

Beyond survival: cognitive, linguistic, and quality-of-life outcomes after an out-of-hospital cardiac arrest in a neurologically complex patient

Marianna Christodoulou Devledian^{1*}, Astero Constantinou², Tasos Tsokkos², Tonia-Flery Artemi³, Andrea Lori¹, Elena Yiangou¹, Chryssoula Thodi¹ and Fofi Constantinidou⁴

¹ European University Cyprus, Nicosia, Cyprus.

² Cyprus Institute of Neurology & Genetics, Nicosia, Cyprus.

³ Neapolis University Pafos, Pafos, Cyprus.

⁴ University of Cyprus, Nicosia, Cyprus.

* Correspondence: mari.christodoulou@euc.ac.cy; Tel.: +35722029904

Received: 12 February 2026; **Accepted:** 3 July 2026; **Published:** 30 September 2026

Edited by: Elena Molchanova (American University of Central Asia)

Reviewed by: Mohamed Taiebine (Université Euro-Méditerranéenne de Fès UEMF);
Gulnara Kurmanova (American University of Central Asia)

<https://doi.org/10.31117/neuroscirn.v9i3.550>

ABSTRACT: Out-of-hospital cardiac arrest (OHCA) often results in hypoxic–ischemic brain injury with persistent neurocognitive sequelae that may not be fully captured by routine neuroimaging. We report a detailed neuropsychological and language profile of a 32-year-old Greek-speaking Cypriot male assessed six months after OHCA. The case was neurologically complex, as the patient had a history of right frontal traumatic brain injury, chronic right frontal gliosis, post-traumatic epilepsy, and long-term antiepileptic treatment prior to the OHCA. A standardized, culturally appropriate battery with qualitative analysis assessed attention, processing speed, executive functions, memory, language, and visuospatial abilities, alongside mood and quality of life. Findings showed a heterogeneous pattern, including severe impairments in verbal episodic memory and moderate-to-severe executive dysfunction, mild attentional inefficiency, and relatively preserved visuospatial skills and nonverbal memory. Language performance was characterized by impaired lexical access and discourse/narrative organization, consistent with executive–linguistic interaction. The profile was interpreted cautiously as potentially reflecting interacting contributions from post-arrest hypoxic–ischemic vulnerability, pre-existing frontal pathology, epilepsy-related factors, and medication effects. Patient reported outcomes indicated preserved emotional well-being and satisfactory quality of life. This case underscores the value of early cognitive-linguistic and psychosocial screening following OHCA and supports multidisciplinary follow-up assessment to identify impairments affecting communication, activity, and participation. To our knowledge, this is the first detailed post-OHCA neuropsychological characterization of a Greek speaking Cypriot patient, highlighting the need for culturally and linguistically tailored assessment. This contributes data to an underrepresented population and suggests priority targets for intervention.

Keywords: Cardiac arrest; Hypoxic brain injury; Cognitive function; Cognitive impairment; Cognition

©2026 by the Devledian *et al* for use and distribution in accordance with the Creative Commons Attribution (CC BY-NC 4.0) license (<https://creativecommons.org/licenses/by-nc/4.0/>), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original author and source are credited.

1.0 INTRODUCTION

The sudden cessation of cardiac activity outside a hospital setting, otherwise referred to as Out-of-Hospital Cardiac Arrest (OHCA), frequently results in hypoxic-ischemic brain injury and lasting neurocognitive sequelae ([Cronberg et al., 2021](#); [Sandroni et al., 2018](#); [Sandroni et al., 2021](#)). While survival rates have improved with advances in resuscitation and post-arrest care ([Husain et al., 2013](#); [Zijlstra et al., 2016](#); [Myat et al., 2018](#); [Yan et al., 2020](#)), cognitive outcomes remain heterogenous and incompletely characterized across populations.

Cognitive impairments are a prevalent consequence of out-of-hospital cardiac arrest (OHCA), primarily resulting from hypoxic-ischemic brain injury sustained during the no-flow and low-flow phases of the arrest ([Cronberg et al., 2021](#); [Sandroni et al., 2018](#); [Sandroni et al., 2021](#)). Deficits typically affect memory, language, and verbal fluency executive functioning, attention, and processing speed abilities essential for independence and daily functioning ([Joshi et al., 2024](#); [Jaszke-Psonka et al., 2016](#); [Mędrzycka-Dąbrowska et al., 2018](#)), reflecting the vulnerability of the frontal and temporal-parietal areas associated with anterior, middle and posterior cerebral artery circulation to hypoxia ([Cronberg et al., 2021](#); [Sandroni et al., 2018](#)). Executive functions and working memory, regulated primarily by the prefrontal cortex and hippocampus, are especially vulnerable to ischemic insults ([Small et al., 2011](#)). Case and cohort studies have shown that such deficits can persist for months after cardiac arrest, especially among patients with delayed return of spontaneous circulation (ROSC) or prolonged hypoxia ([Moulaert et al., 2009](#); [Geva et al., 2024](#)).

Surviving a cardiac arrest is increasingly conceptualized as a multidimensional outcome that extends beyond survival alone to include cognition, emotional distress, health-related quality of life, return to activity, and social participation ([Nolan et al., 2021](#); [Mion et al., 2021](#); [Hagberg et al., 2022](#)). Cognitive linguistic impairments may affect return to work, social participation and resuming everyday responsibilities, thus diminishing overall quality of life ([Nolan et al., 2015](#); [Nolan et al., 2021](#)). Psychological consequences such as anxiety, depressive symptoms, and emotional blunting often co-occur with cognitive-linguistic deficits and further affect social reintegration and well-being ([Lilja et al., 2015](#); [Evald et al., 2025](#)). Recent longitudinal work indicates that long-term cognitive and psychosocial outcomes require early identification and tailored follow-up ([Glimmerveen et al., 2025](#)), particularly in patients with

complex neurological histories, in whom post-cardiac arrest cognitive findings may reflect interacting contributions from hypoxic-ischaemic injury, pre-existing brain pathology, epilepsy, and treatment effects. These considerations are particularly pertinent to the present case, in which interpretation of post-arrest cognitive linguistic findings was complicated by the patient's pre-existing neurological history.

The severity and extent of dysfunction following cardiac arrest vary widely among individuals, influenced by factors such as the quality and duration of cardiopulmonary resuscitation (CPR), time to ROSC, initial neurological presentation, and the application of targeted temperature management ([Bisht et al., 2022](#)). These diverse outcomes underscore the complexity of hypoxic-ischemic encephalopathy and its interplay with patient-specific variables. In light of this variability, early neuropsychological and language screening, coupled with timely initiation of rehabilitation, is essential to optimize recovery and mitigate long-term burdens on both healthcare systems and families ([Byron Alhassan et al., 2021](#); [Jensen et al., 2024](#)).

While large cohort studies identify general population-level risk patterns ([Phelps et al., 2011](#)), detailed single-case evaluations are essential for capturing individual profiles. By exploring post-OHCA cognitive-linguistic complexity and psychosocial trajectories in depth, they better inform treatment targets ([Behn et al., 2019](#); [Krasny-Pacini & Evans, 2018](#); [Alexander et al., 2011](#)).

We present a comprehensive neuropsychological, language, and quality-of-life assessment of a 32-year-old, bidialectal Greek-speaking Cypriot male evaluated six months after OHCA. Importantly, this was a neurologically complex case, as the patient had a history of right frontal traumatic brain injury (TBI), post-traumatic epilepsy, chronic right frontal gliosis, and long-term antiepileptic treatment prior to the cardiac arrest. Using standardized tests with Greek adaptations and qualitative analysis, we delineate domain-specific weaknesses and preserved abilities, relate findings to suspected neural substrates, and consider functional implications for daily life. To our knowledge, this is the first detailed post-OHCA cognitive-linguistic characterization from Cyprus, contributing data from an underrepresented population while also illustrating the interpretive challenges and clinical value of culturally and linguistically tailored assessment in neurologically complex patients to inform individualized rehabilitation.

2.0 CASE PRESENTATION

2.1 Case Report

The patient was a 32-year-old, right-handed, Greek-speaking male with 12 years of formal education. At the time of the OHCA, he was engaged to be married and employed in manual labor. His past medical history was notable for a post-traumatic epilepsy following a right-sided closed frontal head injury sustained in a bicycle fall at age 16. Prior to the OHCA, there was no reported functional cognitive sequelae; however, the patient had been receiving long-term antiepileptic therapy. Collateral history indicated that he had completed high school, was employed, maintained family and social roles, and functioned independently in everyday life. No formal premorbid neuropsychological assessment was available. He had no known cardiovascular risk factors, including hypertension, obesity, and diabetes mellitus. Lifestyle history was notable for a 7-year smoking habit.

On the day of the event, the patient was found by family members lying on the ground with foamy oral secretions. He was unconscious, and bystander cardiopulmonary resuscitation (CPR) was initiated, with an estimated downtime of approximately 8 minutes. Upon arrival, Emergency Medical Services (EMS) identified ventricular fibrillation; two DC shocks were delivered, resulting in return of spontaneous circulation (ROSC). He was transferred to the Emergency Department (ED), where he experienced recurrent pulseless electrical activity (PEA). CPR was re-initiated,

and ROSC was achieved after two cycles. The patient was subsequently intubated, mechanically ventilated, sedated, and admitted to the intensive care unit (ICU). The precise overall duration of cerebral hypoxia could not be reliably determined. It was reported that approximately one month prior to this event, the patient had discontinued his antiepileptic medication.

After 48 hours, he was successfully extubated and, once clinically stable, transferred from the ICU to the general ward. Approximately one week into the admission, he developed agitation, disorganized behaviour, and paranoid ideation. Following neurological consultation, an electroencephalogram (EEG) was performed, demonstrating intermittent generalized epileptiform discharges. Antiepileptic treatment was initiated with levetiracetam 500 mg twice daily, which was later switched to valproic acid 750 mg twice daily. In addition, following psychiatric consultation, olanzapine 5 mg twice daily was initiated.

Brain CT performed on admission and repeated on hospital day 2 showed no intracranial haemorrhage or acute focal or global ischaemia, and no intracranial arterial occlusion without interval change. The known right frontal hypodensity, consistent with chronic gliosis following prior head trauma, was identified as seen in Figure 2. Brain MRI performed during the admission was significantly limited by motion artefacts; therefore, no additional diagnostic information could be obtained.

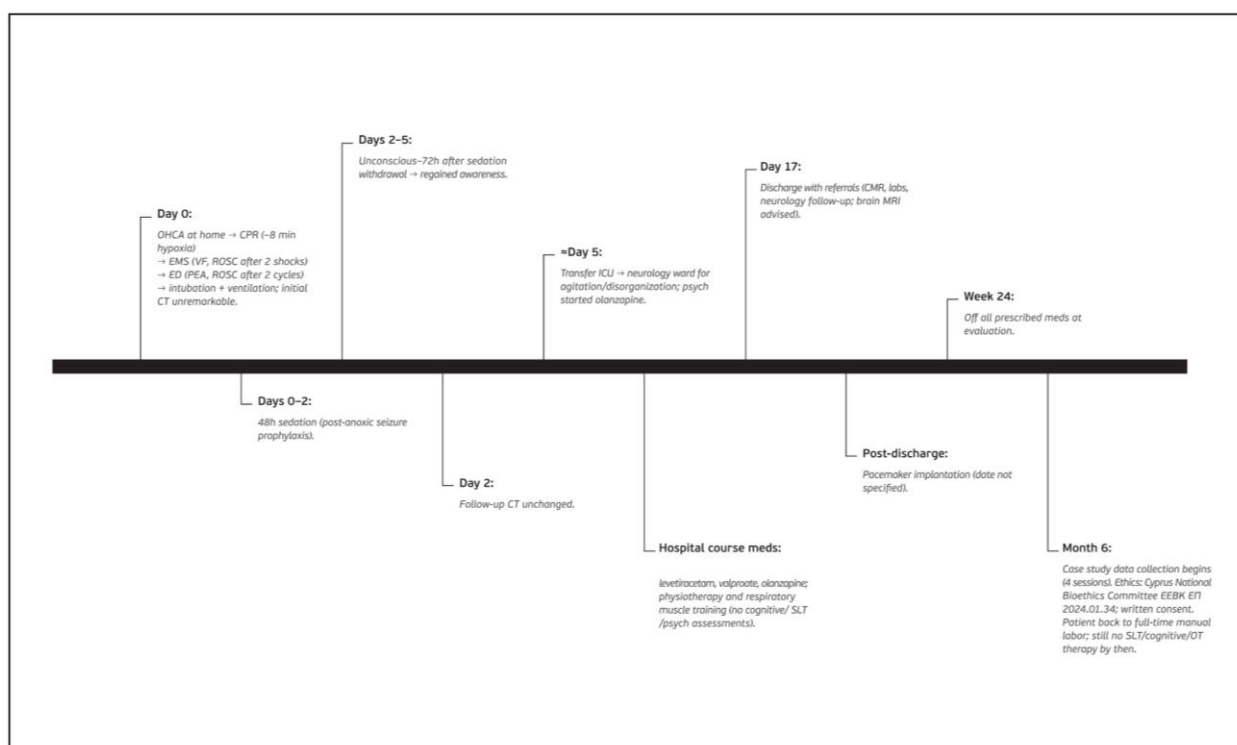


Figure 1. Summary of the patient's clinical course, diagnostic work-up, results, and treatment.

Transthoracic echocardiography performed during the admission demonstrated normal left ventricular systolic function. Holter monitoring and the discharge electrocardiogram showed sinus rhythm without ST-segment or T-wave abnormalities.

The patient also received physiotherapy and respiratory rehabilitation. No formal cognitive, language, or neuropsychological assessments were conducted during hospitalization. The patient was discharged 17 days after the OHCA, haemodynamically stable and fully ambulatory. The aetiology of the cardiac arrest remained unclear. A seizure-related mechanism was considered in view of the patient's history of structural epilepsy; however, a definitive causal relationship between epilepsy and the cardiac arrest could not be

established; no motor seizures were observed during the hospital admission. Discharge planning included recommendations for close outpatient follow-up with cardiology, neurology, and psychiatry. An EEG performed externally three weeks after discharge demonstrated mild diffuse cerebral dysfunction, without epileptiform discharges. Figure 1 shows the patient's clinical course, diagnostic work-up, results, and treatment.

2.2 Investigations and medical work-up during hospital stay

Table 1 summarizes the imaging, electrophysiological, and cardiopulmonary investigations performed during the index hospitalisation.

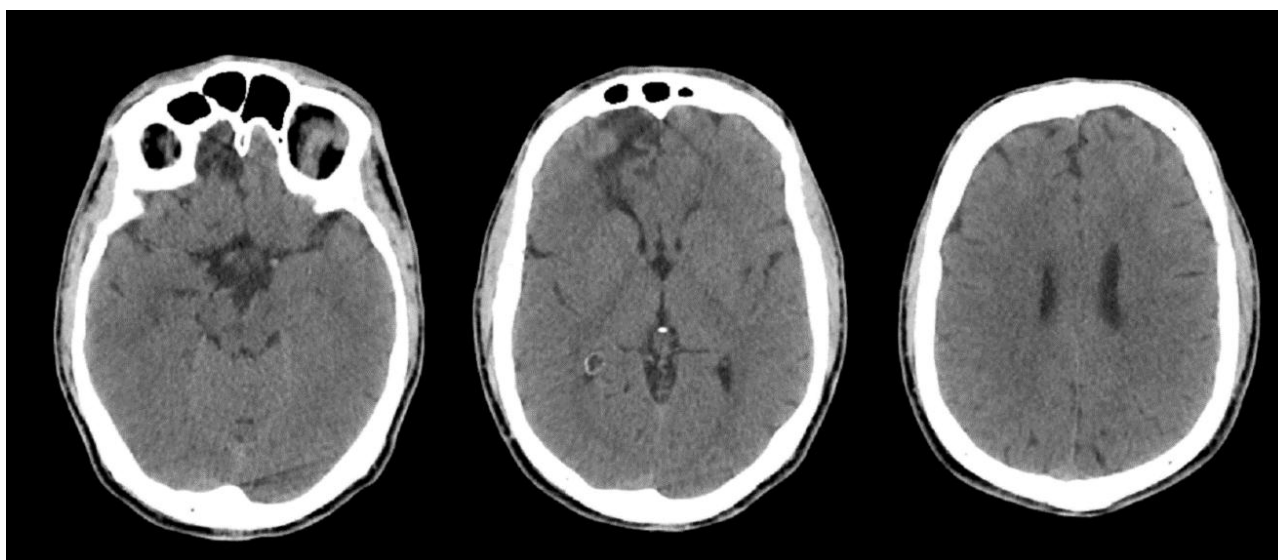


Figure 2. Non-contrast brain CT performed on admission following out-of-hospital cardiac arrest. Representative axial slices demonstrate preserved grey–white matter differentiation, including at the level of the basal ganglia, with no evidence of acute intracranial haemorrhage, mass effect, or diffuse cerebral oedema. A focal right frontal hypodensity consistent with chronic gliosis related to prior head trauma is noted.

3.0 METHODOLOGY

3.1 Neuropsychological assessment and data collection

Data collection began 6 months post-event and spanned four sessions. By this time, the patient had received no SLP/cognitive/OT therapy and had resumed full-time manual labor. Neuropsychological testing was conducted in Greek using quantitative and qualitative methods across orientation, attention, memory, language, visuospatial processing, and executive function. Performance was compared with Greek-validated norms from standardized instruments and with estimates of premorbid ability.

Assessment was grounded in Luria's systems framework ([Mikadze et al., 2019](#)) and the International Classification of Functioning, Disability and Health framework (ICF) model ([Tate & Perdices, 2008](#)). Additionally, the selection of test materials was based on assessment tools that have been systematically applied in research with Greek-Cypriot participants ([Constantinidou, 2019](#); [Constantinidou, et al., 2015](#); [Chadjikyprianou et al., 2021](#); [Constantinidou, et al., 2012](#)), ensuring cultural and linguistic appropriateness and alignment with evidence-based methodologies. Instruments are summarized in Table 2.

Table 1. Summary of imaging, electrophysiological and cardiopulmonary results

Investigation	Timing	Key findings	Interpretation/Notes
Brain CT with CT-angiography	On admission	No intracranial haemorrhage or acute ischaemia; midline structures preserved without shift/mass effect; no evidence of intracranial arterial occlusion; right frontal hypodensity consistent with gliosis; no skull fracture identified.	No acute intracranial pathology; chronic right frontal gliotic change
Repeat brain CT	Hospital day 2	No significant interval change compared with admission CT and prior CT	Stable findings
CTPA	On admission	No filling defect in main pulmonary arteries or major branches; fibro-atelectatic changes; bilateral basilar opacities; small ill-defined right-sided ground-glass opacities; no pleural or pericardial effusion	No radiological evidence of pulmonary embolism; non-specific basal changes
Brain MRI	During admission	Marked motion artefact limiting assessment; available sequences showed focal T2 hyperintensity in right frontal juxtacortical region	Limited diagnostic yield due to motion; focal right frontal T2 signal abnormality noted
EEG	During admission	Intermittent generalised epileptiform discharges.	Findings supportive of epileptiform activity.
EEG	Three weeks after discharge	Diffuse background slowing (7Hz); no evidence of epileptiform potentials.	Mild diffuse cerebral dysfunction; no epileptiform activity.
Transthoracic echocardiography (TTE)	During admission	Sinus rhythm; LV size normal with borderline hypokinesia; LA diameter 42 mm; RA/RV normal size; no valvulopathy; normal aortic dimensions; no pericardial effusion	Mild functional LV abnormality reported; mild LA enlargement (by diameter); otherwise unremarkable
Holter ECG	During admission	Predominant sinus rhythm; mean HR 56 bpm; min HR 36 bpm; max HR 81 bpm; 3 episodes of sinus bradycardia; no pauses >2 s; rare ventricular ectopy; no atrial fibrillation (AF) episodes	Normal sinus rhythm without significant pauses or atrial fibrillation.

Quantitative performance was interpreted relative to available normative data and is reported using standardized deviation-based classification. This approach is consistent with recommendations for communicating neuropsychological test performance using uniform qualitative labels derived from standardized score ranges ([Guilmette et al., 2020](#)). Raw scores are not presented because clinical interpretation depends on age-, education-, and language-adjusted normative transformations, and raw values are not directly comparable across instruments ([Christ et al., 2023](#)).

3.2 Reporting standards

This case report was prepared in accordance with the CARE (CAsE REport) guidelines ([Gagnier et al., 2013](#)).

4.0 RESULT

4.1 Cognition

4.1.1 Orientation

The patient was assessed for orientation across temporal, spatial, and personal domains. He accurately identified the current month, year, and day of the week, but was unable to report the specific date, indicating a possible disruption in temporal continuity despite being in a structured (he had returned to his prior employment full time and resumed all social activities) and supportive environment. Orientation to person was intact; the patient was able to provide accurate autobiographical information, including place of birth, name of partner, and current occupation. Spatial orientation (e.g., city, district, and setting) were reported without any difficulties.

Table 2 Neuropsychological and language measures used in this case study.

Domain	Instrument (Greek adaptation/version)	Primary construct(s) Evaluated
Orientation	MMSE — Orientation subscale (Greek) (Fountoulakis et al., 2000)	Orientation to person/place/time
Attention/Processing Speed	Symbol Digit Modalities Test (SDMT) (Smith, 1973)	Sustained attention; Processing speed; Visual graphomotor coordination
Attention/Immediate Memory Span	Digit Span — Forward (WMS-R, Greek)	Attention; immediate verbal recall
Working Memory/Central Executive	Digit Span — Backward (WMS-R, Greek)	Working memory; Mental manipulation
Executive/Processing Speed/Attention	Stroop Test (Greek) (Zalonis et al., 2009)	Inhibitory control; Cognitive flexibility; Selective attention
Attention/Visual Scanning	Trail Making Test A (Greek)	Attention; psychomotor speed
Executive (Set Shifting)	Trail Making Test B (Greek)	Cognitive flexibility; Task switching
Verbal Episodic Memory	WMS-R Logical Memory Stories Test A/B (Greek)	Immediate/delayed story recall
Visuoconstruction	Rey–Osterrieth Complex Figure (Copy)	Visuospatial constructional skills; perceptual organization
Visual Memory	Rey–Osterrieth Complex Figure (Delayed)	Nonverbal memory; executive planning
Visuoperceptual/Visuospatial	Clock Drawing Test (Libon et al., 1993)	Visuoconstruction; Receptive Language; Numerical knowledge; Sustained attention; working memory; executive functioning
Language — Lexical Retrieval	Greek Verbal Fluency Task — Animals (COWAT mod.) (Kosmidis et al., 2004)	Semantic retrieval; Lexical access; Executive Functioning
Language — Aphasia Battery	Boston Diagnostic Aphasia Examination (Greek) (Goodglass et al., 2013)	Naming; repetition; comprehension
Higher-level Language/Metalinguistic Ability (Informal)	Inferencing; problem solving; idioms; metaphors; proverbs	Discourse/pragmatics; abstract reasoning; metasemantics
Mood	Beck Depression Inventory (Greek)	Depressive symptoms
Quality of Life	WHOQOL-BREF (Greek) (World Health Organization, 1998)	QoL domains: physical; psychological; social; environment

Note. Greek adaptations were used where available; constructs reflect primary intended use of each instrument.

Abbreviations: SDMT = Symbol Digit Modalities Test; WMS-R = Wechsler Memory Scale–Revised; WHOQOL-BREF = World Health Organization Quality of Life–BREF.

4.1.2 Attention

Attention was tested by administering the Digit Modality Test, Digit Span Forward, the Stroop Test and Trail A. The Symbol Digit Modalities Test (SDMT; [Smith, 1973](#)) presents a reference key pairing nine digits (1–9) with unique symbols; over 90 seconds, examinees transcribe the digit that corresponds to each randomly ordered symbol. Performance primarily indexes

processing speed and sustained attention, with contributions from visuomotor/graphomotor integration. On this measure, the patient scored within 1.5 SDs below age-normative means, placing performance in the below-average range.

The Digit Span Forward task, which requires verbatim repetition of auditorily presented number sequences,

assesses attention and immediate verbal recall (Wechsler, 1997). The patient’s performance was within 1.5 SDs below the normative mean, reflecting a below-average attention span.

The Stroop Color-Naming Task assesses cognitive control by requiring naming of the ink color of incongruent color words, indexing selective attention, processing speed, and inhibition (Stroop, 1935). The patient’s score was within 2 SDs above the normative mean, corresponding to below-average performance. The Stroop Word-Reading condition, in which color words printed in black ink are read aloud to assess automatic word recognition and processing speed (Golden, 1978), was 3 SDs above the mean, reflecting exceptionally low, markedly slowed performance.

The Trail Making Test Part A, which requires rapid connection of numbered circles in ascending order to assess visual scanning, attention, and processing speed (Reitan, 1958), was within 1 SD below the normative mean, indicating performance within normal limits. Attention test performance across measures is summarized in Table 3.

4.1.3 Memory

Memory was assessed using the Digit Span Backward, the Logical Memory Stories Test, and the Rey-Osterrieth Complex Figure Test. The Digit Span Backward task assesses working memory, particularly central executive functioning, by requiring repetition of number sequences in reverse order (Wechsler, 1997). Performance was within 1 SD below the mean, consistent with working memory within normal limits.

Table 3. Summary of attention results.

Test	Subtest / Component	Deviation from Mean	Interpretation
Symbol Digit Modalities Test	—	Within 1.5 SDs below mean	Below average processing speed and/or attention
Digit Span	Forward	Within 1.5 SDs below mean	Below average attention span
Stroop Test	Color Naming	Within 2 SDs above mean	Below average
Stroop Test	Word Reading	Within 3 SDs above mean	Exceptionally Low
Trail Making Test	Part A	Within 1 SD below mean	Normal performance

Note. SD = standard deviation. For accuracy-based measures, performance below the normative mean reflects lower-than-expected accuracy or output. For timed measures, performance above the normative mean reflects slower-than-expected completion time and therefore reduced efficiency.

Table 4. Summary of memory results.

Test	Subtest / Component	Deviation from Mean	Interpretation
Digit Span	Backward	Within 1 SD below mean	Normal performance
Logical Memory Stories Test	Immediate Recall Story A	2 SDs below mean	Exceptionally Low
Logical Memory Stories Test	Immediate Recall Story B	3 SDs below mean	Exceptionally Low, very marked weakness
Logical Memory Stories Test	Delayed Recall Story A	More than 3 SDs below mean	Exceptionally Low, very marked weakness
Logical Memory Stories Test	Delayed Recall Story B	More than 3 SDs below mean	Exceptionally Low, very marked weakness
Trail Making Test	Part A	Within 1 SD below mean	Normal performance

Note. SD = standard deviation. For accuracy-based measures, performance below the normative mean reflects lower-than-expected accuracy or output. For timed measures, performance above the normative mean reflects slower-than-expected completion time and therefore reduced efficiency.

The Logical Memory Stories Test evaluates verbal episodic memory through immediate and delayed recall of short narrative stories, indexing encoding, retention, and retrieval (Wechsler, 1997). The patient’s immediate

recall was 2 SDs below the mean for Story A (exceptionally low performance) and 3 SDs below the mean for Story B (exceptionally low range), indicating marked verbal memory weakness. Delayed recall performance was exceptionally low, with minimal to absent retrieval, indicating a marked weakness in delayed verbal recall.

The Rey–Osterrieth Complex Figure Test assesses visuospatial construction and visual memory by having individuals copy a complex figure and later reproduce it from memory ([Meyers & Meyers, 1995](#)). Copy performance is reported under visuoconstruction; for the memory condition (immediate and delayed recall of the figure), the patient scored within 1 SD above the mean at both time points, indicating intact visual memory. Memory test performance across measures is summarized in Table 4.

4.1.4 Executive Function

Executive function was assessed by administering the Trail Making Test Part B, the Stroop Interference Condition, the Semantic Verbal Fluency Task, as well as non-standardized tasks aiming to assess volition, planning, intentional action, and effective execution.

The Trail Making Test Part B, which requires alternating between numbers and letters in sequence to assess cognitive flexibility and set-shifting ([Reitan, 1958](#)), was within 2 SDs above the mean, placing performance in the below-average range. On the Stroop interference condition, requiring naming the ink color of incongruent color words, performance was >3 SDs above the mean, indicating exceptionally low performance and marked difficulty with inhibitory control.

The Semantic Verbal Fluency Task assesses lexical access, semantic memory, and executive functioning by requiring individuals to generate as many words as possible from a given category; in this case, it was animals, within 60 seconds ([Lezak et al., 2012](#)). The

Table 5. Summary of executive function results.

Task	Domain assessed	Performance summary	Interpretation
Trail Making Test – Part B	Cognitive flexibility; task switching	Within 2 SDs above mean	Below average
Stroop Test – Interference	Inhibitory control; selective attention	>3 SD above mean	Exceptionally Low, very marked weakness
Verbal Fluency	Initiation; strategy use; inhibition; cognitive flexibility	Within 3 SDs below mean	Exceptionally Low
Metalinguistic Similarities Task	Abstraction	Simple, vague, off-target responses	Impaired conceptual abstraction
Idiom & Proverb Interpretation	Higher-order language; abstract thinking	Literal, simplistic responses	Poor figurative-language comprehension
Homophone Interpretation	Lexical Ambiguity; Cognitive flexibility	Irrelevant answers	Impaired mental flexibility
Alternative Object Use	Semantic Access; Divergent thinking; Inhibition	Vague responses; limited ideas; lexical access difficulties	Reduced creativity; poor lexical access
Word Categorization—High-frequency words	Cognitive flexibility; Inhibition	Correct thematic and taxonomic classification	Preserved for familiar content
Word Categorization—Low-frequency words	Cognitive flexibility; Inhibition	Reduced accuracy; difficulty classifying less-familiar items	Impaired for less familiar content
Volition	Planning; initiation; intentionality	Basic, incomplete planning	Poor volitional and planning abilities

Note. SD = standard deviations. For accuracy-based measures, performance below the normative mean reflects lower-than-expected accuracy or output. For timed measures, performance above the normative mean reflects slower-than-expected completion time and therefore reduced efficiency.

patient's performance was within 3 SDs below the mean, indicating an exceptionally low range and marked weakness in semantic retrieval.

Non-standardized tasks were also used to assess executive functions. Specifically, the aim was to further examine volition, planning, intentional action, and effective execution. A metalinguistic task required the patient to identify verbal similarities (e.g., "steam-cloud") and interpret idioms, proverbs, and homophones, all of which target higher-order language processing, conceptual reasoning, and mental flexibility. Across these tasks (similarities, homophone interpretation, idioms, and proverbs) the patient's responses were simplistic, vague, lacked specific content, and were often irrelevant to the auditory stimulus.

Cognitive flexibility was further assessed through an alternative-object-use task (e.g., "How else could you use a screwdriver?"), in which responses were also vague, lacking detail, and produced with delayed response times indicative of lexical access difficulties.

A word-categorization task was used to assess cognitive flexibility, shifting, and inhibition. The patient was presented with two sets of nine words (high-frequency and low-frequency), each of which could be grouped either taxonomically or thematically. In the high-frequency set, he successfully categorized the words using both strategies, performing thematic grouping more easily and quickly. In contrast, he was unable to categorize the low-frequency words using either approach.

Volition was assessed through two personally relevant activities: "Vacation Planning" and "Wedding Ceremony." Although the patient identified some basic steps for each, his descriptions were incomplete, lacked coherence, and he repeatedly stated, "I don't know what else is needed." Executive function performance across measures is summarized in Table 5.

4.2 Language

Comprehensive language assessment was conducted using the Boston Diagnostic Aphasia Examination and associated subtests. On core measures of auditory comprehension, language expression, reading, and writing, the patient performed within 1 SD below the mean, indicating average abilities.

However, more detailed tasks revealed selective but significant impairments. On the Boston Naming Test–

Short Form, he scored 3 SDs below the mean, consistent with an exceptionally low, marked weakness in confrontation naming. Narrative discourse elicited using the Cookie Theft picture demonstrated marked discourse-level impairment: in spoken output, he failed to convey the main theme and produced fragmented, poorly coherent descriptions, while in writing, despite legible handwriting, his narrative lacked key content words, showed syntactic weaknesses, and conveyed limited meaningful information. Notably, no phonemic or semantic paraphasias were observed in either modality.

4.3 Visuospatial abilities

The Rey–Osterrieth Complex Figure copy trial, a measure of visuoconstructive and broader visuospatial abilities (including attention to detail and spatial organization), was within 1 SD above the mean, indicating normal performance. The Clock Drawing Test, which taps visuoperceptual/visuospatial skills as well as numerical knowledge, working memory, and executive functions ([Lezak, 1995](#)), showed that the patient accurately drew the clock face and placed the hands, but wrote only the numbers relevant to the target time.

4.4 Quality of life and patient-reported outcomes and mental health

On the WHOQOL-BREF, the patient obtained raw domain scores of 24 on Physical Health, 24 on Psychological Health, 14 on Social Relationships and 37 on Environment. When transformed to the 0-100 scale, these correspond to 60.7, 75.0, 91.7 and 90.6, respectively, indicating average physical health, good psychological health, and very high satisfaction with social relationships and environmental factors.

On the Beck Depression Inventory II ([Beck et al., 1996](#)), the patient obtained a total score of 10, which falls within the non-depressed range (0-13), indicating absence of clinically significant depressive symptoms.

5.0 DISCUSSION

5.1 Interpretation in the context of pre-existing neurological comorbidity

This case study presents the neuropsychological profile of a Greek-speaking Cypriot male, six months post-OHCA. The assessment revealed a heterogeneous cognitive – linguistic profile characterized by pronounced executive and memory deficits with relatively preserved visuospatial and affective functioning. Importantly, the present neurocognitive profile should be interpreted considering the patient's pre-existing neurological history, including right frontal

TBI, chronic right frontal gliosis, post-traumatic epilepsy, recent epileptiform activity, and antiepileptic treatment. These factors are particularly relevant to the dysexecutive aspects of the current profile, including reduced inhibition, cognitive rigidity, inefficient planning and discourse-level disorganization. Frontal systems are central to executive processes such as monitoring, inhibition, cognitive flexibility, and behavioral regulation ([Friedman & Robbins, 2022](#)). However, performance on executive tasks reflects distributed network function rather than a single anatomically specific frontal locus ([Basso, 2025](#)). Therefore, the patient's dysexecutive findings cannot be attributed exclusively either to the pre-existing right frontal gliosis or to OHCA-related hypoxic-ischemic injury. Rather, they are best interpreted as reflecting possible interaction between post-arrest hypoxic-ischemic vulnerability, pre-existing frontal pathology, epilepsy-related factors, and medication effects.

Nevertheless, collateral history suggested premorbid functional independence, including completion of secondary education, employment, and typical family and social participation. Thus, the prior injury did not appear to have produced overt functional limitations in daily life before the OHCA. Cognitive reserve provides a useful framework for interpreting the discrepancy between the patient's prior structural brain injury and his reported premorbid autonomy ([Stern, 2009](#); [Oliva et al., 2025](#)). However, because no formal premorbid neuropsychological assessment was available, this history should be interpreted as evidence of functional independence rather than objective evidence of intact premorbid cognition. Although collateral history indicated high functional independence before OHCA, this does not exclude subtle compensated weaknesses. The post-arrest neurological burden may have exceeded these compensatory resources, potentially unmasking or exacerbating vulnerabilities associated with the pre-existing injury ([Oliva et al., 2025](#)).

Medication effects should also be considered. The patient was treated with levetiracetam during hospitalization, later switched to valproic acid, and olanzapine was initiated following psychiatric consultation. Antiepileptic and antipsychotic medications may contribute to sedation, slowed processing speed, attentional inefficiency, and reduced executive efficiency ([Alsukhni et al., 2023](#); [Park & Kwon, 2008](#); [Eddy et al., 2011](#); [Reimers et al., 2025](#)).

Overall, the most cautious interpretation is that the observed cognitive-linguistic profile reflects a complex

interaction among pre-existing right frontal pathology, post-traumatic epilepsy, recent epileptiform activity, post-arrest hypoxic-ischemic vulnerability, and medication effects. The relative contribution of each factor cannot be determined in the absence of premorbid neuropsychological data.

5.2 Cognitive status

The patient was alert and cooperative, oriented to person and place but mildly disoriented to time, indicating impaired temporal orientation and a reduced functional sense of time. This finding aligns with the known early vulnerability of episodic memory systems to hypoxic damage ([Mędrzycka-Dąbrowska et al., 2018](#); [Zhang et al., 2021](#); [Chareyron et al., 2024](#)), but should be interpreted in the context of the patient's pre-existing right frontal pathology, epilepsy-related factors, and medication status. Collateral information was obtained from the patient's immediate family, who indicated significant difficulties in managing daily routines and adapting to unscheduled events, consistent with disrupted prospective memory and impaired temporal planning, as well as maintaining routines that require flexibility and adjustment. These patterns further support the view that temporal disorientation often reflects underlying disruptions in memory encoding and attentional regulation ([Lezak, 1995](#)).

Overall performance across attention and processing speed measures was largely within normative limits, with scores clustering in the low-average range on speeded and attentionally demanding tasks. Relative inefficiency was most evident on tasks requiring rapid, automatic verbal responding, whereas simpler attention span measures were comparatively less affected. Collectively, this pattern suggests relative inefficiency in speeded and attentionally demanding tasks rather than a global attentional impairment, consistent with existing literature demonstrating the interdependence of attentional load, working memory, and executive functioning ([Heled et al., 2012](#); [Sohlberg & Mateer, 1987](#); [Lambez et al., 2024](#); [Kim et al., 2023](#)). This pattern is frequently observed in post-anoxic encephalopathy, where diffuse white matter damage can impair attentional networks ([Lee et al., 2022](#); [Gugger et al., 2023](#)).

Marked deficits were evident in verbal episodic memory, particularly in delayed recall tasks, where minimal retrieval after delay indicates a marked weakness in verbal retention. Although this pattern is compatible with medial temporal vulnerability following

hypoxic-ischemic injury ([Rempel-Clower et al., 1996](#)), executive encoding inefficiency, medication effects and the absence of premorbid neuropsychological data limit causal interpretation. In contrast, visuospatial memory performance on the Rey-Osterrieth Complex Figure was within normal limits, indicating relatively preserved right medial temporal and parietal systems. This clear dissociation between verbal and visual memory has been frequently reported after cardiac arrest ([Moulaert et al., 2009](#)). The discrepancy between preserved digit span and impaired story recall further suggests executive contributions to encoding and retrieval inefficiency ([Baddeley, 2000](#)). While digit span relies primarily on short-term storage, story recall requires higher-level processes such as organizing information, integrating details, and inhibiting distractions. When these executive mechanisms weaken, the individual may hold simple information briefly but struggle to encode and retrieve more complex, meaningful material. Functionally, this may manifest as difficulty remembering conversations, multi-step instructions, or daily events, even though the person can recall short, discrete pieces of information without difficulty.

Executive functioning showed relative inefficiency on select standardized measures, including the Stroop Interference Task and verbal fluency, while set-shifting performance on the Trail Making Test Part B remained within normative limits. This dissociation may reflect the non-unitary nature of executive functioning, with relative preservation of externally guided set-shifting alongside deficits in inhibition and self-initiated verbal control. This dysexecutive profile may reflect disruption of frontal-subcortical systems, but in the context of the patient's pre-existing neurological vulnerability, causal attribution to OHCA-related hypoxic-ischemic injury alone is not warranted.

Non-standardized assessments confirmed conceptual rigidity, poor abstraction, reduced cognitive flexibility, and impaired volitional planning, consistent with fronto-temporal network dysfunction ([Wawrzyniak et al., 2017](#); [Leyhe et al., 2011](#)). Interestingly, the patient was able to categorize high-frequency words using both taxonomic and thematic strategies, suggesting that performance might vary in relation to the novelty, familiarity, or complexity of the stimuli, especially under conditions of reduced mental flexibility and inhibitory control ([Shebani et al., 2017](#); [Goldberg, 2001](#)).

5.3 Visual/Spatial skills

Visuospatial and constructional abilities were largely preserved. On the Rey-Osterrieth Figure Copy and Clock

Drawing Test, the patient demonstrated accurate spatial organization. His omission of non-relevant clock numbers may reflect executive or attentional difficulties, rather than a primary constructional deficit.

5.4 Language

Language abilities appeared mildly compromised, with deficits primarily affecting lexical retrieval, narrative discourse, and semantic organization, despite the absence of classical aphasia. Language performance was variable: while basic auditory comprehension, verbal expression, and reading/writing skills were broadly preserved (within one standard deviation below the mean), marked impairments were observed in confrontation naming and narrative discourse. On the Boston Naming Test, the patient showed significant word-retrieval difficulties. Additionally, spontaneous narrative output, both oral and written, was notably disorganized, lacking cohesion and informativeness. This pattern suggests disruptions in lexical-semantic access and narrative construction, processes typically mediated by left temporal and frontal language regions ([Levelt et al., 1999](#); [Indefrey & Levelt, 2004](#); [Marini et al., 2005](#); [Byron-Alhassan et al., 2021](#)). The patient's word retrieval failures were characterized by inconsistent access to lexical items; performance was context-dependent and improved with semantic and phonemic cueing. These findings suggest that his naming impairments may be better explained by executive dysfunction than by primary aphasia, indicating preserved semantic representations but possibly inefficient retrieval strategies.

Narrative discourse was disorganized and tangential, consistent with dysexecutive processes affecting coherence and planning rather than primary linguistic deficits ([Adrover-Roig et al., 2012](#); [Crowther & Martin, 2014](#)). These deficits are consistent with findings in OHCA survivors, where language impairments are thought to arise not solely from primary language dysfunction but also from underlying executive deficits that compromise higher-order language organization ([Adrover-Roig et al., 2012](#); [Crowther & Martin, 2014](#)). Nevertheless, while the observed anomia is plausibly attributable to dysexecutive processes that disrupt efficient lexical access, a subtle compromise of the language network remains a possibility, particularly given evidence that OHCA survivors may present with mixed executive–language impairments ([Hagberg et al., 2022](#); [Goossens et al., 2014](#)).

5.5 Psychosocial impact

Psychosocial measures indicated good emotional well-being and high satisfaction within social and environmental domains. The patient's BDI-II score fell in the non-depressed range, suggesting preserved emotional resilience and adequate coping. However, lower physical health scores may reflect post-OHCA cardiac fatigue or residual cardiorespiratory difficulties ([Geri et al., 2017](#)). This relatively positive affective profile aligns with evidence that, despite significant cognitive sequelae, many OHCA survivors report satisfactory quality of life ([Smith et al., 2015](#)), even though mood disturbances are not uncommon, especially in younger patients with OHCA ([Chen et al., 2023](#); [Wimmer et al., 2021](#)).

5.6 Limitations and future directions

This single-case design limits external validity and is vulnerable to bias and uncontrolled confounds ([Yin, 2014](#); [Tanious et al., 2024](#); [Eisenhardt, 1989](#)). The case was selected because it represented a rare opportunity to conduct a comprehensive neuropsychological, language, and health-related quality of life assessment in a young Greek-speaking Cypriot survivor of OHCA, a clinical presentation that is uncommon in the local context. However, the patient's pre-existing neurological history means that the findings should not be interpreted as an etiologically pure post-OHCA profile. A key limitation of the present case is the absence of formal premorbid neuropsychological data. Although family-reported history indicated premorbid functional independence, this information cannot substitute for objective baseline cognitive measurements. Interpretation is limited by pre-existing neurological vulnerability, epileptiform activity, centrally acting medications, and the absence of diagnostically adequate post-arrest MRI because of motion artefact. Future work should combine detailed neuropsychological assessment with task-based fMRI to clarify whether word-retrieval difficulties are primarily executive or linguistic in origin and include additional memory subtests to delineate executive–memory interactions. Longitudinal studies with larger, more diverse Greek-speaking samples are needed to validate these preliminary findings. Moreover, longitudinal or randomized controlled trials should examine how integrated psychosocial and rehabilitation interventions affect long-term psychological well-being and quality of life in OHCA survivors ([Amacher et al., 2022](#)).

5.7 Clinical Implications

In our case, repeated brain CT scans showed no acute intracranial pathology; however, brain MRI was

significantly limited by motion artefacts and did not allow reliable assessment for subtle hypoxic–ischaemic injury. In survivors of out-of-hospital cardiac arrest, brain MRI abnormalities—when present—may include diffusion restriction in cortical and deep grey matter structures, involvement of the basal ganglia or hippocampi, and diffuse white matter changes, reflecting hypoxic–ischaemic encephalopathy ([Keijzer et al., 2022](#); [Kang et al., 2023](#)). Nevertheless, normal or near-normal findings on conventional brain MRI have also been reported after OHCA, even in patients who subsequently exhibit cognitive or neuropsychological impairment, indicating that the absence of overt structural abnormalities does not exclude clinically relevant brain injury ([Choi et al., 2015](#)). Such impairment is thought to reflect diffuse cerebral dysfunction that may not be readily captured by routine structural imaging and has been associated with adverse cognitive outcomes following cardiac arrest ([Choi et al., 2015](#); [Hagberg et al., 2022](#)). The electroencephalographic evidence of mild diffuse cerebral dysfunction observed in our patient represents a nonspecific finding and may reflect post-anoxic injury and/or the effects of centrally acting medications, including antipsychotic therapy ([Kaplan et al., 2011](#)).

Consistent with this literature, the overall neurocognitive and linguistic profile of this patient reflects a mixed pattern of deficits that are consistent with hypoxic-ischemic injury, particularly affecting frontal and medial temporal brain regions. Severe impairments in verbal memory and executive functioning, contrasted with relatively preserved visuospatial and nonverbal memory, point toward a material-specific amnesia and dysexecutive syndrome, common in post-cardiac arrest encephalopathy ([Lim et al., 2004](#); [Brownlee et al., 2020](#)). Conceptual and lexical rigidity, combined with planning and volition deficits, also raises concerns about functional independence and decision-making capacity, especially in contexts requiring future planning or abstract reasoning.

This profile underscores the importance of comprehensive, multidimensional neuropsychological assessment in the aftermath of cardiac arrest, as focal screening tools may underestimate the extent and complexity of cognitive dysfunction. These findings also highlight the need for rehabilitation strategies that target both verbal memory encoding and executive control, while leveraging preserved visuospatial abilities to support compensatory interventions. More broadly, in neurologically vulnerable individuals, including those with prior TBI, structural brain lesions, epilepsy, or long-

term antiseizure medication use, baseline or periodic neuropsychological assessment during adolescence or early adulthood may provide clinically valuable reference data. Such information may improve the interpretation of later acquired neurological events by helping distinguish pre-existing cognitive weaknesses from newly acquired or exacerbated deficits.

6.0 CONCLUSIONS

This study highlights the need for systematic cognitive screening prior to discharge, followed by comprehensive neuropsychological and language assessment during follow-up, to adequately identify and address the cognitive-linguistic needs of OHCA survivors. It underscores the importance of integrating cardiac, neurological, neuropsychological, and speech-language pathology rehabilitation within a coordinated, ICF-aligned multidisciplinary framework that addresses impairments in body functions as well as communication, activity performance, and participation; an approach increasingly reflected in emerging specialized post-cardiac arrest clinics. Notably, this case adds to the speech-language pathology literature as the first to examine post-OHCA cognitive-linguistic function in a neurologically complex Cypriot patient who uses both Standard Modern Greek and the Greek-Cypriot dialect in his everyday activities. At the same time, the case also illustrates the importance of cautious etiological interpretation in neurologically complex OHCA survivors, particularly when pre-existing neurological vulnerability may interact with post-arrest hypoxic-ischemic injury.

Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by the Cyprus National Bioethics Committee (EEBK EP 2024.01.34).

Consent to Participate / Publish

Written informed consent was obtained from the participant for the publication of the case details and of any potentially identifiable images or data included in the article.

Competing interests

The authors declare no competing financial or non-financial interests relevant to the submitted work.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author contributions

Conceptualization, methodology, data analysis; writing - original draft preparation: MCD. Writing: Major Review & Editing: AC. Review of medical history, interpretation of neuroimaging findings: TT. Writing, review & Editing: TFA, EY CT. Data collection, curation & interpretation: AL. Methodology, Supervision, Writing, Review & Editing: FC. All authors have read and agreed to the submitted version of the manuscript.

Acknowledgements

The authors used ChatGPT 5.2 to help refine the manuscript language and generate draft tables from author-supplied data. All AI-generated material was reviewed, verified, and edited by the authors, who take full responsibility for the integrity and accuracy of the final content.

Data availability

All data supporting the findings of this case report are included in the manuscript. Further inquiries can be directed to the corresponding author.

References

- Adrover-Roig, D., Sesé, A., Barceló, F., & Palmer, A. (2012). A latent variable approach to executive control in healthy ageing. *Brain and cognition*, 78(3), 284–299. <https://doi.org/10.1016/j.bandc.2012.01.005>
- Alexander, M. P., Lafleche, G., Schnyer, D., Lim, C., & Verfaellie, M. (2011). Cognitive and functional outcome after out of hospital cardiac arrest. *Journal of the International Neuropsychological Society*, 17(2), 364–368. <https://doi.org/10.1017/S1355617710001633>
- Alsukhni, R. A., McDonald, A., Shanker, R., & Pirmohamed, M. (2023). Valproate-induced reversible cognitive decline presenting as dementia and associated clinical features: a literature review. *Seizure*, 108, 62–67. <https://doi.org/10.1016/j.seizure.2023.03.017>
- Amacher, S. A., Bohren, C., Blatter, R., Becker, C., Beck, K., Mueller, J., Loretz, N., Gross, S., Tisljar, K., Sutter, R., Appenzeller-Herzog, C., Marsch, S., & Hunziker, S. (2022). Long-term survival after out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Journal of the American Medical Association Cardiology*, 7(6), 633–643. <https://doi.org/10.1001/jamacardio.2022.0795>
- Baddeley, A. D., & Hitch, G. J. (2000). Development of working memory: should the Pascual-Leone and the Baddeley and Hitch models be merged?. *Journal of experimental child psychology*, 77(2), 128–137. <https://doi.org/10.1006/jecp.2000.2592>

- Basso, D., Bosio, I., Tarantino, V., & Carabba, F. (2025). Frontal regions and executive function testing: a doubted association shown by brain-injured patients. *NeuroSci*, 6(4), 105. <https://doi.org/10.3390/neurosci6040105>
- Beck, A. T., Steer, R. A., & Brown, G. (1996). Beck Depression Inventory–II [Dataset]. In *PsycTESTS Dataset*. <https://doi.org/10.1037/t00742-000>
- Behn, N., Marshall, J., Togher, L., & Cruice, M. (2019). Setting and achieving individualized social communication goals for people with acquired brain injury (ABI) within a group treatment. *International Journal of Language & Communication Disorders*, 54(5), 828–840. <https://doi.org/10.1111/1460-6984.12488>
- Bisht, A., Gopinath, A., Cheema, A. H., Chaludiya, K., Khalid, M., Nwosu, M., Agyeman, W. Y., & Arcia Franchini, A. P. (2022). Targeted Temperature Management After Cardiac Arrest: A Systematic Review. *Cureus*, 14(9), e29016. <https://doi.org/10.7759/cureus.29016>
- Brownlee, N. N. M., Wilson, F. C., Curran, D. B., Lyttle, N., & McCann, J. P. (2020). Neurocognitive outcomes in adults following cerebral hypoxia: A systematic literature review. *NeuroRehabilitation*, 47(2), 83–97. <https://doi.org/10.3233/NRE-203135>
- Byron-Alhassan, A., Collins, B., Bedard, M., Quinlan, B., Le May, M., Duchesne, L., Osborne, C., Wells, G., Smith, A. M., & Tulloch, H. E. (2021). Cognitive dysfunction after out-of-hospital cardiac arrest: Rate of impairment and clinical predictors. *Resuscitation*, 165, 154–160. <https://doi.org/10.1016/j.resuscitation.2021.05.002>
- Chareyron, L. J., Chong, W. K. K., Banks, T., Burgess, N., Saunders, R. C., & Vargha-Khadem, F. (2024). Anatomic-functional changes in neural substrates of cognitive memory in developmental amnesia: insights from automated and manual Magnetic Resonance Imaging examinations. *Hippocampus*, 34(11), 645–658. <https://doi.org/10.1002/hipo.23638>
- Chadjikypranou, A., Hadjivassiliou, M., Papacostas, S., & Constantinidou, F. (2021). The neurocognitive study for the aging: longitudinal analysis on the contribution of sex, age, education and APOE ε4 on cognitive performance. *Frontiers in Genetics*, 12, 680531. <https://doi.org/10.3389/fgene.2021.680531>
- Chen, X., Li, D., He, L., Yang, W., Dai, M., Lan, L., Diao, D., Zou, L., Yao, P., & Cao, Y. (2023). The prevalence of anxiety and depression in cardiac arrest survivors: A systematic review and meta-analysis. *General Hospital Psychiatry*, 83, 8–19. <https://doi.org/10.1016/j.genhosppsych.2023.03.013>
- Choi, W. S., Kim, J. J., & Yang, H. J. (2015). Brain magnetic resonance imaging in patients with favorable outcomes after out-of-hospital cardiac arrest: many have encephalopathy even with a good cerebral performance category score. *Acute and Critical Care*, 30(4), 265–271. <https://doi.org/10.4266/kjccm.2015.30.4.265>
- Christ, B. R., Kosciak, R. L., Jonaitis, E. M., Clark, L. R., Hermann, B. P., & Sager, M. A. (2023). Normative data estimation in neuropsychological tests. *Neuropsychology Review*, 34, 1040–1051. <https://doi.org/10.1007/s11065-023-09591-6>
- Constantinidou F. (2019). Effects of Systematic Categorization Training on Cognitive Performance in Healthy Older Adults and in Adults with Traumatic Brain Injury. *Behavioural Neurology*, 2019, 9785319. <https://doi.org/10.1155/2019/9785319>
- Constantinidou, F., Christodoulou, M., & Prokopiou, J. (2012). The effects of age and education on executive functioning and oral naming performance in greek cyriot adults: the neurocognitive study for the aging. *Folia phoniatica et logopaedica: official organ of the International Association of Logopedics and Phoniatrics*, 64(4), 187–198. <https://doi.org/10.1159/000340015>
- Constantinidou, F., Prokopiou, J., Nikou, M., & Papacostas, S. (2015). Cognitive-Linguistic Performance and Quality of Life in Healthy Aging. *Folia phoniatica et logopaedica: official organ of the International Association of Logopedics and Phoniatrics*, 67(3), 145–155. <https://doi.org/10.1159/000440835>
- Cronberg, T., Greer, D. M., Lilja, G., Moolaert, V., Swindell, P., & Rossetti, A. O. (2020). Brain injury after cardiac arrest: From prognostication of comatose patients to rehabilitation. *The Lancet Neurology*, 19(7), 611–622. [https://doi.org/10.1016/S1474-4422\(20\)30117-4](https://doi.org/10.1016/S1474-4422(20)30117-4)
- Crowther, J. E., & Martin, R. C. (2014). Lexical selection in the semantically blocked cyclic naming task: the role of cognitive control and learning. *Frontiers in Human Neuroscience*, 8, 9. <https://doi.org/10.3389/fnhum.2014.00009>
- Eddy, C. M., Rickards, H. E., & Cavanna, A. E. (2011). The cognitive impact of antiepileptic drugs. *Therapeutic advances in neurological disorders*, 4(6), 385–407. <https://doi.org/10.1177/1756285611417920>
- Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, 14(4), 532–550. <https://doi.org/10.2307/258557>
- Evald, L., Skrifvars, M. B., Virta, J. J., Tiainen, M., Laitio, T., Leithner, C., Søreide, E., Hassager, C., Rasmussen, B., Grejs, A. M., Jeppesen, A. N., Kirkegaard, H., & Nielsen, J. F. (2025). Long-term functional outcome and quality of life 5-8 years after out of hospital cardiac arrest. *Resuscitation*, 215, 110672. <https://doi.org/10.1016/j.resuscitation.2025.110672>
- Fountoulakis, K. N., Tsolaki, M., Chantzi, H., & Kazis, A. (2000). Mini-mental state examination (MMSE): a validation study in Greece. *American Journal of Alzheimer's Disease & Other Dementias*, 15(6), 342–345.
- Friedman, N. P., & Robbins, T. W. (2022). The role of prefrontal cortex in cognitive control and executive function. *Neuropsychopharmacology*, 47, 72–89. <https://doi.org/10.1038/s41386-021-01132-0>
- Gagnier, J. J., Kienle, G., Altman, D. G., Moher, D., Sox, H., Riley, D. S., & the CARE Group. (2013). The CARE guidelines: Consensus-based clinical case reporting guideline development. *Journal of Medical Case Reports*, 7, 223. <https://doi.org/10.1186/1752-1947-7-223>

- Geri, G., Dumas, F., Bonnetain, F., Bougouin, W., Champigneulle, B., Arnaout, M., Carli, P., Marijon, E., Varenne, O., Mira, J. P., Empana, J. P., & Cariou, A. (2017). Predictors of long-term functional outcome and health-related quality of life after out-of-hospital cardiac arrest. *Resuscitation*, 113, 77–82. <https://doi.org/10.1016/j.resuscitation.2017.01.028>
- Geva, S., Hoskote, A., Saini, M., Clark, C. A., Banks, T., Chong, W. K. K., Baldeweg, T., de Haan, M., & Vargha-Khadem, F. (2024). Cognitive outcome and its neural correlates after cardiorespiratory arrest in childhood. *Developmental Science*, 27(4), e13501. <https://doi.org/10.1111/desc.13501>
- Glimmerveen, A. B., Verhulst, M. M. L. H., Delnoij, T., Bonnes, J. L., Keijzer, H. M., Hofmeijer, J., & BROCA investigators (2025). Early prediction of long-term cognitive function, emotional distress, and health-related quality of life in cardiac arrest survivors. *Resuscitation*, 215, 110708. <https://doi.org/10.1016/j.resuscitation.2025.110708>
- Goodglass, H., Kaplan, E., & Barresi, B. (2013). Διαγνωστική Εξέταση της Βοστώνης για την Αφασία [Boston Diagnostic Aphasia Examination]. In L. Messinis, E. Panagea, P. Papathanasopoulos, & A. A. Kastellakis (Scientific eds.). Patras, Greece: Gotsis Editions. ISBN 978-960-9427-36-4
- Goldberg, A. E. (2001). Patient arguments of causative verbs can be omitted. *Language Sciences*, 23(4–5), 503–524. [https://doi.org/10.1016/S0388-0001\(00\)00034-6](https://doi.org/10.1016/S0388-0001(00)00034-6)
- Golden, C. J., & Freshwater, S. N. (1978). *Stroop color and word test: a manual for clinical and experimental uses*. Stoelting.
- Goossens, P. H., & Moulart, V. R. (2014). Cognitive impairments after cardiac arrest: implications for clinical daily practice. *Resuscitation*, 85(12), A3–A4. <https://doi.org/10.1016/j.resuscitation.2014.09.022>
- Gugger, J. J., Walter, A. E., Parker, D., Sinha, N., Morrison, J., Ware, J., Schneider, A. L. C., Petrov, D., Sandsmark, D. K., Verma, R., & Diaz-Arrastia, R. (2023). Longitudinal Abnormalities in White Matter Extracellular Free Water Volume Fraction and Neuropsychological Functioning in Patients with Traumatic Brain Injury. *Journal of Neurotrauma*, 40(7–8), 683–692. <https://doi.org/10.1089/neu.2022.0259>
- Guilmette, T. J., Sweet, J. J., Hebben, N., Koltai, D., Mahone, E. M., Spiegler, B. J., Stucky, K., Westerveld, M., & Conference Participants (2020). American Academy of Clinical Neuropsychology consensus conference statement on uniform labeling of performance test scores. *The Clinical neuropsychologist*, 34(3), 437–453. <https://doi.org/10.1080/13854046.2020.1722244>
- Hagberg, G., Ihle-Hansen, H., Sandset, E. C., Jacobsen, D., Wimmer, H., & Ihle-Hansen, H. (2022). Long Term Cognitive Function After Cardiac Arrest: A Mini-Review. *Frontiers in Aging Neuroscience*, 14, 885226. <https://doi.org/10.3389/fnagi.2022.885226>
- Heled, Y., Peled, A., Yanovich, R., Shargal, E., Pilz-Burstein, R., Epstein, Y., & Moran, D. S. (2012). Heat acclimation and performance in hypoxic conditions. *Aviation, Space, and Environmental Medicine*, 83(7), 649–653. <https://doi.org/10.3357/asem.3241.2012>
- Husain, S., & Eisenberg, M. (2013). Police AED programs: a systematic review and meta-analysis. *Resuscitation*, 84(9), 1184–1191. <https://doi.org/10.1016/j.resuscitation.2013.03.040>
- Indefrey, P., & Levelt, W. J. (2004). The spatial and temporal signatures of word production components. *Cognition*, 92(1–2), 101–144. <https://doi.org/10.1016/j.cognition.2002.06.001>
- Jaske-Psonka, M., Piegza, M., Ścisło, P., Pudło, R., Piegza, J., Badura-Brzoza, K., Leksowska, A., Hese, R. T., & Gorczyca, P. W. (2016). Cognitive impairment after sudden cardiac arrest. *Kardiologia i torakochirurgia polska = Polish journal of Cardio-thoracic Surgery*, 13(4), 393–398. <https://doi.org/10.5114/kitp.2016.64893>
- Jensen, M. K., Christensen, J., Zarifkar, P., Thygesen, L. C., Wieghorst, A., Berg, S. K., Hassager, C., Stenbæk, D. S., & Wagner, M. K. (2024). Evaluating neurocognitive outcomes in out-of-hospital cardiac arrest survivors: a comparative study of performance-based and reported measures. *Resuscitation*, 202, 110310. <https://doi.org/10.1016/j.resuscitation.2024.110310>
- Joshi, V. L., Borregaard, B., Mikkelsen, T. B., Tang, L. H., Nordström, E. B., Bruvik, S. M., Wieghorst, A., Zwisler, A. D., & Wagner, M. K. (2024). Observer-reported cognitive decline in out-of-hospital cardiac arrest survivors and its association with long-term survivor and relative outcomes. *Resuscitation*, 197, 110162. <https://doi.org/10.1016/j.resuscitation.2024.110162>
- Kang, C., Min, J. H., Park, J. S., You, Y., Jeong, W., Ahn, H. J., In, Y. N., Lee, I. H., Jeong, H. S., Lee, B. K., & Jeong, J. (2023). Association of ultra-early diffusion-weighted magnetic resonance imaging with neurological outcomes after out-of-hospital cardiac arrest. *Critical Care*, 27(1), 16. <https://doi.org/10.1186/s13054-023-04305-z>
- Kaplan, P. W., & Rossetti, A. O. (2011). EEG patterns and imaging correlations in encephalopathy: encephalopathy part II. *Journal of clinical neurophysiology : official publication of the American Electroencephalographic Society*, 28(3), 233–251. <https://doi.org/10.1097/WNP.0b013e31821c33a0>
- Keijzer, H. M., Verhulst, M. M. L. H., Meijer, F. J. A., Tonino, B. A. R., Bosch, F. H., Klijn, C. J. M., Hoedemaekers, C. W. E., & Hofmeijer, J. (2022). Prognosis After Cardiac Arrest: The Additional Value of DWI and FLAIR to EEG. *Neurocritical Care*, 37(1), 302–313. <https://doi.org/10.1007/s12028-022-01498-z>
- Kim, N., Jamison, K., Jaywant, A., Garetti, J., Blunt, E., RoyChoudhury, A., Butler, T., Dams-O'Connor, K., Khedr, S., Chen, C. C., Shetty, T., Winchell, R., Hill, N. J., Schiff, N. D., Kuceyeski, A., & Shah, S. A. (2023). Comparisons of electrophysiological

- markers of impaired executive attention after traumatic brain injury and in healthy aging. *NeuroImage*, 274, 120126. <https://doi.org/10.1016/j.neuroimage.2023.120126>
- Kosmidis, M. H., Vlahou, C. H., Panagiotaki, P., & Kiosseoglou, G. (2004). The verbal fluency task in the Greek population: Normative data, and clustering and switching strategies. *Journal of the International Neuropsychological Society*, 10(2), 164–172.
- Krasny-Pacini, A., & Evans, J. (2018). Single-case experimental designs to assess intervention effectiveness in rehabilitation: A practical guide. *Annals of Physical and Rehabilitation Medicine*, 61(3), 164–179. <https://doi.org/10.1016/j.rehab.2017.12.002>
- Lambez, B., Vakil, E., Azouvi, P., & Vallat-Azouvi, C. (2024). Working memory multicomponent model outcomes in individuals with traumatic brain injury: Critical review and meta-analysis. *Journal of the International Neuropsychological Society : JINS*, 30(9), 895–911. <https://doi.org/10.1017/S1355617724000468>
- Lee, H. Y., Hyun, S. E., & Oh, B. M. (2022). Rehabilitation for impaired attention in the acute and post-acute phase after traumatic brain injury: a narrative review. *Korean Journal of Neurotrauma*, 19(1), 20–31. <https://doi.org/10.13004/kjnt.2023.19.e1>
- Leyhe, T., Saur, R., Eschweiler, G. W., & Milian, M. (2011). Impairment in proverb interpretation as an executive function deficit in patients with amnesic mild cognitive impairment and early Alzheimer's disease. *Dementia and Geriatric Cognitive Disorders Extra*, 1(1), 51–61. <https://doi.org/10.1159/000323864>
- Levelt WJM, Roelofs, A, & Meyer, AS. A theory of lexical access in speech production. *Behavioral and Brain Sciences*, 1999; 22(1): 1–75. <https://doi.org/10.1017/s0140525x99001776>
- Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment* (5th ed.). Oxford University Press
- Lezak, M.D., Howieson, D.B., Loring, D.W. (1995). *Neuropsychological assessment* (3rd ed.). Oxford University Press.
- Libon, D. J., Swenson, R. A., Barnoski, E. J., & Sands, L. P. (1993). Clock drawing as an assessment tool for dementia. *Archives of Clinical Neuropsychology*, 8(5), 405–415.
- Lilja, G., Nilsson, G., Nielsen, N., Friberg, H., Hassager, C., Koopmans, M., Kuiper, M., Martini, A., Mellinghoff, J., Pelosi, P., Wanscher, M., Wise, M. P., Östman, I., & Cronberg, T. (2015). Anxiety and depression among out-of-hospital cardiac arrest survivors. *Resuscitation*, 97, 68–75. <https://doi.org/10.1016/j.resuscitation.2015.09.389>
- Lim, C., Alexander, M. P., LaFleche, G., Schnyer, D. M., & Verfaellie, M. (2004). The neurological and cognitive sequelae of cardiac arrest. *Neurology*, 63(10), 1774–1778. <https://doi.org/10.1212/01.wnl.0000144189.83077.8e>
- Marini, A., Boewe, A., Caltagirone, C., & Carlomagno, S. (2005). Age-related differences in the production of textual descriptions. *Journal of Psycholinguistic Research*, 34(5), 439–463. <https://doi.org/10.1007/s10936-005-6203-z>
- Meyers, J. E., & Meyers, K. R. (1995). *Rey Complex Figure Test and recognition trial: Professional manual*. Psychological Assessment Resources.
- Mikadze, Y. V., Ardila, A., & Akhutina, T. V. (2019). A.R. Luria's approach to neuropsychological assessment and rehabilitation. *Archives of Clinical Neuropsychology: the official journal of the National Academy of Neuropsychologists*, 34(6), 795–802. <https://doi.org/10.1093/arclin/acy095>
- Mion, M., Case, R., Smith, K., Lilja, G., Blennow Nordström, E., Swindell, P., Nikolopoulou, E., Davis, J., Farrell, K., Gudde, E., Karamasis, G. V., Davies, J. R., Toff, W. D., Abella, B. S., & Keeble, T. R. (2021). Follow-up care after out-of-hospital cardiac arrest: a pilot study of survivors and families' experiences and recommendations. *Resuscitation Plus*, 7, 100154. <https://doi.org/10.1016/j.resplu.2021.100154>
- Moulaert, V. R., Verbunt, J. A., van Heugten, C. M., & Wade, D. T. (2009). Cognitive impairments in survivors of out-of-hospital cardiac arrest: a systematic review. *Resuscitation*, 80(3), 297–305. <https://doi.org/10.1016/j.resuscitation.2008.10.034>
- Myat, A., Song, K. J., & Rea, T. (2018). Out-of-hospital cardiac arrest: current concepts. *Lancet*, 391(10124), 970–979. [https://doi.org/10.1016/S0140-6736\(18\)30472-0](https://doi.org/10.1016/S0140-6736(18)30472-0)
- Mędrzycka-Dąbrowska, W. A., Czyż-Szybenbejl, K., Kwiecień-Jaguś, K., & Lewandowska, K. (2018). Prediction of cognitive dysfunction after resuscitation - a systematic review. *Postępy w kardiologii interwencyjnej = Advances in Interventional Cardiology*, 14(3), 225–232. <https://doi.org/10.5114/aic.2018.78324>
- Nolan, J. P., Sandroni, C., Böttiger, B. W., Cariou, A., Cronberg, T., Friberg, H., Genbrugge, C., Haywood, K., Lilja, G., Moulaert, V. R. M., Nikolaou, N., Mariero Olasveengen, T., Skrifvars, M. B., Taccone, F., & Soar, J. (2021). European Resuscitation Council and European Society of Intensive Care Medicine Guidelines 2021: post-resuscitation care. *Resuscitation*, 161, 220–269. <https://doi.org/10.1016/j.resuscitation.2021.02.012>
- Nolan, J. P., Soar, J., Cariou, A., Cronberg, T., Moulaert, V. R., Deakin, C. D., Bottiger, B. W., Friberg, H., Sunde, K., Sandroni, C., European Resuscitation Council, & European Society of Intensive Care Medicine (2015). European Resuscitation Council and European Society of Intensive Care Medicine 2015 guidelines for post-resuscitation care. *Intensive Care Medicine*, 41(12), 2039–2056. <https://doi.org/10.1007/s00134-015-4051-3>

- Oliva, G., Masina, F., Hosseinkhani, N., Montemurro, S., & Arcara, G. (2025). Cognitive reserve in the recovery and rehabilitation of stroke and traumatic brain injury: A systematic review. *The Clinical Neuropsychologist*, 39(6), 1450–1486. <https://doi.org/10.1080/13854046.2024.2405226>
- Park, S. P., & Kwon, S. H. (2008). Cognitive effects of antiepileptic drugs. *Journal of Clinical Neurology (Seoul, Korea)*, 4(3), 99–106. <https://doi.org/10.3988/jcn.2008.4.3.99>
- Phelps, M., Christensen, D. M., Gerds, T., Fosbøl, E., Torp-Pedersen, C., Schou, M., Køber, L., Kragholm, K., Andersson, C., Biering-Sørensen, T., Christensen, H. C., Andersen, M. P., & Gislason, G. (2021). Cardiovascular comorbidities as predictors for severe COVID-19 infection or death. *European heart journal. Quality of Care & Clinical Outcomes*, 7(2), 172–180. <https://doi.org/10.1093/ehjqcco/qcaa081>
- Reimers, A., Odin, P., & Ljung, H. (2025). Drug-Induced Cognitive Impairment. *Drug Safety*, 48(4), 339–361. <https://doi.org/10.1007/s40264-024-01506-5>
- Reitan, R. M. (1958). Validity of the trail making test as an indicator of organic brain damage. *Perceptual and Motor Skills*, 8, 271–276. <https://doi.org/10.2466/PMS.8.7.271-276>
- Rempel-Clower, N. L., Zola, S. M., Squire, L. R., & Amaral, D. G. (1996). Three cases of enduring memory impairment after bilateral damage limited to the hippocampal formation. *The Journal of Neuroscience*, 16(16), 5233–5255. <https://doi.org/10.1523/JNEUROSCI.16-16-05233.1996>
- Sandroni, C., D'Arrigo, S., & Nolan, J. P. (2018). Prognostication after cardiac arrest. *Critical Care*, 22(1), 150.
- Sandroni, C., Cronberg, T., & Sekhon, M. (2021). Brain injury after cardiac arrest: pathophysiology, treatment, and prognosis. *Intensive Care Medicine*, 47, 1393–1414. <https://doi.org/10.1007/s00134-021-06548-2>
- Shebani, Z., Patterson, K., Nestor, P. J., Diaz-de-Grenu, L. Z., Dawson, K., & Pulvermüller, F. (2017). Semantic word category processing in semantic dementia and posterior cortical atrophy. *Cortex*, 93, 92–106. <https://doi.org/10.1016/j.cortex.2017.04.016>
- Small, S. A., Schobel, S. A., Buxton, R. B., Witter, M. P., & Barnes, C. A. (2011). A pathophysiological framework of hippocampal dysfunction in ageing and disease. *Nature reviews: Neuroscience*, 12(10), 585–601. <https://doi.org/10.1038/nrn3085>
- Smith, A. (1973). Symbol Digit Modalities Test (SDMT) manual. Western Psychological Services.
- Smith, V. L. (1982). Microeconomic systems as an experimental science. *The American Economic Review*, 72(5), 923–955.
- Smith, K., Andrew, E., Lijovic, M., Nehme, Z., & Bernard, S. (2015). Quality of life and functional outcomes 12 months after out-of-hospital cardiac arrest. *Circulation*, 131(2), 174–181. <https://doi.org/10.1161/CIRCULATIONAHA.114.011200>
- Sohlberg, M. M., & Mateer, C. A. (1987). Effectiveness of an attention-training program. *Journal of Clinical and Experimental Neuropsychology*, 9(2), 117–130. <https://doi.org/10.1080/01688638708405352>
- Stern, Y. (2009). Cognitive reserve. *Neuropsychologia*, 47(10), 2015–2028. <https://doi.org/10.1016/j.neuropsychologia.2009.03.004>
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18(6), 643–662. <https://doi.org/10.1037/h0054651>
- Tanious, R., Manolov, R., Onghena, P. et al. Single-case experimental designs: the importance of randomization and replication. *Nature Reviews Methods Primers*, 4, 27 (2024). <https://doi.org/10.1038/s43586-024-00312-8>
- Tate, R. L., & Perdices, M. (2008). Applying the International Classification of Functioning, Disability and Health (ICF) to clinical practice and research in acquired brain impairment. *Brain Impairment*, 9(3), 282–292. <https://doi.org/10.1375/brim.9.3.282>
- Wawrzyniak, M., Hoffstaedter, F., Klingbeil, J., Stockert, A., Wrede, K., Hartwigsen, G., Eickhoff, S. B., Classen, J., & Saur, D. (2017). Fronto-temporal interactions are functionally relevant for semantic control in language processing. *PLoS One*, 12(5), e0177753. <https://doi.org/10.1371/journal.pone.0177753>
- World Health Organization. (1998). Development of the World Health Organization WHOQOL-BREF quality of life assessment. *Psychological Medicine*, 28(3), 551–558.
- Wimmer, H., Lundqvist, C., Šaltytė Benth, J., Stavem, K., Andersen, G. Ø., Henriksen, J., Drægni, T., Sunde, K., & Nakstad, E. R. (2021). Health-related quality of life after out-of-hospital cardiac arrest – a five-year follow-up study. *Resuscitation*, 162, 372–380. <https://doi.org/10.1016/j.resuscitation.2021.01.036>
- Wechsler, D. (1997). *Wechsler Adult Intelligence Scale* (3rd ed.). The Psychological Corporation.
- Wechsler, D. (1997). *Wechsler Memory Scale—Third edition: Administration and scoring manual*. The Psychological Corporation.
- Yan, S., Gan, Y., Jiang, N., Wang, R., Chen, Y., Luo, Z., Zong, Q., Chen, S., & Lv, C. (2020). The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. *Critical Care*, 24(1), 61. <https://doi.org/10.1186/s13054-020-2773-2>
- Yin, S., Ding, S. X., Xie, X., & Luo, H. (2014). A review on basic data-driven approaches for industrial process monitoring. *IEEE Transactions on Industrial Electronics*, 61(11), 6418–6428. <https://doi.org/10.1109/tie.2014.2301773>

- Zalonis, I., Christidi, F., Bonakis, A., Kararizou, E., Triantafyllou, N. Paraskevas, G., Kapaki, E., Vasilopoulos, D. (2009). The stroop effect in greek healthy population: normative data for the stroop neuropsychological screening test. *Archives of Clinical Neuropsychology*, 24(1), 81–88, <https://doi.org/10.1093/arclin/acp011>
- Zijlstra, T. J., Leenman-Dekker, S. J., Oldenhuis, H. K., Bosveld, H. E., & Berendsen, A. J. (2016). Knowledge and preferences regarding cardiopulmonary resuscitation: A survey among older patients. *Patient Education and Counseling*, 99(1), 160–163. <https://doi.org/10.1016/j.pec.2015.07.025>
- Zhang, H., Roman, R. J., & Fan, F. (2022). Hippocampus is more susceptible to hypoxic injury: has the Rosetta Stone of regional variation in neurovascular coupling been deciphered?. *GeroScience*, 44(1), 127–130. <https://doi.org/10.1007/s11357-021-00449-4>