrain headset could therefore have a double interest for dyslexic patients: improving their reading accuracy and increasing their motivation to work on written language differently. However, we note that using this headset can be unpleasant when the user is tired. Similarly, the vocal feedback created by the headset and the

wearing of the headset itself may be disliked by some. We were able to note that control subjects did not wish to train with the headset due to the vocal feedback phenomenon. The Forbrain headset thus appears to be a tool that can be used with certain patients, but its use is not unanimous.

C) Towards a study on reading comprehension

Finally, reading is the product of two components, which are the identification of written words and their comprehension (Gough & Tunmer, 1986). The identification of written words is the factor that poses problems for dyslexic individuals. However, difficulties in reading comprehension can be added to their decoding difficulties. Moreover, reading fluency is decisive for reading comprehension. The use of the Forbrain headset, in addition to the adapted training of Torabi et al. (2018), appears to accelerate and improve the reading accuracy of young dyslexics, thus making their reading more fluent. In addition, Torabi et al. (2018) study demonstrated effects on the reading comprehension of their subjects with reading difficulties. It could therefore be interesting to test the effect of using the Forbrain headset in the adapted training of Torabi et al. (2018) with dyslexic patients who have difficulties in reading comprehension.

Conclusion

Our study aimed to test whether the use of the Forbrain headset, as part of Torabi et al.'s (2018) adapted training, could influence the speed and accuracy of reading as well as working memory and verbal short-term memory abilities in two dyslexic patients. Through the results of our experimentation, some results are encouraging. It seems that wearing the Forbrain headset improved reading accuracy in the two subjects tested. The participants made fewer errors during their post-protocol reading. These results could therefore open up new perspectives for the treatment of written language disorders, provided that the patient enjoys using the Forbrain headset. Furthermore, all four subjects in the study, whether they did the training with or without the Forbrain headset, saw their reading speed increase and their working memory capacity improve. Torabi et al.'s (2018) adapted training seems to be the cause of these improvements. However, the heterogeneous results obtained by the subjects for verbal short-term memory do not allow us to conclude a positive effect for either the use of the Forbrain headset or the training performed. Moreover, these results cannot be generalized to all dyslexic patients given the small sample size recruited for this study. These initial results nevertheless lead to new hypotheses for future research. These should recruit much larger populations and follow a strictly identical protocol between participants.

Finally, the results of previous studies and those we obtained in this thesis open up new perspectives. Future research could aim to study the combined effect of the Forbrain headset and Torabi et al.'s (2018) adapted training on the written comprehension of dyslexic patients in order to perhaps imagine new avenues for treatment for these disorders.