Experimental psycholinguistics as an approach to the study of lexical creation[1]

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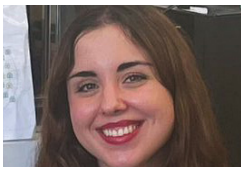

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Abstract

This paper presents an innovative experimental psycholinguistic methodology for the exploration of neology and lexical creation, which may prove crucial for characterising neology in both general and specialised language domains. Utilising lexical decision tasks alongside electroencephalography and eye tracking, we grasp the cognitive processes involved in real-time word formation and in the dynamic interplay between linguistic creativity, lexical access, and visual attention, offering valuable insights into the mechanisms underlying the formation of new lexical units.

KEYWORDS: *terminology, neology, lexical creation, lexical decision, ERP, eyetracking*

Resum

Psicolingüística experimental com a enfocament per a l'estudi de la creació lèxica

Aquest article presenta una metodologia psicolingüística experimental innovadora per explorar la neologia i la creació lèxica, crucial per caracteritzar la neologia tant en dominis de llenguatge generals com especialitzats. Utilitzant tasques de presa de decisions lèxiques juntament amb electroencefalografia i seguiment ocular, capturem els processos cognitius implicats en la formació de paraules en temps real i en la interacció dinàmica entre la creativitat lingüística, l'accés lèxic i l'atenció visual, i oferim valuosos coneixements sobre els mecanismes subjacents a la formació de noves unitats lèxiques.

PARAULES CLAU: *terminologia, neologia, creació lèxica, decisió lèxica, ERP, seguiment ocular*

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1 Introduction

Research into the processing of neological uses is one of the essential pillars for the characterisation of both *neology* in a broad sense and *neonymy* or *terminological neology* (Rondeau, 1984) originating in specialised fields of communication (with variable diffusion in the field of general language). In this framework, among the tools offered by psycholinguistics for its approach, lexical decision tasks stand out for their significant achievements in the interpretation of language comprehension processes. In addition, new methods have been incorporated which offer a detailed sequential picture of word processing in natural contexts. Thus, on the one hand, EEG applied to the analysis of event-related evoked potentials (ERPs), due to its high temporal resolution, provides us with an optimal sequential description of the brain response generated by the feeling of neologicity. On the other hand, eye tracking, which analyses fixation and regressions during the reading of utterances, allows us to delineate specific patterns in the processing of linguistic information, which is very useful for establishing precise distinctions between modalities and assessing the impact of the various factors that affect these processes. In this paper we are concerned with the possible contributions of these three resources.

2 Lexical decision as a means of approaching neological usages

Lexical decision tasks (LDT) represent a key tool in the framework of experimental psycholinguistics, with an important trajectory as regards the number of studies relating to lexical processing which are based on LDT and, particularly, the many studies relating to the organisational aspects of semantic memory. Indeed, the measurement of recognition times is an essential resource for expanding not only our knowledge about the processes of access to lexical and sublexical information and the performance of the procedural mechanisms involved in the interaction between these elements during linguistic processing, but also about the associative configuration of these elements in the form of dynamic networks that are strengthened through repeated activation.

In any case, the approach to lexical decision from the angle of production (or the perspective of the speaker) is outside the scope of these studies. The fact of communicating something requires the individual to make a conceptual decision and to choose, among other possibilities, the semantic contents required to express the intended meaning (semasiological process) and then to project them onto certain formal structures (onomasiological process). In contrast to other research focusing on language comprehension, the in-depth study of lexical production and the use of experimental methods is hampered by the limitation of observations to the last stage of a sequential process and by the inaccessibility of earlier stages, as well as by the difficulty of controlling the input and the variables influencing experiments. We are consequently dealing with a tool that provides us with only partial information from the perspective of the receiver,[2] in which – although the onomasiological approach seems to prevail since we are talking about the recognition of lexical forms – the semasiological perspective is present, as is demonstrated precisely by the effects of semantic facilitation reported ever since the first studies based on this resource.

Assuming that during the process of linguistic comprehension the structure and form of the lexical representation guide and constrain semantic interpretation (Marslen-Wilson, 1992, p. 359), the approach to lexical creation through LDT provides a suitable opportunity to analyse the impact and experimental effects of these uses both in the field of general and specialised communication and to evaluate aspects such as transparency, fixation, appellative force, and communicative efficacy. Consequently, the data derived from this type of approach are extremely useful to determine the preferred trends in different communicative environments.

With regard to its beginnings, although studies based on this type of task had already been conducted in the 1960s, the introduction of the term "lexical decision task" and the acknowledgement of its relevance for studies on lexical recognition and semantic memory are due to the work of authors David E. Meyer and Roger W. Schvaneveldt, who demonstrated for the first time that the reading of a word facilitates the recognition of another with which it has a semantic relationship. Their research therefore contributed to clarifying the organisation of long-term memory and the retrieval of information from it (*cf.* Meyer and Schvaneveldt, 1971; Schvaneveldt and Meyer, 1973).

The advantage of this task compared to others, such as categorisation, matching, naming, repetition, or discrimination, lies in its great versatility, as it can be adapted to visual or auditory inputs and allows the introduction of different variables to measure experimental effects, which are also observable through more recent techniques such as EEG and eye tracking (see sections 3, 4 and 5). On the other hand, although it is mostly associated with on-line study techniques, which reveal exact temporal latency data from which to extract cognitive information based on responses that can be adapted to the "yes/no" or "go/no go" paradigms (Gordon and Caramazza, 1982; Gordon, 1983; Perea, Rosa and Gómez, 2002), its utilisation as an off-line resource provides valuable information that refines and even improves the results of purely temporal analyses, which are of great interest in the case of lexical creation to explore in more detail the feeling

of neologicity and the degree of integration of these usages into the general language or specialised communication.

In this task, in which, as is well known, the subject is asked to make a decision on a verbal stimulus in order to measure the response latency time, the introduction of pseudowords, as opposed to words and nonwords, is of interest. This category includes those whose phonological/orthographic structure is similar to that of a real word, i.e., those that correctly respect the phonotactics of the language, as well as those creations whose morphological structure is systemically permitted but not recorded in the linguistic norm. In relation to this, any form should also be considered functionally a pseudoword if it is not previously known to the subject. It can therefore be said that a neological usage assumes this behaviour.

However, this type of task is associated with a particular conception of the lexicon as a store of knowledge about the formal and semantic aspects of words, where such aspects are represented as part of long-term memory so that they can be retrieved at any time during word processing. Regarding this frequently accepted approach in psycholinguistic research, especially resulting from the LDT approach to neology, we have to question notions such as "representation" and "access" as key elements in explanatory models of lexical processing (*cf.* Bennett and Hacker, 2006; Casasanto and Lupyan, 2015). We are confronted here with the problem of the mental representation of neological units, both formal and semantic. Indeed, according to the most relevant models of lexical processing in the psycholinguistic literature, in the case of formal neology the phonological sequence of these units does not exist as such in the lexicon, while in the case of semantic neology, although these units are phonologically present in the lexicon, they are linked to senses that do not correspond to the set of contents associated with each entry concerned. Such a singularity, compared to the common lexicon, would explain different results in LDT, considering the need to resort during linguistic processing to lexical reconstruction processes and cognitive strategies, both associative and procedural, for adequate interpretation.

Hence, despite the simplicity of its nature, the lexical decision turns out to be a fundamental resource to illustrate the performance of many cognitive processes during linguistic processing, which can be applied to the field of neology research. Experiments based on this type of task have shown that we recognise a word before the speaker has finished uttering it (Marslen-Wilson and Tyler, 1980) and since its introduction for the comparative analysis of words, nonwords and pseudowords, different experimental effects have been observed, among which frequency (*cf.* Burani and Caramazza, 1987; Colé, Beauvillain and Segui, 1989; Grainger, 1990; Meunier and Longtin, 2007), and semantic facilitation/interference (James, 1975; Koriat, 1981; Kiger and Glass, 1983; Ballota and Chumbley, 1984; McNamara and Altarriba, 1988; Neely, Keefe and Ross, 1989), along with other remarkable aspects such as phonological priming (Forster and Shen, 1996; Pollatsek, Perea and Carreiras, 2005), attention and automaticity (Den Heyer, Briand and Dannenbring, 1983), polysemy and ambiguity (Hino and Lupker, 1996; Hino, Lupker and Pexman, 2002), and age of acquisition (Morrison and Ellis, 1995), just to give a few examples.

In this regard, the analysis by means of LDT applied to the case of neology – as it functions as a special kind of pseudoword whose effects on the access process differ greatly from those manifested by the units considered as real words – was the subject of the research presented in Varo Varo (2013). Specifically, on the grounds of the results obtained by means of an off-line study based on written questionnaires, we approach the essential cognitive mechanisms involved in the processing of neological units (*cf.* Cabré, 2021) in view of their different types and of the main factors involved in the interpretation of sentences that incorporate formal or semantic neologisms, in order to assess the interaction of these factors and the degree of communicative efficiency, as well as to detect singularities in the processing of newly created units. This practical approach allowed us to verify a series of effects which contribute to the characterisation of this phenomenon from a psycholinguistic perspective. The first of these effects is frequency, which, as we have found, in addition to affecting the word as a whole, also concerns the constituents in an unequal manner. Secondarily, we highlight the effects of semantic facilitation, the superiority of the word, the similarity with other words and, above all, the contextual availability or ease with which a subject can imagine a specific circumstance in which the word to be recognised could occur.

As an example of an on-line approach, Varo Varo (2019) analysed the cognitive strategies that affect the processing of neological uses in various contexts and the differences between formal neology and semantic neology through an experimental approach based on the recording of lexical decision times (using the software-prime 3.0 of Psychology Software Tools). For this purpose, a set of contextualised neological uses were taken as a reference, representing the main manifestations of both types. The results of this study have not only enabled us to verify the implications of the different cognitive strategies that affect the way in which we process language, but also helped us to draw a general temporal map of the processes of reconstruction of the semantic and formal structure of the word of these forms. Furthermore, the data obtained add to the strategy of contextual enrichment, already pointed out by previous studies on the functioning of pseudowords and metaphors, an effective strategy of syntagmatic embedding. Lastly, the role of facilitation in lexical and sublexical frames is illustrated here, along with

some evidence supporting the existence of semantic and morphological parser cooperation.

In summary, the experimental approach through LDT to the essential cognitive mechanisms involved in lexical processing offers a suggestive opportunity to assess neological uses from the perspective of their impact on the receiver, due to the important connection of the temporal data (interpreted in terms of cognitive effort) and the answers provided in this type of task with aspects such as the different degrees of familiarity and transparency that determine their greater or lesser complexity and fixation in the language. Recent research on word recognition times points to a rather complex network organisation model, which incorporates not only semantic, phonic, and morphological connections, but also extralinguistic relations or relations based on the individual's experience. In this respect, we consider it necessary to combine online approaches, which provide objective information, with off-line studies, which allow us to delve into the associative and procedural processes that lead to the successful processing of novel linguistic uses.

3 Exploring neologisms through event related potentials analysis

Methods from the domain of neuroscience have been integrated into the sphere of experimental linguistics, offering a valuable avenue for investigating neural activity associated with language-related functions. Employing scalp-attached electrodes of minimal size, electroencephalography (EEG) records neuronal activities on the brain's surface. This approach provides a precise temporal depiction of neuronal events linked to specific linguistic processes.

EEG proves particularly advantageous in linguistic research due to its non-invasive nature and its capacity to capture participant responses across both active and passive tasks. This adaptability accommodates research involving a diverse spectrum of individuals, ranging from typical participants to those with various conditions such as aphasia, individuals spanning various age groups, and individuals with motor impairments, mutism, or reading and writing challenges. This technique enables the measurement of brainwave patterns originating from cortical activity using harmless electrodes assessing various brainwave frequencies. Among other facets, these frequencies are associated with the exploration of language.

To harness the rich linguistic insights offered by EEG, a profound understanding of the central role played by event-related potentials (ERPs) is imperative. ERPs manifest as discernible waves of cerebral activity, either negative or positive, in response to an array of visual, auditory, or tactile stimuli (Luck and Kappenman, 2011). Notably, within the linguistic domain, the most extensively scrutinised ERPs (Beres, 2017) encompass the N400, intricately connected with semantic integration and awaiting exploration in greater depth subsequently; the P600, which, alongside LAN (left anterior negativity) and ELAN (early left anterior negativity), manifests in response to syntactic incongruities; and MMN (mismatch negativity), elicited by auditory stimuli that deviate from previously encountered ones.

The N400 ERP is closely entwined with the realm of semantic processing and often signifies an anomaly in cognitive processing. Its nomenclature is derived from its inherent characteristics, specifically denoting a negative (N) waveform that attains peak amplitude within the timeframe of 380 to 400 milliseconds following the presentation of a stimulus. Since its initial discovery by Kutas and Hillyard in 1980, the field of neuroscience has made substantial strides in elucidating the nature of the N400. Presently, it is well established that the majority of words evoke an N400 response (Kutas, 1997), thus rendering it a reliable indicator of semantic processing. Of particular interest in the realm of N400 research is its remarkable sensitivity to the semantic relationships between words, encompassing both individual word-to-word associations and the contextual integration of words within a sentence and discourse framework. This sensitivity is encapsulated by the following axiom: "the better the semantic congruence between a word and its contextual environment, the more attenuated the amplitude of the N400" (Hagoort, Brown and Osterhout, 1999, p. 280).

The application of this technique holds significant promise in the domain of neology research, particularly in cases involving neonymy and terminology. Neonymy is characterised by low usage frequency, which affects its comprehension due to the fundamental role of memory in language processing. Frequency, in this context, refers to an individual's historical encounters with a specific word (typically estimated from normative frequency counts), and this factor has been the focal point of active research lines, some of which prioritise memory and attention related investigations (*cf.* Besson, Kutas and Van Petten, 1992; Mitchell, Andrews and Ward, 1993; Van Petten *et al.*, 1991) over language processing per se. Speakers rely upon the reservoir of knowledge stored in their memory for the dual purpose of encoding their intended discourse and deciphering the auditory input they receive. It is readily apparent that the cognitive load associated with processing a familiar and commonly employed word is notably diminished. This reduction in cognitive effort stems from the automaticity of decoding such terms, a swifter and more streamlined process owing to their firmly entrenched status within the linguistic repertoire (Schmid, 2007).

The comprehension of a neologism inherently involves a progression through three distinct phases: firstly, an initial stage of recognition is observed, characterised by the emergence of a novelty sensation

triggered when juxtaposing the neologism with stored memory units. Subsequently, in a second stage, the neologism serves as a discursive anchor, facilitating the activation of linguistic elements residing within the memory reservoir. This activation engages linguistic categories employed for the purpose of organising the external realm, and various other cognitive resources are harnessed to attribute meaning to this novel linguistic form. Lastly, during the final phase, recourse is made to shared memory to assess the extent and frequency of usage within the user's speech community. This phase serves the vital function of determining whether the neologism exclusively pertains to the recipient or encompasses all members of the linguistic community to which the user belongs (Lavale-Ortiz, 2019). The phenomenon of neology effectively illustrates the adaptability inherent in lexical innovation processes since individuals do not engage with pre-existing linguistic units during the process of language comprehension (*cf.* Varo, 2013, 2019, 2020). As a neurocognitive underpinning for both formal and semantic creativity, which manifest in our daily communicative interactions through the interplay of cognitive faculties and language, we would like to underscore, primarily, the concept of dynamic focalisation. This concept bears significant relevance due to its implications in the construction and interpretation of discursive meaning, serving as a foundational component of pragmatic enrichment. It is noteworthy that, while it may initially arise unconsciously or automatically, as mediated by neural alert circuits, once the novel element has been identified and, consequently, sensory and information processing resources have been set into motion (as governed by neural orientation circuits), it ultimately evolves into a conscious or controlled process intricately linked to our executive cognitive capacities, as governed by neural networks associated with executive attention (Varo, 2020).

These techniques may allow us to theorise about the differences between semantic and formal neology. Regarding semantic neology, both frequency and repetition influence multiple components of the ERP, some of which are affected by both factors. Probably the most useful ERP component for this matter is N400. High-frequency words tend to elicit smaller N400s than low-frequency words. The frequency effect on N400 amplitude is, however, qualified by interactions with both repetition and semantic constraint (Besson, Kutas and Van Petten, 1992; Rugg, 1990; Halgren and Smith, 1987). In other words, low-frequency words show a disproportionate repetition effect so that N400 amplitude is equalised by repetition. Sentence and text processing experiments show that semantic context is also capable of wiping out the N400 frequency effect. The N400 effects are thus well characterised and orderly: we have seen that amplitude is influenced by frequency, repetition, and semantic constraints, and all three factors interact as if operating through a common mechanism (*cf.* Kotz, Holcomb and Kounios, 1992). There are other ERP components that hold significant potential in the study of neology and terminology, such as LPC (late positive component). In word lists, this LPC is larger for the second than for the first presentation of a word, and further is specific to low- rather than high-frequency words (Rugg, 1990; Rugg and Doyle, 1992; Young and Rugg, 1992). Nevertheless, in cases where we have contrasted the initial presentation of words with their subsequent appearances within connected discourse, we have noted that late positivity tends to diminish rather than intensify with repetition (Van Petten *et al.*, 1991).

However, concerning formal neology and terminology, according to Lavale-Ortiz (2019) if the creation of new words is based on elements that are well entrenched within our cognitive memory, it results in a streamlined process for decoding these fresh lexical additions and their seamless assimilation into our mental lexicon. Consequently, when neologisms are crafted by building upon an established lexeme, such as the creation of a verb from an adjective already embedded in our cognitive memory, it expedites the activation of the new term's meaning, surpassing the temporal constraints encountered when constructing neologisms from lexemes lacking substantial cognitive resonance. The use of this high temporal resolution technique is very promising for the study of neology. With this type of methods, it is possible to make approaches to determine the level of neologicity of a neologism or the degree of technicality of a term.

4 Eye tracking as a method for studying neological uses

Over the past few years, research in the field of linguistics has been considerably expanded and enriched through the integration of technologies that record eye movements and report data on visual behaviour with regard to lexical-semantic processing. Eye tracking, as an experimental method in applied linguistics and language research, contributes to the assessment of attentional and cognitive processes, word perception and recognition, as well as morphological, semantic, syntactic and pragmatic mechanisms of different linguistic units. Additionally, it contributes significantly to the investigation of language acquisition, development and associated disorders. This perspective on analysing cognitive processes remarkably enhances the findings derived from EEG techniques.

The high-speed capture of visual data and detailed measurement of eye movements triggered by stimuli with text displayed on screen has shed considerable light on how language processing unfolds during reading in real time (*cf.* Rayner, 1998; Clifton, Staub and Rayner, 2007; Siyanova-Chanturia and Elgort, 2023). Therefore, such measures as fixation duration

and position offer researchers crucial insight into how lexical units are recognised and integrated in the span of text comprehension, yielding values that are intricately linked to parsing and semantic analysis (Clifton, Staub and Rayner, 2007).

It is important to note that eye tracking techniques have significant advantages over traditional measures of offline linguistic processing (Meyer and Schvaneveldt, 1971; Carpenter and Just, 1975). Mainly, the reason is that it enables processing of cognitive responses to visual stimuli with text in real time and in contexts that resemble the conditions of a natural environment (Tatler, Hansen and Pelz, 2019; Harston and Faisal, 2022), providing more accurate and reliable data on eye movements within the paradigm of the visual world (Tanenhaus *et al.*, 1995; Dahan and Tanenhaus, 2005; Huettig, Rommers and Meyer, 2011).

In this way, the approach to linguistic processing opens new paths towards the characterisation of mental mechanisms that underpin the processes of neological creation (Díaz Hormigo and Varo Varo, 2012; Varo Varo, 2013), temporal sequencing and processing time of neologisms formed through composition and derivation (Varo Varo, 2022), and response time in the TDL in order to distinguish between formal and semantic neology (Varo Varo, 2019), as well as strategies used in the translation of neologisms (Chen, 2021), the effects of scientific terminology comprehension on cognitive process (Yun, 2021), and the neological nature of lexical units bounded by morphological, semantic and pragmatic aspects (Llopart Saumell *et al.*, 2014), among other empirical contributions.

However, despite the fact that eye tracking is nowadays widely used in research for different purposes, it is still necessary to continue collecting data on neologism processing and the feeling of neologicity (Vega Moreno and Llopart Saumell, 2017; Díaz Hormigo, 2020; Varo Varo, 2021), as seen from a neurocognitive perspective, in order to delve deeper into the temporal and attentional analysis of lexical creation and the influence of syntactic, semantic and pragmatic factors on the linguistic processing of new words (Penas Ibáñez *et al.*, 2023, pp. 74-75).

Making a more in-depth examination of eye tracking, this biometric tool detects and measures eye behaviour, including fixations, saccades (*cf.* Rayner, 1998) and microsaccades, as well as backward movements known as regressions, along with pupil dilation. It is worth noting that, in the context of neologism processing,[3] the primary focus of analysis lies on fixations and saccadic movements.

In a recent study investigating the impact of background information accessibility and awareness of extra-linguistic context on the cognitive effort required for translating neologisms from Chinese to English, Chen *et al.* (2021, pp. 315-321) conducted an experiment using three texts as stimuli. Each text featured approximately 5-7 neologisms, selected based on various criteria, including whether they constituted newly coined lexical units or existing units with a newly acquired meaning. Various metrics assessing cognitive processing effort, such as gaze tracking on both source and target texts, as well as keystroke measures, were analysed, alongside with a retrospective interview and an evaluation of translation quality. The results revealed that compensating for a lack of familiarity with the underlying cultural context resulted in augmented effort in translating Chinese neologisms, as evidenced by objective measures. This compensation elicited a greater endeavour from beginner learners compared to those who were advanced or professional. Interestingly, the facilitation effect exhibited variability when translating non-Chinese neologism units: knowledge of context notably aided novice translators in reducing their cognitive effort to a greater extent than observed in the other two groups (Chen *et al.*, 2021, pp. 333-335).

In the realm of lexical-semantic analysis, a crucial step involves the delimitation of areas of interest (AOI) within the recorded timelines of different participants. These designated areas serve as focal points for extracting filtered data, enabling more in-depth analysis and insights. In the Tobii Pro Lab software, there is an option to manually draw or select an area required for metric analysis, encompassing either a word, a part of a word, a compound unit, a collocation or an utterance. Additionally, the programme provides the option for automatic areas of interest, which are segmented by letters, words or sentences. Likewise, the option to categorise areas of interest by tags is available. This categorisation streamlines the extraction of data based on variables defined by the tags. It also facilitates further distinctive analysis, allowing for the visualisation of processing patterns.

The other additional parameters that provide information about the specificity of processing along the timeline are events and times of interest (TOI) (Tobii AB, 2022). Events are markers that are linked to an important action or occurrence that takes place within the timeline of an eye tracking record, which are determined by the researcher according to the research criteria. In the case of an experiment with neologisms, events can be created for a line of the text, defined by the margins of the stimulus, in which a neologism is inserted. Consequently, the event "start point" can be called "enter or observe line with neologism", which means that eye gaze enters this line, while the event "end point" can be called "leave line with neologism", which describes the exit from the textual line. In this process, each event is assigned its shortcut, which is then placed at the recording time of a participant, setting an interval of a custom time of interest (TOI). As such, custom TOIs allow segmenting different actions and grouping periods in the recording of different participants (Tobii AB, 2022).

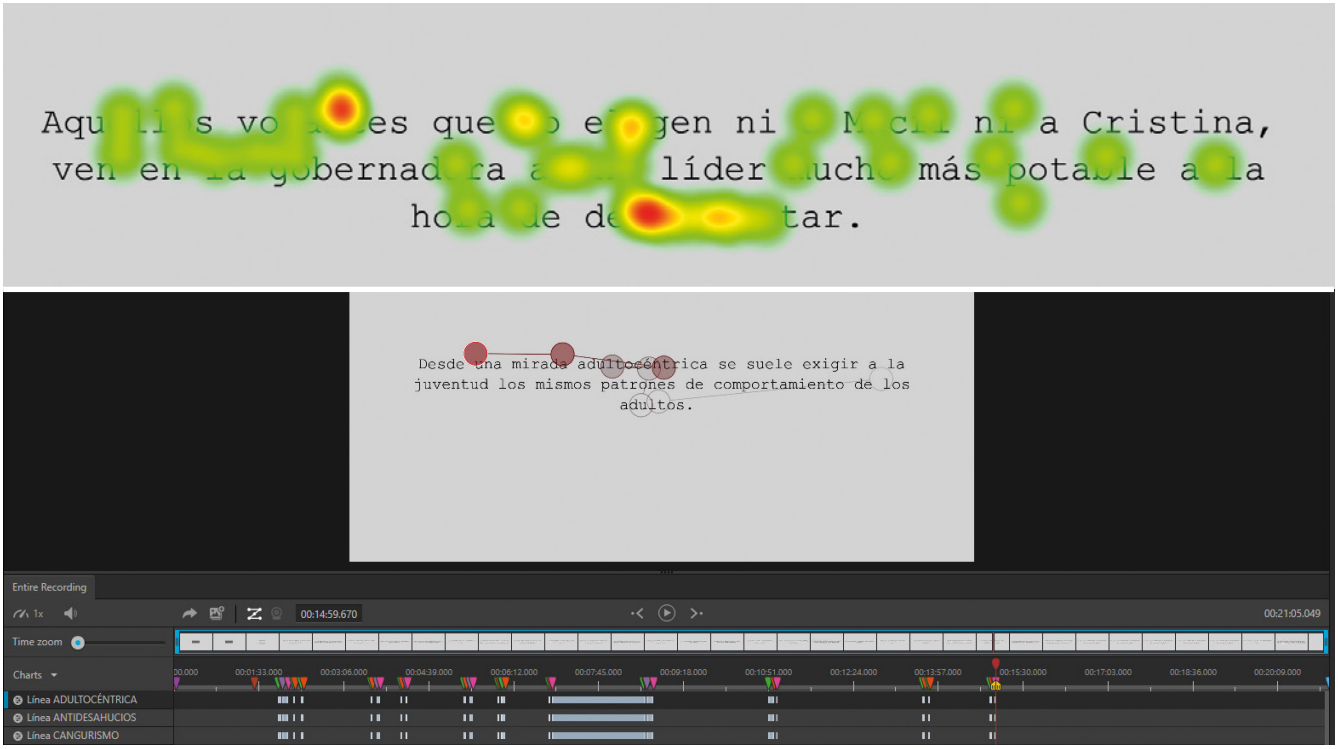


FIGURE 1. Samples of an ongoing research at ILA: a) Heat map for "Aquellos votantes que no eligen ni a Macri ni a Cristina ven en la gobernadora aquella líder mucho más potable a la hora de desengrietar" (The voters who do not choose either Macri or Cristina see the latter political figure as a much more palatable leader when it comes to the unification of opinions). b) Gaze plot for "Desde una mirada adultocéntica se suele exigir a la juventud los mismos patrones de comportamiento de los adultos" (From an adult-centred standpoint, young people are usually expected to show the same patterns of behaviour as adults)

The data output provides visual and numerical metrics of all recorded measures which are subsequently calculated by the software.

Thus, to analyse the processing of lexical items, a set of time, position and distance metrics is generally selected. The value of these metrics depends on contextual constraints as well as lexical-semantic, syntactic and pragmatic factors (*cf.* Clifton, Staub and Rayner, 2007; Huettig, Rommers and Meyer, 2011). Among the various, albeit interrelated, measures (Clifton, Staub and Rayner, 2007) which serve as dependent variables, the following metrics are commonly extracted and analysed: *first-fixation duration* (duration of the first fixation on a word), *first-gaze duration* (sum of all fixations before the participant moves the gaze forward or back), *right-bounded durations* (sum of all fixations on a word before continuing progressively) and *regression-path duration* (sum of the duration of all fixations from the moment the participants fixate their gaze on a word until the moment they move forward progressively) (Koornneef, 2021, pp. 459 -469).

Likewise, a further group of eye tracking metrics which is traditionally attributed to the measures delimited by AOIs could be outlined. These include *number of fixations*, *gaze duration mean*, *fixation duration mean*, *number of gazes* on each AOI (percentage of participants fixating a specific AOI), *time to first fixation* on a target area (Jacob and Karn, 2003, pp. 584-586), *first-fixation duration*, *regressions out* (which mean a probability of regressing outside the AOI), *second pass-reading time* and *total reading time* defined as an amount of all fixations and forward and regressive saccades (Clifton, Staub and Rayner, 2007, pp. 348-349).

Moreover, the metrics that are amenable to visualisation, such as *scanpath* similarity (Duchowski, 2007, p. 173) – also denoted as *gaze plot* in Tobii Pro Lab's terminology – furnish data on eye movement position and sequence markers. Paired with *heat maps*, these tools serve the dual purpose of illustrating trends for individual participants and facilitating the comparative analysis of cognitive biomarkers among distinct subjects.

Thus, the outcomes of these measures and metrics should align with the theoretical underpinnings of employing eye tracking as a method of linguistic research. This theory postulates that, similarly to measuring reaction time in response to a stimulus or assessing the time taken to process a lexical item, it serves as an indicator of the cognitive effort required for processing (Carrol and Conklin, 2014, p. 1 and 7). This underscores the correlation between temporal measures of fixations, saccades and regressions and the processing of neologisms of varying lengths, as well as different levels of formal and semantic complexity.

On balance, eye tracking techniques used in real-time biometric tools with proper design, implementation and interpretation of output data constitute a powerful research approach enabling their application to the study of language processing patterns related to lexical creativity and innovation.

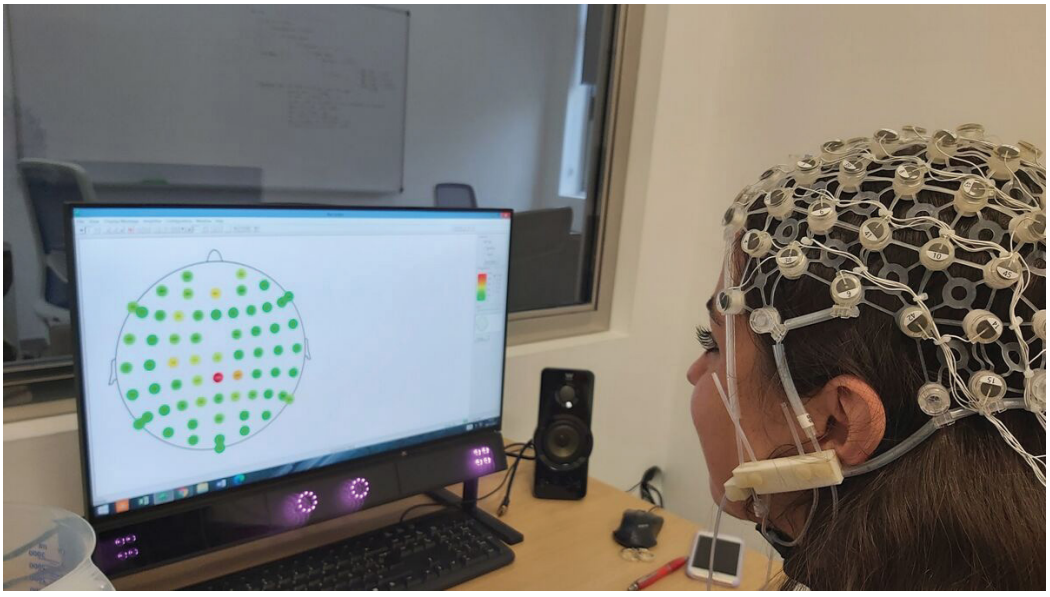
5 Combined techniques for neologism analysis

Furthermore, EEG and the study of ERP components are greatly enhanced by their combination with other behavioural techniques, such as LDT and eye tracking, which can be used complementarily as well.

Abundant studies contrast the processing of previously learned words and new lexical creations. Lexical decisions do not imply the processing of the word meaning; phonological patterns can be correctly recognized as words even if their meaning is not known, that is why the simultaneous use of EEG and LDT is so promising. Recent studies show that in the context of lexical decision tasks, the usage of average source localisation images elucidated the neural substrates involved in various cognitive processes. Concurrently, the expectancy strategy was correlated with notable activation in the right posterior temporal and right frontal cortices. In contrast, the post-lexical strategy demonstrated a distinct neural signature characterised by heightened activation in the right frontal region, the anterior cingulate cortex, and bilateral superior parietal areas (Silva-Pereyra *et al.*, 2003).

Regarding the combination of LDT and eye tracking, it is pertinent to highlight research into word recognition that has demonstrated that the pupillary response exhibits sensitivity to variations in word frequency. However, a critical concern arises as to whether this observed pupillary effect is a byproduct of the response-execution process rather than a direct reflection of the word processing phenomenon. In an endeavour to explore this possibility, two experimental studies involving a lexical decision task (LDT) were conducted (Haro *et al.*, 2017), all while closely monitoring pupillary responses. In the initial experiment, participants engaged in a conventional LDT, whereas in the subsequent experiment they undertook a delayed LDT. The introduction of a temporal delay in the response phase enabled us to make a comparative analysis of pupillary dilations, considering the presence or absence of the response execution component. The findings from both experiments unequivocally indicated that word frequency exerted a discernible influence on pupillary responses. This empirical evidence bolsters the credibility of employing pupillometry as a valuable tool in the domain of word recognition research, with a promising future in the study of neology.

The combination of eye tracking and ERP analysis offers a unique approach that enables simultaneous recording of eye movements and electrophysiological activity, providing a single, highly accurate technique with both high spatial and temporal resolution (Sereno and Rayner, 2003). Simultaneously recording eye movements and electroencephalographic activity allows for the synchronisation of oculomotor behaviour analysis, which reflects the perception of visual information, with the analysis of brain reactions associated with information processing. This synchronisation is accomplished with the same high temporal resolution. The resulting identification of what is known as eye-fixation-related potentials (EFRPs) entails EEG components temporally linked to oculomotor events, such as fixations or the onset of a saccade. EFRPs provide valuable insights into the interaction between information acquisition (eye movements) and the immediate processing of that information (ERP).



Font: Photo taken by the authors at the ILA

FIGURE 2. Sample of a combination-based experiment of eye tracking and EEG at ILA

6 Conclusions

In conclusion, we believe that an experimental approach (which is not solely limited to the techniques described above) allows for a dynamic interpretation of the neology phenomenon. This approach observes the coexistence of the activation processes of semantic-conceptual bonds, facilitated through the selection of features, and the morphosyntactic integration processes of the word's formal structure. These processes take into account their multiple connections with the neurocognitive procedures involved in processing linguistic information. Additionally, this method of analysis aligns with the objectives of 1) identifying the predominant tendencies in the formation of new lexical units across different languages; 2) deepening our understanding of the psycholinguistic processes and neurocognitive mechanisms that explain the interpretation of new units, and 3) analysing lexical creativity in various types of communication.

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Notes:

1. This study forms part of the research lines on neology and neologisms pursued by the Red Neológica de la Universidad de Cádiz (NEOUCA), integrated in the Red de Observatorios de Neología del Castellano (NEOROC), which is coordinated by the Observatori de Neologia of Universitat Pompeu Fabra's Institut de Lingüística Aplicada (IULA). It also belongs to the lines of work of the Gabinete de Industrias de la Lengua of the Instituto de Lingüística Aplicada (ILA) (Universidad de Cádiz) and the excellence group of the Andalusian Research Plan Semaínein (HUM 147). In particular, it is part of the R&D&I project "Aplicaciones de la lingüística digital al ámbito de la terminología: la creación de un léxico relacional bilingüe de los usos terminológicos de la semántica léxica" (TerLexWeb) (PID2022- 139201OB-I00), funded by the State Research Agency of the Ministry of Science and Innovation
2. To investigate its terminological diffusion, we examined the presence of "lexical decision" in 37 linguistic dictionaries. Of these, only two contained a specific entry (Trask, 1998, p. 137; Richards and Schmidt, 2010, p. 345), while there were general mentions under other entries in seven other dictionaries, generally associated with priming and in some cases with bilingualism or clinical linguistics. In none of the dictionaries is the speaker's perspective addressed. This terminological review, the results of which are not presented here for reasons of space, is part of the R&D&I projects "Comunicación especializada y terminografía: usos terminológicos relacionados con los contenidos y perspectivas actuales de la semántica léxica" (Specialised communication and terminography: terminological uses relating to current perspectives and contents of lexical semantics) of the Spanish State Programme for the Promotion of Scientific and Technical Research of Excellence, and "Lingüística y nuevas tecnologías de la información: la creación de un repositorio electrónico de documentación lingüística" (Linguistics and new information technologies: the creation of an electronic repository of linguistic documentation) of the Andalusian R&D&I Programme.
3. Laboratorio de Lingüística Experimental at the Instituto de Lingüística Aplicada of UCA is equipped with Tobii Pro Spectrum 1200 Hz hardware, which offers a high sampling rate, and it employs Tobii Pro Lab software (software version 1.217, 2023, Tobii AB, Danderyd, Sweden), suitable for conducting experiments with the eye tracker device. Several experiments on neology employing this cutting-edge technique are currently being performed at ILA.