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ARTIGO DE PERSPECTIVA

Language Domains in Alzheimer's Disease: State of the Art and Future Directions

Domínios da Linguagem na Doença de Alzheimer: Estado da Arte e Direcionamentos Futuros

Dominios del Lenguaje en la Enfermedad de Alzheimer: Estado del Arte y Direcciones Futuras

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Abstract: Alzheimer's disease (AD) is a progressive neurodegenerative condition that involves several cognitive functions, with language being one of the most affected. This article aims to examine the state of the art on linguistic impairments in AD, with a specific focus on six domains: phonetics, phonology, morphology, syntax, semantics, and pragmatics. Linguistic manifestations vary according to the stage of the disease and address both language production and comprehension. In initial projects, we observed difficulties in lexical access, anomia, and a decline in semantic verbal fluency. As the disease progresses, phonetic-phonological, morphosyntactic and pragmatic alterations worsen, impairing the cohesion, coherence, and effectiveness of communication. Cross-cultural studies indicate that the linguistic structure of each language can influence these patterns of decline, while factors such as working memory and semantic complexity are also important for the observed diversity. It is concluded that the detailed study of linguistic domains in AD is essential for early diagnosis, monitoring of progression and the development of personalized intervention strategies. Considering advances in artificial intelligence, neuroscience and interdisciplinary approaches, there are promising prospects for the creation of more effective methods for preserving communication and autonomy of individuals affected by the disease.

Keywords: Language disorders, Alzheimer's disease, neurodegenerative disorder, neuropsychology; communication; cognition.

Resumo: A doença de Alzheimer (DA) é uma condição neurodegenerativa progressiva que envolve diversas funções cognitivas, sendo a linguagem uma das mais afetadas. Este artigo tem como objetivo examinar o estado da arte sobre os comprometimentos linguísticos na DA, com foco específico em seis domínios: fonética, fonologia, morfologia, sintaxe, semântica e pragmática. As manifestações linguísticas variam de acordo com o estágio da doença e envolvem tanto a produção quanto a compreensão da linguagem. Em fases iniciais, observam-se dificuldades no acesso lexical, anomia e declínio na fluência verbal semântica. À medida que a doença avança, alterações fonético-fonológicas, morfossintáticas e pragmáticas se agravam, comprometendo a coesão, a coerência e a eficácia da comunicação. Estudos transculturais indicam que a estrutura linguística de cada idioma pode influenciar esses padrões de declínio, enquanto fatores como memória de trabalho e complexidade semântica também são importantes para a diversidade observada. Conclui-se que o estudo detalhado dos domínios linguísticos na DA é essencial para o diagnóstico precoce, o acompanhamento da progressão e o desenvolvimento de estratégias de intervenção personalizadas. Considerando os avanços da inteligência artificial, da neurociência e das abordagens interdisciplinares, há perspectivas promissoras para a criação de métodos mais eficazes de preservação da comunicação e da autonomia dos indivíduos

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Palavras-chave: Transtornos de Linguagem; Doença de Alzheimer; Doenças Neurodegenerativas; Neuropsicologia; Comunicação; Cognição.

Resumen: La enfermedad de Alzheimer (EA) es una condición neurodegenerativa progresiva que afecta varias funciones cognitivas, siendo el lenguaje una de las más comprometidas. Este artículo tiene como objetivo examinar el estado del arte sobre las alteraciones lingüísticas en la EA, con un enfoque específico en seis dominios: fonética, fonología, morfología, sintaxis, semántica y pragmática. Las manifestaciones lingüísticas varían según la etapa de la enfermedad y abarcan tanto la producción como la comprensión del lenguaje. En etapas iniciales, se observan dificultades en el acceso léxico, anomia y un deterioro en la fluidez verbal semántica. A medida que la enfermedad progresa, las alteraciones fonético-fonológicas, morfosintácticas y pragmáticas se agravan, afectando la cohesión, la coherencia y la eficacia de la comunicación. Estudios transculturales indican que la estructura lingüística de cada idioma puede influir en estos patrones de deterioro, mientras que factores como la memoria de trabajo y la complejidad semántica también son relevantes para la diversidad observada. Se concluye que el estudio detallado de los dominios lingüísticos en la EA es esencial para el diagnóstico precoz, el seguimiento de la progresión y el desarrollo de estrategias de intervención personalizadas. Considerando los avances en inteligencia artificial, neurociencia y enfoques interdisciplinarios, existen perspectivas prometedoras para la creación de métodos más eficaces para preservar la comunicación y la autonomía de las personas afectadas por la enfermedad.

Palabras clave: Trastornos del Lenguaje; Enfermedad de Alzheimer; Enfermedades Neurodegenerativas; Neuropsicología; Comunicación; Cognición.

Introduction

Alzheimer's disease (AD) is the most common neurodegenerative disorder, accounting for 60%–70% of all dementia cases[1]. AD is marked by the extracellular accumulation of beta-amyloid proteins and the intracellular deposition of hyperphosphorylated tau, forming senile plaques and neurofibrillary tangles. These deposits result in neuronal degeneration, synaptic dysfunction, and chronic inflammation, followed by the progressive impairment of cognitive functions[2-3].

In AD, cognitive impairments follow a hierarchical progression based on the affected neurological substrates. Memory impairment is the earliest and most prominent symptom, followed by deficits in other cognitive domains such as language, attention, and executive functions[4]. However, language impairment has received increasing attention due to its central role in communication and social interaction, both fundamental to the quality of life of patients and their caregivers. Progressive impairment of language skills in people with Alzheimer's disease (pwAD) involves not only verbal communication, but also the ability to express basic needs, emotions, and interests, complicating caregiving and reducing patient autonomy[5-7].

Evidence for language studies covers the spectrum of symptoms in AD[8-9], from subtle alterations in speech production to severe deficits that affect speech comprehension and production[10-12]. Different linguistic domains – phonetics, phonology, morphology, syntax, semantics and pragmatics – are impacted differently during disease progression and in specific patterns that can be useful clinical markers in early diagnosis and monitoring the evolution of the condition. The study of these domains allows a more comprehensive description of the cognitive deficits caused by AD and permits the development of more effective therapeutic interventions[13-14].

Indeed, studies reveal that the deficit in the language domain can be identified very early in AD and more pronounced with advancing disease[10-11]. These deficits impact multiple linguistic domains, with each domain exhibiting unique but interconnected patterns of decline[13-14]. In the early stages, deficits may be subtle, with a predominance of lexical and semantic difficulties, while in the more advanced stages there is a global impairment of the language, with impacts such as difficulties in interpreting social cues or maintaining coherence[14-16].

The recent advancements in neuroimaging modalities and automatic speech and language analysis techniques have enriched the study of linguistic impairments in AD. These tools have helped map progressive declines in each linguistic domain, enabling earlier and more accurate diagnosis[17-19].

This review aims to examine the current state of art on linguistic impairments in AD, with a particular focus on the six linguistic domains.

Pathophysiology of Language in AD

AD is characterized by cognitive and linguistic impairment that evolves in a hierarchical manner, depending on the neurological structures affected. Although the severity of the disease varies, a common pattern has been identified. Initially, lesions occur in the entorhinal cortex and hippocampus, regions that are essential for forming new memories[3,20]. Therefore, early symptoms include difficulty remembering recent events, learning new information, and retaining information over a long period of time. For this reason, delayed memory tests are present in all memory screening assessments in adults[4].

As AD progresses, lesions spread to adjacent cortical areas, such as the inferior temporal lobe, the temporo-occipital junction, and the temporoparietal junction. Damage to these areas results in loss of word recognition and meaning, suggesting that the semantic representations necessary for meaningful language reside in these areas. In addition, the temporoparietal region is connected to the dorsolateral prefrontal cortex, which plays an important role in working memory and executive function. Thus, atrophy in this area impairs the ability to recruit resources from the frontal lobe for cognitive and linguistic processes, causing difficulties in the production and comprehension of complex language[21-23].

Language and memory in AD are closely linked, because language function requires memory skills. Difficulties in speech production and comprehension are often associated with memory impairment[24]. The decline in linguistic comprehension and expression results in an overall reduction in communicative performance, while loss of evocative memory restricts active vocabulary[25]. Additionally, significant correlations between Mini Mental State Examination (MMSE) and Clinical Dementia Rating scale (CDR) scores with measures of articulation, verbal fluency, repetition, and naming have already been described[26].

PwAD often have difficulty in tasks involving semantic knowledge, such as object naming, verbal fluency, and picture recognition. These difficulties emerge early in the disease and become more severe during the disease, reflecting persistent deficits in semantic memory. This memory is responsible for storing general information about the world, including concepts and word meanings, and can be assessed through priming, categorical fluency, and object or image naming tests[24,27-28].

Research shows that cognitive function declines in healthy individuals, patients with mild cognitive impairment (MCI), and patients with AD[29]. In semantic memory tests, patients with MCI perform similarly to healthy individuals, but demonstrate difficulties in verbal fluency tasks, which involve both semantic knowledge and executive functions and short-term memory[30-31]. As the disease progresses, the role of the temporal cortex may explain the increased difficulty with semantic memory in patients with mild AD. While MCI primarily affects episodic memory, semantic memory may be preserved at this stage, but declines in the early stages of AD[11].

The neural basis of episodic memory in AD has been investigated using neuroimaging techniques such as functional magnetic resonance imaging, diffusion tensor imaging, and positron emission tomography. However, few studies have focused on identifying ecological and functional changes associated with language impairment. Studies comparing healthy individuals and patients with MCI have demonstrated neuroanatomical differences between episodic and semantic memory. Regions of interest analyses indicated that episodic memory performance is associated with the integrity of the bilateral entorhinal cortex/hippocampus, while semantic memory was associated with the integrity of the left medial perirhinal cortex and bilateral entorhinal cortex/hippocampus[19].

The posterior corpus callosum connects the superior parietal, posterior temporal, and occipital areas involved in working memory processing and is affected in AD. The superior longitudinal fasciculus, a bundle of fibers connecting the four cerebral lobes, plays an important role in language processing and is also affected

in patients with MCI and AD. This may lead to functional impairment of the prefrontal cortex and posterior brain regions, leading to impaired working memory performance[32-34].

Therefore, cognitive and language impairments in AD are thought to be related to developmental and atrophic processes in specific brain regions. The impact on semantic memory and verbal fluency highlights the need to develop language screening tools for early detection of MCI and AD. Neuroimaging studies may help understand the neural mechanisms underlying these deficits and facilitate early diagnosis and intervention.

Linguistics Domains

Language is a uniquely human ability that enables the production of an infinite number of verbal expressions and concepts through its various structures. While language is a system of symbols used for communication, it is not synonymous with communication itself, which encompasses the broader process of sharing information through various symbol systems[35].

Linguistics is divided into many different areas, each of which is determined individually. Not all linguists accept this distinction. Of course, these divisions are not rigid, but the interconnected parts support each other. An example is grammar, which includes the parts of phonology, morphology, and syntax, which show the connections between the different levels of linguistic analysis. Furthermore, experienced linguists often consider the fields of semantics and pragmatics as separate fields, because there are many connections between them[36].

This division of language reflects the attempt to understand its complexity by analyzing specific aspects, while recognizing the importance of a holistic view to capture the interaction between the various linguistic components. Linguistic research shows that language is a flexible and dynamic system, with cognitive, social, and pragmatic functions, playing an important role in the construction of meaning and effective communication[37].

In Table 1 we can see each linguistic domain and its definition.

Table 1. Glossary of linguistic domains

Linguistic Domain	Definition
Phonetics	It is the systematic study of speech sounds, taking into account how they are produced, perceived and what physical aspects are involved in their production[35,38].
Phonology	It is the study of the sound systems of languages and how those sounds are organized, patterned, and used to convey meaning[35,38].
Morphology	It is the system that governs the structure of words and the construction of word forms[37].
Syntax	It refers to the rules that govern how words can be combined to form sentences[37].
Semantics	It examines how words, phrases, sentences, and texts convey meaning, focusing on the relationships between linguistic expressions and what they refer to in the real or abstract context[35,37].
Pragmatics	It is the social rules of language for the purpose of communication, including using the interaction between people to initiate, maintain, and finish conversations[37].

Source: Authors.

In the following sections, relevant studies examining language function during the progression of AD will be reviewed and summarized, focusing on the most studied language domains. These studies examined a range of measures across the expressive language domain. These measures were then aggregated and grouped into language domains.

Phonetic and Phonology

In the early stages of AD, speech production is often still present. However, as the disease progresses, significant changes begin to occur in speech, reflecting impairments in both phonological-linguistic planning and phonetic-motor planning. Studies suggest that these

changes are related to dysfunction in the motor areas of the brain responsible for speech coordination, with similarities observed with apraxia of speech[8,38-41].

One of the first phonetic manifestations observed in AD is a decrease in the rate of articulation. Studies show that the rate of articulation in mild and severe AD differs from that of healthy adults. In addition, significant differences in speech rate and hesitation time were found between the experimental groups, except for patients with moderate and severe AD, who presented similar performances. These findings suggest that, as the disease progresses, there is a progressive slowing down in speech production[11,39,42].

Several studies have shown that pwAD exhibit a variety of phonological abnormalities, including inter-protrusive prolongation, vowel and consonant lengthening, substitution, addition, sound distortion, sound modification attempts, resistance, and inversion. These features are not seen in healthy adults, suggesting that this is a characteristic deficit of the disease. These manifestations become more common in the moderate and severe stages. It is related to the progressive decline in the ability to monitor one's own speech, a lower capacity for self-correction. In addition, patients with moderate and severe AD tend to make more attempts at the syllabic level and present a greater number of additions in speech[39-41].

Phonemic errors in AD have complex anatomical correlates involving several regions of the left hemisphere, such as the superior and posterior parts of the middle temporal gyrus, the parietotemporal part of the Sylvian fissure, the supramarginal gyrus, and the inferior frontal cortex and insula. Speech and phonological processing in AD also show distinct metabolic patterns: semantic errors are associated with the anterior and inferior parts of the middle temporal gyrus, phonemic errors are associated with the supramarginal gyrus and adjacent superior temporal cortex, and visual errors are associated with the medial part of the middle temporal gyrus[43-45].

However, changes in phonological speech representation across the stages of AD are still poorly understood. It is not clear when these events begin to occur, how they progress over time, and whether a specific pattern is found in each stage of the disease. Studies have shown that speech difficulties are seen in the early stages of the disease, and that speech-body changes become more pronounced as the disease progresses. In the milder stages, AD patients appear to use compensatory strategies to solve motor planning problems, which may explain the emergence of speech disorders at this stage. However, as the condition worsens, more problems emerge, and the frequency of speech-phonological disorders increases in the moderate and severe stages[8,39,46].

The progression of the disease also influences the ability to maintain fluency in oral production. In the early stages, the occurrence of omissions and substitutions can still be corrected by the patients themselves, but this ability is significantly reduced as the disease progresses. Cluster analysis of phonetic-phonological manifestations in different stages of AD showed that articulatory rehearsals and repetitions occurred similarly in all stages, but the frequency of praxic manifestations was lower in the mild stage than in the more advanced stages[46-47].

As AD progresses, patients' speech tends to become more hesitant, with an increase in pauses and distortions of sounds. In the severe stage, so-called sound-level starters become more frequent, evidencing a severe impairment in speech motor planning. These motor and phonetic manifestations are essential for characterizing the speech profile in AD and can serve as important markers for the diagnosis and monitoring of disease progression[39,43-46].

In summary, phonetic-phonological manifestations in AD evolve over time, with an increasing impact on speech production. While the initial stages are marked by compensations and attempts at self-correction, the more advanced stages of the disease are characterized

by a greater frequency of distortions, hesitations, and motor failures, which result in a more fragmented and impaired speech pattern. Studying these patterns can contribute to a better understanding of linguistic deficits in AD and aid in the development of more effective intervention strategies.

Morphology

The study of morphology in AD is still a limited field of research, but the results of some studies indicate trends about the linguistic deficits. Difficulty using suffixes, prefixes and verbal inflections is common in these patients, leading to the production of incorrect grammatical constructions. This leads to specific problems, such as the omission of functional words, including articles, prepositions, and conjunctions, which affect both the fluency and coherence of speech. Such omissions hinder comprehension, making communication more fragmented and often difficult to follow[10,11,25,48-50].

Another important aspect of the language of pwAD is the preservation or impairment of grammatical structures. The answer to this question may vary depending on the language in question, which is why this topic is well suited for linguistic research. Regarding pronouns, for example, the understanding and use of pronouns is often impaired in pwAD, because the process of activating reference and working memory is impaired. This leads to patients becoming more efficient at establishing coreference with repeated nouns, but having difficulty correctly identifying pronouns in different contexts[51].

Although the studies with English speakers[48,51] have found that pwAD have difficulty with verb inflections in connected speech, a study[52] with Italian-speaking AD individuals that used a sentence completion task to elicit regular and irregular present and past tense forms found that these individuals did not demonstrate obvious difficulties with verb inflections, suggesting that the semantic complexity of verbs may be an important factor.

A study with Greek AD individuals identified that pwAD were accurate on items related to subject/verb agreement, but made numerous errors on items related to verb tense[53]. Similarly, another research with speakers of Bengali, a highly inflected language, have shown that pwAD did not have significant difficulties with noun and verb inflections, suggesting that in languages with complex morphological systems, preservation of verb morphology may occur until later stages[51].

It is important to note that as the disease progresses, AD patients tend to produce syntactically simpler and shorter sentences. Excessive use of pronouns is often observed, replacing the use of specific nouns. These results contribute to less precise and vague speech. In addition, the production of inflection errors in nouns and verbs, such as difficulty in producing verb tenses is another striking feature in the language of these patients[51,54].

Studies have also suggested that verb difficulty in pwAD can be explained by the semantic complexity of verbs. Kim & Thompson, 2004[55] have investigated the semantic complexity of verbs in 14 pwAD and 10 individuals with agrammatism, and found that pwAD had more difficulty naming and producing two-argument verbs compared to one-argument verbs. This pattern suggests that pwAD have more difficulty when they need to process verbs that involve multiple participants or complex actions.

Another notable difference observed is the dissociation in the use of verb tense. PwAD have greater difficulty using the past tense than the gerund, which may indicate a difficulty in accessing temporal information related to events. This type of dissociation in verbal production may indicate a failure in the processing of temporal information and in the construction of consistent narratives[56-57].

Furthermore, verb agreement errors, especially in relation to tense and aspect, are a prominent feature of the early stage of AD. The study of Greek pwAD[53] showed that the greatest number of difficulties were related to aspect agreement, followed by tense, person and number agreement. These findings suggest that, while AD affects

several areas of verbal morphology, the verb aspect may be one of the most affected areas.

In general, studies have shown that people with AD experience a gradual decline in language production and comprehension in morphology. However, there is variation across individuals and languages. Deterioration in the ability to correctly use suffixes, prefixes and verb inflections, the omission of function words and difficulties with the use of pronouns and the production of more complex sentences are common features of this decline, reflecting the widespread impact of the disease on linguistic ability.

Syntax

In AD, syntactic production and comprehension are significantly affected, although the extent of this impairment remains controversial. Some studies indicate that patients have difficulty producing simple and routine sentences, especially in the early stages of the disease, which seems somewhat paradoxical because the basic structure is expected to be maintained over a long period of time[58-59].

Syntactic comprehension is also impaired, especially when sentences contain complex verbs or multiple prepositions. Although some researchers point to specific syntactic deficits, others argue that these difficulties arise from problems related to memory and semantics, making the issue controversial. Despite this, there is evidence that pwAD produce fewer subordinate clauses than healthy elderly individuals, and narrative studies show that the average sentence length in these patients is reduced[58].

Comparison between pwAD and those with semantic dementia showed no significant differences in syntactic complexity or accuracy between the two groups during spontaneous speech. However, when patients were asked to process syntactic information without semantic support, their ability declined significantly. Patients with AD in the early stages have milder difficulties in understanding certain types of sentences, but this impairment worsens as the disease progresses, leading to an almost complete loss of the ability to process the syntactic structure of sentences in the more advanced stages[60-62].

An interesting question is why pwAD tend to produce simpler syntactic and grammatical sentences. Evidence shows that they experience greater difficulty when using less canonical grammatical structures, such as experiencer sentences, compared to more straightforward agent-theme constructions. This suggests that the further a sentence deviates from the typical argument structure, the more challenging it becomes for the patient to process it correctly[59,62]. One possible explanation is that deficits in working memory play a central role in the difficulty patients face when managing complex syntactic operations within narratives. Since working memory is essential for holding and manipulating linguistic information, its decline directly affects the ability to construct more elaborate and syntactically rich sentences. This is evidenced by the reduced production of non-finite verbs, which is associated with lower syntactic complexity and greater difficulty in forming more intricate structures[54]. In summary, AD impacts syntax in multiple ways, affecting both sentence production and comprehension. These deficits appear to be closely linked to general cognitive and memory impairments, which compromise the organization of discourse and the grammatical construction of sentences.

Semantics

Lexical access

AD progressively affects lexical access, verbal fluency and discursive production. Among the first manifestations of AD, difficulty in naming objects, people and places stands out, with anomia being one of the earliest signs. PwAD often have difficulty finding words during spontaneous speech. From the early stages of dementia, they often perform poorly on formal object-naming tests, and this difficulty tends to worsen as the disease progresses. Patients often resort to generic terms instead of specific words, demonstrating difficulties in lexical retrieval,

even when other linguistic skills appear to be preserved[9,11,63,64].

This deficit may be attributed to lexical-semantic degradation rather than visual perceptual difficulties, as suggested by studies showing that patients with AD name images less accurately and use fewer single words compared to healthy elderly individuals. Furthermore, semantic errors are prevalent in the early stages of the disease, progressing to substitutions for superordinate terms and, in more advanced stages, to responses such as "I don't know."[10,25,65].

Access to the lexicon in naming tasks appears to be influenced by different factors. PwAD name words acquired earlier in life with greater accuracy, while the frequency of word use does not significantly impact their retrieval. However, other lexical properties, such as typicality and familiarity, seem to influence the speed of lexical access, suggesting that the disease selectively affects different aspects of semantic organization. Additionally, picture naming tasks reveal that words learned earlier in life are more easily retrieved, whereas the frequency of use has little effect on access. This pattern indicates that AD primarily impacts the structure of semantic networks, making it more difficult to access information that has been stored for a shorter period[9,65-67].

On the other hand, there is evidence that the semantic system remains preserved, at least in the early stages of AD. This suggests that, at this stage, individuals do not present a direct impairment in the organization of semantic knowledge, but rather difficulties related to working memory. In other words, the challenges faced by these individuals seem to be more linked to deficits in the retention and retrieval of information, which affect access to the lexicon during the execution of tasks, than to a semantic failure[68].

Verbal fluency

Verbal fluency tasks assess the ability to retrieve words based on specific criteria. The most common types include semantic fluency (generation of words within a category, such as "animals") and phonemic fluency (generation of words beginning with a given letter). Additionally, there are tasks focused on verb fluency (producing verbs or words representing actions) and free verbal fluency. PwAD have more pronounced deficits in semantic fluency than in phonemic fluency, which suggests that access to the lexicon through semantic associations is more impaired than access based on phonological cues. This pattern can be explained by the progressive impairment of connections between the semantic system and the executive areas of the brain[25,28,69,70].

In addition, patients with AD demonstrate greater difficulty in activating semantic representations from visual stimuli, which can compromise accuracy in naming pictures. Studies indicate that, as dementia progresses, semantic organization becomes less structured, leading to greater overlap of categories and more random semantic judgments. This weakening of semantic connections directly impacts the comprehension and production of sentences, resulting in less informative and more fragmented speech[28,69-72].

Regarding verb fluency, pwAD show reduced word production compared to healthy older adults. Since verbs require a more complex semantic organization for retrieval, they tend to be more sensitive to cognitive decline. While some studies indicate that verb retrieval relies on frontal and subcortical regions, including the motor cortex and basal ganglia, others report no significant differences between noun and verb fluency or between action verb and noun retrieval in AD patients. The cognitive demands of verb fluency tasks require the integration of multiple linguistic and executive functions, making deficits in this area an early and prominent feature of dementia[72-73].

To date, no studies have been found in the literature investigating free verbal fluency in patients with Alzheimer's disease. Most research focuses on semantic and phonemic fluency, leaving a gap in understanding how the ability to generate words without categorical restrictions in AD.

Semantic processing

Another relevant aspect is the difference between the processing of nouns and verbs in AD. Studies indicate that patients with AD tend to produce more verbs than nouns in descriptions of figures, which contrasts with normal patterns of speech production. This may be related to the semantic organization of verbs, which have more defined hierarchical structures, facilitating their recovery[56,74,75].

Verbs, on the other hand, require more complex semantic processing and are affected by AD in different ways. Patients have more difficulty with verbs that have a greater argumentative load and that depend on dynamic representations, which suggests an impact of AD on the integration of semantic information and the construction of argumentative structures[76-77].

Pragmatics

Pragmatic changes are a reflection of the cognitive and linguistic impairment that affects the ability to communicate in social situations. These changes often result in interactive or confusing interactions, impairing the patient's quality of life and hindering their interpersonal relationships[76,78,79].

One of the main impairments observed in pwAD is the difficulty in maintaining focus on a single topic during a conversation. This leads to abrupt or tangential changes in speech, impairing thematic coherence. The inability to sustain the topic can result in fragmented communications that are difficult for interlocutors to follow, especially in more complex dialogues[61,80].

Another important aspect is the difficulty in making inferences and connecting the content of the conversation with knowledge of the world. PwAD have problems integrating information and logical reasoning, which makes it difficult to interpret the communicative context. For example, when listening to a story, they have difficulties relating the events narrated to personal experiences or previous knowledge, generating responses that do not make sense or that deviate from the context presented[81-82].

Furthermore, these individuals often have trouble understanding non-verbal cues, such as facial expressions, gestures, and tone of voice. This limitation can lead to misunderstandings, as elements that are crucial to interpreting the speaker's intention are ignored or misinterpreted. This is compounded by the difficulty in understanding figures of speech, such as metaphors, sarcasm, and idioms. As a result, pwAD tends to interpret these constructions literally, which can create uncomfortable or embarrassing social situations[11,12,76,77].

Studies on pragmatics in individuals with AD in semi-spontaneous interactions indicate that the speech of these patients is disorganized and characterized by significant changes. Difficulties include impaired self-perception, episodes of depersonalization in more advanced stages of the disease and the presence of echolalic events. The speech of individuals with AD also presents a higher frequency of disfluencies, such as hesitations and repetitions, in addition to a high number of communicative breakdowns, compared to healthy elderly individuals[81].

In more structured interaction tasks, such as describing images, patients with AD perform more perseverations. However, these tasks may be simpler for patients due to the presence of visual stimuli, which provides support for the construction of discourse. Even so, only about 50% of the interpretations provided by these individuals fit the context presented, completely failing to interpret what is expected, which demonstrates a significant impairment in the organization of thought and language[83-84].

The linguistic production of these patients is also characterized by a high number of irrelevancies, redundancies, and incorrect statements. These failures not only hinder communication, but also make the discourse confusing and difficult to understand. The frequency of these errors correlates with the dimensions of the ability to maintain coherence and clarify when dealing with a topic[78,79,85].

The overall coherence of discourse is another point that is frequently compromised. Studies

comparing pwAD to dynamic controls show that the ability to maintain a theme or a narrative line throughout an interaction is significantly reduced. This can be achieved even in tasks such as structured interviews, in which there is support for speech organization. Despite these difficulties, patients in more advanced stages of the disease may present compensatory strategies, such as increasing the frequency of questions asked throughout the interaction. This attitude suggests that, in some cases, there is a partial perception of communication difficulties, and questions are used as an attempt to compensate for pragmatic deficits[11,85].

In general, the speech of pwAD is disorganized, confused and marked by frequent communicative breaks. These pragmatic alterations not only impact the quality of social interactions, but also make it difficult for the patient to engage in complex communicative contexts.

Considerations for Future Research

In view of the studies presented on changes in linguistic domains in AD, some gaps and challenges must be observed for carrying out future research.

Expanding linguistic and cultural diversity

Most studies on language impairment in AD have been conducted in English speakers. However, structural diversity among the world's languages may result in different patterns of language decline. Therefore, it is essential to expand research to languages that have not yet been studied, considering the specificities of the linguistic domains of these languages. In addition, research with populations from different sociocultural and ethnic backgrounds is essential to ensure the universal applicability and validity of the findings.

Use of multiple elicitation methodologies

Various methods of speech and language collection are essential to comprehensively estimate linguistic differences in the different stages of AD. The analysis of naming tasks, narrative recall and spontaneous interactions should be combined to obtain a more robust characterization of language impairment.

Improving linguistic characterization in AD

For a more precise understanding of speech and language disorders, future research should use multilevel analyses, including linguistic micro and macrostructures. This will allow a more detailed understanding of specific difficulties in different domains, such as textual cohesion, syntactic complexity, and verbal fluency.

Investigations in bilingual populations

Studies with bilinguals can provide valuable information about language processing and cognitive control in pwAD. Questions such as the possible bilingual advantage in language preservation and the interaction between the two languages throughout the progression of the disease deserve greater attention.

Increasing sample size and methodological rigor

Many studies still use small samples and lack longitudinal data. Future studies should seek to increase the number of participants and include more follow-up points over time. In addition, it is crucial to control variables such as age, gender, education and hearing status in order to minimize potential biases and increase the reliability of the findings.

Use of artificial intelligence and machine learning

The application of advanced algorithms for automated analysis of speech and language has shown great potential in the early detection of AD. Computational models can identify subtle patterns of language decline before clinical symptoms become evident, aiding in the diagnosis and

monitoring of disease progression.

Integration with functional neuroimaging

Combining language tasks with functional neuroimaging techniques may improve our understanding of the neural basis of language impairment in AD. Future research should explore how brain connectivity changes as the disease progresses and how this impacts language production and comprehension.

With these directions, it is expected that future investigations will expand our knowledge about language and speech alterations in AD, favoring more accurate diagnoses and more effective interventions for patients.

Conclusion

AD is a progressive neurodegenerative condition that affects several cognitive functions, with language being one of the most compromised domains. As the disease progresses, difficulties in lexical retrieval, grammatical structure and social communication are observed, significantly impacting the quality of life of patients and their caregivers. The detailed study of linguistic domains – phonetics, phonology, morphology, syntax, semantics and pragmatics – has been fundamental to understanding the patterns of cognitive decline in AD and to improving diagnostic and intervention strategies. Despite advances in research, challenges remain since most studies have been conducted in English speakers, which limits the understanding of the impacts of AD in different languages and cultural contexts. Furthermore, bilingualism has been associated with a delay in the onset of AD symptoms, suggesting that future research should explore the impact of linguistic diversity on disease progression. The impact of linguistic decline on the quality of life of patients with AD reinforces the need for continued research. With advances in artificial intelligence, neuroscience and interdisciplinary collaboration, there is hope that more effective methods will be developed to preserve communication and autonomy for individuals affected by the disease.

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