ALZHEIMER'S DISEASE AND IMPLICIT MEMORY

Sergio Machado[1,3], Marlo Cunha[1,3], Daniel Minc[1], Claudio Elidio Portella[1], Bruna Velasques[1,3], Luis F. Basile[4,5], Maurício Cagy[6], Roberto Piedade[1], Pedro Ribeiro[1,2,3]

Abstract – Specific neuropsychiatric disorders, such as Alzheimer's disease (AD) affect some forms of memory while leaving others relatively intact. In this review, we investigate particularities of the relationship between explicit and implicit memories in AD. It was found that implicit memory is preserved in AD, irrespective of the task used; in other words, there was not interference from explicit memory. In addition, it was verified that is possible through implicit memory compensatory strategies such as, activities of daily living (ADL) to compensate for the explicit memory deficits. In this sense, cognitive rehabilitation (CR) demonstrates reasonable results in the process of compensation of explicit memory deficits. Concluding, the decline in explicit memory suggests that both systems are functionally independent even if the other is compromised. We expect that when explicit memory system is not involved in competition with the implicit system, the final effect of learning is better, because all of the implicit memory capacity is engaged in learning and not in competition with the explicit system.

KEY WORDS: activities of daily living, Alzheimer's disease, cognitive rehabilitation, implicit memory.

Doença de Alzheimer e memória implícita

Resumo – Distúrbios neuropsiquiátricos específicos, tais como a doença de Alzheimer (DA), podem afetar algumas formas de memória enquanto deixam outros relativamente intactos. Nesta revisão, nós investigamos particularidades da relação entre as memórias explicita e implícita na DA. Foi verificado que a memória é preservada na DA, independente da tarefa usada; ou seja, não ocorre interferência da memória explícita. Além disso, foi verificado que é possível através de estratégias compensatórias de memória implícita, tais como, atividades da vida diária (AVD) compensar os déficits da memória explícita. Neste sentido, a reabilitação cognitiva (RC) demonstra resultados razoáveis no processo de compensação dos déficits da memória explicita. Concluindo, a queda na memória explícita sugere que ambos os sistemas são funcionalmente independentes mesmo que outro esteja comprometido. Esperamos que quando o sistema de memória explícita não está envolvido em competição com o sistema implícito, o efeito final de aprendizagem é melhor, porque toda a capacidade da memória implícita está engajada na aprendizagem e não na competição com o sistema explícito.

PALAVRAS-CHAVE: atividades da vida diária, doença de Alzheimer, memória implícita, reabilitação cognitiva.

Memory is the recording, retention and retrieval of information. It accounts for all knowledge gained through experience. Memory is not a unitary process, but is composed of dissociable systems that mediate specific types of mnemonic function[1]. Specific neuropsychiatric disorders, such as Alzheimer's disease (AD) can affect some forms of memory while leaving others relatively intact. One form of memory, explicit memory (EM)[2,3], is the ability to consciously and directly recall or recognize recently processed information. It is under the control of the hippocampus and temporal lobe connections, essentials for the formation of new episodic memories[4,5]. This type of memory is highly impaired in AD patients and is usually the first symptom of dementia. It has been linked to pathological, structural and functional abnormalities within the mesial temporal lobe (MTL) and diencephalic struc-

[1]Brain Mapping and Sensory Motor Integration, Institute of Psychiatry of Federal University of Rio de Janeiro (IPUB/UFRJ), Rio de Janeiro RJ, Brazil; [2]School of Physical Education, Bioscience Department (EEFD/UFRJ), Rio de Janeiro RJ, Brazil; [3]Brazilian Institute of Neural Bioscience (IBBN), Rio de Janeiro RJ, Brazil; [4]Division of Neurosurgery, University of São Paulo Medical School, Brazil; [5]Laboratory of Psychophysiology, Faculdade de Psicologia e Fonoaudiologia, UMESP, Brazil; [6]Division of Epidemiology and Biostatistics, Institute of Health Community, Federal Fluminense University (UFF), Rio de Janeiro RJ, Brazil.

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Dr. Sergio Eduardo de Carvalho Machado – Rua Professor Sabóia Ribeiro 69 / 104 - 22430-130 Rio de Janeiro RJ - Brasil. E-mail: secm80@yahoo.com.br

tures. Such facts are based on studies using post-mortem examination[6], structural imaging[7], resting metabolism[8] and functional imaging[9-14].

Another form of memory, implicit memory (IM), is the ability to improve task performance. It reflects the unconscious effects of previous experiences on subsequent task performance, without conscious recollection. IM is independent of the middle temporal lobe (MTL) and diencephalic structures[14]. It is involved with the unconscious recognition of an object (i.e., priming) and the correct completion of the steps in a task (i.e., procedural memory)[15]. IM is assessed indirectly by measuring facilitation in performance (i.e. decreased processing time or increased accuracy) due to previous exposure to identical or related information. It has been consistently shown that procedural memory remains relatively preserved throughout the course of AD[16-21].

In this review, our objective was investigating particularities of the relationship between explicit and implicit memories in AD. In this sense, we focus on the following questions: (a) if implicit memory is affected by explicit memory deficits; (b) if implicit memory compensatory strategies such as activity of daily living (ADL) and could be employed to compensate for the explicit memory deficits. According to the above questions, we developed a strategy for searching studies in the main databases. The computer-supported search used the following databases: *Pubmed, Medline, ISI Web of Knowledge* and *Scielo*. Only clinical and experimental reports published in English and conducted from 1987 up to 2008 were considered. The key words used were: *implicit memory, habit learning, motor learning, motor skills, priming, procedural memory and sequence learning,* all of them in combination with *Alzheimer's disease*. The inclusion criteria for the studies related to first question were: (a) a clinical diagnosis of Alzheimer's disease based on specified and generally accepted criteria; (b) implicit tasks; (c) task performance expressed in time or error measures, and not only in fMRI or other imaging data.

ALZHEIMER DISEASE AS A MODEL TO UNDERSTAND MEMORY

Models may be literally viewed as a *partial* approximation of reality, in the sense that we do not intend to replace the phenomenon *per se*, but compose them by elements of the phenomenon[22]. By this definition, models are parts of the reality that researchers have chosen to assemble together in order to more clearly observe the phenomenon itself[23]. Pathologies that impair the central nervous system (CNS) functions lead to pathophysiological states that can be seen as models for our understanding of how the healthy CNS works. Scientists have also been strenuously trying to figure out different patterns of pathological behavior by means of models[24]. At the same time, CNS diseases being a synonym of pain and suffering for patients and family members, the use of models that select specific disease peculiarities may aid us in the prevention, better management during the course of the disease, and occasionally its cure. AD is no exception to this paradigm. AD has become a "stage" type of model for the study of mental processes, in particular of different kinds of memory. Over the last 30 years, an increasing amount of time, effort and money have been devoted to decipher memory storage and recovery processes by means of the AD pathophysiological model. During this era, a vast amount of physiological knowledge was produced in our attempts to cure or slow down the normal course of AD. The present manuscript is a contribution to this effort, aiming at the relationship between explicit and implicit memory and their possible mechanisms, where we review state of the art experiments designed to uncover mechanisms of explicit and implicit memory by their relations with the AD process.

EXPLICIT MEMORY DEFICITS AFFECT THE IMPLICIT MEMORY?

A task performance is a complex network of operations. A subject may be instructed to remember a previous event (i.e., explicit retrieval task) or simply perform a task with no reference to a previous event (i.e., implicit retrieval task). However, one may evoke any cognitive process in performing a memory task, and thus may intentionally evoke explicit processing (e.g., using previous memory) to improve performance on an implicit task. This is relating to as explicit contamination[4,25,26]. Several older individuals, with and without AD, have explicit memory impairment, therefore, using implicit tasks that are known to draw some degree on explicit processing will result in compromised implicit memory compared to young subjects. To address this problem, it is important to use priming tasks that are known in AD patients[27]. Other methods that have been used to measure and to minimize explicit contamination in priming include using within-task manipulations, such as depth-of-encoding, that affect explicit but not implicit performance[28], presenting test-phase stimuli very briefly[25,29], and extending the interval between the study and the test phase[29]. In addition, Mitchell and Brus[29] verified that priming was constant when different groups (i.e., young, middle aged and old subjects) were intentionally submitted to explicit strategies in implicit retrieval. Moreover, the authors concluded that most implicit memory processes remain stable and justifiably cautioned that explicit contamination of implicit retrieval should be rigorously monitored in aging studies.

According to evidence, priming and procedural memory share a few underlying neural activation in the neostriatal system, where gradual learning occurs across trials, even without conscious recognition. However, each process has separate mechanisms[26,30,31]. Priming is influenced by frontal cortex, which may reflect its attentional demands[32-34] and procedural memory is influenced by the striatum, sensorimotor cortex and cerebellum[30,35,36], which may reproduce its motor skills. Explicit memory impairment is one of the earliest AD symptoms, and its loss characterizes all the stages of AD[37]. Although some types of implicit memory are also lost in AD, certainly, other ones are preserved into late stages of disease[5]. The neurodegenerative pattern of AD progression and the dissociation of implicit and explicit memory enable patients to preserve some types of implicit memory despite of severe explicit loss. This finding is supported by evidence from priming and procedural memory studies, demonstrating that individuals in the mild to moderate stages of AD show improvement in implicit memory tasks[5,38,39]. In this sense, interventions in AD patients have potential to maintain function through increased speed or accuracy when completing a task.

When these patients are repeatedly expose to an object, these patients can process information faster and/or more accurately compared to baseline[5,40]. The perceptual priming spare in AD patients has been demonstrated using words[38], objects nonverbal responses to pictorial material[41,42] and a picture fragment task[38,43]. On the contrary, conceptual priming becomes impaired early in AD[42,44,45] due to its reliance on semantic memory, which is also impaired in early stages of AD. Thus, AD patients demonstrate intact perceptual priming despite impaired conceptual priming[5,43,46]. Moreover, long-term retention of procedural memory among mild- to moderate-stage AD patients has been found when the tasks are practiced under constant but not in random practice conditions[21]. These patients demonstrate the same amount of improvement in implicit skill learning (despite a lower baseline performance) on tasks as normal control subjects[21,47]. Performance improvement in these implicit memory skills among AD patients is similar to healthy controls[5]. According to such facts, these dissociations account for a common clinical situation: AD patients who can accurately use a toothbrush while they can no longer name a picture of a toothbrush or describe the steps used. In this sense, in the next two subsections we will discuss whether implicit memory is affected by explicit memory deficits.

Modulation of implicit learning capacity due to explicit memory deficits in ad patients

Several studies highlight the implicit learning capacity of AD patients. Some studies using a Maze test in which blindfolded subjects had to trace a complex pathway reporting that the AD patients were able to learn new motor-skills implicitly[48-51]. Other studies apply a Rotor-Pursuit task, where subjects had to maintain contact between a hand-held stylus and a rotating spot, demonstrating preserved learning abilities in AD patients[52-56]. In agreement with the above findings, studies based on a Puzzle-Assembly task[57] and based on a Mirror-Tracing task[47] shown the same results' pattern. In order to investigate this capacity in AD patients, others experiments used the Serial Reaction-Time task (SRTT) in which subjects had to respond as fast as possible when a stimulus appeared in one of four places by pressing a response key. It was observed that AD patients demonstrated implicit learning capacity as reflected by the difference in reaction times (RTs) between blocks with a decrease in RTs in a fixed sequence of stimuli presentation and prolonged RTs in a random block[56,58-60].

On the contrary, others studies, indicate that the implicit learning capacity in AD patients is affected because they presented inferior outcomes when accuracy was taken into account[56] or when the data were log-transformed because of the unequal variance in RT[60]. However, Ferraro's experiment found preserved procedural memory (SRTT) only in the "very mildly AD" group and less in the "mildly AD" group although it is relevant to mention that almost all studies used a subtle disease classification[61]. Thus, regardless of task used, the studies assessing Procedural Memory in AD patients and shown positive outcomes. Indeed, Hirono et al. observed that patients with mild AD were able to acquire motor and perceptual as well as cognitive skills in various motor skills learning tasks[62].

Remaining performance level and amount of learning in AD patients

According to the previous discussion about the preserved implicit learning capacities in AD patients, our next question is for how long this process will last? In this manner, two aspects in implicit memory issue should be differentiated, i.e., overall performance level and amount of learning, for example, the decrease in RT in the SRTT task. Several studies found preserved procedural memory in AD patients, although their performance level in terms of reaction and movement time were inferior when compared with controls. However, when it takes the level of learning into account, the results are less consistent.

Some results were not reported with enough detail to show unambiguously the amount of learning which AD patients shown when compared to the controls[57]. Some comparative studies did not include a healthy control group in addition to the patient groups[50-52,59,63] preventing patient-control comparisons. Other studies using a Maze test reported learning capacities in the AD group but less improvement across trials compared to the controls findings[48,49], which can be explained by the use of a task without visual feedback. In the same way, in SRTT studies AD patients shown the same amount of learning (decrease in RT during the blocks with the fixed sequence) as the normal controls[56,58,60,61]. The Rotor-Pursuit experiments there were also no patient-control differences in amount of learning[53-56,58,62,64-66]. Taken together, all studies shown preserved procedural memory in AD patients regardless of the task used.

Their performance levels, however, never reached the levels of the healthy controls, demonstrated by their prolonged reaction and movement times. The AD patients' level of learning also varied depending on the task to be performed. It suggests that visual feedback has a positive effect on their learning pace. They also seem to experience more problems with motor skills learning when performing the SRTT in two learning processes. Therefore, the subjects have to dominate both spatial and motor regularities[67], do not remembering that is the learning of spatial regularities that may be impaired in AD patients, a process that is less implicated in the Rotor-Pursuit task in normal motor skills learning in AD patients.

IMPLICIT MEMORY MAY BE USED A COMPENSATORY STRATEGY TO COMPENSATE FOR THE EXPLICIT MEMORY DEFICITS?

During the initial stages of explicit learning, involving trial and error, subjects have to find out the correct movement. The critical requirement is the novel establishment of perceived sensory cues with the correct motor commands. For this purpose, subjects have to attend to sensory cues. They have to decide which movement will be initiated immediately (if feedback is given) and they have to encode the perceived response in memory. Thus, the establishment of a novel arbitrary sensorimotor association (as it is required during learning by trial and error) is closely related to attention[68], decision and selection of movements, sensory feedback processing and working memory. Once subjects figure out the correct movements the map of sensorimotor translation is provided. Sensory stimuli have to be retained in working memory to be translated to the motor output[69], performance of actions is still slow and unskilled and feedback and attentional processing play a critical role[70].

In this manner, during the implicit learning (i.e., with practice), sensorimotor maps become stronger and are stored in long-term memory. Visual cues are transformed accurately and rapidly to the precise motor response. Hence, action can be performed with less intensive sensory feedback processing and at higher speed. After long-term practice, movements become automatic and can be performed at high speed and accuracy, even if subjects do not attend to the action. Thus, variables such as practice and feedback can be structured differently to enhance learning at each stage. Feedback in early stage, for example, may need to be more specific and applied more frequently to enhance learning, while feedback may be weaned toward the third stage of learning[71]. It has been proposed that in implicit learning the three stages might overlap or be ordered differently. There is support for a parallel development of implicit and explicit knowledge in learning[72].

According to the evidence found in the previous section, AD patients seem to have the implicit memory preserved. Thus, in the following section, we will discuss if through implicit memory compensatory strategies, such as: ADL is possible to compensate for the explicit memory deficits. In this manner, we based on two variables, practice and feedback, that play a worthwhile role in implicit memory.

Practice role in AD patients' performance

In relation to variable practice, the principle "the more you practice, the more you learn", implies that the amount of practice should maximize the implicit memory. However, does more practice improve the implicit memory performance in AD patients? Dick et al.[54] found on the Rotor Pursuit that both AD and control groups had reached their optimal performance after 40 trials due to subsequent practice failed to yield any additional augmenting effect. It would be interesting to determine whether this also holds for other tasks like the Maze test in which, relative to the controls, an inferior amount of learning was observed for AD patients[48,49]. In this sense, some issues still create doubts. An important factor in relation to the types of practice is what is the best type of practice to preserve implicit memory? Other one that merits closer attention is whether the task should be learned as a whole or per components. Moreover, the amount of practice is also an important question that merits a greater investigation. In relation to this discuss, there are three traditional terms in the literature, random, blocked and constant. Early evidence suggests that random practice might be most effective to acquire motor skills, whereas during the acquisition of a specific motor-skill, performance benefits most from blocked practice[73].

All available studies show that AD patients learn best under constant practice conditions[18-21]. According to Dick et al.[18], humans use their episodic memory of the training trials to accurately perform a task while learning a skill. They suggest that because AD patients experience problems with episodic memory, constant practice is more effective due to repeated running of the same neural networks (NNs) and does not require an intact episodic memory. The second reason why random practice may be less effective is that other cognitive functions that play a role in random practice, e.g., the ability to divide attention, are affected in AD patients.

In this manner, Dick et al.[18,21] try to explain the superior learning performance of AD patients under constant practice condition in terms of the schema theory originally developed by Schmidt[74]. In this experiment, the authors propose a more open-loop account for motor control. The theory of Schmidt assumes the existence of generalized NNs that are acquired through practice and that define the "form" of the action. Moreover, Schmidt claims that these NNs can be altered to meet environmental demands by a closed-loop system using sensory feedback[75]. Consequently, Dick et al.[18,21] based on the theory of Schmidt concluded that AD patients can develop and access a NN in training situations that emphasize movement consistency. However, they do not formed the NNs needed to successfully achieve a movement when the environmental demands change because they are unable to encode and to store the different types of information about a motor pattern.

Feedback role in AD patients' performance

Other crucial variable that influences implicit learning is the type of feedback. There are two types of feedback, intrinsic where the sensory information is provided by motion and extrinsic where information comes from an external source like a verbal command. These types of feedback can contain summary or constant information of performance. It is known that constant feedback enhances only motor performance, not the level of learning. With less frequent feedback, learners have to depend on other cues, which entail more elaborate encoding. In this sense, extrinsic feedback can be shared into "knowledge of results", in which the movement outcome is given in terms of goal, and "knowledge of performance", where the feedback provides the movement pattern itself, e.g., a decreased response time in a SRTT task[73].

When observed, almost all studies on motor-skill learning in AD patients employed visual feedback. However, only the Maze tasks were applied according to blindfolded conditions and the amount of learning in the AD patients proved inferior when compared with the controls[48,49]. In another way, the Rotor-Pursuit experiments individualize the velocity of the target to equate initial performance. According to these findings, some studies indicate that controls generally tracked at a faster rate than the AD patients[54,55,63,64]. Possibly, AD patients can only perform this task at a slower rate because they depend on visual feedback more than controls. The only experiment using a Rotor-Pursuit task in explicit form investigated the role of visual feedback on performance in AD patients. It was demonstrated a decrease in performance when the visibility of the moving target was reduced during the learning phase[53]. On the contrary of the normal controls, the performance of patients did not improve across trials in the restricted-vision condition. In the full-vision condition the patients shown normal learning. It appears that constant visual feedback is important in implicit learning for AD patients. However, it was not found any studies concerning the frequency of external feedback, and whether knowledge of results and knowledge of performance makes a difference in AD group.

In this manner, our results suggest that both forms of feedback knowledge probably place too much weight on the cognitive abilities in AD patients and therefore contribute little to successful performance. According to previous results, the recent findings of Tippett and Sergio[76] demonstrated that the integration of eye and hand information may be impaired in AD patients. In this experiment, it was investigated whether the accuracy of movements requiring a visuomotor transformation in neurologically healthy elderly subjects compared with patients diagnosed with probable Alzheimer's disease. Subjects made sliding finger movements over a clear touch-sensitive screen positioned in three spatial planes to displace a cursor from a central target to one of four peripheral targets viewed on a monitor. These spatial plane were repeated under conditions where the direction of cursor motion was rotated 180° relative to the direction of hand motion. Significant results were observed between AD patients and control groups on reaction time and movement time measures. Also, significant increases in task completion errors were observed in AD population. Further, performance was more affected by visual feedback changes relative to the plane location changes. Notably, there were substantial deficits observed in AD patients' performance, even those with minimal cognitive deficits.

Cognitive rehabilitation based on the relative implicit memory spare to assist the ADL

Cognitive rehabilitation (CR) is composed of techniques and strategies that aim for minimizing deleterious effects originated by lesion or dysfunction of cognitive functions[77]. These functions are seen as a support for primary mental activities, e.g., memory, attention, thought, language, logic reasoning, etc. In this sense, CR strategies are used to compensate for the deficits caused in the ADL. In relation to AD, the CR focuses on minimizing the existing deficits due to the deterioration of memory systems. Particularly, it is seen that patients in mild to moderate stages of AD firstly show a degradation of the explicit memory, while implicit memory stays preserved for a longer time. In this way, recent studies have shown an increase in use of rehabilitation strategies which establish an association between explicit and implicit memory[78-80]. In this sense, Light and Singh[78] compared young and elderly individuals in two different tasks. The first, an explicit task (aided recall from the first 3 letters of word, e.g., "ant...") and the second an implicit task (word completion from the radical formed by the first 3 letters of word, e.g., "ant..."). Although, the auxiliary elements were identical on the tasks, the procedures were different. The subjects received specific instructions about how they had been doing the tasks. The results demonstrated a better performance regarding the young subjects of 30% compared with elderly subjects during the aided recall and, a difference around 6% during the word completion task.

Such evidence focused on the possibility that therapeutic strategies are based on the relationship between explicit and implicit knowledge as the disease progress. A possible therapeutic strategy is to link nonverbalized implicit knowledge to conscious effort when individuals are exposed to different tasks. Over the last years, two general intervention approaches and have been applied in AD patients with memory deficits. The first approach aims to work the residual skills of the compromised memory[81]. The other one intends to work the intact memory to compensate for the deficits of the compromised memory[82].

The first approach intervenes through techniques like the Reality Orientation Therapy (ROT), which involves a continued and organized presentation of data. Its objective is creating environmental stimuli that have eased the temporal and spatial orientation of the patient[83]. Other technique employed in this same approach is the reminiscent therapy (RT). RT aims to stimulate the recall of mnemonic information through figures, pictures, musics, games and other stimuli related to patient youth[84]. A third technique supported itself on external aids as agendas, notes, alarm clocks, posters and signals aiming to compensate for the memory deficits that cannot be directly faced[85].

In relation to second approach, supported by the compensation of the implicit memory, several techniques as errorless and sensorimotor learning are useful to learn and retain new information by mild AD patients[86]. As for the first technique, it was reported that errors made by patients during the learning process impair the retention of information[87]. This mechanism error-free based on a dynamic in favor of the elaboration of new implicit memory. According to Wilson[88], individuals with amnesic deficits in the episodic memory, as AD patients, are not able to remember their own errors, thus they do not learn as subjects without memory deficits.

It is knowledge that through repetitive practice and mechanisms of implicit memory, AD patients can be trained for complex tasks[89]. However, it is due to the strict and specific features of implicit learning, that the patients cannot using their learning in flexibly way. In this sense, it suggested that will have been doing training based on specific knowledge with direct application in ADL[90]. All available studies reviewed on this matter[18-21] show that AD patients learn best under constant practice conditions. According to Dick et al.[18], humans use their episodic memory of the training trials to accurately perform a task while learning a skill. They suggest that because AD patients experience problems with episodic memory, constant practice is more effective because repeated running of the same motor program does not require an intact episodic memory.

In relation to sensorimotor learning technique, AD patients seem to benefit from multisensory situations where associations of verbal, visual and kinesthetic cues are enhanced and conditioned through particular circumstances[85]. Therefore, feedback is important for procedural learning in the AD patients. In this sense, there are two types of feedback, intrinsic where the sensory information is provided by motion and extrinsic where information comes from an external source like a verbal command. It is common knowledge that constant feedback enhances only motor performance, in contrast to the level of learning. The lack of feedback entails in the dependence on other cues, which provide more elaborate encoding. Numerous investigations related to motor-skill learning in AD patients employed visual feedback. Nevertheless, just the Maze tasks were performed according to blindfolded conditions. In these experiments, it was observed that the amount of learning in the AD patients was inferior compared with the controls[48,49].

Other experiments (Rotor-Pursuit task) individualized the velocity of the target to equate initial performance. According to these experiments, it was verified that controls generally tracked at a faster rate than the AD patients[54,55,63,64]. Perhaps, AD patients can just perform the task at a slower rate due to their dependence on visual feedback more than controls. In this manner, only one Rotor-Pursuit experiment in explicit form examined the role of visual feedback on performance in AD patients. It was verified a decrease in performance when the visibility of the moving target was diminished during learning[53]. In opposition to the controls, the performance of patients did not pick up through trials in the restricted-vision condition. In the full-vision condition AD patients showed normal learning. It appears that constant visual feedback is important in learning and retention (procedural memory) for AD patients. However, it was not found any studies concerning the frequency of external feedback.

In a longitudinal study involving 3 probable AD patients, it was investigated the effects of a cognitive rehabilitation program. This program aims to work the residual explicit and implicit memories through ADL, compensation strategies and cognitive skills still preserved. Such findings indicate cognitive improvement, functional stabilization and reduced behavioral problems after the first year of the neuropsychological rehabilitation program. However, this improvement was not observed on second year, due to disease's progression[77].

FINAL REMARKS

Concluding, our review yielded the following significant findings. In relation to first question, the results showed that preserved implicit memory irrespective of the task used, i.e., it not interference from explicit memory. AD patients are capable of learning without awareness simply by repeated exposure, although their performances will not reach normal levels. This is expressed in their prolonged performance when compared with unimpaired controls. Moreover, the extent of learning will differ depending on the task to be skilled. The reviewed studies showed that implicit learning, constant, or rather frequent and consistent practice is important for AD patients. This way of learning draws less on episodic memory and other cognitive functions compromised in AD patients. These results also suggest that practice under dual-task conditions should also be avoided. In addition, the amount of training needed by a patient will depend on the task being performed.

In relation to second question, the results showed that is possible through implicit memory compensatory strategies (i.e., ADL) to compensate for the explicit memory deficits. However, the effects of massed and distributed practice in this generally older patient group need to be addressed in future investigations. AD patients appear to remain dependent upon visual feedback throughout training and performance. The type and point in time when external feedback needs to be given and its effect on learning in AD also warrants attention in future research. In this sense, cognitive rehabilitation based on practice and feedback principles demonstrates reasonable results; with more highlight for second approach. Therefore, AD patients can use preserved implicit learning capacities in cognitive rehabilitation programs in order to compensate for explicit memory deficits.

Thus, the decline in explicit memory suggests that both systems are functionally independent and one can function normally even if the other is compromised. Patients with more impaired explicit memory system performed better on the implicit learning task. A possible speculation is that impairment in the explicit memory system results in better performance on the implicit memory task due to elimination of competition between the systems. We expect that when explicit memory system is not involved in competition with the implicit system, the final effect of learning is better, because all of the implicit memory capacity is engaged in learning and not in competition with the explicit system.

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