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Noun and Verb Naming in Epilepsy: Evidence from an Italian Cohort

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Abstract

Naming difficulties are the most commonly lamented deficit in epilepsy, with up to forty percent of temporal lobe epilepsy patients reporting struggles with this aspect of cognitive functioning. Nonetheless, naming is often assessed using long established tests that have been suggested to underrepresent this deficiency, with many patients affected by lighter naming deficits being classified as normal. The present study addressed this issue by introducing a new Action Naming Test (Papagno et al., 2020) to the screening and follow-up battery used for epilepsy patients at the Neurological Institute of Milan "Carlo Besta", administering it alongside a short version of the generally recommended Boston Naming Test (Vestito et al., 2023). Fifty-four patients with drug-resistant epilepsy completed both measures. Contrary to expectations, the two tests largely agreed, and among discordant cases it was the Boston Naming Test that flagged impairment twice as often. This asymmetry was clarified by the tests' differing sensitivity to clinical variables: Boston Naming Test performance was predicted by epilepsy laterality, surgery status, age and education years, whereas no variable predicted Action Naming Test performance, pointing to a left-lateralisation bias in noun naming rather than a general superiority of either measure. These findings are discussed in light of current evidence on the localisation of noun and verb networks in the brain, adding to debates regarding their graded overlap and neurological vulnerability.

Chapter 1: Epilepsy and Naming Deficits

1.1 Epilepsy: an overview

Epilepsy is a neurological disorder that has been investigated for thousands of years, as its long and controversial history details a provable difficulty in settling for a unified, formal definition. Historically, the first written description of an epileptic seizure (the defining feature of epilepsy) can be found in a 4000-year-old Akkadian tablet, a document whose production is both connational and more or less contemporary to the oldest surviving tablets of the Epic of Gilgamesh (Carey, 2020; Kaculini et al., 2021). This very first known account of the disease, rooted in mesopotamian tradition, saw the Babylonians attributing its root cause to spiritual possession, prompting a number of ineffective shamanic interventions to be administered as treatment (World Health Organization, 2005). In this regard, historians remark how these spiritual views of the disease gathered a popular and stubborn success in the following years, as it took more than fifteen centuries for an alternative account of epilepsy to emerge: when Hippocrates first hypothesised that the disease could be due to malfunctions located in the brain. This Hippocratic hypothesis, despite the stark and authoritative opposition to supernatural explanations of the disease, was nonetheless unsuccessful in overcoming spiritual conjectures about the nature of seizures, as they remained the prominent viewpoint for the most part of the construct's history. Indeed, it was only around the 17th century that epilepsy began to be recognised as an issue located in the brain, thanks to Thomas Willis' intuitions concerning the nature of the disease aimed at elucidating the pathophysiology of epilepsy. Importantly, Willis was among the first to introduce a number of ideas that helped in narrowing down a more medical definition of seizures. For instance, Willis understood that seizures were caused by an "explosive event" in the brain, an insight that greatly anticipated the modern idea of electrical discharge as the cause of epilepsy, and gave support to the notions that epilepsy could be hereditary and that it could be both idiopathic or acquired following head trauma (Eadie, 2003). It was thanks to these foundational writings that epilepsy began to be explored as a physical issue of the brain as - albeit very rudimentarily - they indicated more clearly measurable features of its

pathology and their locations, kickstarting a long process of scientific exploration of the epileptic brain.

The definition and understanding of epilepsy has greatly evolved since these historical accounts of the disease, with the International League Against Epilepsy (ILAE) working to periodically update its official delineation. Currently, epilepsy is defined as a neurological disorder constituted by the persistent susceptibility to seizures, together with the psychological, cognitive and social consequences that are associated with it. From this, given their principal role in this rendition, the characterisation of seizures has also been made strictly rigorous, as they are formally described as an episode of transient behavioural change (with objective or subjective symptomatology) caused by an anomalous neuronal activity in the brain (Devinsky et al., 2018). Together, these two core definitions give us a useful framework to identify epilepsy, offering much simpler terminology compared to the historical accounts of earlier neurologies, which saw a promising path to explain epileptic disorders in more complex mechanisms (e.g., the vascular etiology of epilepsy popularised in the early 20th century; Leblanc, 2019). The acceptance and recognition of this set of defining features of epilepsy goes along the more strictly defined criteria that are used for diagnosis, agreed upon by the ILAE. In particular, a person is affected by epilepsy when one (or more) of three criteria is fulfilled (Fisher et al., 2014):

- A minimum of two unprovoked seizures occurring more than a day apart.
- A single unprovoked seizure paired with at least a 60% chance of recurring seizures within 10 years suggested by an adequate risk factor (equivalent to the risk after a second seizure).
- A standing diagnosis of epilepsy syndrome. Indeed, epilepsy is considered a syndrome due to its variety of etiologies, making the manifestation of its symptoms attributable to a variety of causes. This distinguishes it from diseases, which generally imply a unified pathophysiological process.

Finally, the diagnosis of epilepsy is viewed as standing until there are the specific grounds needed to consider epilepsy as “resolved”. Those, according to the ILAE, are met whenever a person is past the relevant age for an age-dependent epileptic syndrome, or if they have stayed seizure-free for 10 years or more, and off anti-seizure medication for at least the last 5 years (Devinsky et al., 2018; Fisher et al., 2014).

The pathophysiological mechanisms that generate and sustain an epilepsy disorder have also been explored, with two main areas of inquiry being identified to describe both epilepsy onset and the factors responsible for seizure outbreak. The first, epileptogenesis, refers to the process or processes that lead a healthy brain to develop epilepsy. In other words, the passage from a state in which no seizures are experienced or expected at all, to one in which there is an ongoing tendency to suffer seizures. In this regard, it is currently accepted that almost *any insult* affecting brain functioning could lead to epileptogenesis - a notion representing a great expansion of the primitive classification offered by Thomas Willis. Indeed, epileptogenesis can be triggered by a wide range of etiologies, including genetic variants, malformations of cortical development, mesial temporal sclerosis (e.g. hippocampal sclerosis), and structural damage following traumatic brain injury (TBI) (Pitkänen & Engel, 2014; Scheffer et al., 2017). Nonetheless, while an extended variety of etiologies of epilepsy have been formally described, this high number of explanations can contribute to the impossibility to determine the underlying cause for the disorder in single patients, whose epileptogenesis often remains cryptogenic (Devinsky et al., 2018). The second main facet important to understand epilepsy is ictogenesis: the precise causes and processes that lead to the generation of seizures and their recurrence. In other words, the passage from a non-seizure state (i.e. interictal) to a seizure state (i.e. ictal). A wide variety of circumstances are implicated in ictogenesis, just like it happens for epileptogenesis, as many different factors can directly contribute to ictal activity, spanning from inflammation in the brain (Vezzani et al., 2008) to altered plasticity in synapses and neuronal cells (like in the case of focal epilepsy, a form of epilepsy characterised by seizures that have a localised origin; Lehnertz et al., 2008). Overall, these contributing drivers can all subsidise the abnormal or excessive electrical activity connected to seizures in different ways, giving rise to different types of seizures. To better understand this heterogeneity, a summary of seizure classifications is offered in Figure 1.

It is this profound complexity that, together with the variety of different ways the disorder can originate and sustain itself in an affected brain, makes epilepsy one of the most widespread serious brain conditions. Indeed, it is estimated that epilepsy affects more than 70 million people worldwide (Thijs et al., 2019), an assessment that is still accompanied by evidence that a substantial proportion of patients still have unmet needs, as the recently concluded Global Epilepsy Needs Study (GENS) comprehensively documents (Baker et al., 2026; International Bureau for Epilepsy, 2026). Adding to this, as previously mentioned,

epilepsy comes with a noticeable burden found in a variety of cognitive impairments that contribute to the struggles represented by dealing with epilepsy on a day to day basis (see also, Zhao et al., 2014). Among these cognitive difficulties, however, one deficit stands out both for its prevalence and its functional relevance: word-finding difficulty, or anomia. In this, it is notable that difficulties with naming - related to anomia - are the most commonly reported cognitive complaint in temporal lobe epilepsy (TLE), an issue that is suggested to be extended to other types of epilepsy as well (Hamberger, 2015; Jackson et al., 2019; Reardon et al., 2025). In this sense, the present dissertation will focus on this aspect of cognitive impairment in epilepsy, detailing the results and impact of new experimental work on the topic conducted in the Neurological Institute of Milan “Carlo Besta”.

Figure 1

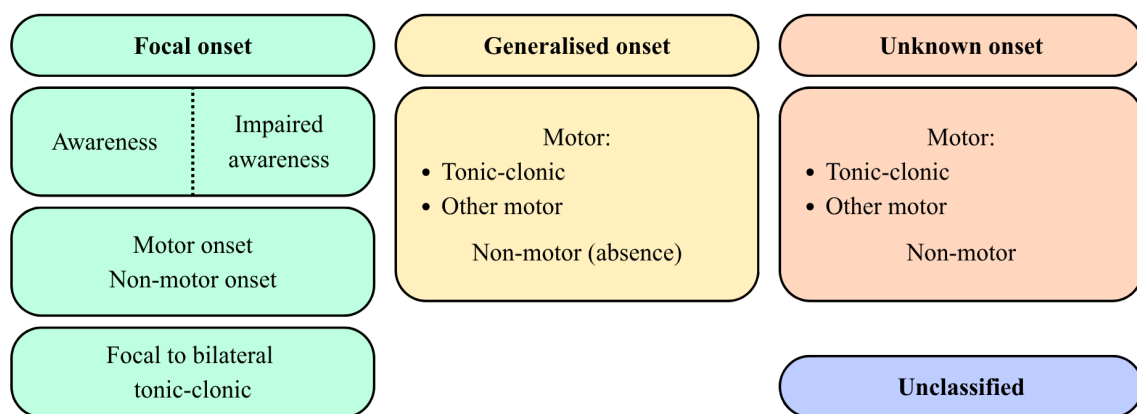


Figure 1. A condensed seizure classification chart adapted from the 2017 ILAE seizure classification statement, reproduced as presented in Devinsky and colleagues’ 2018 paper. In this classification, seizures are distinguished by onset, discriminating focal from generalised and unknown onset - all of which can manifest both a motor and non motor onset. Finally, whenever possible, focal seizures are further distinguished depending on whether the patient’s awareness is preserved during the ictal state, specifying also whether the seizure propagates to both hemispheres or not.

1.2 Naming and naming deficits

This next section will define what we mean by “naming” and directly address the cognitive exercises associated with both naming and word production in general. In this, important definitions will be offered, illustrating the type of operations patients with epilepsy engage with each time they are faced with the widespread variety of linguistic tests targeting this cognitive domain. In neuropsychology, naming represents the cognitive ability to recognise a visual stimulus and output the correct label associated with it either in written or spoken form (see also, Geschwind, 1967). Naming is a specific type of operation falling under the bigger umbrella term of “word production” (Indefrey & Levelt, 2004), which more generally refers to the action of generating a word regardless of the circumstances in which this happens (e.g. in isolation or as part of speech). While intuitively a simple operation, producing a word involves a wide network of neurons across different lobes working in tandem. It follows that, in order to understand the finer subsections of this task, many scholars have attempted to devise theoretical models mapping the underlying mechanisms of word production, some of which date as early as the late 19th century. These early publications served as a crucial stepping stone to the development of contemporary linguistic models. Classically, one of the first models addressing word production emerged from contributions by both Carl Wernicke and Ludwig Lichtheim in the late 1800s. The resulting model was not specifically concerned with word production *per se*, but rather was one of the first works that aimed to describe language functioning as a whole by tying single language faculties to the neural correlates believed to be responsible for them. In this sense, the early “Wernicke-Lichtheim” model can be understood as a neurocognitive one, meaning that both *cognitive* functioning and the respective *neural* substrates are accounted for (Laine & Martin, 2024). Crucially, although initially developed to account for different types of aphasia, this model is important to discuss as it established the conceptual and anatomical framework from which modern naming assessments and conceptualisation derive from. A visual representation of the model is available in Figure 2.

In their foundational diagram (famously renamed “Lichtheim's house” due to its shape), the authors described different types of aphasia under the same psycholinguistic theory, offering a useful tool to quickly categorise aphasic symptoms and identify the neural substructures affected. In this, word retrieval and production (or, in the case of nonfluent aphasia, lack

thereof) was modeled as a function pertaining to the components displayed in the centre-left side of the model, dedicated to linguistic output (e.g. speaking), specifying two areas majorly responsible for word production: the area in charge of concept elaboration (i.e. *Begriffszentrum*) and the area indicated as the centre for motor images (Compston, 2006; Laine & Martin, 2024). The strictly motor centre of Lichtheim's house could be the target of direct focal lesions, which result in a form of Broca's aphasia, while the concept hub could suffer a disconnection from the motor area that allows for speech, resulting in a type of disorder mapping onto transcortical motor aphasia, in which speech is impaired with preserved understanding and repetition (Goldstein, 1948). With the advent of the Wernicke-Lichtheim model a psycholinguistic account of word production was finally made available, outlining the substrates underlying lexical output. Albeit rudimentary and lacking the later nuance of more modern descriptions, the model represented the fundamental groundwork necessary for further explorations of the construct to evolve, narrowing down on specific aspects of language such as naming and word production.

Figure 2

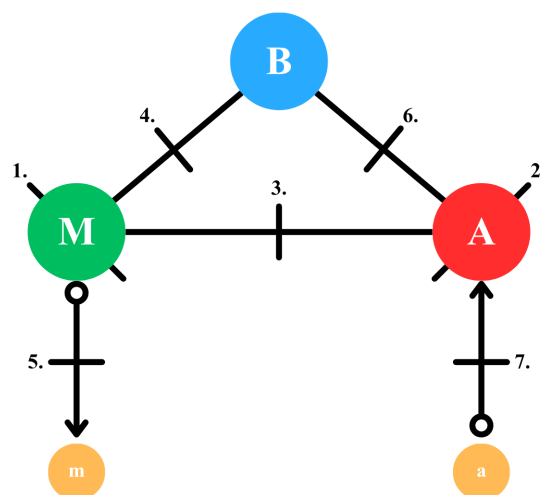


Figure 2. The Wernicke-Lichtheim model. The image is adapted from Compston's 2006 presentation of the diagram. Circles labeled with capital letters represent the three main linguistic hubs of the model: A stands for the auditory representation area, B stands for the conceptual understanding area, M stands for the motor images area. The uncapitalised letters represent the pathway to motor linguistic output (m) and the afferent auditory input (a). Finally, all possible lesion sites responsible for different aphasia profiles are labelled using

transverse lines numbered from 1 to 7. A lesion in site 1 or 4 would directly impact the overarching mechanisms of word production. A lesion in site 3 would impair repetition (the connection between auditory representation and motor images), while a lesion in site 5 would spare the underlying faculty of word production, but nonetheless prevent any linguistic output to be transferred to motor organs.

The approach put forward by models like the Wernicke-Lichtheim one remained popular for almost a century after its initial conception, as scholars focused on generating accounts of language looking at both brain and behaviour together. It was in the second half of the 20th century that a paradigm shift began to appear, as an increasing number of researchers focused on strictly cognitive descriptions of language functioning, giving rise to what we now call “box-and-arrow” models, which later were further refined and updated by “connectionist” models starting from the 1980s (Laine & Martin, 2024). Connectionist models aimed to describe the steps of linguistic processing and production, depicting them through a sequence of representational “stores” (boxes) connected by arrows - making sure to describe their content and relationship. These graphic portrayals of representational stores proved to be particularly useful to isolate the specific types of linguistic images (e.g. morphological, semantic or phonological) involved at different times during linguistic functioning (e.g. the *logogen* model; Morton & Patterson, 1980). The diagram did not merely point to a “functional centre” connected to specific brain areas, like previous models, but rather explained each part by illustrating what representational stores contain and how they are connected. Models pertaining to this time period were developed by integrating findings from a variety of different sources, paying particular attention to the analysis of linguistic errors and experimentations made with early computational tools (Laine & Martin, 2024). The adoption of this type of models made it possible to analyse and illustrate temporal properties of linguistic faculties such as word production, achieving a more nuanced and refined understanding of it.

As described above, there are multiple ways to conceptualise word production and naming stemming from this forty-year-long tradition of psycholinguistic models. Currently, one of the most influential theories of lexical access (i.e. pulling a word out of our mental lexicon) is found in Levelt and colleagues’ (1999) *WEAVER++* model (Word-form Encoding by Activation and VERification; Roelofs, 1997) aiming to explain how we prepare and generate words. This model remains relevant even more than twenty five years after its original

publication, offering a clear example of how more contemporary psycholinguistic models continue to narrow their scope by focusing on specific faculties rather than trying to explain the entirety of our linguistic system. The WEAVER++ model displays word production as a feed-forward process undergoing discrete steps. The first stage concerns a selection of a single item we wish to express from our mental lexicon, in other words, a preparation of “conceptual semantics”. This is followed by the retrieval of the specific lexical semantics (i.e. the correct *lemma*) pertaining to the lexical concept; these are lexical properties such as word category (noun, verb, etc.) and gender that precede any other elaboration of word-form as an independent processing stage (see also, Badecker et al., 1995). The third stage of lexical access sees the recovery of morphological and phonological information in a process of “syllabification” of the chosen word, as morphemes are retrieved to form full lexemes. Finally, phonemic encoding occurs as a phonetic plan is formed in order for the last step of the theory, word articulation, to happen (Laine & Martin, 2024; Levelt et al., 1999; Roelofs & Ferreira, 2019; Dell et al., 2014). Figure 3 provides a visualisation of the model’s steps.

Figure 3

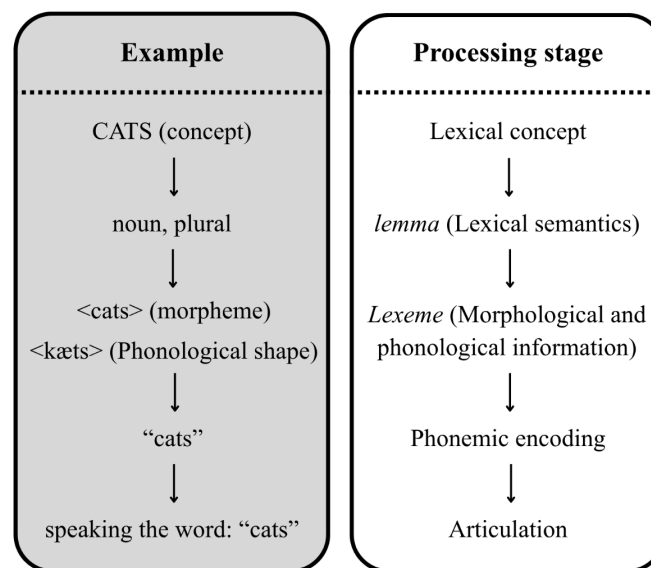


Figure 3. A visual representation of the lexical retrieval steps found in the WEAVER++ model, adapted from diagrams found in Levelt and colleagues’ (1999) original study as well as Dell et al. (2014) and Laine and Martin’s 2024 book. A step-by-step example of word retrieval is provided to the left of the model.

Models such as the WEAVER++, by outlining these clear successive stages that connect concept selection to word production, brought together evidence from lexical access errors in order to provide a tool to easily discriminate different types of word production mistakes. This apparatus also applies to naming that, as part of word production, follows these steps in a similar way to word finding in ordinary speech. Indeed, the visual stimuli presented to participants in naming tasks can be thought of as “lead-in” processes, activating the first step of the model: lexical concept selection (Levelt & Indefrey, 2000). To cite an example, instead of the word finding occurring spontaneously, it is being shown a picture of a cat as part of a naming task that prompts us to retrieve the conceptual image of the animal, which in turn leads to the completion of all other steps necessary to finally output the word: “Cat”. In this sense, the WEAVER++ model can serve as a model of picture naming just as much as it does for general lexical access, and it follows that the process of naming can go wrong at every stage of the process, from the initial concept selection to articulation (e.g. Hanley, 1996). In the case of TLE, for instance, naming impairments seem to be connected to later stages of word production, as semantic meaning is generally preserved, unlike naming deficits connected to Alzheimer’s disease and semantic dementia, which are due to the loss of highly relevant semantic features affecting the lexical conceptualisation stage (Catricalà et al., 2015; Miozzo & Hamberger, 2015). This means, for instance, that while patients affected by semantic dementia are unable to correctly name the picture of a zebra because they lost the ability to conceptually discriminate it from a horse, patients with TLE (the most impacted variant) maintain the semantic representation of the animal but have issues with retrieving later lexical and phonological information pertaining to the target word. Both of these paths result in naming failure (i.e. *anomia*) but due to different underlying reasons.

In conclusion, naming deficits in epilepsy seem to originate from a certain interference with circuits that are responsible for connecting word shape and phonological organisation to the unaffected retrieval of conceptual information. This type of dysfunction, characterised by recurring anomia, can be an important indicator of broader linguistic and cognitive deficits, as its correct evaluation and detection through neuropsychological testing remains of utmost importance. Accordingly, the rest of this chapter will focus on describing the impact of anomia as well as underlying the benefits of accurate diagnosis of naming deficits.

1.3 Naming deficits and quality of life in epilepsy

It is well established that epilepsy contributes to a demonstrably reduced quality of life (QoL), as adjusting to seizure recurrence can prove to be difficult, especially when medications are unable to tame ictal activity (Phabphal et al., 2025). In this regard, a study by Karakis and colleagues (2023) aimed to quantify the well-documented impact that epilepsy has on QoL over a variety of domains. This paper is particularly relevant as it reports the results of a cross-sectional analysis coming from data of a pooled sample of over one-thousand patients with epilepsy and two-thousand people who experienced seizures without a direct diagnosis of epilepsy, offering one of the biggest recent investigations of the effects of the disorder on patients' wellbeing. Their findings corroborate previous evidence of QoL in epilepsy (e.g. Karakis et al., 2014), highlighting markedly reduced physical and mental QoL scores that remain stable across socioeconomic and demographic groups. It is important to note that lower scores of physical QoL remained significant even after accounting for comorbidities and education, indicating a possible direct link between this factor and epilepsy, positioning the disorder as the worst determinant of physical health status and physical functioning among the investigated disorders (namely: depression, migraine, diabetes and epilepsy) and additional chronic conditions (namely: hypertension, heart diseases and cancer). The situation is analogous when taking into account mental health status, as only depression, among the investigated disorders, is associated with stronger pejorative effects than epilepsy. Karakis and colleagues (2023) also expand their analysis by assessing functional and educational effects experienced by people with epilepsy (PWE), describing how the syndrome is connected to worse work and day-to-day household limitations, as well as lower educational attainment. In this respect, epilepsy was once again found to be associated with the greatest impact on these factors compared to all other investigated disorders. This clear and extended burden that PWE carry, resulting in alarming self-report scores, is accompanied by appropriate research looking to identify its determinants. Such an effort breaks down the impact of epilepsy on QoL by isolating targetable components, for example social stigma, physical pain and cognitive functioning (e.g., Pervin et al., 2022; Quintas et al., 2012) that public health workers can focus on. In this sense, we can focus on how impaired cognitive functioning plays a determining role in aggravating the QoL of PWE.

In research looking to explain the consistently lower QoL levels found in epilepsy, cognitive functioning repeatedly comes up as an important contributor to explain score differences (e.g. Giovagnoli et al., 2014). Indeed, overall, researchers tend to agree that the perception of QoL in PWE cannot be explained by strictly clinical factors such as seizure frequency alone (e.g. Lozano-García et al., 2021). For instance, Alonso-Vanegas and colleagues (2013) conducted a retrospective study showing how certain neuropsychological test scores could predict lower scores on a measure of overall QoL. Despite their study focusing on memory functions, the results highlight how lower scores of semantic fluency (a semantic-cue based version of the broader verbal fluency test category) correlate with lower scores of overall QoL, outlining a possible link between poor language functioning and reduced QoL. This result is in accordance with previous evidence from Meneses et al.'s 2009 study, as the authors observed that language (including semantic fluency), general intelligence and attention measures were the best neuropsychological predictors of QoL, strengthening the idea that impaired linguistic functionality negatively impacts QoL in epilepsy. Adding to this, a recent study by Lozano-García and colleagues (2021) both replicated this finding in a TLE sample, emphasising an association between cognitive functioning and QoL, and showed how this evidenced link can be mediated by the number anti-seizure medications (ASM) patients take. This result is especially relevant as it suggests that some cognitive complaints could be due to reversible and more easily manageable factors such as ASM's side-effects, rather than by epilepsy *per se*. In this sense, the correct evaluation and identification of cognitive deficits in PWE gains renewed importance when considering the possibility of tertiary mediators influencing the connection these have to QoL.

When it comes to naming impairments specifically, no research has focused on their unique contribution to QoL scores yet. This is true for any sample, meaning there is currently no available data both for epilepsy and general neuropsychological research. To the best of the author's knowledge, the only publication providing correlation scores for naming abilities and QoL in epilepsy is Tani & Adali's 2025 study on Moroccan TLE patients. In their assessment, cognitive abilities were measured using the Arabic version of the Montreal Cognitive Assessment (MoCA) battery and, while the composite score of the screening test correlated with QoL, virtually none of its subtests (which include a naming task of three animal drawings) individually reached significance. This could be explained by the brevity and high sensitivity of each subtest, perhaps rendering them unrepresentative of thorough neuropsychological assessment. Nonetheless, while no direct correlation has been explored

between naming impairment and QoL measures, naming represents the most common cognitive complaint among epilepsy patients, with TLE variants being especially affected (Hamberger, 2015). Indeed, up to 40% of people with TLE experience naming deficits (Zhao et al., 2014), a number that, while high, might still be unrepresentative of the whole population of PWE. In fact, recent evidence suggests that naming difficulties, just like other language faculties, are often present in other epileptic variants as well - as current neuropsychological testing might be underdetecting the scope of linguistic impairment (Reardon et al., 2025). When looking at cognitive determinants of QoL, naming is therefore impossible to ignore, as this speculated connection between naming performance and QoL can also be looked at by stressing the importance of subjective complaints. In this, Miller et al. (2019) measured how naming decline is directly associated with subjective language complaints following epilepsy surgery, a factor that is in turn directly connected to QoL scores (Giovagnoli & Avanzini, 2000; Giovagnoli et al., 2014). Finally, naming failure also represents the hallmark symptom of aphasia, a fact that has been commented by Fridriksson (2020), as he advocates that naming measures should be used as an outcome measure for aphasic disorders as well, expressly hypothesising a connection with QoL. The main takeaway of these findings is that the assessment of naming, one of epilepsy's most common cognitive complaints, represents one of the most important facets of neuropsychological screenings of PWE, as the adoption of shared, updated and accurate tests for this cognitive faculty would allow for better targeted interventions aimed at ameliorating day-to-day life for PWE.

1.4 The importance of accurate assessment and rehabilitation

Accurately detecting naming deficits in epilepsy as part of broader language complaints does not only narrow down a possible source of distress caused by the disorder, but most importantly represents the necessary condition to tackle the issue with targeted interventions. Indeed, the severity and impact of naming impairments rarely remain stable over time, as affected individuals' subjective and objective ratings tend to change. An analysis of this phenomenon can be found in a study by Sachs and colleagues (2020), who longitudinally measured naming impairments in a sample of aphasia patients using the Boston Naming Test (BNT; Kaplan et al., 1983), a test that is standard even for epilepsy neuropsychological

batteries (Busch et al., 2009). In their research, representing one of the largest longitudinal studies of anomia, the authors highlight how performance on the BNT of their sample saw a promising improvement over the course of twenty years, an outcome that stood unaffected when accounting for demographic variables. Moreover, Sachs et al. (2020) observed how patients with a higher deficit at the outset of the study ended up improving significantly more than the other participants, as the initial BNT score inversely correlated with over time improvement, an effect explained by possible “ceiling effects” encountered by participants with milder naming impairments. This type of evidence clearly points to an optimistic prognosis of naming deficits, especially when rehabilitation therapies are taken into account. In this regard, all participants in this study had a documented history of looking for rehabilitation in the chronic stage of this acquired linguistic impairment - further highlighting the possible benefits of these procedures. When looking at epilepsy, specifically refractory TLE localised in the language-dominant hemisphere, a recent study by Walther and colleagues (2025) monitored performance on the BNT preceding and following temporal lobe resection surgery. In their analysis, looking to outline the long term outcomes of such an invasive procedure, the authors found a similar pattern to the previous Sachs et al. (2020) investigation, as performance on the BNT improved in most patients even after a span of only two years from surgery. Indeed, in their cohort, patients who acquired a naming impairment postoperatively (less than 50% of tested participants) generally saw an improvement over time in their performance, reaching preoperative levels after only two years in the majority of cases. Of this subgroup, only 26% of patients did not experience a full recovery of naming abilities, as their scores sat on average at 19% lower than preoperative levels. Nonetheless, this study finds that even for PWE experiencing a refractory variant of the disorder, the prognosis for naming impairments remains overall positive, with encouraging improvements being evidenced (see also, Parente et al., 2019). An important consideration when interpreting this result is the lack of information regarding possible language rehabilitation programs the patients might have engaged with between follow-up sessions. To this regard, Walther et al. (2025) highlight the importance of proper pre- and rehabilitation especially for these patients at risk (i.e. showing a noticeable naming decline preoperatively) - possibly explaining a portion of the permanent deficits that emerged at the two-year follow up. Taken together, these data suggests that - even for long term outcomes - early recognition of naming deficits remains of utmost importance in order to direct patients to appropriate services responsible for the support of linguistic abilities.

Concerning the effectiveness of interventions directed at the support and enhancement of cognitive abilities, the literature review by Cano-López and colleagues (2025) offers the most recent meta-analysis of this type of research in epilepsy. In their study, pooling over 250 overall participants, the authors were able to underline a noticeable advantage of cognitive interventions, as PWE engaging with these programs experienced an overall increase in cognitive ability with a moderate effect size. This effect was especially evident in adult samples rather than the pediatric one, as a direct difference was detected between adult PWE engaging in therapies vs. people who are not (e.g. are in a waiting list). In this, one of the biggest overall benefits of these interventions was reported to be in the language domain (surpassed only by procedures targeting episodic memory). Such a result is particularly interesting, as language benefits emerged from the general meta-analysis even if only three studies specifically employed language-directed therapies. This data suggests that the linguistic domain can indirectly benefit even from broader cognitive enhancement strategies, pointing to an important malleability of linguistic functionality. This outcome becomes even more relevant when considering that linguistic ability was measured using a visual confrontation naming test in the majority of cases, highlighting how the recorded sensitivity of language abilities to cognitive rehabilitation (especially when directly targeting the linguistic domain) refers mainly to naming performance.

An example of a possible intervention aimed at naming abilities in epilepsy can be in the form of a presurgical prehabilitation process. Indeed, whenever PWE experiences seizures that are resistant to medications and choose to undergo surgical treatment, an increasingly popular approach advises for cognitive functions to be "strengthened" in order for the patient to have an easier time dealing with the consequence of surgery. Recently, a pilot study by Sabadell and colleagues (2025) investigated the effects of anomia prehabilitation in language dominant TLE, testing naming abilities of their participants at different times both before and after surgery, with the latest follow-up happening at 6 months postoperatively. In this study a clear pattern emerged: only when tested on untrained words did the participants exhibit a naming decline post surgery, with trained words seeing a slight (though nonsignificant) increase in performance. Albeit a pilot study, such an effect directly depicts how prehabilitation can have a protective effect on naming abilities. This is especially true when considering that the latest follow up was only 6 months after surgery, a critical time in which the brain could still be adjusting to the surgical aftermath. In fact, as we previously saw in the Walther et al. (2025) study, the greatest (possibly spontaneous) increase in naming

performance only emerged after two years from surgical intervention in the language-dominant temporal lobe.

Another way to tackle naming complaints is found in the more classical approach offered by cognitive rehabilitation. In these cases, only after a cognitive deficit is established and documented, a series of steps are taken to guide the affected patient through multiple sessions dedicated to specific exercises aimed at ameliorating their cognitive performance in the lamented domain. An indication of the benefits of this therapeutic practice was offered in Trébuchon and colleagues' (2025) study focusing specifically on anomic profiles in epilepsy, as their participants struggled with semantic paraphasias and more general word omissions. In their procedure, a 10-step therapy session was administered on three different occasions to patients undergoing stereo-electroencephalography (SEEG) recordings, training naming abilities on a selection of coloured drawings taken from the Multipic database (Duñabeitia et al., 2017) - a type of stylised stimulus similar to the ones included in the BNT (Kaplan et al., 1983). The results of their intervention are especially striking, as six out of the ten patients tested exhibited an improvement in naming abilities after only three sessions, with five of the participants' performances also featuring quicker naming responses. In particular, the increased accuracy of the "good respondents" was so great that the overall accuracy of the entire sample significantly increased nonetheless. In other words, even if four participants did not significantly benefit from the three therapy sessions, the group's average was still noticeably higher. The authors connect this effect to neuroplasticity-related electrical activity recorded in the inferior frontal gyrus (IFG; i.e. Broca's area), showing how even a small number of targeted rehabilitation sessions can lead to meaningful effects for PWE suffering clinically significant naming deficits.

The overwhelming evidence in favour of cognitive rehabilitation for naming deficits (whenever resources permit its adoption) points to clear paths and interventions that are associated with long-term benefits for PWE, yet it is important to acknowledge an important prerogative for these procedures to happen: the early and accurate detection of naming impairment. As we were able to see, a great number of studies rely on quick and easily administered measures such as the BNT - usually in isolation - an approach that can lead to an underestimation (or simply a misrepresentation) of the naming deficits experienced by PWE, especially in patients with refractory variants that periodically undergo ictal activity. Reardon et al. (2025) reported how, in their study, only 15% of patients resulted clinically

deficient in noun-naming, while 85% of them were labeled as impaired when assessed with the larger battery of the Comprehensive Aphasia Test (CAT). The authors argue that this staggering disparity represents an important piece of evidence displaying how classic naming tests cannot detect naming deficits accurately when used alone, as they warn against a risk of underestimating the magnitude of naming deficits in PWE that lament one. In other words, it is possible that patients burdened by impaired naming are flagged as non-deficient when the assessment of their linguistic abilities relies entirely on single naming or verbal fluency tests. Such a concern is echoed in recent recommendations included in Tomaiuolo and colleagues' 2026 paper, as they advocate for consistent and thorough neuropsychological assessment, stressing how it is an essential gateway to accurate rehabilitation practices. In the case of language, in fact, they suggest the inclusion of at least a naming test, a "token-test" and a verbal fluency task. Regarding the specific naming test, given that their paper is tailored to Italian institutions, they indicate the *Esame Neuropsicologico per l'Afasia* (ENPA). In conclusion, the importance of accurate psychometric assessment of naming represents a necessary step to a better overall management of the cognitive symptoms PWE might experience. An undiagnosed patient is also one that does not qualify for treatment - especially when availability is limited. The rest of this dissertation will focus on the assessment of the available measures, offering a new piece of empirical data adding an important piece to the literature dedicated to the psychometrics of naming in epilepsy.

Chapter 2: Literature Review of Noun vs Verb Naming

2.1 Nouns and verbs in the brain

Nouns and verbs are discussed to pertain to two different word classes that are separable to some extent (Laine & Martin, 2024). As a matter of fact, nouns and verbs play starkly different syntactic roles when constructing a sentence, yet whether their distinction is categorical rather than on a gradient has long been debated (Croft, 1991). Nonetheless, in languages such as Italian and English, these two word classes remain intuitively discernible thanks to their syntactic distribution and morphological inflections. This functional distinction we make between these two word classes has led to question whether these two are also differently represented in the brain or are processed by two separate neural systems. This proved to be especially relevant given the a long history of behavioural evidence, extending back almost three-hundred years, showing how patients affected by a variety of neurological conditions can be selectively impaired in either noun or verb processing (see also, Crepaldi et al., 2011; Laine & Martin, 2024). Pertaining to this, one of the most important research pieces on the topic is found in Damasio and Tranel's (1993) landmark paper presenting three brain-lesioned case studies exhibiting a clear double dissociation between verb and name production. For a better visualisation of lesion distribution, their stylised depiction is offered in Figure 4. Specifically, two patients were greatly impaired in noun processing (and naming) with verb performance remaining at control-level, while another patient displayed the opposite pattern, with a verb impairment accompanied by spared name performance. Correlating these specific deficits with their lesions, Damasio and Tranel (1993) were able to conclude how noun processing was related to left anterior and middle temporal cortices and verb processing was reliant on the frontal cortex. With this argument, Damasio and Tranel (1993) popularised what is now known as the "Fronto-Temporal Dichotomy Hypothesis" (FTDH) of noun and verb processing - a theory that would initially gain support in the following years. For instance, the seminal review by Cappa and Perani (2003) focusing on the neural correlates of noun and verb processing, concluded that there was enough accumulated neuropsychological evidence to believe that deficits with noun and verb processing were connected to temporal and frontal lesions

respectively, confirming the initial FTDH crafted ten years prior. Nonetheless, it is important to note that the authors were careful in pointing out how an increasing number of emerging evidence pieces pointed to the importance of other factors (namely, semantic, phonological and syntactic) in explaining the noun-verb dissociation, rather than suggesting a general and overarching word-class difference. Such a possibility gained increasing support in the following years, strongly challenging the clear-cut explanation offered by the FTDH.

Figure 4

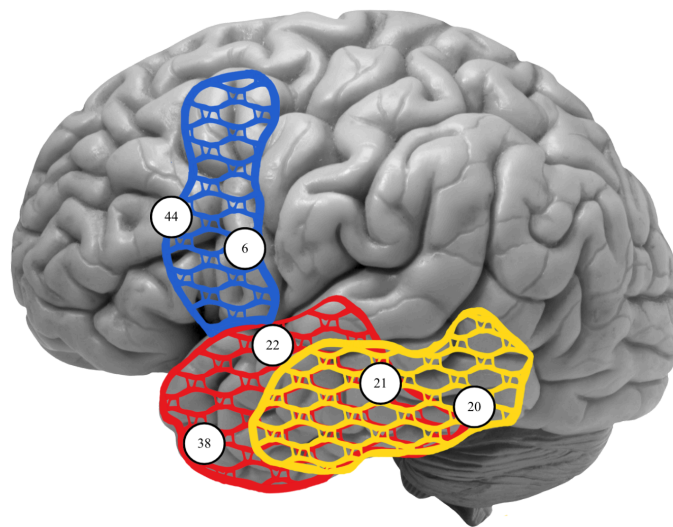


Figure 4. A stylised depiction of the lesions reported by the patients discussed in Damasio and Tranel’s 1993 study. Lesions were located in the left hemisphere. Red and yellow markers outline the lesions of the participants who reported an noun-specific naming deficit. Specifically, red refers to patient “Boswell” and yellow refers to patient “AN-1033”. The blue marker outlines the lesion suffered by patient “KJ-1360”, who exhibited a verb-specific naming deficit. The numbered circles represent the Brodmann areas affected by the lesions. Only KJ-1360 had an intact temporal lobe, with his lesion interesting the posterior segment of the inferior frontal gyrus and the anterior segment of the precentral gyrus.

As time progressed, a growing number of studies evidenced clinical patterns that were inconsistent with the FTDH. Consequently, the current picture concerning the anatomical correlates of noun-verb dissociations is much more contradictory, with no single replicated result championing all others in identifying distinct neural bases for the two word types. Crepaldi and colleagues (2011) conducted an extensive review of the available literature on

the subject, highlighting a great deal of inconsistency among findings, with the original FTDH dissociation being rarely supported and hardly ever replicated. This high degree of disagreement is aggravated by the possibility that the distinct anatomical correlates of verbs and nouns could be specifically recruited for unique levels of linguistic processing, like lexical-semantic or phonological encoding. Even when considering evidence from research making use of naming tasks, the authors concluded that it was inconsistent with the FTDH, suggesting instead that noun and verb naming are subserved by a shared network. This result is possibly favoured by the fact that action pictures usually include an object that, in itself, needs to be processed and represented even when producing its name is not expressly required (e.g., when a patient is shown a picture representing the action “to cut”, an object such as a pair of scissors is generally depicted as well). More recent publications reviewing noun-verb dissociations also undermine the validity of the FTDH, with Crepaldi et al. (2013) also concluding that the available evidence did not suggest a high degree of anatomical specificity when it comes to the neural bases of these word class differences. They argue that the fMRI and PET investigations that are able to outline a clearly distinguishable circuitry are probably isolating an effect happening at the periphery of a bigger - and mostly shared - network between nouns and verbs that includes frontal, temporal and parietal areas. This type of conclusion is supported by even more recent publications, as de Aguiar and Rofes (2022) also argue for an almost completely shared network between noun and verb processing, pointing to the possibility that the straightforward distinction we intuitively make between nouns and verbs might be more graded in anatomical terms. In fact, the dissociations that were evidenced in the past (e.g., Daniele et al., 2013) might be better explained by the influence of psycholinguistic variables on both nouns and verbs, especially given that impairment dissociations also occur for linguistic operations pertaining to a single word class as well (e.g., Marusch et al., 2018). Importantly, evidence hinting at this conclusion was already present in Damasio and Tranel’s (1993) original study, as one of the two patients with an object naming impairment (namely, patient Boswell) did not exhibit the same degree of deficiency for all object classes. Indeed, they fared much better with tool/utensil naming (76% accuracy) compared to animals and fruits/vegetables (respectively, 24% and 25% accuracy).

Currently, the most accredited account of noun-verb representation in the brain still hypothesises an almost entirely shared network between the two, pushing the narrative towards a possible causal role played by psycholinguistic factors in explaining the

dissociations observed in the past. For instance, Delikishkina et al. (2020) recently proposed that the frontal involvement once considered typical of verb processing could be due to the higher difficulty in lexical selection caused by the higher number of synonyms, hyperonyms and hyponyms that verbs have compared to nouns. A similar argument was made by Crepaldi and colleagues (2011), as they proposed that nouns and verbs might require a different magnitude of extralinguistic activity, such as task monitoring or attentional processes, leading to a double dissociation on performance scores or simply different patterns of fMRI activation. Finally, in de Aguiar and Rofes' (2022) recent chapter on this matter, the authors discuss a variety of psycholinguistic accounts that could explain the noun-verb difference, concluding that current literature does not directly contradict grammatical accounts (i.e. lexicalist theories) of the issue. These support, for instance, the possibility that different grammatical requirements of the words used could contribute to drive the impairments (e.g. the number of arguments a certain verb has).

In this scenario, circling back to the principal interest of this dissertation, the rationale behind embracing investigations of both objects and actions in the realm of naming impairments lies in the bigger variety of items this double testing allows for. For instance, by focusing solely on object naming, one might lose the nuance offered by the variability in psycholinguistic factors gained when looking at verbs as well. In other words, a naming deficit could be missed if not thoroughly assessed through a wide enough pool of target words. Adding to this, Mätzig and colleagues (2009) highlighted an unbalanced impairment pattern for object and action naming, as they describe how, whenever object naming is impaired, action naming also tends to be impaired, while whenever action naming is impaired, object naming is more likely to be spared. This suggests that action naming and object naming, while dissociable, could be differently demanding, with action naming representing a more taxing exercise - making it more fragile. Considering these findings when assessing the psychometric measures we use with epilepsy patients could be beneficial. In fact, while picking between (or both) an action and an object-naming test might not help the localisation of different brain circuits, it could certainly affect a battery's effectiveness in detecting a naming deficit (see also, Yurchenko et al., 2017).

2.2 The Boston Naming Test

When looking at the psychometric tools in use to measure naming abilities, the Boston Naming Test (BNT) - originally developed by Kaplan et al. (1983) - is certainly among the most widespread, representing somewhat of an industry standard especially in epilepsy research and care. On this topic, recent findings by Puntambekar and colleagues (2025) offer a clear example of how popular the BNT really is. In their study, the authors investigated which measures are used to keep track of postoperative language changes in epilepsy, and found that visual confrontation naming is the most widespread, being administered in 95% of the surveyed papers. Of that 95%, the BNT contributed to 64% of the total share of naming tests across all languages, a result that put it in first place among *all tests* surveyed, even ones pertaining to different linguistic faculties such as verbal fluency or auditory comprehension. Findings like this one truly illustrate how preponderant the BNT is in neuropsychological assessment, especially in epilepsy, with the test enjoying such a position thanks to its reliability, quickness, and simplicity in administration. The test is composed of 60 line-drawing stimuli representing a variety of different objects, ranging from “easiest” (e.g. tree) to “hardest” (e.g. abacus). To vary the difficulty in name retrieval the objects included can be of high frequency or low frequency in spoken language. Two example stimuli taken from the BNT are shown in Figure 5. The administration procedure starts with the patient being shown the first stimulus of the list, after which they are given 20 seconds to produce the right name (in some cases multiple synonyms are considered acceptable as well). After 20 seconds, if a correct response has not been produced, a semantic cue is verbally provided to the patient in order to aid the retrieval, and another 20 seconds are granted. For example, if the target picture represents a beaver, a semantic cue could be: “it gnaws on wood”. After the second 20 second time window, if the patient has not articulated the correct name or they produce a wrong answer, a final phonemic cue is given, offering the beginning of the target word. Following on from the previous example, the phonemic cue for the target name “beaver” could be the first syllable: “Be-”. Any right response during the first 20 seconds or after the semantic cue is considered correct, and scores a point. Correct responses after the phonemic cue or no correct response are considered wrong and do not score any points. The experimenter also writes down whether the answer has been received after a semantic or phonemic cue whenever that is the case, also reporting any relevant alternative wrong answer

produced before the correct one (Basura et al., 2024; Fastenau et al., 1998; Neils-Strunjaš, 1998; Nicholas et al., 1989).

Figure 5

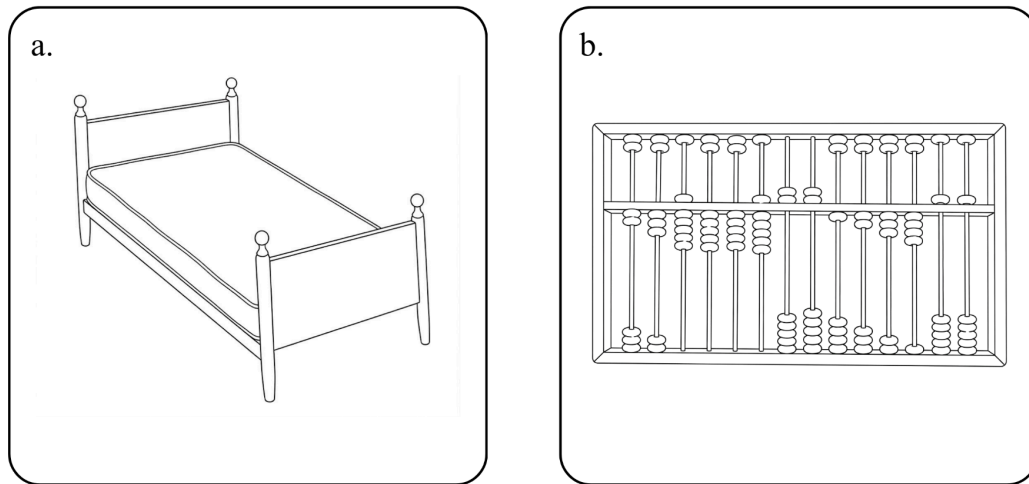


Figure 5. Reproductions of example stimuli taken from the BNT (Kaplan et al., 1983). These images were reproduced faithfully using Google Gemini’s image generation feature. Figure 5a, on the left, shows a more frequent, easier stimulus: “bed” (in Italian, “letto”). Figure 5b, on the right, shows instead a less frequent and harder stimulus to name: “abacus” (in the Italian version there are two acceptable responses, either “abaco” or “pallottoliere”).

The widespread adoption of the BNT is not necessarily a drawback, as it provides a crucial advantage: universally shared neuropsychological measures ensure a stable foundation for both research collaboration and patient mobility. In this regard, the ILAE has repeatedly pushed for neuropsychological test selection homogeneity. For instance, in a 2025 report, the association flagged test heterogeneity as one of the major neuropsychological challenges for epilepsy screening in low-to-middle income countries (Smith et al., 2025). At the same time, to make sure neuropsychological data about patients is as transferable as possible across institutions, the ILAE also worked on the development of a classification system aimed at harmonising cognitive diagnostics. This effort, conducted by McDonald and colleagues (2023), led to the creation of The International Classification of Cognitive Disorders in Epilepsy (IC-CoDE), a tool useful to unify the description of generalisable “cognitive phenotypes” across five cognitive domains, including language. In this, it is the popularity of the BNT that made it possible to indicate it as the “poster” measure to assess naming ability

in the language domain, clearly demonstrating how the large convergence on the BNT can come with meaningful upsides. Nonetheless, relying entirely on this single test can be risky, as neuropsychological batteries call for a periodical and strict evaluation of their robustness, as the risk of overreliance on single measures is always a possibility. Indeed, the BNT is not without criticism, as multiple scholars pointed out possible weaknesses and shortcomings. Particularly, Harry and Crowe (2014) addressed the criticisms received by the BNT in their review, as they highlight a wide array of aspects that could render the BNT unfit for its purpose. For instance, they strongly point to the fact that the BNT - despite being the most adopted among noun-naming tests - does not include a thorough enough exploration of noun categories that could highlight a category-specific impairment similar to that exhibited in the previously discussed Damasio and Tranel (1993) study. More precisely, they claim how any kind of category-specific deficit (e.g., tools, animals, furniture, musical instruments) could not emerge due to the inadequacy of the items dedicated to the assessment of these specific categories (see also, Catricalà et al., 2014; Drane et al., 2008) - a shortcoming that would make the BNT suboptimal even as a specifically *noun*-naming test, let alone for naming in general. Indeed, the BNT either includes very few items dedicated to these categories, or they require general responses. For instance, the BNT picture of a flower calls for “flower” as a response, rather than indicating the specific species, such as “lily”. Another clear example is offered by the omission of sublabels in categories such as “fruit”, with no picture showing items like “apple” or a less frequent stimulus like “mango”. Another point the authors make concerns the general psychometric properties of the BNT, characterised by a negative-slope score distribution, as scores tend to cluster around the maximum obtainable result (60/60). While it has been argued that this type of distribution is due to the test merely highlighting a naming *deficit* rather than assessing general naming abilities in control populations, Harry and Crowe (2014) point out how a non-normal score distribution can include errors in the interpretation of z-scores, as well as ceiling effect causing poorer diagnostic accuracy. Indeed, if control patients cluster around the maximum score, it remains unknown whether they are scoring 60/60 because that is *all they can do*, or whether that is the case because that is *all there is to get* - rendering any inference about clinical deficits more difficult.

These problems the BNT has been connected to are aggravated by more issues with inter-rater reliability and lack of proper widespread standardisation. In fact, even when moving away from criticisms concerning the test *per se*, Harry and Crowe (2014) also discuss how the BNT is usually administered in different ways. This is exemplified by an almost 50%

split between neuropsychologists adopting a more lenient interpretation vs. a more rigorous interpretation of the procedure - with test administrators either counting phonemic-cue errors (meaning a correct response is produced only after the phonemic cueing) as part of the six consecutive errors needed for discontinuation or not. Furthermore, the extensive endorsement of the BNT clashes with the guidelines the ILAE has for neuropsychological batteries. Importantly, while it has been discussed how the BNT being commonplace can be a good thing, that is only true when the test is appropriately standardised for the population it is used in (Baxendale et al., 2019). On this remark, the Italian version of the 60-item BNT remains one of the most popular tests for epilepsy care despite lacking adequate standardisation, with pathological scores being determined by a one-fits-all cutoff score. In other words, there is currently no way for Italian patients to be assessed on a 60-item BNT in a way that takes into consideration relevant factors influencing performance level such as age, sex, education years or ethnicity. Altogether, it is for these reasons that assessing other tests to either substitute or accompany BNT measures can be beneficial, aiming for a more accurate, standardised and up-to-date screening of naming abilities in epilepsy patients.

2.3 Finer batteries and the Action Naming Test

In scrutinising the available naming batteries, the BNT might turn out to be inferior to other accessible measures. Despite this, there are not a large number of alternatives to the BNT, contributing to the prevalence of this specialised single-test. Regardless of this, research in epilepsy has nonetheless demonstrated how impairments with linguistic functioning are often missed by this traditional assessment, calling for a deeper analysis of language faculties (Reardon et al., 2025). Indeed, neuropsychological studies have shown how noun-naming might be more clearly impaired in left TLE patients, with this laterality difference disappearing whenever an action-naming test is used instead (Yurchenko et al., 2017). The biggest risk of relying on a single test lies exactly in the possibility that the measurement could flag deficits for a specific cohort at a different rate with respect to the whole population it is being administered in. In the case of the BNT, left TLE patients could be diagnosed as pathologically impaired in naming more frequently than other epilepsy variants while the difference might not be actually there, or at least not to the same degree (Reardon et al., 2025). In light of this, it is reasonable to consider other possible alternatives for testing this

linguistic ability in epilepsy in order to ensure this cognitive deficit is appropriately detected. A number of additional or alternative measures will be discussed with an Italian population of PWE in mind.

2.3.1 The Graded Naming Test

The Graded Naming Test (GNT) was reported to be the second most popular naming test used with postoperative epilepsy patients in the recent review by Puntambekar et al. (2025), representing possibly the strongest option out of naming tests behind the BNT. The GNT was originally developed by McKenna and Warrington (1983), and it comprises 30 total items. The test - another strictly noun-naming test - is noticeably harder than the BNT, with its items pertaining to different and clearly separable superordinate semantic categories. For example, the item showing “tweezers” falls under the “tools” category, while “kangaroo” falls under the “living creature” category. This feature of the GNT overcomes some of the criticism the BNT received, adhering to the previously mentioned recommendations made by Harry and Crowe (2014), indicating that a noun-naming test should include stimuli spanning across a variety of different semantic categories, given they could be selectively impaired. Adding to the advantages of GNT, the test has enjoyed a much-needed revision by Murphy and colleagues (2020), addressing pivotal issues with the previous versions. In fact, the authors tackled evidence showing how some items of the GNT suffered a steep decline in naming performance in younger populations (aged 18 to 29) by validating a shorter 25-item version of the GNT that omits the most problematic items. The performance shift seen in younger participants was due to cultural factors, as some of the stimuli presented in the original test are not as frequent anymore (e.g. Sporrán - the small leather pouch found in traditional Scottish attire). Such a correction makes the GNT a desirable alternative (or simply, complement) to the BNT as, to the best of the author’s knowledge, the latter has yet to receive an update looking at performances of younger generations. Nonetheless, the GNT still focuses solely on names and, albeit it does so in an arguably more structured way, it might not be enough to catch the scope of naming deficits in an epileptic population, which can be difficult to detect. Indeed, a more difficult test does not guarantee this expectation is met, especially considering how suggestions about category-specific impairments emphasise the role of psycholinguistic variability, a scope that a shorter and noun-only test might miss (de Aguiar & Rofes, 2022). Furthermore, considering applications for an Italian cohort, a standardised Italian version of the GNT has yet to be developed, a feat made even more

difficult by the presence of culture-specific items. In fact, while items such as “scarecrow” might easily translate in another language, items like “yashmak” (a traditional turkish veil) would prove to be more problematic given the different culture the test would have to be adapted into.

2.3.2 The Comprehensive Aphasia Test

The Comprehensive Aphasia Test (CAT) is a battery originally developed by Swinburn and colleagues in 2004, at the time representing the first new English-language aphasia battery in twenty years (Howard et al., 2010). The battery is divided in three sections: a cognitive screening part in which possible factors influencing the language scores are individuated (e.g., visual neglect), followed the “language battery” proper, and a final disability questionnaire pertaining to linguistic abilities. The language battery is thorough in its assessment, being further divided into five subsections looking in turn at different aspects of language: spoken/written language comprehension, repetition, spoken output (including both object and action naming), reading aloud, and writing (Howard et al., 2010; Swinburn et al., 2004). This battery is especially relevant because it is the one used by Reardon and colleagues (2025) to show the staggering diagnostic difference between the CAT and the BNT when administered in a sample of focal epilepsy patients. As previously mentioned, the study highlights how, while 85% of PWE tested were impaired on at least one subtest of the CAT, only 15% of them turned out to be impaired on the BNT. Importantly though, the most striking detail of Reardon and colleagues’ (2025) research lies in the fact that most of the 85% share of patients that were impaired in the CAT is made up by a single subtest: action naming. Particularly, more than 70% of PWE tested were impaired in action naming, a number more than double the share represented by the second most significant subtest: spoken picture description (just over 30%). Adopting the CAT would represent a great step forward for linguistic diagnostics in epilepsy, as this evidence clearly points to a clear advantage of such an extensive test being used. For example, the rate of agreement between self-reported difficulty and objective impairment was almost 70% for the CAT, while the BNT only scored 11%. Despite the undeniable benefits of such thorough investigation of language, it is nonetheless logistically impossible to truly recommend this procedure as an industry standard. The CAT is an extensive battery, and its time-consuming administration process makes it very hard to imagine alongside standard cognitive testing requirements. Moreover, while the lengthy procedure already disqualifies such long language assessments

from standard practice, the CAT has also yet to receive a standardised adaptation into Italian. Regardless of these insurmountable limitations, we could still isolate the most relevant subtest for epilepsy in order to integrate it into the larger neuropsychological batteries that usually contain the BNT. This reasoning leads to the description of one final test: the Italian-made Action Naming Test (Papagno et al., 2020).

2.3.3 The Action Naming Test

The Action Naming Test (ANT), developed by Papagno et al. (2020) offers the possibility to test patients on verb naming specifically, isolating the CAT subtest that was shown to be most successful in identifying linguistic deficits in PWE (Reardon et al., 2025). The test was developed by Papagno and colleagues (2020) as they selected 50 items (plus 3 example items) from a previous naming test published in Crepaldi et al., (2006), which originally included a set of 123 stimuli. The test consists of line-drawings depicting a variety of different actions, and its administration procedure is much stricter than the BNT, making the test both harder and quicker. Participants are asked to name the presented picture by producing the correct verb (or one of the correct verbs, in case there are multiple acceptable answers) describing the action taking place. Correct responses score one point, while any incorrect response, self-repair or latencies longer than three seconds are considered as an error. Verbs are accepted in both finite (e.g., “cammina” - he walks) and infinitive forms (e.g. “camminare” - to walk), while close synonyms are considered correct only when they were produced by at least 5% of the tested control population (e.g., “sbucciare” and “pelare” - both meaning “to peel”). An example of the stimuli used in the test is offered in Figure 6.

The ANT provides one of the most targeted and easily administered naming tests available for an Italian population, offering an interesting opportunity to extend or substitute the current neuropsychological assessment of language in epilepsy mainly reliant on the BNT alone. Indeed, the ANT would work both as a substitute and a complement to the BNT, especially considering how quickly it is conducted. In this respect, once a patient has been explained the task, the 3-second time limit for each response ensures the testing does not exceed a duration of only a few minutes - a substantial advantage making it easy to insert in longer, routinely conducted cognitive assessments. This type of structural feature would also make it easier to track verb-naming production longitudinally, including the completion of this test in postoperative follow-up sessions as well. Finally, by specifically asking to recall

verbs, naming performance is tested on words with starkly different psycholinguistic properties than nouns, contributing to both a more thorough assessment of naming performance and a better identification of deficits altogether (de Aguiar & Rofes, 2022; Harry & Crowe, 2014). In fact, by targeting verbs as well, we would be directly assessing a word domain that has proven to be significantly more fragile than nouns (Mätzig et al., 2009). Despite this, the test has never been administered in an epileptic population, with action vs. object naming only ever being assessed using the larger CAT battery on a limited sample of patients (Reardon et al., 2025). For this reason, an experimental study was conducted to fill this gap, assessing the performances of PWE on the ANT and a shorter, recent version of the BNT (Vestito et al., 2023) - correlating their scores with relevant clinical variables. The rest of this dissertation will focus on the details of this effort, with the next chapter offering a full account of the experimental work. First, an introduction will briefly go over the premises of the study, contextualising part of the evidence that was already discussed. Second, methods and results will be schematically outlined, with a full section-based discussion closing the final part of the next chapter.

Figure 6

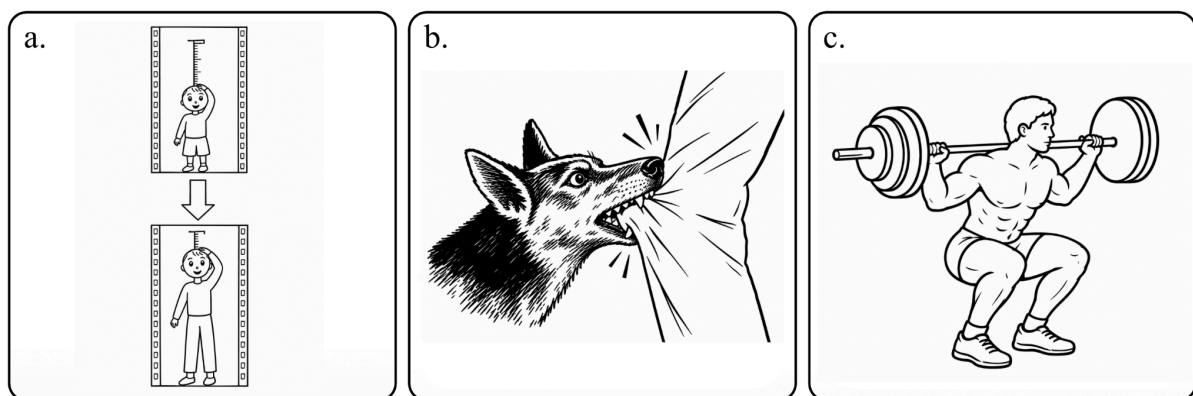


Figure 6. Reproductions of example stimuli taken from the ANT (Papagno et al., 2020). These images were obtained using ChatGPT’s image generation feature. On the left, Figure 5a shows the action “*crescere*” (“to grow”). In the middle, Figure 5b represents the action “*mordere*” (“to bite”), with alternative acceptable synonyms being “*morsicare*” and “*azzannare*”. Finally, on the right Figure 5c depicts the action “*sollevare*” (“to lift”), with an alternative response being “*alzare*”.

Chapter 3: Experimental Study

3.1 Introduction

As previously discussed, epilepsy is a widespread condition affecting tens of millions of people worldwide, representing one of the most prevalent severe neurological conditions (Thijs et al., 2019; World Health Organization, 2024). The advent of this disorder, characterised by recurrent seizures (or a serious risk of recurrent seizures), results in a variety of adverse effects for the affected patient, with cognitive functioning usually facing some degree of impairment depending on the specific etiology of the epileptic syndrome (Devinsky et al., 2018; Zhao et al., 2014). Considering this variety of debilitating cognitive deficits presented by PWE, the language domain has been shown to be one of the most affected, as recurring ictal activity can directly disrupt the normal functioning of linguistic behaviour (Bartha-Doering & Trinka, 2014). Specifically, the most commonly found impairment among language functions in epilepsy is “naming”, referring to the process of articulating the correct label associated with a presented item, which is generally a picture or a line drawing (Geschwind, 1967). Indeed, difficulties with naming are actually one of the most frequent cognitive complaints in PWE altogether, with up to 40% of patients lamenting pervasive instances of *anomia* (i.e., naming failure) affecting their daily life (Laine & Martin, 2024; Lomlomdjian et al., 2011; Zhao et al., 2014). In this light, language assessment in epilepsy serves as a tool useful to detect these deficits, serving a double function. Particularly, it is crucial to gather valuable information towards the localisation of a possible epileptic focus, and to eventually point the patient towards appropriate pre- or rehabilitation in case it is considered necessary (e.g., Kaestner et al., 2019). Nonetheless, despite the fact that the presence of cognitive deficits like this one can cause a significantly detrimental impact on patients’ quality of life (Giovagnoli et al., 2014), there is evidence pointing to a substantial gap between the naming impairment that PWE experience and the actual diagnoses current tools produce (Reardon et al., 2025). Indeed, the most widely adopted tool for naming assessment in epilepsy is the BNT (Kaplan et al., 1983; Puntambekar et al., 2025), yet recent work by Reardon and colleagues (2025) found that it identified nearly five times fewer impaired patients than a longer assessment like the CAT (Swinburn et al., 2004). This

inconsistency between experienced naming difficulties and their formal recognition as a linguistic deficit is most likely a problem of instrumentation, as current tools might not be enough to detect the nuances of language impairment pertaining to PWE (see also, Drane et al., 2008; Harry & Crowe, 2014). Indeed, the BNT tests patients on object-naming, specifically focusing on a set of highly imageable nouns, including mostly concrete objects like “bed” or “saw” as their stimuli. It follows that this structure narrows the scope of naming targets the test can assess, rendering it weaker than more thorough analyses (Harry & Crowe, 2014). On this topic, the study by Reardon et al. (2025) found that, among the subtests of the CAT, action naming was the most successful, surpassing the other assessments present in the battery - including noun naming - by a very large margin. This evidence therefore suggests that noun-naming tasks as a whole might not be fit-for-purpose whenever used as the sole measurement of naming ability, with other stimuli-types providing better ground for testing.

In consideration of possible alternatives or complements to the standard administration of the BNT, naming of actions offers a favourable stimulus set that might be better suited for an epileptic cohort, thanks to its focus on verb naming. Indeed, while the classic FTDH hypothesis (Damasio & Tranel, 1993) has been thoroughly called into question (Crepaldi et al., 2011), naming of nouns has been repeatedly shown to be a dissociable faculty from naming of verbs, with the latter representing a more fragile mechanism that is much easier to disrupt (Mätzig et al., 2009). The reason behind this asymmetry has been suggested to be due to the two word classes sharing a different set of psycholinguistic variables that could be determining a higher naming difficulty for verbs (therefore, making it a more precarious faculty; de Aguiar & Rofes, 2022). So, even if - anatomically - recent evidence points to noun and verb naming sharing mostly the same neural substrates located in fronto-temporo-parietal areas (Crepaldi et al., 2011; 2013), verbs seem to generally require a higher degree of effort in order to be retrieved. Furthermore, a study by Yurchenko et al. (2017) has shown that naming tasks focusing on verbs overcome lateralisation effects that cause score differences, with left TLE and right TLE patients performing at more comparable levels, unlike noun tasks in which left TLE patients tend to perform systematically worse. It follows that, if classic noun naming seems to be failing at accurately recognising naming deficits in epilepsy, the more sensitive features of action naming could make it a strong candidate to do the job. This claim is reinforced when taking into account the logistical constraints that neuropsychological assessment usually faces, as a lot of different tests are required and only limited time is available to deliver them. Indeed, these factors disqualify any thorough and

time consuming assessment of language functioning (such as the CAT) during a routine screening session, making action naming an even more advantageous alternative. A final limitation concerns the fact that the BNT only relies on a fixed cutoff in its Italian iteration, without accounting for relevant variables such as age and years of education - a shortcoming that leads to running the meaningful risk of omitting relevant individual differences when judging patients' performances.

Having an Italian population in mind, Papagno and colleagues (2020) have recently developed and standardised a fifty-item Action Naming Test, representing the most up-to-date short-form action naming measure available. This test, derived from a larger 123-item pool (Crepaldi et al., 2006), contains a set of line-drawings that the patient is asked to name while respecting a strict three-second response window, making it considerably faster to administer than the standard 60-item BNT, which grants up to 40 seconds per stimulus across cueing stages. Despite these advantages, the ANT has never been tested in an Italian epileptic population, with the different contributions of noun vs. verb naming only having been explored twice in PWE: once using dedicated noun and verb production tasks (Yurchenko et al., 2017), and once using a large and impractical language battery (Reardon et al., 2025). It follows that, at the moment, it is still unknown whether the patterns evidenced by previous studies looking at these two types of naming will be replicated when using two short-form tests that are easily adaptable in larger neuropsychological batteries for epilepsy. This shortcoming is further compounded by considering that a great number of epilepsy studies concerned with linguistic functioning tend to focus solely on people with TLE (e.g. Zhang, 2025). The present study addresses this gap directly: using the ANT to explore how a wide cohort of patients with epilepsy perform both preoperatively and postoperatively on both noun and verb naming, aiming to correlate any incongruent performance with clear clinical variables. Indeed, while the two word classes might not directly correlate to different affected networks, the adoption of a new test could represent a meaningful step forward in cognitive diagnostic quality. The research question being investigated asks whether a wide sample of PWE (with different disorder etiologies) will be diagnosed differently by the ANT and the BNT, with the newly developed ANT possibly representing a more sensitive measure than its object-naming counterpart. Specifically, there are three separate hypotheses:

- 1) First, it is hypothesised that the two tests will produce several dissociations in their diagnostic assessment, with a greater number of patients being impaired on the ANT

compared to the BNT. This is due to previous evidence from Reardon et al. (2025) pointing to an overwhelming majority of epilepsy patients being labeled as pathological by the action naming test subsection of the CAT compared to the BNT.

- 2) Furthermore, it is predicted that patients whose epileptic focus is in the left hemisphere will perform worse on the BNT than right-lateralised patients. This is expected as it would be in line with previous studies showing how object naming flags impairment at a disproportionately higher rate for left lateralised TLE patients (e.g., Yurchenko et al., 2017).
- 3) Finally, it is expected that patients with TLE will perform worse than patients with extratemporal foci in both assessments, further disproving the classic FTDH in support of theories hypothesising shared networks for nouns and verbs in the brain. This is hypothesised as recent evidence increasingly points to a shared network of nouns and verbs, with the temporal lobe being commonly discussed as one of the most relevant hubs (e.g., de Aguiar & Rofes, 2022). In accordance, TLE patients have also been shown to be especially affected by naming deficits (Hamberger et al., 2015), further justifying this hypothesis.

The remainder of chapter three will discuss the details of the experimental procedure and statistical analysis, also including a section entirely dedicated to discussing the results obtained both in clinical and theoretical terms.

3.2 Methods

3.2.1 Participants

A total of 56 drug-resistant epilepsy patients were initially recruited for the study. Two participants (P043 and P049) were later excluded from the final analysis: one due to a lack of information concerning their clinical history, and one due to them presenting an atypical electroencephalographic status lasting several days, rendering the possible diagnosis of epilepsy unclear. The final sample included 54 participants. Clinical and demographic

variables pertaining to the cohort are summarised in Table 1. All of the partakers were recruited via convenience sampling, as they were administered the naming tests as part of their routine neuropsychological screening and follow-up sessions at the Neurological Institute “Carlo Besta” of Milan. In order to take part in the study, participants had to be native Italian speakers (or bilingual Italian, in one case) with an epilepsy diagnosis, be over 18 years of age, have normal or corrected-to-normal vision, and obtain a non-pathological score in the Raven’s Coloured Progressive Matrices (CPM) test (Raven, 1947). The CPM score was used as an index of general nonverbal reasoning abilities, ensuring all participants did not have an intellectual impairment that could confound the naming tests’ outcome. Included patients were not compensated for their participation.

Table 1

Patient Characteristic	Value
Age (years; $M \pm SD$, <i>range</i>)	40 ± 13.2 , 18-70
Education (years; <i>Mdn</i> , <i>range</i>)	13, 7-18
Sex	Male: 25 / Female: 29
ASM in use (<i>Mdn</i> , <i>range</i>)	2, 0-4
Epilepsy onset (years; $M \pm SD$, <i>range</i>)	21.2 ± 15.7 , 0-62
Epilepsy laterality (hemisphere)	Left: 24 / Right: 27 / Bilateral: 3
Seizure presence	Free: 25 / Ongoing: 29
Surgery status	Preoperative: 25 / Short f.up: 17 / Long f.up: 12
Epilepsy location (as per MRI results)	Extratemporal: 17 / non-mesial TLE: 16 / mesial TLE: 19

Note. Descriptive statistics of clinical and demographic variables for the 54 patients included in the study. Seizure presence classifies patients into two groups: one in which patients are

still experiencing recurrent seizures, and one in which they are not, being free for over a year. The surgery status line classifies patients depending on how much time has passed from their surgical intervention: “preoperative” means they have not had surgery, “short follow up” refers to patients that have undergone surgery either one or two years prior, “long follow up” groups patients that have had surgery either five or ten years prior to the testing. These data points reflect the actual distribution of follow-up intervals at the Institute. For two patients (P039 and P047) it was not possible to determine the exact location of the epileptic focus after the magnetic resonance imaging (MRI) scan, as the exam either came out negative or was inconclusive. As a result, they were included in the general analysis but their data points were removed from the pool concerning epileptic focus. No notable correlations between these variables was evidenced except for a positive moderate correlation between age and age at epilepsy onset ($r = .55$). That is to be expected as, by definition, it is more likely for older people to present a later epileptic onset.

3.2.2 Materials

The tests used in the study to investigate naming ability were the 50-item ANT (Papagno et al., 2020) and the shorter 15-item version of the BNT by Vestito and colleagues (2023). This latter test was preferred to the classic 60-item BNT (Kaplan et al., 1983) thanks to its recent validation and standardisation, allowing for age - and education- adjusted normative scoring. Both tests, containing sets of line drawing images the participant has to name, were administered in full. All stimuli were presented to the patients on a flat surface, printed on A4 paper sheets collected in two dedicated plastic binders - one per test. The BNT items were printed vertically, while the ANT items were printed in landscape. Additionally, the CPM test (Raven, 1947) was also used in full to index general nonverbal reasoning. This test is made up of three sections, in which each trial requires participants to pick out of six alternatives to logically fill the missing piece of a coloured sequence or pattern. Finally, MRI scans were conducted using brain scanners with a field strength of either 1.5T or 3T.

3.2.3 Procedure

Two naming tests were administered as part of a longer, complete neuropsychological assessment to all patients, in a within-participants design. The study took place in one of the

rooms at the “Carlo Besta” Institute, with the patient either sitting down at a table (for postoperative cases) or on their hospital bed (for preoperative cases). The environment was set up to ensure maximal privacy and quietness during the session. The two tests were administered one after the other, generally around halfway through the full neuropsychological battery, strictly following the procedures indicated in the reference studies (Papagno et al., 2020; Vestito et al., 2023). In our study, the ANT was administered first and the BNT second. For both naming tests, patients were first briefly instructed on the requirements of the task and, in the case of the ANT, walked through the three example stimuli. After this, they completed the full battery, including both naming tests, without breaks throughout. The assessment took place as the experimenter moved from one stimulus to the next by flipping the pages of the binders containing the line drawings, keeping the presentation order stable across all participants. All responses were noted down on two dedicated correction sheets created *ad hoc* and printed on A4 paper, all while indicating the presence of possible semantic and phonemic cues. All of the correct responses that did not follow a phonemic cue scored one point, contributing to a score out of 50 (for the ANT) and out of 15 (for the BNT) respectively. In the case of the 15-item BNT, its scores were extracted from the longer, original 60-item version of the BNT (Kaplan et al., 1983) for almost all patients, a measure the Institute requires all of its epilepsy patients to take. This was possible thanks to the 15-item BNT only including items present in the longer version as well. For the remaining small subset of participants, the shorter 15-item BNT was directly administered instead. To obtain equivalent scores (ranging from 0 to 4, following Italian neuropsychological convention), necessary scoring and corrections were conducted using the correction sheets provided in the initial studies (Papagno et al., 2020; Vestito et al., 2023). At the same time, an additional standardisation of the raw scores was conducted, using sample data (mean and standard deviation) to obtain z-scores useful for direct statistical comparisons. A final anonymised database was ultimately compiled by sourcing the neurological reports available at the time of testing, allowing for the collection of relevant clinical variables pertaining to all participants.

3.3 Results

Three separate data analyses were conducted in order to test for the hypotheses formulated at the outset of the experiment. First, dissociations in equivalent scores were examined in order to determine whether the two tests diagnose differently and/or differ in overall sensitivity. Secondly, two linear models were used in parallel to investigate the influence of clinical and demographic variables on the naming test scores. These results will be described in turn.

3.3.1 Diagnostic dissociations

A closer look at the equivalent scores obtained by participants revealed an overall agreement between the ANT and the BNT. These scores ranged from 0 to 4, with each integer categorising the patient's performance as either pathological (i.e., "0"), borderline (i.e., "1") or normal (i.e., "2", "3" or "4"). One participant (P044) was removed from this analysis due to a missing BNT score, as they experienced a seizure mid-administration. 69.8% of our cohort (37 patients) was categorised the same way in both the ANT and the BNT, with the remaining 30.2% (16 patients) showing a dissociation between tests. The term "dissociation" is used in reference to any score deviation that would result in the patient's performance to be recorded as categorically different - in terms of either normal, pathological or borderline - and does not refer to *any* equivalent score difference (e.g. a score of "3" and one of "2" - which are both normal). Only 7.5% of participants (4 patients) had strong dissociations, meaning they obtained a normal score in one test and a pathological one in the other. The majority of dissociations (12 out of 16) were weak, meaning they involved borderline scores. In this regard, a schematic visualisation of diagnostic dissociations can be consulted in Table 2.

There was also no notable difference in the overall number of patients diagnosed as pathological or borderline, as 14 patients performed at a pathological or borderline level on the ANT, and 19 on the BNT. A final analysis on diagnostic dissociations between ANT and BNT was conducted using a McNemar test, coding the equivalent scores as "impaired" (0-1) or "normal" (2-4). Despite the dissociation pattern showing that - among discordant cases - the BNT flagged impairment twice as often as the ANT (OR = 2.0), this did not reach statistical significance (McNemar's $\chi^2 = 1.07$, $p = .302$).

Table 2

Scores	Borderline (BNT)	Normal (BNT)	Pathological (BNT)	ANT total
Borderline (ANT)	3	4	1	8
Normal (ANT)	7	29	3	39
Pathological (ANT)	0	1	5	6
BNT total	10	34	9	53

Note. The table displays equivalent score categorisations for both the ANT and BNT. The dotted line connects numbers pertaining to matching diagnostic categorisation between tests, with the remaining numbers indicating mismatching diagnostic categorisations (i.e. dissociations) between tests.

3.3.2 ANT score analysis

A linear model was fitted using standardised scores as a dependent variable, a value that was in turn calculated from raw scores obtained by participants on the ANT. Raw scores ranged from 28 to 50 ($M = 43.41$, $Mdn = 44.5$, $SD = 4.89$), out of a maximum of 50. Their distribution presented a clear negative skew pattern. Standardized ANT scores ($M = 0$, $SD = 1$ by construction) instead ranged from -3.15 to 1.35, with a median equal to 0.22. Following a data-driven approach, the initial model included all the clinical and demographic variables available as fixed effects. These were: age, education years, sex, anti-seizure medication in use, age at epilepsy onset, epilepsy laterality, seizure presence, surgery status, and epilepsy location. No interactions were explored. After this initial fit, model selection followed a top-down strategy, with predictors that did not improve the model's fit being removed one at a time using the `drop1()` function in R (Chambers, 1992). This approach was chosen in order to isolate which individual differences meaningfully predicted raw test scores on the ANT while accounting for all recorded variables. Five participants were excluded due to missing data points on a single predictor. Specifically, P009 had an unknown seizure onset, P039 and

P047 had an inconclusive MRI scan making it impossible to correctly determine epilepsy location, and P027, P040 and P051 had bilateral epilepsy laterality. Once the final model was reached, a Shapiro-Wilk test revealed a non-normality of residuals, $W = 0.92, p = .002$, an observation confirmed by a visual inspection of the Q-Q plot, which indicated a deviation of normality around the edges of the graph. In order to solve this assumption violation, the three observations scoring the highest Cook's distance (P018, P031, P044) were removed from the final model. Without these three, the model passed diagnostic testing, as both the Shapiro-Wilk test ($W = 0.96, p = .057$) and studentised Breusch-Pagan test for homoscedasticity ($BP(1) = 0.76, p = .382$) came out as non-significant. Prior to the removal of these influential observations, education years emerged as a significant predictor of standardised ANT scores, $B = 0.09, SE = 0.04, p = .018$, as the model was also significant overall, $F(1,52) = 5.96, p = .018$, adjusted $R^2 = .09$. Nonetheless, after these omissions the model became non-significant, $F(1,49) = 3.57, p = .065$, adjusted $R^2 = .05$. The final output is reported in Table 3.

Table 3

Coefficients	<i>B</i>	<i>SE</i>	<i>p</i>
Intercept	-0.51	0.38	.179
Education years	0.05	0.03	.065 •

Note. The table displays the output of the final model pertaining to ANT standardised scores, after the drop1() selection process and removal of influential observations. The *B* column reports values pertaining to the unstandardised slope of each coefficient. No variable significantly predicted ANT standardised scores.

3.3.3 BNT score analysis

A second linear model was fitted employing the same criteria used in the case of the ANT, with standardised BNT scores as our dependent value. Once again, main effects of all descriptive and clinical variables were investigated following a data driven, top-down approach. On top of the five participants excluded in the previous analysis, which were not included in this one as well, an additional participant (P044) was removed due to a missing

score on the BNT, as the patient experienced a seizure during test administration. After sequential selection, the final model was significant, $F(5,44) = 6.56$, $p < .001$, adjusted $R^2 = .36$, and retained all of the main effects that explained significant variance in the BNT standardised scores. The model's output is reported in Table 4.

Table 4

Coefficients	<i>B</i>	<i>SE</i>	<i>p</i>
Intercept	-0.29	0.63	.643
Epilepsy laterality (SX)	-0.69	0.22	.003**
Surgery status (Preoperative)	0.59	0.28	.042*
Surgery status (Short f.up)	0.69	0.31	.029*
Age	-0.02	0.01	.017*
Education years	0.08	0.03	.017*

Note. The table displays the output of the final model pertaining to BNT standardised scores after the selection process. Epilepsy in the left hemisphere was associated with a reduction in BNT performance compared to epilepsy in the right hemisphere. Regarding surgery status, both preoperative and short follow up statuses (1-2 years) were connected to a higher score in the BNT compared to long follow up status (5-10 years), which was the reference variable. Any increment in education years was associated with an increase in the test's score, while any increment in general age was associated with a reduction in the test's score.

3.4 Discussion

3.4.1 *ANT vs. BNT*

While it was hypothesised that the ANT would flag patients as impaired at a higher rate than the BNT, the present findings contradict this prediction. Indeed, the two tests showed a great deal of agreement, with four out of fifty-four tested patients being flagged as unimpaired on one test and pathological on the other. Even when grouping pathological and borderline equivalent scores as one unified classification, within-patient dissociations were still rare,

with the McNemar test failing to reach statistical significance. In previous research, the bigger psycholinguistic variability (and arguably richness) of verb stimuli suggested a greater difficulty of verb stimuli in naming tasks compared to noun stimuli (de Aguiar & Rofes, 2022; Mätzig et al., 2009), yet the current experiment challenges this posit by highlighting an entirely different pattern. Crucially, despite the lack of a systematic effect, the dissociation pattern observed when organising equivalent scores into two groups qualitatively indicates that the ANT flags impairment at a lower rate than the BNT. Altogether, among discordant cases, the BNT classified twice as many patients as impaired as the ANT (10 vs. 5; OR = 2.0). This means that, in two thirds of total dissociations, patients obtained a pathological or borderline score on the BNT and a normal one on the ANT - a pattern that is in direct contrast with previous evidence (Reardon et al., 2025; Yurchenko et al., 2017), which this study failed to replicate. In interpreting the current results, it could be that the verb-specific tests used in previous studies with an epileptic sample were notably more difficult, or were influenced by relevant external variables. For example, Reardon and colleagues' (2025) study administered the verb naming test as part of the CAT, a much longer assessment focusing *solely on language functions*, a setting that might have caused a greater impact of fatigue effects. At the same time, the greater amount of dissociations including a low equivalent score on the BNT (obtained by a majority of left lateralised patients) could be due to the heightened sensitivity of noun-based naming tests on left hemisphere epileptic foci (e.g. Busch et al., 2009; Tranel et al., 2005; Yurchenko et al., 2017). It follows that, rather than reflecting a generally greater ANT sensitivity to impairment, these qualitative patterns raise the possibility of a left-lateralisation bias in the BNT. In this light, the lack of large ANT vs. BNT dissociations could be due to the fact that, while noun naming catches impairments exceptionally well with left lateralised patients, action naming might not have the same tendency - a speculative hypothesis that is supported by the present linear model analyses, which will be discussed in turn. Nonetheless, this null result warrants further explorations with a larger sample of epileptic patients looking specifically at this issue of laterality (and its interaction with lobe-location) between action and noun naming, using standardised tests.

3.4.2 ANT: clinical and demographic variables

From the data-driven exploration of clinical and demographic variables' influence on ANT scores, no main effect of any variable was highlighted - as the general model was also nonsignificant. Among investigated factors, only education years approached a significant

effect as a predictor of higher ANT scores, an eventuality that would have been in accordance with an overwhelming amount of literature on cognitive testing altogether (e.g., Le Carret et al., 2003; Rehnberg et al., 2024). In this regard, an effect of education years for the ANT might be weak in this sample alone rather than confidently null, especially considering the meaningful number of observations that were excluded from the model. Part of this null result contributes to the discussion of the different lateralisation of the relevant areas needed for noun and verb naming raised in 4.1. Importantly, the fact that epileptic laterality did not predict ANT scores is consistent with previous evidence on the topic (Reardon et al., 2025; Yurchenko et al., 2017), further suggesting how verb naming might be equally challenging for both left and right lateralised epilepsy patients. Despite this, the null result concerning the role of epilepsy location (either in the temporal lobe, mesial temporal lobe, or extratemporal) is, instead, at odds with the initial hypothesis, which predicted a lower performance for TLE patients. While this nonsignificance could be due to an overreliance on MRI data to determine the location of epileptic foci (which could have underestimated the extent of circuitry damage), it is still consistent with theories of verb-processing indicating a wide brain network involving multiple lobes and both hemispheres, in accordance with conclusions from Crepaldi and colleagues (2013). Furthermore, the null result concerning epilepsy onset is also coherent with evidence from Yurchenko et al. (2017), whose correlation analysis also failed to find a significant connection between age at onset and verb naming scores (albeit an approaching significance was recorded). In this sense it might be that earlier age at onset, usually associated with higher scores for noun naming (Condret-Santi et al., 2014; Yucus & Tranel, 2007), may offer less protective value for verb naming, making it harder to detect. Finally, the null effect of ASM in use is also consistent with previous evidence, which only points to specific medications - such as topiramate - having detrimental side effects on verbal tasks in a portion of the population (Mula et al., 2003).

3.4.3 BNT: clinical and demographic variables

Unlike for the ANT, a number of relevant factors significantly predicted BNT scores, as the overall model was significant. Notably, left-hemisphere lateralisation was connected to reliably lower scores, representing the biggest effect of the entire analysis ($p = .003$). This result is entirely in accordance with previous studies, contributing to strengthen the idea that noun-naming is disproportionately impaired in patients with left hemisphere epileptic foci (see also, Loring et al., 2008). Moreover, both preoperative and short follow up statuses were

associated with higher BNT scores. This means that patients either that had not undergone epilepsy surgery, or at their 1-2 year check-up appointment, performed significantly better than patients at a 5-10 year follow up session. While this evidence is cross-sectional, making it more difficult to draw meaningful conclusions about the longitudinal trend of noun-naming abilities, it also represents a rare measurement of naming at a very-late stage post epilepsy surgery. Indeed, other studies analysing naming before and after surgery generally do so by testing up to a year post surgery (Ives-Deliperi & Butler, 2012), and very rarely up to two years (e.g. Walther et al., 2025). In these cases, naming abilities have been documented to decline postoperatively, especially when relevant language areas such as the anterior temporal lobe are resected (Langfitt & Rausch, 1996), with deficits getting substantially better over time (Walther et al., 2025). The current pattern adds to previous research by suggesting that naming deficits might be at its worst many years post surgery, a long time after the initial recovery of naming ability. The present study, though, only tested different patients at different times, and it is important to note that longer follow ups generally mean an older cohort as well, meaning age could be a confounding factor. On this remark, only a more thorough longitudinal analysis - including very late follow ups - can provide conclusive observations useful to investigate this possibility. Adding to this, effects of age and education years were also found, both in accordance with current literature, given the widely known influence two variables have on cognitive performance (Ardila et al., 2000). In fact, higher age was naturally associated with lower scores, while more time spent in education correlated with higher scores. Finally, no effects of seizure presence were found for both the BNT and the ANT, a result that maps onto current literature on the topic. Indeed, seizure frequency has been found to be a meaningful factor in the disruption of fMRI activations of left TLE patients during picture naming, contributing to an overall disturbance of the language network, yet this variable did not predict actual clinical scores (Trimmel et al., 2021). Nonetheless, it is also possible that measuring seizure presence is not enough to detect an effect on naming abilities due to its inherently reduced informational value when it comes to overall, lifelong seizure burden. Indeed, a measure like seizure frequency (and its interaction with epilepsy duration) could more meaningfully predict the psychometric scores in question, offering a better measure of seizure disruption over the whole course of a patient's life with the disorder. Such a question is worth investigating longitudinally, using targeted naming tests employing a rich variety of psycholinguistic properties among the chosen stimuli.

3.4.4 General implications

In summary, the predictions made in the present study's hypothesis were only partially supported by the experimental observation. Contrary to expectations at the outset of this research, the ANT and BNT largely agree in their scoring within participants and, when they do disagree, it is the BNT that flags impairment more often, unlike evidenced in previous papers (Reardon et al., 2025). Another outcome that contrasted with the predictions was the lack of an effect of epilepsy location on test scores. Indeed, lesion-mapping evidence points to temporal areas as crucial in supporting naming function, especially when located in the left hemisphere (Mhanna et al., 2025). In light of this, the current lack of a significant effect could be explained by the possibility that laterality eclipses epilepsy location in driving the predictive effect on test scores. In fact, for the BNT, the meaningful effect of laterality could have had more power than the investigation on epilepsy location, which compared both TLE and mesial TLE separately against the extratemporal portion of the sample. Finally, one of the predictions was confirmed: left lateralised patients did perform worse on the BNT compared to right lateralised patients, and the same pattern was not evidenced in the ANT.

The present investigation, albeit in a limited manner, also speaks to wider theoretical discussions about noun and verb dissociations in the brain. The pattern that has surfaced from testing does not warrant either definite support or confutation to theories advocating for a shared network between noun and verb naming (e.g. Crepaldi et al., 2013), though it remains consistent with those claims, as no evident effect of epilepsy location (within a given hemisphere) emerged. In the same way, while no strong conclusions can be drawn, the lack of a differential effect of epilepsy locality for nouns and verbs does not suggest a stark separation of two word-class networks, like the FTDH suggests, instead backing theories positing a vastly distributed language organisation in the brain (Barba et al., 2026). In this sense, the current results would be hard to contextualise in the narrow framework of the FTDH, placing this study among the many that have previously failed to replicate the original effect obtained by Damasio and Tranel (1993; Crepaldi et al., 2011). Nonetheless, the evidenced effect of laterality is compatible with theories of noun-verb distinction arguing that the two word classes exist on a continuum of psycholinguistic variables which in turn cause behavioural dissociations. Crucially, the fact that left-lateralised patients only performed worse on the BNT, with no clear effect of location, is consistent with the idea that the

psycholinguistic variables (such as arguments or imageability) most commonly pertaining to verbs occupy are driving the lack of laterality effect in epilepsy (de Aguiar & Rofes, 2022). In other words, a possible account could see the two word classes maintaining a shared network, as the set of stimuli present in the BNT cluster around a highly left lateralised representational area, explaining the effect. This suggested structure has pivotal clinical implications regarding neuropsychological testing in epilepsy.

The present study had set itself out to investigate whether the widespread employment of the BNT (Puntambekar et al., 2025) could have benefited from a supplement or replacement of the test in the form of a validated naming test: the current results provide concrete guidance toward this objective. Plainly, the collected data suggests two possible courses of action depending on the primary clinical goal of naming ability testing in epilepsy. If the objective of including a naming test in a wider battery is to help with the localisation of an epileptic focus, the administration of the BNT alone is a more reasonable choice. No clear effect of any clinical variable was found in administering the ANT, given that the left-lateralisation of noun-naming tests like the BNT (e.g. Yurchenko et al., 2017) can offer helpful insights into the possible epileptic focus of the tested patient. By way of explanation, a pathological score on the BNT is likely to be driven by a left-lateralised focus, while - according to this experiment - the ANT cannot provide as much information about it. Otherwise, if the objective of testing is to flag naming impairment in the most systematic way, the addition of an action naming test on top of regular BNT administration could provide real advantages. In fact, while the presented data did not conclusively highlight a clear difference in the diagnostic outcomes of the two tests, it is still important to note that almost a third of participants were categorised differently by the resulting equivalent scores. On top of this, the ANT neutrality to epilepsy laterality makes it an advantageous supplement to standard testing. On the one hand, adding a test of this type would not cause a substantial extension of the total battery's duration, given how quickly it is administered. On the other hand, a more thorough analysis of confrontation naming would be ensured, thanks to the employment of diverse stimuli and the overcoming of any possible left-lateralisation bias.

Future research should build on these issues, employing tests of comparable length in longitudinal designs while controlling for relevant psycholinguistic variables (e.g. imageability, concreteness and arguments). If verbs and nouns lie on a continuum (de Aguiar & Rofes, 2022), then it is imperative to outline the set of grammatical information that is

most impacted by different syndrome etiologies in epilepsy, possibly causing category specific impairments. Acquiring this knowledge would allow for the construction of a new quick, unified, and standardised test with enough psycholinguistic richness to both flag naming deficits more accurately and provide insight useful for the individuation of epileptic foci.

3.4.5 Limitations

The main limitation of this study is the wide length difference between the ANT (50 items) and the BNT (15 items). While it is true that raw scores were not directly compared across tests, the two statistical models that were run in parallel still suffer the constraints of length difference. A single wrong answer in the short BNT is much more impactful on the overall score of the test, with the ANT including a bigger variety of stimuli as well. In this sense, the results should be interpreted accordingly. Moreover, the different administration modalities make any general action vs. noun naming generalisability more complicated. In fact, while the two tests specifically test either “action” or “noun” stimuli, the ANT only offers a 3 second time window to respond, in the absence of any semantic cue or possibility of self repair. This is unlike the BNT, which offers up to 40 seconds to respond, allowing for semantic cues and no limit for wrong responses preceding the correct one. It follows that, while addressing separable constructs, analysing these two tests in tandem also means that the evidenced effects could depend on the administration procedures required, which are substantially different. This especially true when considering the fact that most patients underwent the full 60-item administration of the BNT, with 15-item scores only being extracted later, adding to measurement inconsistency. Another limitation is the lack of fMRI recordings ensuring that all patients of our cohort (or at the very least within the two TLE groups) had a left-lateralised language dominance. Indeed, this information can only be reasonably assumed, with very little fMRI data available at the time of testing. In this regard, the laterality effects found need careful interpretation, as patients’ handedness was also not included as an eligibility factor for the study. Additionally, the ANT models’ null effect should also be interpreted with caution, as the main effect of education years on the test’s scores was significant prior to exclusions of influential observations - which was imperative to comply with relevant test assumptions. Finally, the last limitation to address lies in the forced methodological choice that was made at the time of analysis, as low sample size did not allow for the statistical models to include interaction effects between the selected

variables. It is likely that many variables could have had an interaction effect (e.g. epilepsy location and epilepsy laterality), though these were not investigated in order not to overwhelm the model, which had a low sample count.

3.5 Conclusion

The current study is the first investigation of the ANT (Papagno et al., 2020) in an epilepsy population, representing one of the few experimental studies of noun vs. verb naming with an epileptic cohort in Italy. Building on previous evidence, the purpose of the study was to explore whether the ANT could provide meaningfully different information than the widely adopted BNT, as both demographic and clinical variables were assessed. This was especially important considering the widespread criticism the BNT has received, as different naming assessment tools might better fit PWE by providing more reliable diagnostic classifications or by applying to a wider range of epileptic etiologies. Three hypotheses were put forward: that the ANT would diagnose at a greater rate than the BNT, that the BNT would assign lower scores to left-lateralised patients (with no such effect in the ANT), and that temporal epileptic foci would correlate with lower scores on both tests. This investigation only partially supported these hypotheses. Indeed, no difference was found in within-participant diagnostic classifications between the two tests, as equivalent scores were mostly in accordance with each other. At the same time, no clinical or demographic variables were explicitly connected to ANT performance, while BNT scores were predicted by epilepsy laterality, surgery status, age and education years. In this regard, no test score was predicted with epilepsy location, contradicting the hypothesis concerning temporal epileptic foci. Among the BNT predictors, though, left lateralisation did significantly correlate with lower scores. Taken together, these findings suggest that the clinical value of the ANT may not necessarily lie in replacing conventional noun-naming measures, as the test does not straightforwardly outperform the BNT. Instead, action naming may be more appropriately considered as a complementary assessment contributing to a wider variety of test stimuli that allow for a more thorough assessment of different psycholinguistic variables. From this, future research should focus on long-term longitudinal explorations of noun vs. action naming in epilepsy. In these, the focus should precisely be on psycholinguistic variables such as verb arguments, imageability and concreteness. In fact, these might act as better predictors of word class dissociations in naming that could identify specific circuits responsible for selective impairments.

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