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INTEGRATION OF TOUCH TECHNOLOGY IN COGNITIVE REMEDIATION OF VISUOSPATIAL WORKING MEMORY IN SCHIZOPHRENIA

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ABSTRACT

Objective: In this study, our aim was to evaluate the use of new touch technologies including touch pads in cognitive remediation of visuospatial working memory in schizophrenia. **Methods**: The study was performed with 20 individuals with schizophrenia (DSM-IV-TR), hospitalized for long stays and stabilized clinically. The remediation phase took place over 12 months when cognitive assessments were conducted to assess the progression of patients. **Results**: Promising results in terms of improved cognitive function were obtained. Cognitive remediation by the touch interface allows better performance on visuospatial working memory in people with schizophrenia. Furthermore, the use of touch technology is a positive contribution in terms of interest, acceptability, motivation, sense of efficacy and satisfaction associated with the use of this method of remediation. **Conclusion**: These results lead us to consider the need to integrate the new touch technologies in cognitive remediation in schizophrenia programs.

KEYWORDS: Schizophrenia, Cognitive Remediation, Working Memory, Touch Technology, Motivation, Ergonomics.

1. INTRODUCTION

In recent years, the cognitive dimension in schizophrenia gained increasing interest. The cognitive deficits in patients with schizophrenia are better recognized, tracked and taken into consideration in the pharmacological and psychosocial management of the disease.

Indeed, early in the disease, cognitive disorders were found in 85% of patients with schizophrenia.[1] These disorders that remain inaccessible to chemotherapy were correlated to the functional prognosis of the disease.[2] They remain relatively stable even after the remission of positive symptoms.[3]

The cognitive deficits in schizophrenia affect all areas of cognitive functioning, affecting predominantly the attention, memory, executive functions and processing speed.[4-11] Deficits in working memory among schizophrenic patients are preferential targets because of their frequency, their relationship with functional prognosis and their involvement in all aspects of daily life.

Cognitive remediation is becoming more and more formal in the treatment of schizophrenia; this is due to proven efficacy and lack of other therapeutic means that can improve the targeted deficits. Work on schizophrenia in functional aspects of the brain and cognitive neuropsychology studies encourage deeper reflection on models and cognitive remediation techniques. In addition, researchers are interested in factors that would maximize the effects of cognitive remediation.

Yet the consequences of certain negative symptoms such as apathy, listlessness, loss of desire, energy and interest are reflected in people with schizophrenia by a lack of persistence at work or in various activities and an inability to undertake or complete a rehabilitation program. This is why programs should be individualized, designed according to the specific nature of cognitive deficits and resources of each. They should also consider elements such as self-esteem, motivation and acceptability. The techniques used are varied, ranging from simple training to more advanced learning techniques that seem to work better.[12]

New technologies have an increasingly important impact on the development of prevention and rehabilitation methods. For example, the virtual reality is currently used as part of the treatment of phobias or autism and with elderly patients in the early detection of dementia. Touch technology is one of the innovative technologies that now occupy a proper place in the life of every day and their use is widespread in all areas. This innovative technology provides a new way of interacting and seems to be a real opportunity for the disability sector. She prodigiously evolves at present, creating a new context of use, particularly in the medical and paramedical fields.

In this context, our research is moving towards the use of new interactive technologies including touch interfaces in cognitive remediation. These interfaces have a playfulness offering new opportunities to access and manipulate information. They also stimulate the user by in terms of interactivity, simplicity and ease of use. The objective of our study is to evaluate the use and contribution of touch technology in cognitive remediation and propose new interactive methods of care for cognitive deficits in schizophrenia.

1.1. Disorder of the Working Memory in schizophrenia

The working memory (WM) is a short-term memory, with limited capacity, which simultaneously maintains cognitive representations and handling them, while performing tasks involving mental processing.[13] It's about a storage and online use system and in real-time visual-spatial and verbal information, which role is predominant in most daily activities (understand a text, retain a phone number, memorize a route, etc.). According to Baddeley's model[14-17], the WM has two slave systems responsible for the temporary retention of information (visuospatial sketchpad and phonological loop), a central administrator and episodic buffer.

The information is retained at a very accessible stage of consciousness, under the control of a subsystem that manages the selection of useful information, the inhibition of irrelevant information and the coordination of feedbacks at the same as processing information.[13,16] Contemporary research has shown that working memory is an essential component of the fluid reasoning and other higher cognitive processes, and it is also very closely linked to the success and learning.[18-20] Working memory is a very cognitive process involved in executive functions. It has its own rules of operation and is underpinned by specific brain networks.[17] This system can be affected in isolation in focal lesions in some contexts or in certain functional disorders such as schizophrenia and depression, as it may be part of a constellation of other deficits, particularly in neurodegenerative diseases.

Working memory plays a central role in the field of cognitive processes schizophrenia.[21] Some authors consider working memory disorders such as cognitive impairment most frequently encountered in schizophrenia.[22] The majority of recent studies shows deficits affecting all working memory components in patients with schizophrenia.[23] Its alteration, widely documented in patients with schizophrenia.[24] intervene in the unfolding of several aspects of executive function, attention, episodic memory and insight.[11,15,25,26]

This central role in cognition allow better understanding of the various cognitive deficits in schizophrenia and justify the choice of the working memory as one of the priority therapeutic targets of the new antipsychotic molecules.

Deficits in working memory does not appear to be related to age, gender, duration of disorder and positive symptoms of the disease but appear correlated with a low level of education and the negative symptoms and disorganization. They are present from the onset of the disorders and are also found among the relatives of patients and in subjects with schizotypal personality which may thus constitute markers of vulnerability of this disorder. Its operating level was found highly predictive according to the degree of acquiring professional skills and contributing to the functional prognosis of long-term illness. Its deficit was the subject of a specific cognitive remediation with the result of a measurable and sustainable improvement.[23]

Moreover, the exploration of the working memory among schizophrenic patients has been the subject of numerous studies on different populations and using a wide range of cognitive tests. Despite the diversity of methodologies, the majority of recent studies shows deficits affecting all working memory components in patients with schizophrenia.[23] A recent meta-analysis[27] shows that there is a significant deficit of visuospatial working memory in schizophrenic patients and that this deficit concerns both the memory of faces, images or abstract figures. The authors suggest that this deficit is related to disturbances during encoding rather than when storing or retrieving information.

1.2. Cognitive remediation in schizophrenia

Cognitive remediation is a technique that is similar to rehabilitative treatment methods. It is increasingly used in the treatment of schizophrenia, in addition to the combination of neuroleptics and psychotherapy.[28]

Cognitive remediation aims at exercising certain cognitive functions impaired in patients with the objective to enhance their performance, which may have an impact on its ability to confront the concrete situations of daily life. The exercises may seem very simple and repetitive, but they correspond to cognitive difficulties of schizophrenic patients. They address relatively stabilized patients with cognitive impairment and / or disorganized thinking.

Cognitive remediation works in order to improve the disabling aspects of cognitive impairment.[29] It is to train the impaired cognitive functions[30] or to develop functions preserved through a compensation mechanism.[31]

The individualized methods that are most appropriate include prolonged confrontation of each patient with specific exercises and daily activities with relevance to their needs.[32]

Remediation is expected to foster reorganization anatomical and / or functional bodies concerned through neural plasticity. A considerable amount of work[33] shows that neurons in the human hippocampus retain their capacity to divide throughout life and thus to generate new neurons. The work of Erich Kandel, Nobel Prize 2001, going in the same direction: the learning and practice of new tasks can cause neuro-anatomical changes such as strengthening or establishing connections. Indeed, the improvement of neuropsychological performance can theoretically occur as a direct effect of restoration of deficit functions or, more likely, by the development of supportive networks using the cognitive resources proper to each individual.[34] Thus, neuroimaging studies suggest that in all cases a reactivation of the prefrontal cortex is possible after cognitive remediation work.[12]

The findings of a meta-analysis have demonstrated the effectiveness of cognitive remediation in schizophrenia on large samples of subjects and this regardless of the type of patient or associated treatments.[35]

A meta-analysis conducted from 26 studies[35] shows that cognitive remediation improves overall cognitive functioning and specifically, in six cognitive domains: Attention / Vigilance, processing speed, working memory, learning and verbal memory, reasoning, problem solving and social cognition.

Indeed, cognitive remediation appears to favor the obtaining and maintaining of competitive jobs, increasing the quality and satisfaction in interpersonal relationships and increasing problem solving skills. So the use of such cognitive remediation strategy aims to allow patients to enhance their autonomy, ability to interact with the environment, and therefore find a more satisfying social and professional life.[30]

Different cognitive remediation programs have been developed for the treatment of patients with schizophrenia. These programs are very heterogeneous and differ in several points. They typically have two strategies: the restoration strategy that intensively leads one or more deficient processes through the realization of carefully hierarchized tasks in order to restore the neuroanatomical connections related to the trained cognitive functions.[36] and the reorganization strategy which consists in teaching alternative strategies by relying on preserved functions. Cognitive remediation programs also differ in the material they use (paper, video, computerized interface and / or role play), the therapeutic aim (cognitive, psychosocial and / or symptomatic), the type of application (in group, individual, computer assisted), rhythm (1 to 3 sessions per week), the duration of the sessions (15 to 60 minutes) and the duration of the program. Choosing a program depends on the patient's cognitive deficits, its clinical profile and rehabilitation goals.[37]

Among the cognitive remediation programs most used, there are: Cognitive Remediation in Schizophrenia (RECOS), Integrated Psychological Treatment (IPT) and Cognitive Remediation Therapy (CRT).

1.3. Intrinsic motivation and cognitive remediation

Intrinsic motivation is defined as internal forces which cause the initiation, direction, intensity and persistence of behavior. She led to practice an activity for the pleasure and satisfaction that one withdraws or a sense of competence and self-determination that it provides.[38] So, motivation encompasses cognitive factors (anticipation of purpose, representation of results) and emotional factors (emotions, positive reinforcement, capacity for introspection) that drive the relationship between the organism and the environment.[39]

A lot of work indicates that in a given learning environment, intrinsic motivation is correlated with better learning, which is then associated with a greater engagement in learning activities and longer retention of learning. It is also associated with creativity and self-esteem.[38]

In schizophrenia, a motivational deficit and in particular intrinsic motivation is observed to varying degrees in patients.[30] This lack of motivation is expressed in daily life subjects with schizophrenia by difficulties in performing actions, an important need for stimulation and encouragement, a lack of enthusiasm, and great fatigue.[40] Likewise, the deficit affects their ability to initiate and maintain learning behaviors in a remediation program.

Currently, neurocognition and motivation are considered targets of treatment to improve the operation.[41] Current researches retain the motivational factor as intermediary factor likely to amplify or reduce the impact of cognitive impairment.[40] Higher levels of intrinsic motivation are correlated with a greater improvement in neurocognition over time. Thus, clinically, cognitive remediation should also seek improving intrinsic motivation insofar as it would appear that its improvement leads to greater amplitude of neurocognitive change, which would favor a major functional change.[41]

1.4. Ergonomics, disability and use of innovative technologies

One of the fields of application of ergonomics specifically concerns persons with disabilities. Ergonomics can help various improvements as part of their daily lives and that in order to facilitate accessibility, the use of technical objects and the comfort of life in companies, institutions and care rehabilitation or at home.[42,43] The rehabilitation and ergonomics have complementary goals: indeed, if the rehabilitation focuses clearly on restoring deficient human functions, ergonomics in turn, is directly involved in the search for effectiveness, efficiency rehabilitation devices and the level of satisfaction they can bring. Thus, the components of ergonomics rehabilitation are multidimensional, and affect the interaction between the person with a disability and environmental factors.[44] To this end, Wolff et al. proposed to develop the intrinsic capacities of the individual in order to decrease the functional consequences of disability on one hand, and to modify the environment or compensate certain disabilities through artifacts such as technical aids.[43] It is in this perspective that various technical aids are designed to serve as an interface between the person with disability and its environment.[44]

Indeed, a person with disabilities is facing a socio-technical environment more or less incompatible, as conceived and organized for disabled people. It is possible to reduce the disability by better rearranging of the environment, and by providing the person with disability palliative means such as technical aids.[45] Still, technical aids do not reduce the deficiencies themselves, but reduce certain consequences of these deficiencies. They aim to improve the autonomy of the people, offer a better comfort life and are positive factors of insertion or maintenance in jobs.[46]

Besides, ergonomics provides direct assistance to people with disabilities and those around them by choosing a system that best suits. It may sometimes be a matter of simply purchasing a particular system, but more generally it is also necessary to "configure" various options, to set up the workstation or the workplace, to provide training in the use of system, to provide technical assistance, as well as the evolution of the system, etc. The ergonomist plays there a role of co-designer, advisor and intermediary between the disabled person and his technical and social environment.[45]

Moreover, ergonomics can be corrective for correcting existing or prospective systems that contribute to the design of new systems. The main objective of the ergonomic studies is to remove the difficulties encountered by the users when faced with technologies that are poorly mastered and technical objects which are not well suited to the situation.[47]

Finally, the assessment of the usability and acceptability of the system (product, interface, technical assistance, etc.) is a fundamental approach to ergonomics approach to ensure the performance of the interaction between the user and the device and thereby measuring the suitability to the needs of the person with disability. The evaluation must be carried out with the help of the end user, in the final terms and in well-defined tasks.[48]

Innovative technologies

The use of innovative technologies in the medical and paramedical fields appears to increase for reasons of usability, efficiency and usually related to both the belonging to a new generation.[49] New technologies, especially virtual reality, have an increasingly important impact on the development of methods of prevention and rehabilitation.[50]

Moreover, the virtual reality is currently used as part of the treatment of phobias[51] or autism[52,53] and with the elderly in the early detection of dementia.[54] On the other hand, the playfulness of interactive games has led some nursing homes to be equipped with devices that seem to encourage the mobility and sociability of the elderly. In the context of schizophrenia, digital cognitive assistants are being used to improve the daily lives of people with cognitive impairment.[55] These technological tools are not part of cognitive remediation, but they are intended to compensate for attention, executive or memory deficits. However, they may be used in some patients with cognitive remediation joint and allow to prepare the action of this one if introduced in a dynamic perspective and not in the idea of making their dependent users of the tools at them. This is, indeed, portable digital device type PDAs, handheld computers, equipped with a touch screen and a small keyboard, etc. [37].

Contributions of touch interfaces in cognitive remediation

Touch interfaces are one of the innovative technologies that now occupy a proper place in the life of every day and their use is widespread in all areas. The touch screen is an interesting interface with many advantages. This is a direct interaction device: the user designates directly with a finger, on the screen, the desired graphic item, which allows close actions of interaction with real objects. In addition, the Touch/ or the tactile has a playful aspect and integrates touch gestures in the action: we touch screen and there is a return, the screen scrolls and images are modified.[56]

The touch screen is very intuitive and requires no learning unlike the keyboard or mouse. In addition, the motor and cognitive effort required to designate is lower with a touch screen than with indirect pointing devices. The user of a touch screen can alternately use both hands allowing it to optimize its handling of time or to use their non-dominant hand while the other is occupied. This is more difficult with the mouse that requires to be more or less ambidextrous.[56]

The touch interface can help make information more easily accessible by allowing users to navigate by simply touching the display screen.[57] This user-friendly interface can be less scary and easier to use than other peripherals entry, especially for novice users.[58] The studied people feel less mental effort when using the touch screen than while using the mouse. Similarly, touch screens are considered especially effective in children's learning.[59]

The intention of acceptability of touchscreens is determined by the motivation and perception that could have the potential user of its own ability to cope. The acceptability of tablets will depend on the relationship between applications and ease of use. Moreover, it is dependent on affects and emotions. Positive emotion will significantly and positively influence the use intentions.[60]

However, impairment of cognitive abilities in patients with schizophrenia is a barrier to control interfaces whose use is based on the significant involvement of various fields (attention, memory, executive functions, etc.). Cognitive processes necessary to process visual information as well as triggering appropriate action are also subject to a progressive deterioration in schizophrenia. Indeed, the playful and intuitive aspect of touch interfaces can help increase the motivation and interest of schizophrenic subjects to interact with touch applications during cognitive remediation process. The advantage of this direct interaction for patients is the simplicity, intuitiveness and acceptability of touch tablets.

2. METHOD

2.1. Topics

The sample of this study consists of 20 subjects with schizophrenia. They all meet the diagnostic criteria of DSM-IV-TR (American Psychiatric Association, 2003). The symptomatology was assessed by using the PANSS: Positive and Negative Syndrome Scale.[61]

The subjects were hospitalized during long stay at the Psychiatric Hospital of the Cross in Beirut Lebanon. None of them had a history related to a head injury, a brain disease, to epilepsy, a psychiatric comorbidity, and abuse of substance or electroconvulsive therapy in the previous six months. They all were stabilized clinically and chemotherapeutic plane for more than 3 months. These exclusion criteria are necessary to eliminate the risk of sedative or extrapyramidal side effects caused by some antipsychotics, and the effect of schizophrenic symptoms on attention abilities and motivational level of patients.

The study sample was divided into two equal groups (10 subjects per group) and homogenous (age, performance, level of education). The first group (Group “Classical task" - said control group) was supported by a program using the traditional activity as a means of remediation (classical task t1). The second group (Group “Touch/tactile task" - said test group) followed the program using the touch pad as a remediation tool (touch task t2).

2.2. Course of the experience: process and materials

The cognitive remediation program set up in this 12 months longitudinal study was carried out in three cycles of remediation, each of which included 16 sessions of the visuospatial working memory remediation. Remediation usually takes place at the rhythm of a weekly session. This is an individual session that takes place in the presence of the therapist and with variant duration between 45 and 60 minutes. The technique used in the cognitive remediation session aims to rehabilitate visuospatial working memory in a practical and intensive training via specific therapeutic activities. This technique has been adapted to patients with schizophrenia and its efficacy has been demonstrated.[12,62] Therefore, two activities were systematically used in all cognitive remediation sessions: Memory Cards and Image Recall which were presented in tactile (non-tactile) and non-tactile (wood and cardboard) form according to the each group.

First, the activity Memory Cards was proposed to the patient at the beginning of the remedial session. This activity targets the Spatial Memory direct order and reverses order. It consists of several difficulty levels, where images of animals are shuffled and placed face down. This activity allows the storage of spatial location elements; the subject must discover two like elements forming a pair with the aim to guess all pairs as soon as possible. If the up cards are not a pair they are again covered (automatically with the touch pad and manually with the standard tool) and the game continues until all pairs are discovered.

Then the activity Reminder image was proposed to the patient as the second remediation exercise. This activity targets the Visual Memory (VD1). It is to carefully observe a series of 60 images and signal repetition. The subject should not do anything if the image appears for the first time. By cons, if he notices that the image appears for the second time, he must tap the screen of the touch pad (in case of a tactile remediation) or verbally inform the therapist that he already has (in case of a conventional remediation where images are presented by the therapist.

Finally, a questionnaire of appreciation is presented at the end of remediation session to collect aggregate data on the performance, the Facility, Interest and Progression. This is to assess patient motivation and the acceptability of the remedial tools.

Moreover, as part of this study, 5 sessions of cognitive assessment was conducted to assess the progression of topics. A first cognitive assessment (period denoted P0) is carried out at time 0 before the first cycle of remediation. Then evaluation sessions were proposed after each remediation cycle (periods noted P1 to P3) in order to measure patient progress as and the management. A “remote” evaluation (denoted period P4) was also performed 6 months after the remediation program. The results of this assessment were compared with those of the P3 assessment that was conducted at the end of cognitive remediation program in order to assess the maintenance of long-term mnemonic abilities.

Note that the first assessment (P0) was not taken into account neither in the analysis of the effect of the task (T effect) because it was conducted before starting the remediation program, nor in the assessment of remediation activity by subjects in the study that was assessed from the first cycle of remediation.

2.3. Data collection and Dependent Variables (VD)

Cognitive assessment

During the cognitive evaluation session, participants were subject to an assessment of visuospatial working memory: it is both a measure of the Visual Memory (VD1) using the test MemTrax[63]; and a measure of spatial memory direct order (VD2) and reverse (VD3) made using the MEM-III test: Spatial Memory.[64]

All these tests were standardized on large samples and have, therefore, well-established standards. Thus, the order of the tests performed is the same for all participants. Moreover, every evaluation starts with a detailed description of the task and the instructions associated with each test condition. This step is to ensure that participants have understood the whole task.

Assessment of the remediation activity

The assessment questionnaire that was presented at the end of each cognitive remediation session has 4 evaluations, each being scored on a 20-point scale (from 0 very much unappreciated to 20 very appreciated). Indeed, 4 Dependent Variables (VD) are collected by the assessment quiz.

- Printing of the patient's performance in the training activities (VD4),
- Ease of activity performed (VD5)
- The interest for the session (VD6)
- The progress of the patient in the remediation program (VD7).

These assessments continuously collect the level of appreciation of the remediation activity by the study subjects.

In total, 7 dependent variables were collected in our study (3 VD "Cognitive Assessment" and 4 VD" Evaluation of the activity") (table 7) and will be analyzed for 2 factors studied: Task (t1 experimental group "Touch task" and t2 control group "Classical task"), and periods (P0, P1, P2, P3, P4). We present in Table 2 below, the Dependent Variable (DV) of the study, their scores, and their abbreviations as they appear in the text, in the graphs and tables presented in the following chapter. The factors (variables) underlying the assumptions are also indexed.

Table. 1: The dependent variables and factors of the study.

Dependent variables (VD) and factors studied				
Cognitive Assessment	**No. VD**	**VD "Cognitive Assessment "**	**Abbreviation**	**Score**
Visuospatial working memory	VD1	Visual memory	MV	/ 25
	VD2	Spatial memory direct order	MVSOD	/ 7
	VD3	Spatial memory reverse order	MVSOI	/ 7
Assessment of the activity	**No. VD**	**VD " Assessment of the activity"**	**Abbreviation**	**Score**
Assessment items	VD4	Printing the patient's Performance	Performance	/ 20
	VD5	Easy ease of activity performed	Ease	/ 20
	VD6	Interest in remediation session	Interest	/ 20
	VD7	Patient Progression	progression	/ 20
Factors				
Task	**t1:** Experimental group "Touch task"			
	t2: Control Group "Classical task"			
Periods	**P0:** First evaluation in time 0 (before the treatment)			
	P1: Second evaluation (after a first round of remediation)			
	P2: Third Assessment (after a second round of remediation)			
	P3: Last assessment (after the last cycle of remediation)			
	P4: Remote Evaluation (after 6 months of the end of the remediation).			

3. RESULTS

Data analysis first will focus on the effect of the period (P0, P1, P2, P3), the effect of the task related to the types of groups based task used (t1-t2), the "interaction effect" Task-period ", then the effect of maintaining capacity (effect between P4 and P3). The analyzes of variance (ANOVA: F Snedecor Fisher) were performed in order to compare, on the one hand, the scores of experimental subjects "Touch task" with those of the control group "Classic task" for Dependent Variables (VD) collected from cognitive assessment (MV VD1, VD2 MVSOD, VD3 MVSOI) and the appreciation of the activity (VD4 Performance, VD5 Facility, VD6 Interest, VD7 Progression); and secondly, the scores for the different periods of supported/ or treatment. These analyzes will thus appreciate the evolution of the performance of subjects according to the nature of the material involved. While the Student t test for paired data was used to analyze the effect of the task of maintaining capacity (Table 3).

Table. 2: Clinical and sociodemographic data of 20 subjects.

	Average (years)	SD
Age	38.7	4.6
Level of education	12.05	3.3
Duration of illness	13.7	4.7
	Average (score)	**SD**
PANSS EP	18.3 / 49	5.5
PANSS EN	17.5 / 49	5.1
PANSS EGP	44.4 / 112	11.9

Age, educational level and duration of the disease are given in years. PANSS is able to score the three subscales: Positive Scale (EP); negative scale (EN); general psychopathology scale (EPG).

Table. 3: Data analysis by ANOVA and Student's t test (S: Topic P: Period T: Task, α: significance threshold required).

Test	Effect	Map protocol	Degrees of freedom (dof)	α
ANOVA	Effect of Period	S10 * P4	dof [3, 27] (Global Effect) dof [1, 9] (Conditional Effect)	.05
	Effect of Task (experimental / control group)	S10 <T2> * P3	dof [1, 18] (Global Effect) dof [1, 18] (Conditional Effect)	.05
	Interaction effect Task-Period	S10 <T2> P4 *	dof [3, 54] (Global Effect)	.05
Student	Effect of maintaining capacity	S10 * P2	dof [9]	.05

3.1. Visuospatial working memory (VD1 MV, VD2 MVSOD, VD3 MVSOI)

3.1.1. Period effect (effect of P)

➢ **Experimental group "Touch task"**

The analysis of the overall effect of the period shows a significant difference between the different periods of support for the visuospatial working memory: Visual memory (F [3,27] = 32,326, p <.001; difference of means d = 7.9 / 25), Spatial Memory direct order (F [3,27] = 32,538, p <001;. d = 1.5 / 7) and reverse (F [3,27] = 19.33, p <. 001; d = 1.5 / 7).

➢ **Control Group "Classical task"**

As for the control group “Classical task", the analysis of the overall effect of the period is significant for the visual memory (F [3,27] = 10,287, p <.001, d = 4.9 / 25), indicating a significant increase during the treatment. Compared to the Spatial Memory direct order, the subjects of the group " Classical task" have improved performance as they are being managed (mean difference d = 0.5 / 7). However, this progress has not been significant enough to mark a significant effect in the period.

Therefore, we see that as and from the management, the subjects of the group “Touch task" marked an important progress in the Visual Memory (d = 7.9) and Spatial Memory direct order (d = 1.5 / 7) and reverse order (d = 1.5 / 7) (Figure 1). However, the obvious progress of the group “Classical task" was limited to the Visual Memory (d = 4.9 / 25).

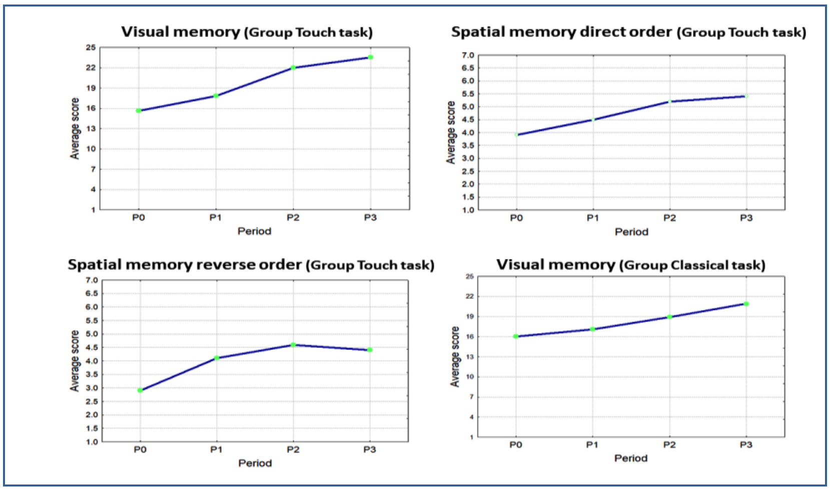

Figure. 1: Effect of the period on the development of patient performance in visuospatial working memory.

3.1.2. Effect of the task (Effect T)

ANOVA on the overall effect of the task, reveals a significant difference in performance between the two groups Touch and Classic for visuospatial working memory: Visual memory (F [1,18] = 4.451, p <. 05; d = 2.13 / 25), Spatial Memory direct order (F [1,18] = 9.816, p <.01; d = 0.77 / 7) and reverse order (F [1,18] = 13,396, p <. 01; d = 0.96 / 7). Indeed, the group's performance "Touch task" was more important than those of the group "Classical task." In this analysis, it was found that the performance of the subjects of the group "Touch task" were consistently higher than those of the "Classical task" group, suggesting an effect of material on the remediation of the cognitive deficits in schizophrenia (Figure 2).

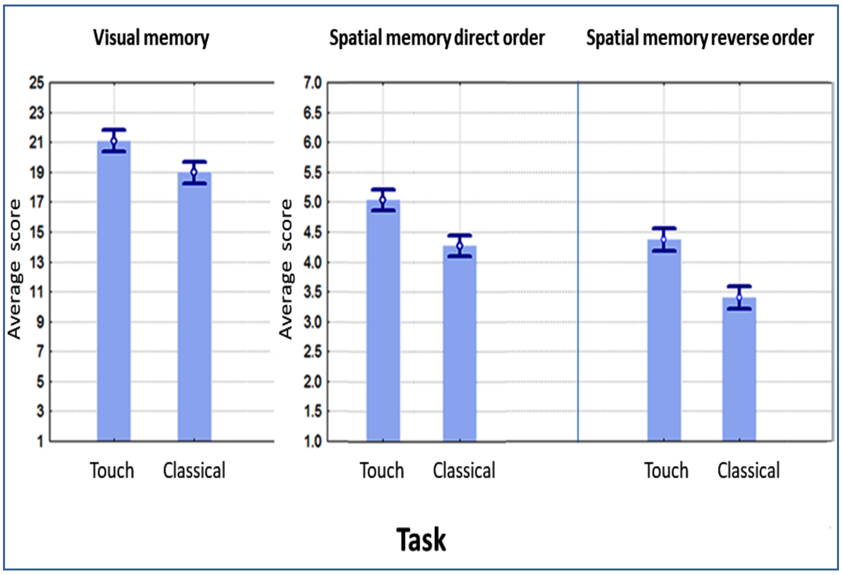

Figure. 2: Effect of the task on improving patient performance in visuospatial working memory.

3.1.3. Interaction effect Task-Period

As regards the effect of Task-period interaction, the analysis of the results shows a significant effect for the visuospatial working memory: Visual memory ($F[3,54] = 3.101$, $p < .05$), direct space spatial memory ($F[3,54] = 5.432$, $p < .01$) and reverse order ($F[3,54] = 7.248$, $p < .001$). This explains that the effect of the task has increased during rehabilitation, which resulted in a significant difference in performance between the two study groups (Figure 3). In fact, the subjects of the group "Touch task" developed performance in visuospatial working memory much higher than those of the group " Classical task" and this difference has become increasingly important as and measurement supported.

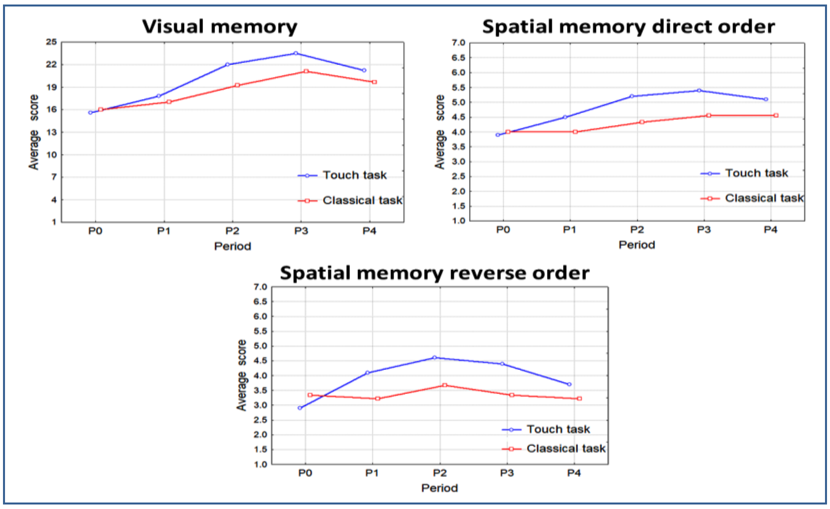

Figure. 3: Evolution of the performance of visuospatial working memory in patients according to the periods of the supported.

3.1.4. Effect of maintaining capacity

In order to assess the effect of the task on maintaining long-term memory abilities, we conducted a remote evaluation (P4) after 6 months of the end of remediation for visuospatial working memory (direct space spatial memory, spatial memory reverse order and visual memory), then we compared the results of the P4 assessment to those of P3 evaluation that was conducted at the end of cognitive remediation program.

The results show in the group " Tactile task" a preserved performance in Spatial Memory direct order and a regression in reverse order Spatial Memory (mean difference $d = 0.7 / 7$) and Visual Memory ($d = 2.3 / 25$). Compared to the group "Classical task" the results show a decline in visual memory ($d = 1.5 / 25$) and a maintaining in spatial memory performance direct order and reverse order. However, the difference is not significant at the Student test (for paired data) only for the "Touch task" group: Visual Memory (t [9] = 3.183, p = .011) and Spatial Memory reverse order (t [9] = 4.582, p = .001) (Figure 4).

Despite this significant decline, the performance of the group " tactile task" remain much higher than those of group " classical task" six months after the end of cognitive remediation program. The regression of patient performance in visual memory and Spatial Memory reverse order could be explained by the lack of cognitive stimulation. This drop stresses the importance of cognitive stimulation on basic cognitive processes in the management of schizophrenia and tends to confirm that brain plasticity is possible in patients with schizophrenia during the chronic phase of the disease. Therefore, these results of the analysis of the effect of maintaining memory abilities determine the importance of cognitive remediation in the treatment of cognitive deficits in schizophrenia.

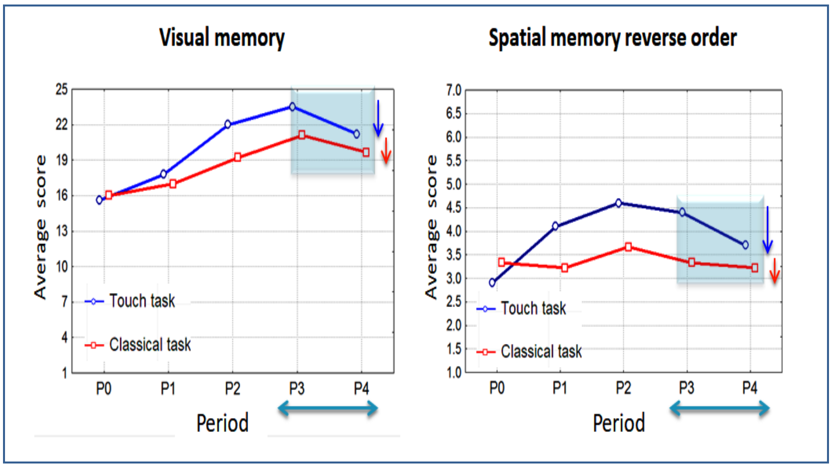

Figure. 4: Effect of the task of maintaining visuospatial working memory capacity after 6 months of the end of remediation.

3.2. Assessment of the activity (VD4 Performance, VD5 Facility, VD6 Interest, VD7 Progress)

3.2.1. Period effect (effect of P)

➢ **Group "Touch task"**

Compared to the appreciation of the remediation activity, the analysis of the overall impact of the period shows a significant difference for the following appreciations items: Performance (F [3,27] = 4.634, p <. 05; d = 1.95 / 20) and Facility (F [3,27] = 5.99, p <.01; d = 1.85 / 20). We see that as the management of the task was improved, the subjects in the 'Tactile task' group saw the remediation activity as easier; in addition, they had the impression of being more efficient (Figure 5).

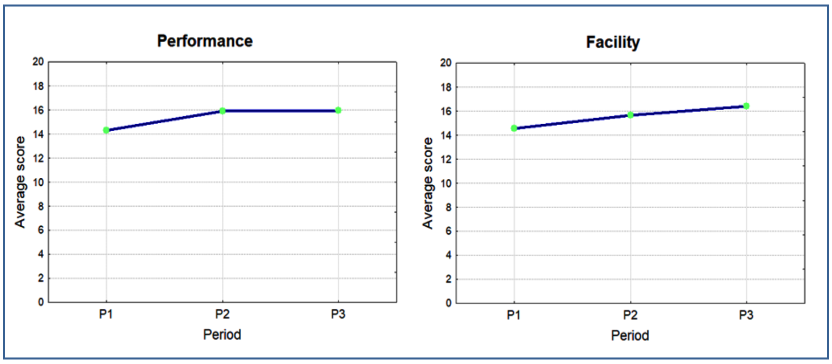

Figure. 5: Effect of the period on the assessment of the remediation activity by the subjects of the group "Touch task".

➢ **Group " Classical task"**

Among the subjects of the "Classical task" group, the period effect was not significant for the assessment items. This indicates that the appreciation of the remediation activity by the subjects of the group "Classical task" has not changed during cognitive remediation program.

3.2.2. Effect of the task (Effect T): Regarding the assessment of remediation activity by the subjects of the study, the analysis of the overall impact of the task shows a significant difference between the two groups for the following items: Facility (F [1,18] = 25.126, p <.001, d = 2.55 / 20), Interest (F [1,18] = 23,088, p <.001, d = 2.55 / 20) and Progression (F [1,18] = 12.163, p <.01;. d = 1.7 / 20). In fact, the subjects of the group "Touch task" had more interest in the remediation session than group "Classical task," and they found the activity as easier allowing them to mark a progression more significant (Figure 6). Regarding the performance item, the difference was not significant between the two groups, however, the subjects of the group "Touch task" were more likely to perform well in the remediation activity than the "Classical task" group (d = 1.1 / 20).

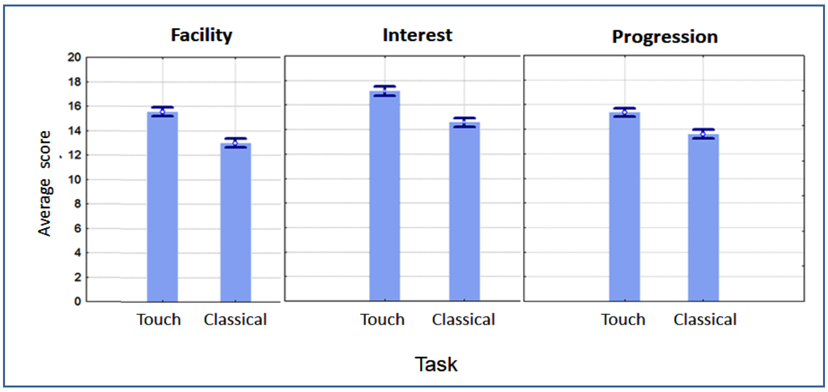

Figure. 6: Remediation activity Assessment of visuospatial working memory by the study subjects.

4. DISCUSSION

The results obtained in this study reflected the difficulties in terms of working memory in people with schizophrenia. These data confirm previous research showing the alteration of these cognitive abilities in schizophrenia.[26,27,65-68] From this research work, we obtain significant results in terms of improvement of visuospatial work memory following cognitive remediation. These results are in agreement with previous studies that have highlighted the beneficial effect of cognitive remediation on memory deficits in schizophrenia.

From this research, we get significant results in terms of improvement of visuospatial working memory after cognitive remediation. These results are consistent with previous studies that have highlighted the beneficial effect of cognitive remediation on working memory deficits in schizophrenia.[23,69,70]

The main objective of this study was to examine the contribution of touch technology in cognitive remediation in schizophrenia. The analysis of the effect of the task showed an improvement of visuospatial working memory higher in the subjects of the group "Touch task" versus the group “Classical task". Moreover, the data collected in the analysis of the effect of the period allowed us to demonstrate the existence of an improvement in visuospatial working memory faster in subjects of the group "Touch task ". This can be explained in particular by the interactive aspect of the touch pad, which facilitates the approach to people with schizophrenia and encourages the motivation of these to become more involved in the remediation program.

Our observations show that remediation by the touch interface would allow a better performance on visuospatial working memory in people with schizophrenia. Touch technology allows accurate remediation of visuospatial working memory disorders through appropriate applications targeting the poor functionality and providing reliable indicators, response time, number of trials and errors. Indeed, it allows for a more appropriate remediation, automatically controlled, parameterized and playful, offering thereby a way that goes beyond traditional tools. These data lead to consider the influence of the nature of the remediation material on patient progress.

In addition, the results of the assessment of the remediation activity by the subjects of the study indicate that the touch technology would be a positive contribution in terms of interest, acceptability and sense of efficacy and satisfaction associated to the use of this method of remediation. These results confirm and extend those obtained in the study by Wolff et al. (2014)[49] and on the contribution of touch pads in the support and assist of children and adolescents with autism.

Similarly, taking into account the intrinsic motivation in the remediation of visuospatial working memory, through the use of touch technology, seems to be an interesting option. Especially that, by the effect of withdrawal and apathy, the apragmatism, and / or long-term hospitalization, subjects with schizophrenia tends to be only slightly stimulated cognitively. Motivation is extremely important and its return is positive on the performance during the remediation itself or during the presentation of the results. Our results have indeed confirmed previous studies that have highlighted the role of motivation in improving neurocognitive functioning, as well as engagement in learning activities [30,38,40,41,71].

As part of this study, touch technology has proven to be effective in improving cognitive functioning of patients with schizophrenia. This technology also offers the ability to achieve the therapeutic objectives and opens up new perspectives in cognitive remediation parallel to the traditional clinical approach, thus responding better to the problem of impaired visuospatial working memory in schizophrenia. Indeed, it has a clear innovation to enrich remediation techniques. It is an effective and promising technique to overcome the cognitive difficulties of the patients in the schizophrenia spectrum.

The contribution of tablets in cognitive remediation in schizophrenia is indisputable. Our research has shown many positive aspects to the use of the touch pad especially in the remediation of visuospatial working memory. The biggest advantage of the touch pad is its fun and interactive appearance and acceptability. It allowed the kind of simplify usage by offering a more direct interaction with the user. Another advantage of the touch pad is its mobility. Indeed, patients with schizophrenia may use the tablet in the rehabilitation center, but also at home. In this case the patient can self-train with specific applications recommended by the therapist. Thereby, the use of a tactile device in cognitive remediation offers the therapist a better management of the activities and the remediation program, and helps the patients to gain individual initiative and to make a "self-remediation." In this case, the responsibilities will be more developed and bring patients to be more autonomous in the remediation process. This strengthening even more social inclusion.

Consequently, we can say that there are very few limits in the use of the touch pad in cognitive remediation in schizophrenia. All the difficulties lie in the design of specific applications and tailored to the remediation of various cognitive functions (attention, memory, executive functions, etc.). The quality of an application depends on its ability to provide a useful and specific means. It is able to target the desired cognitive function and lead it; hence the need to design applications compatible with the nature of the disability and to set up user experiences in order to assess the usability and acceptability of designed applications. Ultimately, innovative technologies such as tablet computers offer new modes of interaction that can be exploited to develop new methods of remediation. The application will be successful if it combines useful service and friendliness of use and whether if it offers a fun interaction that targets simultaneously treatment goals.

Furthermore, this study has limitations that we will try to evoke. A major limitation of this study concerns the subtype of schizophrenia. In fact, the subjects of this study were selected based on their medical diagnosis that is schizophrenia, however, the subtype of schizophrenia (paranoid, disorganized, residual, etc.) has not been considered in the choice of the study sample. It would seem appropriate to consider the subtype of schizophrenia and even take a sample that belongs to the same sub-type which makes it more homogeneous.

On the other hand, the schizophrenic symptoms were assessed by the PANSS only before the management of the working memory. It should have been interesting to also evaluate symptoms after the treatment in order to study the effect of improving the working memory on schizophrenic symptoms. Especially since there is a relationship between cognitive performance and schizophrenic symptoms.

5. CONCLUSION

The objective of our ergonomics approach is to provide the means, through a research activity, to facilitate the appropriation of touch technologies in cognitive remediation and thus improve the care of patients with schizophrenia. The approach consists in developing and structuring ergonomics knowledge that can be used in disability, including integrating and developing assistance for rehabilitation and rehabilitation tools. Moreover, the same principle of the ergonomic approach, it is essential to know the capabilities and needs of patients with schizophrenia in order to build some design rules based on these data. It is therefore a matter to provide elements to the various actors in the areas of rehabilitation and design for the development of methods and rehabilitation tools, so that they meet the requirements of the management of deficits cognitive in schizophrenia.

In conclusion, this work has helped to highlight innovative results on the integration of touch technology in cognitive remediation. It appears that the integration of the touch interface in the remediation process is well accepted by patients and therapists. The assessments caused by use of touch technology in cognitive remediation are key indicators of satisfaction and acceptability. These results emphasize the beneficial effect of the use of touch technology targeting the improvement of working memory in schizophrenia. They should create opportunities for the use of this new therapeutic tool in cognitive remediation.

Our research on the use and accessibility of tablets by people with schizophrenia is, ultimately, extremely relied on the experiments performed. During the experiments, we were pleasantly surprised of the acceptability of the touch pad by the subjects of the group “Touch task". It is certain that the touch pad has almost not been adopted by centers specializing in the treatment of schizophrenia. However, we see through our study of real needs and a positive perception of the touch pad on the part of patients. Indeed, the touch pad is highly recommended. It helps the therapist to provide better care by using innovative tools in cognitive remediation.

However, it is understood that the results of our research concern deficits in schizophrenia working memory. It would be interesting to conduct further studies to evaluate the use of touch technology in the remediation of other cognitive functions. Moreover, it remains to discover whether this technological innovation ensures the rehabilitation of cognitive functions in other diseases that may benefit from cognitive remediation such as Alzheimer's disease, childhood psychosis, hyperactivity in children, addictions etc. We plan to continue our questioning by applying it this time to other mental and cognitive disorders. Thereby, many questions concerning the technical parameters to be retained for the best use of tactile technology in cognitive remediation still persist and will find answers with the multiplication of studies in the field.

Finally, this study has enabled us to respond fully to our initial problem. Indeed, we wondered about the place that could find touch technology in the process of cognitive remediation in schizophrenia. We can now say that it is possible and essential to integrate this innovative technology in the programs of remediation and rehabilitation.

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