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Neuropsychological assessment of non-fluent variant of primary progressive aphasia in a bilingual French-Arabic speaking patient: A case study

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Abstract

Background: This case study presents a comprehensive assessment of a Moroccan patient diagnosed with a non-fluent/agrammatic variant of primary progressive aphasia (nfvPPA).

Objective: The study aimed to investigate neuropsychological and neurolinguistic deficits associated with nfvPPA and the potential implications for intervention.

Methods: A thorough neuropsychological exploration was conducted to assess various cognitive domains, including memory, attention, language, perceptual, attentional and executive functions. Regarding neurolinguistic assessment, the Mini-Linguistic State Examination (MLSE) was used to characterise the patterns of PPA.

Results: Neurolinguistic analysis revealed a clear pattern associated with nfvPPA, which includes impairments in the production of speech sounds, articulation, and phonological processing, alongside a reduced use of grammatical structures. Additionally, the patient exhibits challenges in understanding complex sentences, although his overall comprehension abilities remain relatively intact.
The patient also presented a significant decline in executive functions, memory, attention, and visual-constructive abilities. Linguistic deficits included impaired lexical-semantic abilities, phonological alexia, and lexical agraphia. Despite these impairments, the patient maintained some preserved functions, such as autobiographical memory and visuospatial abilities.

Conclusion: This case study highlights the progressive nature of nfvPPA and its impact on multiple cognitive domains. The patient's presentation aligns with an advanced stage of PPA, characterised by the presence of extralinguistic impairments. Further neuroimaging studies would be beneficial to confirm the underlying pathology and inform targeted interventions.

Keywords: PPA, Aphasia, Non-fluent, Bilingual, Neurocognitive, Agrammatic, nfvPPA

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INTRODUCTION

Primary progressive aphasia (PPA), referred to as Mesulam syndrome, is defined by a gradual and distinct deterioration in language capabilities, primarily resulting from progressive focal atrophy in the left perisylvian regions of the dominant hemisphere [1]. Affected individuals do not exhibit the typical characteristics associated with post-stroke Wernicke's or Broca's aphasia, likely due to the multifocal, partial, or progressive nature of the lesions involved [2]. PPA may present as either fluent speech, where normal speech patterns are preserved, or non-fluent speech, and it can impact phonology, syntax, or semantics to varying extents. Due to its clinical and linguistic variability, classification has been established [3,4] to guide standardised clinical assessments. Neuroimaging methods, such as magnetic resonance imaging (MRI), are utilised to exclude specific causes of aphasia, including stroke or tumours, and may reveal atrophy indicative of the degenerative process. Furthermore, functional imaging techniques like positron emission tomography (PET) may demonstrate localised hypometabolism, which can occur before any noticeable atrophy is detected on MRI [3].

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Table 1. A summary of the four main clinical variants of PPA

Variant	Core Features	Associated Neuropathology (Often, but not always)	Other Common Features
Nonfluent/Agrammatic PPA (nfvPPA)	* Agrammatism (difficulty with grammar) * Effortful, halting speech * Speech sound distortions (apraxia of speech)	Tau-related pathology (e.g., progressive supranuclear palsy, corticobasal degeneration)	* Relatively preserved comprehension * Motor deficits (e.g., rigidity, bradykinesia) may develop
Semantic PPA (svPPA)	* Anomia (difficulty finding words) * Impaired comprehension of single words * Surface dyslexia (difficulty reading irregular words)	TDP-43 pathology (often associated with frontotemporal lobar degeneration)	* Relatively preserved grammar and speech production * Prosopagnosia (difficulty recognizing faces) may be present
Logopenic PPA (lvPPA)	* Word-finding difficulties (pauses, circumlocutions) * Impaired sentence repetition * Phonological working memory deficits	Alzheimer's disease pathology (amyloid plaques and neurofibrillary tangles)	* Relatively preserved single-word comprehension and grammar * Slower rate of progression compared to other variants
Mixed/Unclassifiable PPA	Presents with features of more than one PPA variant but doesn't clearly fit into one of the other categories.	Variable, reflecting the mixed clinical presentation	Varies depending on the combination of features present.

The classification system introduced by Mesulam et al. [4] delineates PPA as a spectrum that includes several distinct variants: the non-fluent and agrammatic variant (nfvPPA), the semantic variant (sv-PPA), the logopenic variant (lv-PPA), which may present with or without challenges in sentence repetition and the mixed variant (mv-PPA), which encompasses any combination of the above-mentioned types (Table 1). Moreover, additional taxonomies have emerged, emphasising narrative discourse and writing as potential early markers of pre-linguistic impairments in PPA [5-7]. Given these insights, it is crucial to reevaluate PPA to adequately address the linguistic, cognitive, neuroanatomical, and biological intricacies and variabilities that characterise each variant while integrating specific screening assessment tools [8]. Our study focused on illustrating the linguistic and neuropsychological profile of a bilingual Arabic-French-speaking patient who has been diagnosed with the non-fluent and agrammatic variant of PPA.

CASE

The neuroimaging showed a fronto-parietal atrophy with a slight hippocampal atrophy (Figure 1). A thorough neuropsychological assessment was conducted over the course of two days every week throughout January 2020 to evaluate the cognitive condition of the patient. Each segment of the testing lasted one hour and utilised neuropsychological evaluations in either Arabic or French, depending on the patient's linguistic proficiency and preferences.

During the neuropsychological assessments, the patient reported experiencing difficulties with recent event recall, reading comprehension, and dressing. The patient demonstrated nosognosia and was informative about his

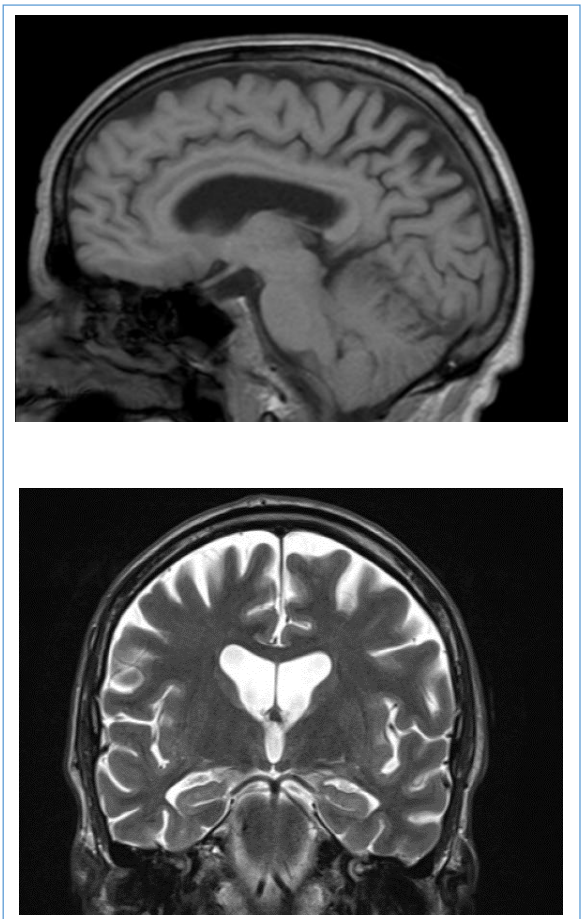

Figure 1. MRI – a) Sagittal cut highlighting a fronto-parietal atrophy b) Coronal cut showing a slight hippocampal atrophy

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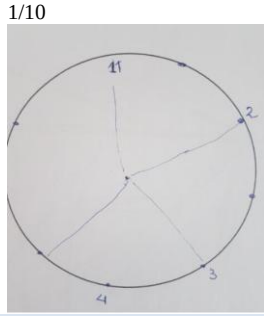
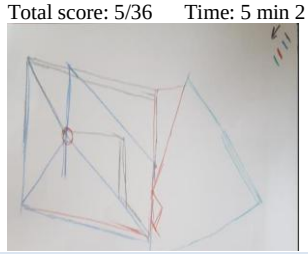
complaint. He expressed significant concern regarding his memory deficits, word-finding difficulties, and occasional fluctuations in cognitive performance throughout the day. He also exhibits reduced autonomy (IADL: 6/8). An interview with the patient's spouse provided more detailed information about the memory complaint. She reported that her husband's forgetfulness began in 2015. More specifically, while they were on pilgrimage in 2017, the deficit intensified, resulting in the patient becoming disoriented for three days, which caused prolonged distress. Subsequently, a topography study office opened by the patient was closed after three years due to forgetfulness and apprehension about committing errors (plans, distance estimations). The patient had a keen interest in Arabic music and played the Arabic guitar (wtar). He possessed extensive knowledge of oriental musical repertoire and demonstrated a clear and harmonious singing voice.

Regarding leisure activities, he had been cycling regularly for 10 years, participating in group rides in the vicinity of Rabat. However, forgetting bicycle repair procedures and losing basic mechanical knowledge were the initial signs that alerted the patient and his friends during cycling events. The patient exhibited high compliance and engagement in conversation, reporting partial details of his daily routine, distant and professional experiences (studies, hobbies, work, and autobiographical information). His speech was well-adapted, and his mood and behaviour did not exhibit any anxiety, depression or apathy signs (apathy scale: score 3/42). He actively participated in cooking therapy and music sessions conducted at the Alzheimer Centre of Rabat.

RESULTS

Three years after the onset of the initial progressive memory disorders (Table 2) the neuropsychological assessment revealed, a severe executive dysfunction that interferes with memory performance (in working and long-term memory), attentional, and visual-constructive abilities within the context of significantly impaired intellectual efficiency and dysfunctional linguistic and lexico-semantic abilities (parallel impairment of spoken language marked by lack of words and a suspicion of phonological alexia associated with lexical agraphia). It should be noted that the processes of encoding and retrieving information require increased cognitive effort compared to previous functioning. Visuo-perceptual abilities remained intact; however, praxis abilities were impaired (presence of gestural apraxia and suspicion of mild dressing apraxia). Visuo-constructional abilities were severely impaired, which is consistent with a left parietal profile (quasi-compliance with the global plan but absence of details). The patient's performance on the Clock Drawing Test (CDT), scoring 1 out of 10, revealed a profound deficiency in visuospatial abilities, executive functioning, and motor coordination. This outcome indicates challenges in understanding the layout of the clock face, organising

Table 2. Neuropsychological assessment of Mr R.

Tests	Initial Assessment in 2020
Montreal Cognitive Assessment (MoCA)	Total score 10/30 Visuospatial/Executive 1/5 Naming 3/3 Attention 2/5 Language 2/3 Abstraction 1/2 Delayed Recall 0/5 and Orientation 1/6
Mini-Mental State Examination (MMSE=	Total score: 15/30 Orientation to time and place 4/10 Immediate recall 3/3, short-term verbal memory 1/3 calculation 0/5, language 7/8, and construct ability 0/1
FAB (Frontal assessment battery)	Total score: 11/18 Conceptualization 3/3 Mental flexibility 2/3 Motor programming 1/3 Sensitivity to interference 1/3, Inhibitory control 1/3 Environmental autonomy 3/3
TMT -Trail Making test	TMT A (6 Errors / 3 min 57 sec) TMT B (11 Errors / 3 min 20 s)
Clock Drawing Test	1/10 
Categorical and literal verbal fluency	Letter Fluency P(9) (3 intrusions) / R (10) (9 intrusions) Semantic category fluency - Animals (9) 0 repetitions /3 intrusions - Fruits (5) 2 intrusion / 0 repetitions
MIS (Memory impairment screen)	Immediate recall: 3/4 Free recall 8/8 cued recall 0/8 Delayed Free recall : 0/8 delayed cued recall 1/8 (5 intrusions)
Digit span task	Digit span forwards (4) Digit span backwards (2)
PEGV (visual perception)	Intertwined figures: 32/36 Identical figures: 7/10 Categorical matching : 10/12 Functional matching: 9/12
Praxis examination	Symbolic gestures 5/5 Pantomines 8/10 Abstract gestures 5/8
Rey-Osterrieth Complex Figure (ROCF) Test	Total score: 5/36 Time: 5 min 2 s 
IADL	6/8

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spatial elements, and executing the drawing task effectively (Table 2).

Regarding episodic memory, the patient exhibited significant executive dysfunction in retrieval mechanisms. No learning effect was observed. Cueing did not normalise or improve performance. Furthermore, there was a substantial deficit in storage (a delayed recall deficit reflecting dysfunction of the hippocampal regions). However, the slight deficit in encoding was more appropriately attributed to the underlying executive deficit (lack of effective memory strategy in immediate recall). Severe executive dysfunction was observed in central executive processes, including inhibition, dual-task processing, flexibility, planning, and maintaining an isolated strategy. Semantic memory demonstrated dysfunction in the retrieval mechanisms of naming and word generation, while perseverative intrusion errors were dysexecutive in nature. Visuo-perceptual abilities did not exhibit difficulties at the level of asemantic or associative agnosia. However, the Rey-Osterrieth Complex Figure (ROCF) Test, which assessed visual-attentional, visuospatial, and constructional functions, revealed significant difficulties in visuospatial perception, constructional abilities, and visual memory. This score suggested that the patient struggled to accurately interpret and replicate a complex visual image, pointing to potential issues with attention, planning, the integration of visual and motor functions and the exploration of space, both at the level of apprehension of spatial relations between the different elements of a figure and at the level of executive processes (organisation and arrangement of details) (table 2).

In terms of spontaneous language, it exhibited reduced categorical and literal fluency (Table 2), accompanied by anomia and certain features of paragrammatism. At the levels of motor speech and oro-practo-motor function, there were no indications of speech apraxia, dysarthria, or oro-linguo-facial apraxia. Neurolinguistic analysis utilising Mini-Linguistic Status Examination (MLSE) [9] (Table 3) demonstrated a distinct pattern of nfvPPA, encompassing mild deficits in in sequencing (phonological processing),

Table 3. MLSE results of Mr R by subtests and main subdomains

Subtests	Patient's results
1-Picture naming (n=6)	6
2- Repetition of mono and multi-syllabic words (n=3)	3
3- Single word comprehension (n=3)	2
4- Repetition (n=3)	3
5- Semantic association (n=4)	2
6- Oral comprehension of sentences 1 (n=4)	3
7- Oral comprehension of sentences 2 (n=4)	2
8- Sentence repetition (n=4)	3
9- Reading (n=10)	7
10- Writing (n=6)	2
11- Picture description (n=5)	3
MLSE subdomains	Patient's results
Motor speech (n=30)	30
Semantics (n=30)	21
Phonology (n=30)	26
Syntax (n=10)	5
Global score (n=100)	82

Table 2. MLSE results of Mr R. H by subtests and main subdomains

Subtests	Patient's results
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4- Repetition (n=3)	3
5- Semantic association (n=4)	2
6- Oral comprehension of sentences 1 (n=4)	3
7- Oral comprehension of sentences 2 (n=4)	2
8- Sentence repetition (n=4)	3
9- Reading (n=10)	7
10- Writing (n=6)	2
11- Picture description (n=5)	3
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Motor speech (n=30)	30
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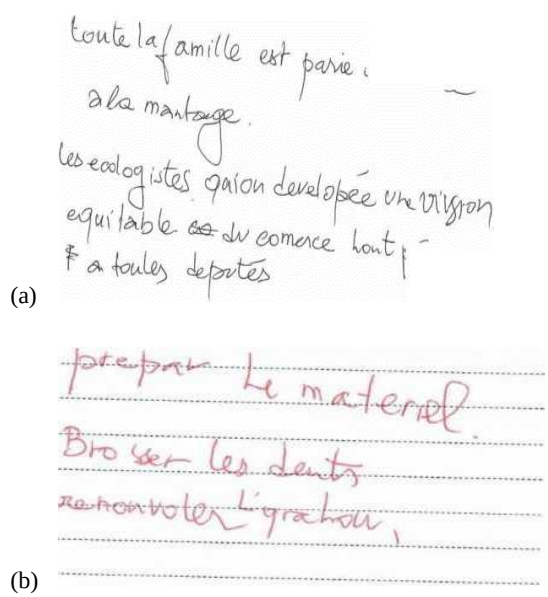

(a)

(b)

Figure 2. Mr R writing performance in French – a) Writing to dictation b) spontaneous writing sample

diminished utilisation of grammatical structures (agrammatic speech) and difficulties comprehending complex sentences (although comprehension skills may be relatively preserved). Furthermore, the patient did not exhibit reduced speech rate, effortful articulation or apraxia of speech which are indicative of motor speech impairment. However, working memory deficits were observable, affecting the capacity to maintain information in short-term memory. Reading aloud was impaired for both regular and irregular words, with particular difficulty in the latter. Paralexic and phonologically plausible errors were produced on pseudo-words and non-words. Lexico-semantic and syntactic comprehension was partially preserved. Generally, the grapho-motor function was coherent, characterised by regular strokes, and performance was maintained over time. At the allographic level, few errors were present; however, at the graphemic level, omission errors were more prevalent than substitutions (Figure 2).

Nevertheless, the fact that Mr. R predominantly employs French in his daily life, despite his inclination towards spoken French infused with the Moroccan Arabic dialect, indicates that the cognitive requirements of written language, especially in formal settings, may differ from those associated with spoken language. Moreover, the partial impairment of L1 (Arabic) alongside relatively better retention of L2 (French) may be elucidated by the distinct linguistic patterns linked to the non-fluent/agrammatic variant of PPA as displayed by MLSE performance.

DISCUSSION

Mr. R demonstrated a distinct pattern of nfvPPA, encompassing deficits in phonological processing, grammatical structures and difficulties comprehending complex sentences in French and Arabic. Furthermore, the patient did not exhibit reduced speech rate, effortful articulation or apraxia of speech, which are indicative of motor speech impairment. Nosognosia is consistently experienced by the patient, who spontaneously expressed these complaints while maintaining some activities of daily living. This clinical presentation suggests a progression towards an advanced stage of nfvPPA. It may also evolve into a mixed variant of PPA while some features of logopenic variant were present or towards a PPA-plus syndrome with more extended cognitive impairments, including episodic memory, gestures and executive functions.

Neurolinguistic assessment of nfvPPA involves assessing various language and cognitive domains. Patients typically present with agrammatism in language production and effortful speech [10]. Key features include phonological and semantic paraphasias, impairment in repetition, writing of non-words, and sentence comprehension difficulties [11]. A comprehensive assessment should include both language and non-language testing to aid in diagnosis and subtyping [12]. Language evaluations often involve connected speech analysis, which is crucial for identifying agrammatism, a core feature of nfvPPA [13]. Simultaneously, non-language cognitive impairments in nfvPPA may include executive function deficits, with relative preservation of memory and visuospatial functions [12]. This contrasts with other PPA variants, such as the logopenic variant, which exhibits impairments in phonological working memory, acalculia, and mild difficulties with memory and visuospatial functions [12]. Notably, some cases of nfvPPA may present with atypical features, such as generalised auditory agnosia, as reported in a case study where the patient was unable to identify verbal sounds, environmental sounds, or familiar songs [14]. Unlike nf-vPPA in our case study, it can evolve into a more complex clinical syndrome known as PPA-plus, which includes additional cognitive and motor symptoms. The evolution of the neuropsychological profile in this progression is characterised by several key features. The neuroimaging profile typically shows initial involvement of the premotor/motor cortex, with subsequent spread into the prefrontal cortex over time [15,16].

The issue of differential language preservation among bilingual individuals diagnosed with PPA presents a multifaceted challenge [17,18], exemplified by the case of Mr. R, who speaks both Arabic and French. Although the emphasis on his bilingualism is noteworthy, a more thorough examination of which language—Arabic or French—remains relatively intact would enhance the understanding of the targeted language in rehabilitation. It is essential to take into account not only the language dominance observed during assessments but also Mr. R's stated language preferences and the typical environments in which he utilises each language throughout his daily activities. His inclination to converse in French, occasionally incorporating the Moroccan Arabic dialect, while predominantly communicating in French through writing, indicates cross-linguistic factors that contribute to the dynamics of language retention and attrition [19].

Several theories may account for this observed linguistic pattern. One potential explanation is that Mr. R's language usage habits prior to the onset of PPA have shaped the progression of his language decline [20]. As long as French served as his primary language for professional or written communication, its more frequent engagement could have offered a cognitive buffer, thereby postponing the disease's effects on this particular language system [21]. In contrast, while Arabic, including the Moroccan dialect, may be more prevalent in social interactions, the informal and potentially less cognitively taxing nature of these exchanges might not afford the same degree of protective benefit. Additionally, the age at which each language was acquired could play a significant role; if French was learned later in life (as a second language which not the case of our patient), it may be more vulnerable to the impacts of neurodegeneration, especially if the disease predominantly affects the brain regions responsible for the acquisition and processing of a

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second language. However, the observation that Mr R primarily uses French in writing, despite his preference for spoken French in Moroccan Arabic dialect, suggests that other factors beyond the simple frequency of use are at play. The cognitive demands of written language, particularly in a formal context, might be different from those involved in spoken language [22,23]. It is possible that the cognitive resources required for written French are relatively preserved compared to those needed for spoken Arabic or that the specific neural networks supporting written French are less affected by the disease process [24]. Furthermore, the quasi-impairment of L1 (Arabic) with relatively better preservation of L2 (French) could be explained by the specific patterns of brain atrophy associated with the non-fluent/agrammatic variant of PPA. Research suggests that this variant often affects frontal brain regions crucial for grammatical processing, and these regions might be more critical for Arabic [25,26], a language with a more complex grammatical structure compared to French. Further investigation into the specific linguistic features affected in each language, along with neuroimaging data, would be needed to explore these possibilities further.

Individualised treatment is paramount, as it underscores the necessity of customising interventions to align with the unique profile of each patient, taking into account their specific strengths, weaknesses, and communication objectives [27]. Though they could be adapted to Mr R, it is worth mentioning that his assessment has not been followed by specific neuro-cognitive interventions. However, the identification of specific neuropsychological and linguistic deficits, such as agrammatism, apraxia of speech, and word-finding difficulties, is crucial for developing targeted intervention strategies. For instance, the presence of significant agrammatism indicates that interventions aimed at enhancing grammatical production, including techniques like sentence structure training and mapping therapy [28], may prove advantageous. To proactively prevent the installation of apraxia of speech, it is essential to implement approaches that focus on motor speech planning and articulation, utilising methods such as Combined Aphasia and Apraxia of Speech Treatment (CAAST) [29].

Furthermore, addressing observed anomia can be effectively achieved through interventions designed to enhance lexical retrieval, employing strategies like semantic feature analysis and cueing hierarchies [30]. Neuropsychological rehabilitation and interventions for nfvPPA focus primarily on language deficits but also address associated cognitive impairments. Research indicates that patients with nfvPPA exhibit deficits in executive, working memory functions and praxis in addition to their core language impairments [31]. These disorders may be present in nfvPPA, even in the early stages, suggesting the need for targeted executive function training [32,33]. Therefore, the complex nature of nfvPPA, with its primary language deficits and associated cognitive impairments, underscores the importance of individualised, multimodal interventions tailored to each patient's specific profile of strengths and weaknesses [34].

Simultaneously, involving caregivers in the intervention process is essential, as providing them with education and support can significantly enhance communication between the patient and their caregivers. Future clinical studies should investigate the effectiveness of specific treatment approaches for nfvPPA and explore innovative intervention techniques such as neuromodulation [35,36]. It is also important to set realistic expectations, recognise the progressive nature of PPA, and emphasise that interventions should aim to maintain communication abilities and improve quality of life rather than attempting to reverse the underlying condition [37]. A multidisciplinary approach is also vital, as it highlights the collaborative roles of various professionals, including speech-language pathologists (SLP), occupational therapists, behavioural neurologists and neuropsychologists, in the intervention process. Additionally, exploring communication strategies, particularly the use of augmentative and alternative communication (AAC) and e-health devices, becomes increasingly important in the later stages of the disease [38,39].

A comprehensive neuropsychological and neurolinguistic assessment for nfvPPA should encompass an assessment of language production and comprehension, executive functions, and other cognitive domains. It is essential to note that the clinical presentation of nfvPPA can be complex, and there may be overlap with other PPA variants or neurodegenerative conditions, necessitating specific assessment and longitudinal follow-up for accurate diagnosis [8,40-42].

Conclusion

The present case study highlighted the neuropsychological and cross-linguistic features of nfvPPA in bilingual Arabic-French-speaking patients. The clinical outcome and prognosis align with extralinguistic impairments as found in advanced stages of mixed variant or PPA plus syndrome, characterised by the emergence of gestural apraxia, significantly impaired constructive apraxia, and agraphia with surface dysorthographia. These findings elucidate the severity of this neurodegenerative condition and its potential progression over time. Further neuropsychological, neurolinguistic, and neuroimaging studies would be beneficial in confirming differential cross-linguistic impairment in French vs Arabic, as well as the underlying pathology, leading to tailoring specific clinical interventions.

DECLARATIONS

Ethical consideration

This study does not possess an ethics code; nonetheless, all ethical considerations were taken into account in the preparation of this article. The participant and his spouse

were informed about the research objectives and its diagnostic phases, and they were assured of the confidentiality of their personal information. Additionally, they were given the option to withdraw from the study at any time they desired.

Consent to publish
All authors agreed on the content of the final paper.

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Competing Interest
The authors declare no conflict of interest

Author contribution
MT contributed to the study's conceptualisation, design, data collection, analysis, drafting and finalisation of the manuscript.

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Availability of data
Data is available upon request to the corresponding author

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