

Structure of Memory in the Context of Neurodegenerative Diseases

بنية الذاكرة في سياق الأمراض العصبية التنكسية

SAHRAOUI Sara *. M'Hamed Bougara University of Boumerdes

sara.sahraoui@ummto.dz

Received: 08 / 05/ 2026

Accepted: 11/06/ 2026

Abstract:

This paper examines how neurodegenerative diseases affect the structure and functioning of human memory. In addition to theoretical analysis, selected clinical observations and illustrative case examples are included to demonstrate how these mechanisms manifest in real-world patient care. Drawing from current theoretical and applied research, the study highlights the distinct vulnerabilities of different memory systems—including declarative, procedural, and working memory—when confronted with conditions such as Alzheimer's disease, Parkinson's disease, and semantic dementia. The analysis is framed by influential cognitive models, notably those of Baddeley for working memory and the serial/cascade frameworks proposed by Levelt, Caramazza, and Paradis for language processing and bilingualism. Findings show that each disease disrupts memory in unique ways: Alzheimer's primarily impairs the formation and retention of new memories; Parkinson's compromises information retrieval and cognitive flexibility; and semantic dementia erodes conceptual understanding. Notably, procedural memory often remains relatively intact in the early stages, providing an important foundation for rehabilitation strategies. The study underscores the value of linguistic markers and cognitive reserve in early detection and intervention, and calls for therapeutic approaches tailored to the specific profile of memory impairment observed in each disorder.

Keywords: Memory structure, neurodegenerative diseases, cognitive models, language, rehabilitation, cognitive reserve

* Sahraoui Sara

ملخص:

تهدف الدراسة الحالية إلى تحليل التأثير الانتقائي للأمراض العصبية التنكسية على بنية الذاكرة البشرية. إضافةً إلى التحليل النظري، تم تدعيم البحث بملاحظات سريرية وحالات عملية توضح كيفية ظهور هذه الآليات في السياق العيادي الواقعي. ركزت الدراسة على النماذج التسلسلية والتراكمية للعمليات المعرفية، مثل نموذج "ليفيلت" و"كارامازا" في معالجة اللغة والإنتاج اللفظي، ونموذج "باراديس" في الثنائية اللغوية، بالإضافة إلى نموذج "بادلي" للذاكرة العاملة. أظهرت النتائج أن كل اضطراب عصبي تنكسي يؤدي إلى نمط خاص من الخلل في أحد أنظمة الذاكرة: حيث يبرز ضعف التخزين في مرض الزهايمر، وتظهر صعوبات الاسترجاع والتنشيط الذاتي في مرض باركنسون، بينما يتمثل الخلل في فقدان المفاهيم لدى مرضى الخرف الدلالي. كما بينت النتائج أن الذاكرة الإجرائية غالباً ما تبقى محفوظة في المراحل المبكرة، مما يوفر قاعدة مهمة لاستراتيجيات إعادة التأهيل وتحسين جودة الحياة. وتوصي الدراسة بأهمية تصميم تدخلات علاجية تستند إلى فهم دقيق لبنية الذاكرة، مع توظيف الاحتياطي المعرفي، واعتماد المؤشرات اللغوية المستمدة من النماذج النظرية كأدوات للتشخيص المبكر وتوجيه التدخلات العلاجية بشكل فعال.

الكلمات المفتاحية:

أنظمة الذاكرة، الأمراض العصبية التنكسية، النماذج المعرفية، الملاحظة السريرية، اللغة، إعادة التأهيل، الاحتياطي المعرفي

Introduction

Human memory involves several steps, such as encoding, storing, and retrieving information that underpins learning, decision-making, and social interaction (Squire, 2004). Memory is not one unit; it is composed of multiple specialized systems. Declarative memory, responsible for consciously remembering facts and events and depends mainly on the medial temporal lobes. In contrast, procedural memory controls skills and habits, relies on the integrity of the basal ganglia and cerebellum (Squire & Dede, 2015). Working memory, as originally conceptualized by Baddeley and Hitch (1974), provides a temporary workspace for the manipulation of information and is closely linked to executive functions mediated by the prefrontal cortex.

Neurodegenerative diseases affect memory systems selectively. Alzheimer's disease usually manifests as deficits in episodic memory, which is associated with the hippocampus and related structures (Squire & Dede, 2015). In contrast, Parkinson's disease affects fronto-striatal circuits and causes difficulties with executive functions and memory retrieval, but long-term memory storage usually remains intact at first (Brown & Marsden, 1990; Gabrieli, 1996). Semantic dementia is characterized by a gradual loss of conceptual and semantic knowledge because the anterior temporal lobes break down over time (Hodges et al., 1992).

The present study uses recent theories to explain how different cognitive processes can fail. The working memory model by Baddeley and Hitch (1974)

explains how short-term information is processed. Serial and modular models of language production and lexical access, as advanced by Levelt (1989) and Caramazza (1997), clarify how disruptions in language can indicate underlying memory deficits. Paradis’s neurolinguistic theories (Paradis, 2004; Paradis, 2009) also shed light on how declarative and procedural systems interact, especially in people who speak more than one language.

The detection of memory impairment in neurodegenerative disease is crucial. As Lambert et al. (2002) highlighted, “diagnosis is the anchor point of therapy,” underscoring the importance of precise neuropsychological assessment for developing effective, patient-centered rehabilitation strategies.

1. Objective

The primary objective of this study is to analyze how neurodegenerative diseases differentially affect the structure and function of major human memory systems. It draws on well-known theories, including Baddeley and Hitch’s working memory model (Baddeley & Hitch, 1974), Levelt’s serial model of speech production (Levelt, 1989), Caramazza’s work on lexical processing (Caramazza, 1997), and Paradis’s models of bilingualism and language processing (Paradis, 2004; Paradis, 2009). By connecting these theories to clinical findings from Alzheimer’s disease, Parkinson’s disease, and semantic dementia, the study points out the unique cognitive patterns in each condition. As Lambert et al (2002) said, “diagnosis is the anchor point of therapy. The findings of this research emphasize that precise neuropsychological assessment, grounded in the framework of cognitive models, is essential for developing personalized rehabilitation plans. The main goal is to help develop better diagnostic tools and treatments that use patients’ remaining strengths to improve their outcomes.

2. Hypothesis

This study suggests that neurodegenerative diseases affect memory systems in both selective and dynamic ways. Each disorder targets specific subsystems, and the interaction between healthy and impaired memory systems can influence how well people compensate or recover.

The study also proposes that interventions which encourage the interaction between intact and disrupted memory processes may help restore or maintain cognitive functions better than those that focus on single systems alone.

3. Approach and Methodology

This article brings together a review of important literature and insights from clinical work in a private psychology practice. Instead of presenting a formal clinical trial or a statistical case series, the goal is to demonstrate how well-known cognitive models and research findings apply to real patients. The

analysis uses clinical examples from neuropsychological assessments regularly conducted in Algeria. These examples do not provide quantitative data, but they help show the range of memory problems seen in everyday practice. By combining theory with practical experience, the article aims to give a clearer picture of how neurodegenerative diseases affect memory systems and to suggest practical ways to assess and support patients individually.

3.1. Population

Our study population includes patients referred from neurology to psychology services for neuropsychological testing. The participants were adults between 55 and 80 years old with different education levels, diagnosed with Alzheimer’s disease, Parkinson’s disease, or semantic dementia. Patients with major psychiatric disorders, vascular aphasia, or serious sensory problems were not included.

3.2. Methodology

The study used both standardized neuropsychological tests and qualitative clinical observation. Every patient completed a thorough set of assessments, including:

- The Mini-Mental State Examination (MMSE ; Folstein et al., 1975)
- The Free and Cued Selective Reminding Test (FCSRT; Grober & Buschke, 1987)
- The Boston Naming Test (Kaplan et al., 1983, French versio
- The Rey–Osterrieth Complex Figure (Osterrieth, 1944)
- The Stroop Test, Moroccan adaptation (El Alaoui Faris et al., 2016)
- The Working Memory Battery of Baddeley, adapted by Saidoune (2003)
- Phonemic and semantic verbal fluency tasks (Benton & Hamsher, 1976)
- Clinical interviews and functional observations (e.g., spontaneous speech, daily routine gestures, following complex instructions)

4. Results

The psychometric and behavioral data collected during our clinical observations revealed distinct pathocognitive profiles, clearly differentiating memory vulnerabilities across patients presenting with Alzheimer’s disease, Parkinson’s disease, and semantic dementia. The quantitative and qualitative findings are structured below by pathology.

4.1. Alzheimer’s Disease

Anterograde episodic memory loss is the main cognitive sign seen in patients with Alzheimer’s disease. For example, a 70-year-old woman with a moderate education scored 18 out of 30 on the Mini-Mental State Examination (MMSE; Folstein et al., 1975) and showed a serious problem with encoding and storing information on the Free and Cued Selective Reminding Test (FCSRT; Grober &

Buschke, 1987). She could recall only 2 out of 16 items, even when given semantic category cues. In the interview, she described her memory struggles by saying, "I know you told me some words... I forget them as soon as we move on to something else." This difficulty in forming new memories, even with cues, may reflect impairment in episodic integration processes associated with the episodic buffer framework (Baddeley, 2000)

There was a clear separation between visual recognition and recall of names during photo-confrontation tasks. Patients often recognized relatives but could not remember their names, as shown in the quote: "بشكون نسيت والله.. بنتي، هذي" (*Hadi bent... wallah nsit chkoun. / "This is my daughter... honestly, I forgot her name."*). Similar problems with visuospatial and executive planning were observed on the Clock Drawing Task (Kaplan et al., 1983). One patient said: "العقارب ندير وين نسيت بصر الأرقام، حطيت" (*Hattit l'arqam, bessah nsit win ndir l'aqarib. / "I placed the numbers, but I forgot where to position the hands."*), which points to difficulties with spatial organization and working memory.

A decline in the semantic network was also common. patients often described objects by their function instead of naming them, as in: "واش ناكل، باش هذي" (*Hadi bach nakoul, wach tsemouha? / "This is for eating, what do you call it?"*). This suggests they lost detailed conceptual knowledge (Caramazza, 1997). Crucially, procedural routines remained intact, preserving automatic daily habits such as preparing traditional coffee (Squire, 2004). Spontaneous language is often disorganized and changes topics frequently: "رحت... البارح" (*Elbareh... rhou... cheft wahad... nsit wach kount nahki. / "Yesterday... I went... saw someone... I forgot what I was saying."*), demonstrating how working memory deficits can disrupt speech flow (Levelt, 1989).

4.2. Parkinson's Disease

Patients with Parkinson's disease showed a cognitive profile marked by slow thinking and clear problems with divided attention. One patient explained, "كي" (*Ki tgoul li ndir zouj hwayej m'a ba'd, nkhalit. / "When you ask me to do two things at once, I get confused."*). The Stroop Test showed that these patients had noticeable processing delays and made more inhibition errors, which suggests a higher risk of interference.

On the Baddeley Working Memory Battery (adapted by Saidoune, 2003), a precipitous decline in dual-task performance was observed after four to five sequences, highlighting a selective vulnerability of the central executive system (Baddeley & Hitch, 1974). Phonemic fluency scores were profoundly suppressed compared to normal baselines. During an Arabic letter fluency task (Benton & Hamsher, 1976), a patient generated only five words before experiencing cognitive halting: "نسيت وبعد؟... مدرسة... مسجد... ماء" (*Ma... masjid... madrasa... w baad? Nsit. / "Water... mosque... school... and then? I forgot."*),

illustrating a failure in self-initiated lexical retrieval and cognitive activation (Levelt, 1989).

On the Baddeley Working Memory Battery (adapted by Saidoune, 2003), dual-task performance dropped sharply after four or five sequences, suggesting a specific weakness in the central executive system (Baddeley & Hitch, 1974). Phonemic fluency scores were much lower than normal. In the arabic version of letter fluency task (Benton & Hamsher, 1976), the patient produced only five words before stopping: "نسيت وبعد؟ مدرسة... مسجد... ماء" (*Ma... masjid... madrasa... w baad? Nsit.* / "Water... mosque... school... and then? I forgot."). This shows a problem with the initiation of word retrieval and cognitive activation (Levelt, 1989).

In contrast to these executive and attentional difficulties, patients' procedural and structural visuospatial skills stayed intact. They were able to complete complex drawings, like the Rey-Osterrieth Complex Figure (Osterrieth, 1944), though their movements were noticeably slower: "شوي ببطء بصر الحركة، درت" (*Dert l-haraka, bessah b'bto' chwia.* / "I executed the movement, but somewhat slowly."). Their autobiographical memory for distant life events was also fully preserved: "بابا مع للبحر نروح كنت صغير كنت كي" (*Ki kont sghir kont nrouh lil bahr m'a baba.* / "When I was a child, I used to go to the beach with my father."), which confirms that long-term memory storage pathways remained intact (Squire & Dede, 2015; Doyon et al., 2009).

4.3. Semantic Dementia

The cognitive architecture of patients with semantic dementia revealed a striking, reverse dissociation: a progressive, cross-modal dissolution of conceptual knowledge contrasting with completely preserved grammatical, executive, and episodic structures. During the Boston Naming Test (Kaplan et al., 1983), patients exhibited profound semantic aphasia, substituting specific target words with broad superordinate categories. For instance, a stethoscope was described as "الطبيب حاجة هذه" (*Hadi haja littbib.* / "This is something for the doctor") and a lion was reduced to "كبير حيوان" (*Hayawan kbir.* / "A big animal") (Hodges et al., 1992). When asked to perform category fluency tasks, patients remained trapped at the highest level of conceptual hierarchy, repeating generic terms: "حيوان، سمك طائر،..." (*Hayawan, ta'er, samak...* / "Animal, bird, fish...").

People with semantic dementia have a distinct pattern: their understanding of concepts slowly fades across different kinds of information, but their grammar, executive skills, and memory remain strong. On the Boston Naming Test (Kaplan et al., 1983), they often show severe semantic aphasia and use broad categories instead of specific words. For instance, they might call a stethoscope "الطبيب حاجة هذه" (*Hadi haja littbib.* / "This is something for the doctor") or a lion "كبير حيوان" (*Hayawan kbir.* / "A big animal") (Hodges et al., 1992). In category

fluency tasks, they usually repeat only general terms like "...بسمك طائر، حيوان،" (*Hayawan, ta'er, samak...* / "Animal, bird, fish...").

Patients' definitions of words often left out key details. For example, one patient described a doctor as: "...السبيطار في واحد" (*Tbib? Wahad fel sbitar.* / "Someone at the hospital."). Still, their ability to remember recent events in daily life was fully intact. They could recall specific situations, such as: "...في ركبتنا اليوم، بنتي مع جيت" (*Jit m'a benti elyoun, rekabna fel taxi.* / "I came with my daughter today; we took a taxi.").

Constructive abilities, executive planning, and visuospatial construction were all intact when patients copied the Rey-figure. Patients commented, "...كيما درتها شوف" (*Chouf, dert'ha kima fel wraqa.* / "Look, I reproduced it exactly like on the paper."). Their spontaneous speech was grammatically correct and fluent, but lacked meaningful content. For example, one said, "...بصح البارح، حاجة درت" (*Dert haja elbareh, bessah man'rafch wach hiya.* / "I did something yesterday, but I do not know what it was."). This pattern, where language structure is preserved but meaning is lost, illustrates the "empty shell" effect described by Paradis (2009). It shows that the mechanics of language can function separately from the semantic networks in the anterior temporal lobe.

In conclusion, our observational findings show that neuropsychological evaluations are important for identifying cognitive deficits. Standardized tests help measure cognitive limits, but they are most effective when paired with careful qualitative observations and analysis of spontaneous speech. This combined approach provides a clearer understanding of the patient's true level of independence. Table 1 shows the different memory patterns and their related indicators.

Table 1. Differential Neuropsychological Profiles and Cognitive Assessments across Disorders

Diagnosis	Episodic Memory	Working Memory	Semantic Memory	Procedural Memory
Alzheimer's disease	Severely impaired	Progressively impaired	Variably impaired	Relatively preserved (early stages)
Parkinson's disease	Relatively spared	Markedly impaired	Relatively spared	Spared
Semantic dementia	Relatively spared	Spared in early stages	Severely impaired	Spared

5. Discussion

The psychometric and behavioral data gathered in this study The results of this study show that neurodegenerative diseases affect memory systems in different ways, indicating that human cognition is complex and not a single process (Squire, 2004). In Alzheimer’s disease, the main problem was trouble forming new episodic memories, as shown by standardized tests (MMSE, FCSRT) and patient reports. People with Alzheimer’s often cannot form or retain new memories, even with prompts, suggesting problems in the episodic buffer and possible issues in the hippocampus and medial temporal lobe (Squire & Zola-Morgan, 2015; Baddeley, 2000). However, daily routines like making coffee or following steps in a task often stayed the same. This supports the idea that declarative and procedural memory systems are separate (Squire, 2004; Doyon et al., 2009).

A key clinical observation in Alzheimer’s disease is the dissociation between preserved visual recognition and impaired naming in photo-confrontation tasks, the difficulty with spatial planning in the Clock Drawing Task, and disorganization in spontaneous speech (frequent topic shifts and unclear references), which reflects how working memory problems affect their speech (Levitt, 1989)

In Parkinson’s disease, the cognitive profile was dominated by slow thinking, attentional deficits, and executive dysfunction. As expressed by patients, the challenge of handling more than one task at a time or maintaining mental flexibility was a recurrent complaint. These difficulties were clearly demonstrated by the Stroop Test and the working memory battery (Saidoune, 2003). Patients’ ability to handle two tasks at once declined rapidly after just a few sequences. Phonemic fluency was also markedly reduced, confirming the vulnerability of the central executive system (Baddeley & Hitch, 1974). Participants can keep up with routine tasks and remember personal events from the past (preserved procedural routines and long-term autobiographical memory). An important distinction between storage impairment and difficulties with information access and manipulation (Brown & Marsden, 1990).

Semantic dementia is marked by a progressive loss of understanding concepts and words. Patients often replace specific words with more general ones. In the early stages, their sentence structure and ability to remember events stay intact (Hodges et al., 1992; Caramazza, 1997). Patients’ spontaneous language is often grammatically correct but semantically empty. Preservation of executive functions, visuospatial abilities, and autobiographical memory in this group indicates that cognitive decline in neurodegenerative diseases is selective.

The results of the present study highlight the importance of neuropsychological assessment, combined with qualitative language and behavioral analysis, in

clinical practice. It helps clinicians to precisely map preserved and impaired cognitive domains. This individualized cognitive mapping is essential for creating targeted rehabilitation protocols that leverage brain plasticity and cognitive reserve (Sten, 2009), and ultimately support patient autonomy and quality of life.

6. Conclusion

This study began with the hypothesis that memory is not a unitary function, but rather an architecture of multiple, specialized systems, closely interlinked with language and other cognitive functions (Squire, 2004). The results confirm that neurodegenerative diseases affect these systems in different ways, depending on which brain areas are involved. For example: the hippocampus and medial temporal lobes in episodic memory (Squire & Zola-Morgan, 1991), the fronto-striatal networks in executive and working memory (Baddeley & Hitch, 1974; Brown & Marsden, 1990), and the anterior temporal cortex in semantic knowledge (Hodges et al., 1992; Caramazza, 1997).

In Alzheimer’s disease, procedural memory is usually preserved, while episodic memory is impaired, which corresponds with the literature on the distinctions between declarative and procedural memory systems (Squire, 2004; Doyon et al., 2009). On the other hand, Parkinson’s disease primarily affects executive and working memory, which can reduce conceptual and lexical knowledge. However, semantic dementia showed a selective breakdown of conceptual and lexical networks, but maintained syntax and episodic recall in the early stages (Hodges et al., 1992; Paradis, 2009).

Overall, our clinical findings are consistent with major cognitive models (Squire, 2004; Baddeley & Hitch, 1974; Caramazza, 1997; Paradis, 2009). Future research should continue to refine assessment tools and intervention strategies, focusing on brain plasticity and each person’s cognitive reserve, to help people with neurodegenerative disorders maintain their independence and quality of life.

7. References

- Baddeley, A. D., & Hitch, G. J. (1974). *Working memory*. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 8, pp. 47–89). Academic Press.
- Benton, A. L., & Hamsher, K. (1976). *Multilingual Aphasia Examination*. University of Iowa.
- Brown, R. G., & Marsden, C. D. (1990). *Cognitive function in Parkinson's disease: from description to theory*. *Trends in Neurosciences*, 13(1), pp. 21-29.
- Caramazza, A. (1997). *How many levels of processing are there in lexical access?* *Cognitive Neuropsychology*, 14(1), pp. 177-208.
- Doyon, J., Penhune, V., & Ungerleider, L. G. (2009). *Contributions of the basal ganglia and functionally related brain structures to motor learning*. *Behavioural Brain Research*, 199(1), pp. 61-75.
- El Alaoui Faris, M., Benomar, A., El Moutawakil, B., & El Otmani, F. (2016). *Étalonnage du test de Stroop chez l'adulte marocain scolarisé*. *Revue Neurologique*, 172(10), pp. 623–627.
- Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). "Mini-mental state". *A practical method for grading the cognitive state of patients for the clinician*. *Journal of Psychiatric Research*, 12(3), pp. 189–198.
- Gabrieli, J. D. E. (1996). *Memory systems analyses of mnemonic disorders in aging and age-related disease*. *Proceedings of the National Academy of Sciences*, 93(24), pp. 13534-13540.
- Grober, E., & Buschke, H. (1987). *Genuine memory deficits in dementia*. *Developmental Neuropsychology*, 3(1), pp. 13–36.
- Hodges, J. R., Patterson, K., Oxbury, S., & Funnell, E. (1992). *Semantic dementia: progressive fluent aphasia with temporal lobe atrophy*. *Brain*, 115(6), pp. 1783-1806.
- Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *The Boston Naming Test*. Lea & Febiger.
- Lambert, J., et al. (2002). *Rééducation neuropsychologique*. Bruxelles, De Boeck.
- Levelt, W. J. M. (1989). *Speaking: From intention to articulation*. MIT Press.

- Osterrieth, P. A. (1944). *Le test de copie d'une figure complexe; contribution à l'étude de la perception et de la mémoire*. *Archives de Psychologie*, 30, pp. 206–356.
- Paradis, M. (2004). *A neurolinguistic theory of bilingualism*. Amsterdam, John Benjamins.
- Paradis, M. (2009). *Declarative and procedural determinants of second languages*. Amsterdam, John Benjamins.
- Saidoune, S. (2003). *ذهنيا والمتأخر العادي الطفل عند وتطورها العاملة الذاكرة بنية (Structure et développement de la mémoire de travail chez l'enfant normal et déficient intellectuel)*. Thèse de doctorat, Université d'Alger 2, spécialité Psychologie, Alger.
- Squire, L. R. (2004). *Memory systems of the brain: A brief history and current perspective*. *Neurobiology of Learning and Memory* Russo, 82(3), pp. 171-177.
- Squire, L. R., & Zola-Morgan, M. (1991). *Conscious and unconscious memory systems*. *Cold Spring Harbor Perspectives in Biology*, 42, pp. 163-190.
- Ullman, M. T. (2016). *The declarative/procedural model: A neurobiological model of language learning, knowledge, and use*. In G. Hickok & S. L. Small (Eds.), *Neurobiology of Language*, Academic Press, pp. 953-968.