Acta Psychologica 180 (2017) 23–32

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Dynamic lexical decisions in French: Evidence for a feedback inconsistency effect

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ARTICLE INFO

PsycINFO classification:
2300 human experimental psychology
2340 cognitive processes*Keywords:*
Visual lexical decision
Mouse tracking
Orthographic consistency
Pseudohomophones
Feedback inconsistency

ABSTRACT

Numerous studies indicate that lexical decision is a dynamic process in which various sources of information (e.g., orthographic, phonological, lexical) need to be integrated over time and that mismatches between these sources produce uncertainty during decision-making. However, the specific contribution of these different sources of information to the decision process, and the specific ways they interact over time, are still incompletely understood. Here we report two experiments conducted to investigate the role of a key characteristic of language - *orthographic consistency* - in modulating reading strategies in a lexical decision task. We aimed to test different theories of how exactly orthographic consistency influences decisions, and the ways lexical and sublexical representations are matched within it. For this, we exploited a key characteristic of the French language: the fact that retrieving spelling from phonology is hard, whereas the reverse is not the case (i.e., French is feedback-inconsistent but feedforward-consistent). Our results indicate a feedback inconsistency effect: uncertainty in our lexical decision task originates from the process of retrieving spelling from phonology, not when retrieving phonology from spelling. These results support the idea of a verification mechanism that compares orthographic sublexical information with lexical information during lexical decisions.

1. Introduction

Lexical decision is a classic paradigm used to study the way we process linguistic stimuli. Despite numerous studies, a number of unsolved problems remain, such as, for example, the way different sources of information (e.g., lexical, orthographic) are combined to produce a lexical decision.

In a recent study, Barca and Pezzulo (2012) investigated whether the mechanisms involved in the lexical decision process are of a discrete or a dynamic nature. They recorded participants' hand's movements during a lexical decision task in which participants had to click with the mouse on one of two options presented on the screen: one lexical and one nonlexical. The task was run in Italian and the hand movements were recorded using MouseTracker software (Freeman & Ambady, 2010). The authors observed that the "lexicality effect" (better performances for lexical vs. nonlexical stimuli) did not show up at the beginning of the motor response, but during the trajectory towards the response: after the initiation of the movement, the hand was more attracted towards the competitor when the stimulus was a pseudoword than when it was a real word. The fact that this competition process occurred after the initiation of the motor response demonstrated that, first, lexical decision had not been completed before the start of the movement and, second, the lexicality effect reflected the dynamic integration of different sources of information during the decision process (for consistent results in the temporal domain, see also Barca & Pezzulo, 2015). The curved mouse trajectories observed during the execution of the motor responses could be interpreted within the *Interactive account of ventral occipitotemporal cortex (vOT) model* (Price & Devlin, 2011), if we consider that (especially) in the case of pseudowords, there is significant conflict between top-down lexical predictions and bottom-up sensory information.

Barca and Pezzulo (2012) also found that the lexicality effect was observable between low-frequency words and pseudowords, but not between high-frequency words and strings of consonants. Again, the *Interactive account of vOT model* (Price & Devlin, 2011) can explain such results. Price and Devlin (2011) explained how, when a word is read, the information from the visual areas activates the vOT which then, in turn, partially activates higher-order areas corresponding to the semantics and the phonology of the written characters. This forward or bottom-up activation is fast and followed by a process in which the

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http://dx.doi.org/10.1016/j.actpsy.2017.08.005
Received 13 April 2016; Received in revised form 19 April 2017; Accepted 9 August 2017
Available online 15 August 2017

activated higher-order areas send information back to the vOT. Next, recurrent interactions between the information from the visual areas and information from higher-order areas take place in the vOT until they become maximally consistent. The connections of the higher-order areas are strengthened with practice, resulting in predictive feedbacks that become more efficient with experience. Thus, extremely frequent words and strings of consonants are responded to quickly and accurately in a lexical decision task because, in the former case, a lot of the feedback information sent to the vOT matches the information from the visual areas and, in the latter case, because no top-down predictions are involved. In both cases, no or only a few prediction errors conflict with the information from the visual areas. Although low-frequency words generate less feedback information than high-frequency words, this information still matches the information from the visual areas. By contrast, pseudowords engage prediction errors from the phonological areas, resulting in mismatching information between top-down and bottom-up processes that makes it difficult to decide that pseudowords are not words.

Similar predictions are also made by the Leaky Competing Accumulator Model (LCA) of lexical decisions (Dufau, Grainger, & Ziegler, 2012). This is a computational model of word recognition in the context of a lexical decision task. In this framework, participants need to make a choice between two response nodes: *word* or *nonword*. This model is based on a previous LCA model (Usher & McClelland, 2001) for binary-decision making, but has been adapted to the particular case of a lexical decision task, in which the choice of the *nonword* response node simply depends on the lack of evidence for the *word* response node. According to this model, response towards the *word* node are the result of a noisy accumulation of evidence in favor of this node and depend on the lexical activity generated by the stimulus. This lexical activity is the reflection of the evidence for a word corresponding to this stimulus. Regarding the activation of the *nonword* response node, it is computed by deducting the lexical activity generated by the stimulus from a constant value. The activation of one node inhibits the activation of the other node and this process is thought to end when the response threshold has been reached for one of the two nodes. Importantly, the response threshold should change from trial to trial and from one experimental condition to another, depending on the response criterion value adopted by the participant.

In sum, despite their differences, both the interactive model (Price & Devlin, 2011) and the LCA model (Dufau et al., 2012) suggest that making a lexical decision is a dynamic and competitive process, in which top-down and bottom-up information is compared and evidence is accumulated to bring about a positive or a negative response. Recording hand movements when participants move the computer's mouse towards the selected response (Barca & Pezzulo, 2012) has proved to be a useful way of studying the dynamic aspects of lexical decisions. However, it is still unclear what kind of evidence in favor of the lexical or nonlexical alternatives is accumulated over time, and the only studies addressing this question with the aid of the Mouse Tracker paradigm are in Italian (see Barca & Pezzulo, 2015, for a review).

The first aim of the present study was to replicate Barca and Pezzulo's (2012) results in a new language, French, in order to shed new light on the type of information that is accumulated over time. Specifically, the use of the French language will make it possible to gain insights into potential differences in the way evidence is accumulated between languages of different orthographic consistencies. Barca and Pezzulo (2012) ran their experiment in Italian, a language with a highly consistent orthography (i.e., a script with a very regular correspondence between the orthographic visual form of a word and its spoken representation). The French language has a more complex spelling-sound relation than Italian, especially for vowels (with several silent letters and a large number of homophones; e.g. “saint”/“sein”/“sain”/“ceins”/“ceint” for the words pronounced [sɛÞ]). Ziegler, Jacobs, and Stone (1996) performed a statistical analysis of orthographic consistency in French and found that, even though the French language is relatively consistent for the purposes of retrieving phonology from spelling (87.6% consistency for monosyllabic words), it is highly inconsistent when it comes to retrieving spelling from phonology (79.1% inconsistency for monosyllabic words). This inconsistency, namely feedback inconsistency as opposed to feedforward inconsistency, is not problematic when accessing the phonological lexical representation in a reading-aloud task (e.g., Ziegler, Perry, & Coltheart, 2003), but can be problematic when trying to activate the right orthographic lexical representation in a written lexical decision task (Ziegler, Jacobs, & Klüppel, 2001; but see Ferrand & Grainger, 2003, discussed below).

Studies investigating the orthographic consistency effects with a visual lexical decision task have typically shown that participants using a language with a highly inconsistent orthography rely more on semantic than on higher-order phonological information than those who use a language with a highly consistent orthography (see Lima & Castro, 2010, for a review). The language with an inconsistent orthography that has received by far the most attention in this context is English. The English and French languages differ in their orthographic inconsistency properties in that English is feedforward and feedback-inconsistent (Ziegler, Stone, & Jacobs, 1997) while French is feedforward-consistent and feedback-inconsistent (Ziegler et al., 1996). If French orthography produces effects similar to those observed with other feedforward and feedback-inconsistent orthographies, this could mean that the effects of orthographic consistency do not originate when phonology is retrieved from spelling, but when participants attempt to retrieve spelling from phonology, in a kind of verification process, as proposed by Ziegler et al. (2001). This would lead us to expect a larger frequency effect (i.e., a greater difference between high and low-frequency words) in French than that reported by Barca and Pezzulo (2012) in Italian, a larger lexicality effect (i.e., a greater difference between pseudowords and low-frequency words), and also a significant difference between high-frequency words and strings of consonants - because we expect participants to favor the use of semantic at the expense of phonological information, high-frequency words should be judged faster than consonant strings. Alternatively, if the conflict originates when retrieving phonology from spelling, the observed results should be similar to those of Barca and Pezzulo (2012) because this process is relatively consistent in French.

Another goal of the present study was to test the variability of the responses. To this end, the experiment was repeated twice with a 5-min interval. Diependale, Brysbaert, and Neri (2012) showed that, contrary to what had previously been assumed, the responses of the participants to specific items in a lexical decision task were quite inconsistent from one presentation to the next (some items that were classed as “words” in one presentation were classed as “nonwords” in the other). Here, our main goal was not to analyze the repetition effects on specific items, but to look for a repetition effect in the pattern of the responses in the second presentation compared to the first. More precisely, we wanted to investigate whether the repetition of the same items would modulate the frequency effect or the strategy adopted by the participants to respond to the items. If repetitions affect the frequency effect, the participants would learn the items they have previously been exposed to. Because lexical access to the most frequent items is already fast and does not generate many prediction errors, these items would be unaffected. By contrast, low-frequency words, pseudowords and strings of consonants should be processed faster and more accurately than in the first presentation. Alternatively, if repetitions affect response strategies, we should observe different response criteria from one presentation to the other (Dufau et al., 2012). Presenting the same items could induce the participants to lower their response threshold because they feel more confident with the items. As a consequence, participants would be expected to respond faster but less accurately (more errors and greater deviations of the hand movements) on all the items, an effect known as the speed–accuracy trade-off (see Pleskac & Busemeyer, 2010, for a review).