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NEIGHBOURHOOD SIZE AND NEIGHBOURHOOD FREQUENCY EFFECTS IN THE RECOGNITION OF ITALIAN WRITTEN WORDS

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CHAPTER 1

1.1. Introduction

The visual word recognition is a very complex task articulated in a set of processes which start from the perceptual information and operate on several types of representations, so allowing to identify the target word by contacting lexical information. In spite of its complexity, this activity has the characteristics of an automatic process: it is rapid, unconscious and, in point of fact, not cognitively overloading. The recognition of a written word is based on "lexical access". By this expression we refer to the assembly of processes responsible for retrieving the lexical information in memory (Frauenfelder & Tyler, 1987). The mental lexicon might be defined as the part of the long-.term memory store containing the entire knowledge of a speaker about the words of his language (Peressotti & Job, 2006): it is constituted by a set of different types of information – phonological, orthographic, grammatical, morphological, semantic – available at different levels of representation (Laudanna & Burani, 1995). In this chapter, we will analyze the different models proposed in the course of the last decades in order to explain the processes underlying the capabilities of recognizing and reading written words.

1.2. The recognition of written words

The written words usually have an internal complex structure: in a word pattern it is possible to isolate different levels each playing an important role in the recognition process. In alphabetic systems, the first level is provided by features which refer to the basic physical characteristics of the letters: vertical, horizontal and oblique lines, open and closed curves, etc. Some studies have found that features play an important role in the correct recognition of letters (Gibson, 1969): a letter (e.g. Z) is recognized more accurately and rapidly if it appears in a context of letters that do not share orthographic features (e.g. O, U, D) than in a context of letters that share some features (e.g. T, K, X). This result can be explained by assuming interference between recognition candidates encoding common features (Rumelhart, 1970). The first model put forward in order to account for feature analysis was the software "Pandemonium" (Selfridge & Neisser, 1960): it was implemented for the recognition of configurations like letters or numbers by postulating that features are the basic units for recognition. This system is based on different levels metaphorically called "demons". The first level, the image demon, holds the iconic representation of the input for few decades of milliseconds; at the second level, the features demons analyse the configuration of lines and specify the positive result of the search by means of an increase of activation. At the third level, the cognitive demons – corresponding to each letter of the alphabet – work on the patterns of activation which they are specialized for. Finally, at the last level, the decisional demon selects the letter having the maximum level of activation. A model exclusively based on the analysis of features cannot easily account for the influence of differences in size, form and type on the recognition of a letter. For this reason it is a common idea that there is a second level in the structure of the word pattern: the level of letters considered as abstract units relatively independent of their physical manifestation. Evett and Humpreys (1981) claimed that the cognitive representation of letters is independent of their graphic realization and that their recognition is not affected by differences in terms of typographic variations. Some recent neuropsychological studies have identified an area in the left cerebral hemisphere (the fusiform gyrus) specialized in the recognition of the letters (Polk, Stallcup, Aguirre, Alsop, D'Esposito, Detre & Farah, 2002). Other studies have argued that the relevant perceptual units are larger than the single letters and have focused on the frequency of certain sequences of letters (Adams, 1980), on the characteristics of syllables (Prinzmental, Treiman & Rho, 1986), on the constituent morphemes (Rapp, 1992), or on the whole pattern represented by the words themselves. The word would represent a third level which interacts in parallel with the other two levels – features and letters - in the recognition of a word pattern. The "word superiority effect" (Reicher, 1969) demonstrates that the recognition of a written word does not proceed sequentially from the level of the features to the level of the letters till to reach the level of the words. A single letter (e.g. K) is recognized more accurately and rapidly when it is embedded in a real word (e.g. WORK) rather than in a pseudo-word (e.g. OWRK) or alone. These results can be explained by two different hypothesis: the first maintains that the word is recognized contemporarily or before the complete recognition of its letters, by a parallel reading process; the other one postulates that the recognition of the word is based on an interactive process between the three levels. One of the first models elaborated in order to account for the recognition of written words has been the Logogen Model (Morton, 1979). Accordingly with this model, the mental lexicon may be described in terms of an organized set of representational units , each corresponding to one word. These representations would be activated by reacting to the sensorial input. The units corresponding to the words (the logogens) are assumed to be dynamic structures, while the mechanism underlying the lexical access would be of passive nature. Each logogen operates like a detector and has an activation threshold which has to be reached for the recognition of the word. When the orthographic information of the input is consistent with the one encoded in the logogen, the logogen becomes active on the basis of the matching between the written word and the whole word representation; the recognition occurs when the logogen reaches its threshold level. The threshold of the logogen results from different factors: the most relevant among them is represented by the word frequency. Logogens which correspond to high frequency words have a lower threshold; thus, they are activated more rapidly than logogens corresponding to low frequency words, which have a higher threshold. By this construal, the model explains the frequency effect and anticipates the results from studies on the orthographic neighbours by assuming that each written word does not activate only one logogen but also many orthographically similar logogens which compete with each other until one of them (presumably the correct one) reaches its threshold. The "logogen system" is strictly related to the "cognitive system" that is responsible for the retrieval of the semantic information: once the logogen is active, it feeds the cognitive system in order to retrieve the corresponding meaning. By hypothesizing this relationship between the two systems, the presentation of a word (e.g. *apple*) would lower the threshold of the semantically related words (e.g. *pear*, *orange*, *banana*, etc.): by this mechanism, Morton explains the semantic priming phenomenon, that is the fact that the recognition of a target word is facilitated if it is preceded by a semantically related word. If the Logogen Model implies that the recognition of the word is reached in presence of a correspondence between the whole input word and its logogen in mental lexicon, other models maintain that the recognition of a written word is based on a complex set of activation processes of more levels of representation corresponding to different detectable units within the word. The most relevant among these models is the Interactive Activation Model (IAM, Mc Clelland and Rumelhart, 1981). It identifies three levels of processing in the word: the feature level, responsible for the processing of physical characteristics of the sensorial input, the letter level, responsible for the processing of abstract letters and the level of words, which are represented as global forms. The IAM is a parallel model in a double sense, both at the same level and among the different levels: the processing is not serial and it does not imply that all the units of one level have been completely identified for forwarding to the following level. Moreover, the model detects two kinds of activation processes: i) the excitatory activation processes among compatible features and letters and compatible letters and words and ii) the inhibitory activation processes among incompatible features and letters, incompatible letters and words, competing letters and competing words. This model may be defined as interactive because the identification of the units at one level is not only driven by the units active at the previous level, but it is also influenced by the units of the following level. By hypothesizing a backward feedback

mechanism from the level of the words to the level of the letters, this model can easily explain the word superiority effect that is more difficult to be accounted for by the Logogen Model.
With a completely different architecture, the Serial Search Model (Forster, 1976) maintains that the recognition of the word is based on a serial search mechanism of the word in the mental lexicon, organized into two phases: 1) the search (ordered by frequency) of the lexical representation corresponding to the input, and 2) the identification and the following access to the lexical unit itself. The model hypothesizes three different peripheral access files where the words are searched on the basis of the input modality: the orthographic access file, the phonological access file and the semantic/syntactic access file. The lexical information is stored only in the master file and it is retrieved only when the access happens. The items are organized in each peripheral access file in different bins and are ordered by frequency: higher frequency words are examined earlier than low frequency words (hence the explanation of the frequency effect). The presence in the master file of cross-references among lexical units would explain the semantic priming effect: the access to a lexical unit (e.g. *dog*) allows the activation of a cross-reference to another semantically related word (e.g. *cat*). Thus, it is not necessary starting again from the peripheral access in order to recognize the latter word.
Finally, we focus on the Multiple Read-out Model (Grainger & Jacobs, 1996) that we will consider in the following chapters in the attempt at explaining some of our empirical data on orthographic neighbours. This model enriches the Interactive Activation Model by incorporating three decision criteria (rather than one) which influence the speed of lexical decision responses. The first is the M criterion, which is sensitive to the activation of single lexical units. According to the model, when the M criterion is reached, lexical selection occurs and a specific word is identified. The second is the Σ criterion, which is sensitive to the degree of overall lexical activation and is represented by the total lexical activity generated by the word and its neighbours. If an input generates enough lexical activity to exceed the current Σ criterion, a word response can be made before lexical selection due to the M criterion. The third criterion is the T criterion, which is a temporal deadline used for generating non-word responses. According to the model, when an input is presented and either the M criterion or the Σ criterion is exceeded before the T criterion, a word response will be produced; otherwise, a non-word response will be given.

1.3. Reading words

Many studies have specifically focused on the processes underlying words reading and have produced important empirical data and interpretative models about the recognition of written words. The research has been initially characterized by the debate between models based on one only processing route and models based on more processing routes in retrieving the phonological form from an orthographic representation. One of the most relevant one- route models is the "Reading by Analogy Model" (Glushko, 1979). According to this model, the pronunciation of the word would be produced by integrating a set of information which are activated in parallel and automatically during the reading process. The information would include the phonological representations of the known words orthographically similar to the input and the specific sets of correspondences between groups of letters and sounds. The concept of word regularity is restated in terms of word congruency: a word would not be regular or irregular depending on the correspondence rules between letters and sounds, but it would be congruent or not congruent with respect to statistical patterns of orthographically and phonologically similar words. Contrary to single-route models, dual-route models (e.g. Morton and Patterson, 1980) assume two different processing routes involved in word recognition and in word and non-word reading: a lexical route, based on the access to the mental lexicon from the recognition of a word as a global orthographic input, and the non-lexical route, based on the grapheme-to-phoneme conversion rules between letters and sounds. Reading a non-regular word - a word that violates the grapheme-to-phoneme correspondence rules - should be uniquely based on its representation stored in the lexicon. On the contrary, non-words could be pronounced only by using the non-lexical route and by applying the grapheme-to-phoneme correspondence rules. The pronunciation of regular words would be influenced by both lexical and non-lexical routes. The two processing routes are jointly activated in presence of any orthographic input. They share the starting step, the identification of a sequence of graphemes on the basis of the perceptual information, and the final step, the activation of a phonemic buffer that computes and temporarily stores the sequence of phonemes corresponding to the input. The two routes interact because both feed information to the phonemic buffer: this information will be congruent in presence of a regular word and not congruent in presence of a non-regular word by determining faster and slower reading times respectively. This model easily explains the empirical data concerning the presence of the regularity effect on low frequency but not on high frequency words (Taraban and Mc-Clelland, 1989). The lexical route produces the phonological representations according to word frequency: it is fast for high frequency words while it is much slower for low frequency words. The non-lexical route, applying the specific conversion grapheme-phoneme rules, is slow both for high frequency and low frequency words: the phonological output produced by the non-lexical route interferes in the phonemic buffer with the lexical route phonological output exclusively in presence of a low frequency word. The Dual Route Cascaded Model (Coltheart, Rastle, Perry, Langdon and Ziegler, 2001) can be considered the most relevant evolution of the dual route framework. It is articulated in different components that are activated in a cascaded fashion: the first step of the identification of the letters is based on the analysis of the features as proposed by the Interactive Activation model. Once the letters are identified, the model hypothesizes two parallel routes to retrieve the phonemic output corresponding to the orthographic input: the lexical route and the sub-lexical route. The most relevant element introduced by the Dual Route Cascaded Model in addition to the non-computational dual route model is the presence of processing cycles that modify the activation or the inhibition of each unit up to the final reading. In the lexical route the features activate the representations of the corresponding letters which, in turn, activate the representations of the corresponding word units in the orthographic lexicon. The activation of the orthographic unit leads to the activation to the corresponding phonological unit that, in turn, activates the phonemes composing the word, along with the information about their respective positions, in the phonemic buffer. The orthographic and phonological units have an activation threshold influenced by word frequency: the activation of a high frequency word increases more rapidly than the one of a low frequency word. The activation of a phonological unit produces the activation of a phoneme for each phonemic set in the buffer by inhibiting the other possible phonemes in the same set. The sub-lexical route applies the grapheme-to-phoneme conversion rules: it is not active during the first ten processing cycles and serially converts each grapheme in its corresponding phoneme from left to right. The two routes are both activated in presence of any orthographic input and envoy their respective outputs to the phonemic buffer: if there is not congruency between the two outputs the reading times increase because more processing cycles are necessary to produce a univocal output. Reading non-regular words and non-words similar to non regular words determines the clearest cases of conflict between the two routes. In the first case, the lexical route produces the correct phonemic output not congruent with the "regularized" output generated by the sub-lexical route. The degree of interference in the phonemic buffer is determined by the speed of lexical route processing: for high frequency words the lexical route computation is very fast and it ends before the sub-lexical route computations generate interference. For low frequency words the lexical route processing is slower and strongly conflicts with the sub-lexical route processing. The DRC also simulates the empirical data showing that the regularity effect is influenced by the position of the non-regular phonemes sequences in the word (Rastle and Coltheart, 1999): low frequency words with irregular phonemes sequences at the beginning have longer reading times than low frequency words with irregular phonemes sequences in the final part of the word. According with the serial sub-lexical route processing, the more left-side the irregular phonemes sequence is, the more the interference between computation of the two different routes. For non-words, instead, the correct phonemic output is uniquely produced by the sub-lexical route: nevertheless, the lexical route activates all the phonological units orthographically similar to the input by sending to the phonemic buffer partially congruent and partially incongruent information. The congruent information sent by the lexical route facilitates the sub-lexical route processing, while the incongruent information slows down the sub-lexical route functioning, increases the number of processing cycles necessary to produce the correct output and lengthens the reading times. By this set of devices, the DRC accounts for the empirical data showing that the non-words have different reading times depending on the degree of congruency with regular words as we will see in the following chapters (see also Glushko,1979; Job, Peressotti and Cusinato, 1998).

The Parallel Distributed Processing Model (Seidenberg and Mc-Clelland, 1989) is grounded on a completely different theoretical view. Far from being a representational model, it is based on a connectionist framework. The core hypothesis is that there are not units corresponding to features, letters and words; the knowledge in the system is distributed over all the units in the net. The model has been successfully trained to simulate language acquisition in children by using a single net which encodes all the orthographic, phonological and semantic information about words. Input and output units of the net are linked through hidden units by an interactive activation mechanism. This system is able to learn by a progressive adjustment of the connection weights and does not need two different processing routes: regular and non-regular words, as well as non-words, are computed by the same net, where orthographic, phonological and semantic information is represented in terms of distributed activation patterns. In presence of the input, the orthographic, phonological and semantic units interact among each other until the network achieves a stable activation pattern (the attractor), corresponding to the correct output. The activation of an output phonological pattern corresponding to the input is determined by three factors: the cumulative frequency of the activation pattern produced by each word during the learning phase, the sum of frequencies of the activation patterns produced by congruent words (the “friends”) and the amount of frequencies of the activation patterns produced by incongruent words. High frequency words have faster reading times than low frequency ones, since they have a higher cumulative frequency of the activation pattern. Regular words have quicker reading times than non-regular words because the cumulative frequency of “friends” is higher than the amount of the frequencies of “enemies”. The interaction between these three factors is not linear: high frequency words will show a smaller regularity effect than low frequency words. The PDP model hypothesizes that there are not differences between the reading processes of words and non-words: reading of unknown or not existing words will be affected by the orthographic and phonological characteristics of known words. In line with these hypotheses, the PDP model easily accounts for the empirical data about different reading times on non-words: they would depend on the degree of congruency with regular words, but, differently from the DRC model, it does not reproduce some contextual effects, like the experimental list composition (Job, Peressotti and Cusinato, 1998).

CHAPTER 2

2.1. The orthographic neighbourhood

Most of the research on the mechanisms underlying the first stages of access to the mental lexicon focused on the study of orthographic neighbours. A shared opinion is that both the complexity of the external world and the limitations of the perceptual system produce non-deterministic access procedures to the mental lexicon. In this perspective, the orthographic neighbours, being highly confusable items with the target word, would be necessarily involved in the recognition of the target word itself. The neighbourhood size is defined by the *N-count* as the number of words that can be generated by changing one letter of the target word, preserving letter positions (Coltheart, Davelaar, Jonasson and Besner, 1977). For instance, the neighbourhood of *sleet* is constituted by the words *fleet*, *sheet*, *skeet*, *sweet*, *slept*, *sleek* and *sleep* while *club* has only one neighbour, *clue*. Differently from the neighbourhood size, the neighbourhood frequency refers to the relationship between the frequencies of neighbours and the frequency of the stimulus word (Grainger, O'Regan, Jacobs & Segui, 1989). Finally, the third measure of the neighbourhood distribution is constituted by the P measure, that refers to the number of letter positions yielding at least one neighbour (Johnson and Pugh, 1994): e.g., the word *banca* has a P measure of 4 because, differently from the other positions, the second position cannot generate neighbours, while the word *cobra* has a P measure of 1 because only the third position can generate neighbours. It is worth specifying that in our study we did not consider the question of the phonological recoding of visual information (Coltheart, 1978, McCusker et al., 1981) and the possibility that a word with a given orthographic neighbourhood might have a larger or smaller number of phonological neighbours[1]. In this chapter we will report the results of some relevant experiments on neighbourhood size and neighbourhood frequency in languages like English, French and Spanish: in the final paragraphs of the chapter we will examine the results found on Italian.

2.2. Neighbourhood size and neighbourhood frequency effects

The last decades of research appear to yield contradictory evidence about how orthographic neighbours affect the word recognition processes: we will show that the conflict in the existing evidence is more apparent than real, because in most cases there are systematic differences between the experiments which point to yielding contrasting conclusions. The first

[1] This possibility is actually much more limited in Italian than in English.

research on the neighbourhood size effects was carried out by Coltheart et al. (1977) who detected a significant neighbourhood size effect in English on non-words but not on words. In particular, they found an inhibitory neighbourhood size effect on English non-words: non-words with a large neighbourhood had slower reaction times than non-words with a small neighbourhood. These results were considered consistent with a logogen-style activation framework where the strength of activation of individual logogens is determined just by sensory input and is insensitive to the activity of other logogens; the inhibitory neighbourhood size effect on non-words was attributed to a decision mechanism influenced by overall lexical activation. Andrews (1989) criticized these results by underlying that Coltheart et al. had controlled but not manipulated the word frequency in their experiments: she assumed that the number of neighbours affects both word recognition and non-words rejection process. Her hypothesis was based on empirical data from previous experiments on the "form priming effects" (e.g. Forster, Davis, Schochnecht and Carter, 1974; Meyer, Schvaneveldt and Ruddy, 1987), which showed that the reaction times on a target word are influenced by the prior presentation of a stimulus differing from the target for only one letter (e.g., *bribe – tribe*, *bamp-camp*). In particular, Andrews started from form priming data (Colombo, 1986), which reveal an interaction between frequency and neighbours by showing a facilitatory form priming for low frequency targets and an inhibitory priming for high frequency targets. Thus, Andrews based her research on the idea that an accurate evaluation of the neighbourhood effect required a factorial manipulation of two variables: neighbourhood size and word frequency. She used a 2x2 factorial design where the two factors were frequency (high/low) and neighbourhood size (large/small). She employed English words, all four-letter long, classified as "large neighbourhood" if they had at least 9 neighbours, or "small neighbourhood" if they had no more than 5 neighbours. By using the lexical decision task, Andrews replied Coltheart et al.' s results on non-words by showing an inhibitory neighbourhood size effect. However, differently from the previous research, she found that the lexical decision latencies on words were sensitive to their neighbourhood size. In particular, the facilitatory neighbourhood size effect was more marked on low frequency words and barely evident on high frequency words. Andrews replied the same results both in environment of both wordlike non-words and non-words containing unusual or non-occuring consonant combinations (the latter non-words should reduce the contribution of decision processes to classification latencies). Finally, in order to show that neighbourhood size effects were located in the lexical access phase and did not affect discrimination/decision processes, Andrews used the word naming task, which presumably involves lexical access processes but does not require the word/non-word discrimination and the strategic components of the lexical decision task. The results found in lexical decision as well as in word naming suggested that neighbourhood size effects have their locus in lexical access, since this is the process shared by the two tasks. This hypothesis was also confirmed by results found by using the delayed naming paradigm (Andrews, 1989): words were presented for pronunciation, but subjects were instructed to defer their responses until the presentation of a pronunciation cue. The delay between stimulus presentation and pronunciation ensured that the processes involved in lexical access and word recognition were completed before the onset of articulation: the absence of any effect of neighbourhood size in the delayed naming paradigm suggested that the neighbourhood size effect observed in word naming task was not located in word production processes but in the lexical access phase. The facilitation due to the neighbourhood size on low frequency words was still detected by using English targets matched for bigram frequency (Andrews, 1992), by using the same stimuli as in Andrews (1989) (Sears, Hino, and Lupker, 1995), and by using a sample of words that included 4- to 6-letter long words (Michie, Coltheart, Langdon, and Haller, 1994). Finally, other relevant evidence of a facilitatory neighbourhood size effect for English words was provided by further experiments that manipulated neighbourhood size and neighbourhood frequency by using a 2x2 factorial design where the two variables were neighbourhood size (large vs small) and neighbourhood frequency (with or without a higher frequency neighbour). Sears et al. (1995) found a facilitatory neighbourhood size effect, but no neighbourhood frequency effects, in four lexical decision experiments using three different samples of 4-letter long stimuli and one of 5-letter long stimuli (Forster and Shen (1996) replicated the same results in three lexical decision experiments by using 5- and 6-letter long words). Contrary to these results, Grainger, O' Reagan, Jacobs and Segui (1989) claimed that the relevant factor is not the neighbourhood size, but rather the frequency of these neighbours as compared to the frequency of the stimulus word. They started from the observation that the most relevant models of word recognition predict effects due to the frequency of the elements in the candidate set and not to the total size of this set. Moreover, Grainger et al. referred to the empirical data from Chambers (1979), who investigated the inhibitory effects on words that were orthographically similar to a more frequent word: he found interference only on words having a more frequent substitution neighbour – a word that differed by a single letter (e.g. *collar* from *dollar*) – but not on words having a more frequent transposition neighbour, that is a word which differed for the relative order of two adjacent letters (e.g. *bale* from *able*). Although Grainger et al. underlined some critical points of this research – like, for instance, the absence of a matching for experiential familiarity on control words and the different length between *collar*-type words and *bale*-type words – they decided to focus on the neighbourhood frequency effect. They used French four-letter words organized into four categories: words with no neighbours, words with at least one neighbour, words with only one neighbour of higher frequency and words with more than one neighbour of higher frequency. The four categories were matched for experiential familiarity – considered by the authors a better predictor of word recognition performance than printed frequency – and for positional bigram frequency. By using the lexical decision task and the eye movement analysis in a semantic comparison task, Grainger et al. found that lexical decision latencies and gaze durations on words with at least one higher frequency neighbour were significantly longer than on words without a more frequent neighbour. They did not find differences between words with no neighbours and words with at least one lower frequency neighbour and between words with only one higher frequency neighbour and those with more than one higher frequency neighbour. In other words, they detected a non-cumulative inhibitory neighbourhood frequency effect and no neighbourhood size effect. Similar results were replicated using other French stimuli (Grainger and Jacobs, 1996) and Spanish stimuli (Carreiras, Perea and Grainger, 1997). The empirical data found using the lexical decision task were strongly influenced by the nature of the non-word environment (the non words might be more or less phonologically legal and orthographically well-structured) and by the range of word and non-word stimuli that people were exposed to. Johnson and Pugh (1994) found inhibitory neighbourhood size effects when words had to be discriminated from legal pronounceable non-words but facilitatory neighbourhood size effects when illegal non-words were used. Carreiras et al. (1997) found that neighbourhood size effect in Spanish was facilitatory when words with large vs small neighbourhoods were presented in separate blocks in an environment of non-words with large or small neighbourhoods. Grainger and Jacobs (1996), using French stimuli, found inhibitory neighbourhood frequency effects and no neighbourhood size effect when words were embedded in highly wordlike non-words. On the contrary, when less wordlike non-words were used, the neighbourhood size effect was facilitatory and the inhibitory neighbourhood frequency effect was reduced. The empirical data showed that neighbourhood size effects were facilitatory under easier discrimination conditions but, contrary to what happens with French and Spanish words, in English the neighbourhood size effect was still facilitatory even in more difficult decision environments. Summing up, the effect of neighbourhood size seems to depend on the nature of the word/non-word environment and varies across different languages. Even though the interpretation of the lexical decision data looks quite arduous, the data themselves should not be considered contradictory. Facilitatory neighbourhood size effects are clear on low-frequency English words and, although they do not occur in French and Spanish under standard task conditions, they can be observed in particular non-word environments. Inhibitory neighbourhood frequency effects have been ascertained on French, Dutch and Spanish words, but rarely on English stimuli. The results obtained by using the word naming task are more homogeneous: many studies detected facilitatory neighbourhood size and neighbourhood frequency effects at least for low frequency words in English, French and Dutch. One exception is given by the results of Carreiras et al. (1997) using Spanish stimuli: in this case there was no overall neighbourhood frequency effect but an interaction with neighbourhood size. In particular, there was a facilitatory neighbourhood size effect only on words having neighbours of higher frequency; the neighbourhood frequency effect was inhibitory for words with few neighbours but facilitatory for words with many neighbours.

The non-word naming task has pervasively showed a facilitatory neighbourhood size effect (Gunther and Greese, 1985; Scheerer, 1987): non-words with a large neighbourhood show faster reading times than non-words with a small neighbourhood. Some authors (Laxon, Coltheart, and Keating, 1992; McCann and Besner, 1987) have argued that the homogeneity of results from the reading aloud task both on words and non-words is explainable in terms of a confounding between neighbourhood size and bigram or trigram frequency effects. Peereman and Content (1995) have rejected this hypothesis by comparing neighbourhood size effects on word naming performances in different environments: their results showed a smaller neighbourhood size effect when French words were mixed with non-words rather than words. If neighbourhood size effects would be due to non-lexical naming procedures, the results should have been the opposite. Thus, the data by Peereman and Content show that facilitatory effects in word naming have to be attributed to the lexical activation of neighbours and not to the strength of correspondences between sets of letters and phonemes.

In other experiments, the perceptual identification task has been used. Snodgrass and Minzer (1993) conducted several experiments in which English words with small and large neighbourhoods were presented in a series of increasing fragments and subjects were required either to successively attempt at identifying the word or to make a single identification response. In the successive guessing procedure the neighbourhood size effect disappeared; instead, it was clearly inhibitory when subjects were required to make a single identification response: in particular, the accuracy was lower for low-frequency words with large neighbourhoods. These results were confirmed by further experiments both on French words

(Grainger and Segui, 1990; Grainger and Jacobs, 1996) and on Spanish words (Carreiras, Perea and Grainger, 1997). In these experiments, a progressive demasking procedure was used, where participants gave a single identification response to a display consisting of interleaved presentations of a target word and a mask in which the length of the target exposure was progressively increased: words with one high frequency neighbour were less accurately identified, especially when the target was a low frequency word. These results were compatible both with search models predictions – the selection of the correct lexical representation would have been delayed by the presence of many neighbours or by one high frequency neighbour – and with activation models predictions, based on intra-level lateral inhibition from neighbours.

The apparently contradictory results found on neighbourhood structure may be conciled. In English, there is both a relatively consistent pattern of results, and no inherent inconsistency between the effects of neighbourhood size and neighbourhood frequency. The effects of neighbourhood size are compatible with the view that the activation of orthographically similar neighbours facilitates word identification. However, the nature of neighbourhood effects varies according to task requirements. The results for French and Spanish show an apparent conflict between the effects of neighbourhood size and frequency. Words with many neighbours do not suffer from inhibition and show facilitation in some contexts, but when words are selected according to the presence of higher frequency neighbours, inhibition is marked. Grainger and Jacobs (1996) attribute this data pattern to the contribution of different common and specific processes to performances in different tasks.

The inhibitory effects of large neighbourhoods observed in the perceptual identification task are likely to reflect sophisticated guessing strategies invoked to resolve partial stimulus information. Under standard clear presentation conditions in LDT and naming tasks, large neighbourhoods are almost always associated with better performance. Although inhibitory effects of higher frequency neighbours have been observed in lexical classifications of French and Spanish words, such effects are not generally observed in English. Andrews (1997) proposed a language-specific criterion to explain why facilitatory effects of neighbourhood size are commonly observed in English but not in French or Spanish. English has an inconsistent relationship between orthography and phonology, with vowels being more inconsistently pronounced than consonants. However, because consonants following a vowel predict its correct pronunciation better than preceding consonants that precede it (Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995), the word body (the orthographic rime) may play a special role in reading English words. It is possible that the strong facilitatory neighbourhood effect obtained in English is due to the fact that most English neighbours are body neighbours and that the body helps disambiguating word phonology (Treiman et al., 1995).Word bodies (and, hence, word-body neighbours) might play a minor role in French or Spanish, because these languages have different orthographic–phonological structures. Finally, some researchers (Johnson & Pugh, 1994; Pugh, Rexer, & Katz, 1994) underlined the relevant role played by the index P, or spread, that refers to the number of positions that yield at least one neighbour. Pugh et al. performed regression analyses on lexical-decision data and reported that P is a better predictor of neighbourhood effects than the traditional N-metric. They detected a facilitatory P effect on word latencies only with easier word-nonword discriminations. The authors attributed this facilitatory P effect to a response bias in the LDT: high neighbourhood values were correlated with the stimulus lexical status and participants would have responded even before having resolved the different neighbourhood alternatives. In contrast, when the word-nonword discrimination was considered difficult (with large neighbourhood non-words) increasing P lengthened word latencies by showing a fundamentally inhibitory P effect. However, the analysis of the P factor represents at the present time a secondary issue in the studies on the orthographic neighbourhood and it will not be considered in our work.

2.3. Empirical data and models on visual word recognition

The models on visual word recognition based on a serial-search mechanism have great difficulties to account for facilitatory neighbourhood size effects and facilitatory neighbourhood frequency effects. In these models, the presentation of a word activates a set of candidate word entries, orthographically similar to the presented word, and higher frequency words are checked before lower frequency words: the search continues until a correct match is found, and at this point word identification is achieved. Because the search is frequency-ordered, responses to words with many neighbours (or with at least one higher frequency neighbour) require longer times: thus, these models predict an inhibitory neighbourhood frequency effect and an inhibitory neighbourhood size effect for low-frequency words, because these words, when surrounded by many neighbours, are more likely to have high frequency neighbours than low-frequency words with few neighbours or than high-frequency words. The inhibitory neighbourhood size effect on non-words in the lexical decision task is correctly accounted for, because all neighbours would interfere with the search and delay decision making. Forster’s (1989) second version of the serial-search model no longer predicts inhibitory neighbourhood size or inhibitory neighbourhood frequency effects for word identification latencies. The crucial modification of the search model is that closely matched entries are not evaluated during the search but merely flagged: flagging is assumed to have no delaying effect on the search process. If a perfect match is found for the stimulus during the first search, the flagged entries can be ignored; if no perfect match is found, the flagged entries will be evaluated in greater detail during a second search stage. The detailed evaluation of neighbours would take place only for non-words and inhibitory size effects would occur for these stimuli, whereas there would be no detectable neighbourhood size effect on word recognition. The interactive activation account predicts the main effects reported in the visual word recognition literature. In particular, the model accounts for neighbourhood effects on words and non-words. Each lexical representation activated by letter representations provides top-down feedback to all consistent letter representations which reinforce the lexical representations. This reverberating excitatory activation between letter and word representations is thought to be responsible for the facilitatory neighbourhood size effects. Likewise, all activated word representations inhibit each other: the amount of inhibition sent out by a word is a function of its activation level, so that words with higher frequency neighbours receive more inhibition than others. This intra-word inhibition explains both the inhibitory neighbourhood frequency and neighbourhood size effects. By adding a temporal criterion mechanism to the interactive activation model, Grainger and Jacobs (1996) have developed the Multiple Readout Model, which provides a task-dependent explanation for inhibitory and facilitatory neighbourhood effects in visual word recognition. This model adds three response criteria (M (word unit criterion), Σ (lexicon criterion), and T (temporal deadline)) at the features of the interactive-activation model. A "no" response is given when the T criterion is reached first. Like in the original interactive-activation model, word recognition occurs when the representation of the stimulus word reaches a critical level of activation, that is the M criterion. A "yes" lexical decision response is generated when either the M or the Σ criterion is reached first. The Σ criterion is based on the activation level of the whole lexicon produced by the stimulus, that is the sum of the activation levels of all word units. In contrast to the M criterion, which is fixed, the Σ criterion varies according to the summed activation level produced by words and non-words during the experiment. The Σ criterion is set lower when non-words produce a low summed activation level, whereas it is set higher when non-words produce a high summed activation level. When non-words have small neighbourhoods, the Σ criterion would generally be set relatively low in comparison to the M criterion: the word stimuli will generate, on average, more lexical activity than non-word stimuli and the Σ criterion will drive responses. In this case, the Multiple Readout model correctly predicts a facilitatory neighbourhood size: words with large neighbourhoods will be more likely to be distinguished from non-words than words with small neighbourhoods, because words with large neighbourhoods will produce more lexical activity than words with small neighbourhoods. When non-words have large neighbourhoods, the Σ criterion is set high because the degree of lexical activation will not be useful for distinguishing words from non-words. The responses are driven by the M criterion and not by the Σ criterion: subjects have to wait until lexical selection is completed before giving a response. In this case an inhibitory neighbourhood frequency effect can be predicted. Thus, the Multiple Readout Model postulates that a) the facilitatory neighbourhood size effects (and any facilitatory neighbourhood frequency effects) in lexical decision do not actually arise from a lexical selection process (due to the M criterion to be reached), but it occurs, instead, when participants use the Σ criterion for responding, and (b) the inhibitory neighbourhood frequency effect is a true lexical selection effect, resulting from the intra-level competitive processes which occur before the M criterion is reached.

2.4. Orthographic neighbourhood effects in Italian

Differently from the studies on English, the literature about the neighbourhood effects in processing Italian words and non-words seems to lack a general study addressing the role of the different neighbourhood measures (neighbourhood size, frequency and distribution) in the different experimental tasks. Researchers have focused from time to time on single aspects of the matter, without trying to put together an unitary framework about the neighbourhood effects in Italian. In particular, most attention has been focused on the reading aloud task, mainly on non-word stimuli, in order to verify the existence of lexical effects in naming even in a language with a shallow orthography, like Italian. In the following paragraphs I will analyse some important studies which have constituted relevant points of reference for the research on neighbourhood effects.

2.5. Orthographic similarity and word frequency effects in lexical decision task

As we have seen in the precedent paragraphs, the study of Andrews (1989) on the neighbourhood size of visually presented English words has been inspired by the results obtained by Colombo (1986) on the relationship between orthographic similarity and word frequency in Italian. Colombo used the orthographic priming paradigm in combination with the lexical decision task: four types of primes were paired with each word and non-word target: a rhyme word prime, a control word prime, a rhyme non-word prime and a control non-word prime. For instance, the target word *fuoco* was paired with the primes *cuoco* (rhyme word prime), *guida* (control word prime), *muoco* (rhyme non-word prime) and *tolpe* (control non-word prime), while the non-word target *madio* was paired with the primes *radio* (rhyme word prime), *vuoto* (control word prime), *fadio* (rhyme non-word prime) and *zarme* (control non-word prime). The results showed an interference determined by the presence of a rhyme prime only on words: the presentation of the word prime raised the activation level in the mental lexicon not only of the corresponding unit but even of the other units sharing letters with it. When the unit corresponding to the prime reached a sufficient level of activation, it started to inhibit other competing units: the amount of inhibition spread to other units depended by the relative activation level of these units and this inhibition was active only on nodes whose activation level had exceeded a certain threshold. In a further experiment Colombo showed different results for high-frequency and low-frequency target words: she used the same experimental task but by manipulating not only the orthographic similarity but also the word frequency. Differently from the expectations of an inhibition on both high- and low-frequency words, her results showed instead a facilitation for low-frequency words primed by a rhyming neighbour. Contrary to the explanation given by Andrews about the facilitatory neighbourhood size effect based on the feedback activation (from the words level to the letters level) of the interactive activation framework, Colombo explained her experimental data according to the verification model. She observed that when the word target was orthographically similar to the prime and was a frequent word, it should have been submitted to the verification stage before the prime, with a consequent inhibition. Instead, when the word target was orthographically similar to the word but was a low-frequency word, it should not have been processed in the verification stage before the prime, with a consequent facilitation.

2.6. Neighbourhood size and neighbourhood frequency effects in non-words naming

Most of the research on the neighbourhood effects in Italian has focused on the non-words reading aloud task. In a language with a deep orthography, like English, it is quite reasonable to expect a strong influence of lexical factors in the reading process, since the print-to-sound mapping is greatly context-sensitive: for instance, the sequence *–eat* in the final word position has different pronunciations in different words (/i:t/ in *treat* , /et/ in *threat*) and it requires the knowledge of the specific word to be correctly pronounced. The sequence *–ean* in the same position, instead, may have one only possible pronunciation (/i:n/ like in *clean*). Some experiments (Andrews,1982; Glushko 1979) have showed that non-words derived from words with inconsistent endings (e.g. *breat*) required longer times to be correctly pronounced than non-words derived from words with a consistent ending (e.g. *hean*). In the past, the consistency effect has been considered as evidence for single-route models of reading: by assuming the existence of a single mechanism for converting print into sound for both words and non-words, these models predict that non-words reading should be affected by the orthographic and phonological features of known words. Contrary to this idea, the dual-route models have been revised in order to account for the consistency effect by maintaining that the lexical and non-lexical routes share an initial stage of letter identification and a final processing stage of phonemic representation, which are both involved in word and non-word reading. Job, Peressotti and Cusinato (1998) have showed that even in a language with shallow orthography, like Italian, the reading of non-words is influenced by lexical knowledge. In particular, they have focused on the pronunciation of the letters *c*, *g* and the letter cluster *sc* that all depend on the following letter(s). When followed by *a*, *o* or *u* they are pronounced /k/, /g/ and /sk/ respectively; when followed by *e* or *i* they are pronounced /tʃ/, /dʒ/ and /ʃ/. Job and colleagues distinguished two types of non-words: consistent non-words (e.g. *delicoto*) , that had the same pronunciation of the target grapheme as in the original word (e.g. *delicato*) and inconsistent non-words, which required the alternative pronunciation (e.g. *deliceto*). According to the results found in English and in Spanish (Sebastian-Gallés, 1991), naming inconsistent non-words required longer times than consistent non-words. Furthermore, Job, et al. (1998) have showed that this inhibitory effect disappeared when the experimental list did not include words stimuli: they explained this effect by observing that the presence of words in the experimental list might favour a greater use of the lexical route, while the absence of words in the experimental list might favour the use of the non-lexical route, thus lowering the possibility of lexical effects. These results are compatible with the predictions of dual-route models but not with those of single-route models that postulate an unavoidable lexical influence as a consequence of the pronunciation based on stored lexical instances.

Arduino and Burani (2004) provided further evidence in favour of lexically mediated reading in Italian by varying orthogonally neighbourhood size and neighbourhood frequency in two experiments on non-words. The high regularity of the print-to-sound mapping in Italian implies that, differently from English and French, the neighbourhood of a given Italian stimulus rarely includes neighbours with inconsistent pronunciations and that, both for words and non-words, the pronunciation resulting from lexically based reading usually converges with the pronunciation resulting from non-lexical reading. Arduino and Burani used a 2x2 factorial design where the two variables were neighbourhood size (large vs small) and neighbourhood frequency (one high-frequency neighbour vs no high frequency neighbour). They showed that in the lexical decision task the results were strongly compatible with those found in languages with deep orthography, like English and French: a significant inhibitory neighbourhood frequency effect and no effect of neighbourhood size and bigram frequency. Non-words with one high-frequency neighbour had longer decision latencies than non-words with no high-frequency neighbour while there were no differences in reaction times between non-words with a large neighbourhood and non-words with a small neighbourhood. These results may be accounted by the Multiple Read-out Model in which the activation of one high-frequency word neighbour by a non-word would contribute to the fast increasing of lexical activation in the word recognition system, thus lengthening the deadline for non-word decision. The presence of only one high-frequency word would also be crucial to avoid mutual inhibition between highly activated word units, which could reduce the lexical activation. Differently from the lexical decision task, the results found by Arduino and Burani using the naming task were not completely compatible with those found in languages with deep orthographies: a facilitatory neighbourhood size effect was found, with no effect of neighbourhood frequency, and a contribution of bigram frequency to the speed of non-words naming. The facilitatory neighbourhood size effect on non-words naming could be explained within the Dual-Route cascaded Model: the information derived from grapheme-to-phoneme conversion could interact in the phonemic buffer with information from the lexical pathway, where orthographically similar words receive some activation. The absence of neighbourhood frequency effect could be explained by assuming no additional facilitatory contribution of a word unit that, having a high level of activation, would constitute more a competitor than a contributor to non-word pronunciation. The results found by Arduino and Burani, thus suggest that, even in Italian, a language in which new letter-strings could easily and efficiently be read through non-lexical grapheme-to-phoneme conversion rules, the reading of non-words is influenced by the lexicon. The additional contribution of the frequency of sub-lexical units such as bigrams, provided further evidence for the parallel activation of lexical and non-lexical reading routes. Finally, Mulatti, Peressotti and Job (2007) starting from the idea that seriality is a relevant feature of both oral and written languages, showed that non-words diverging early from the corresponding words were read more slowly than non-words diverging late. They used non-words deriving from five-letters Italian words by changing either the first or the fourth letter: the results showed that early diverging non-words (e.g. *berpe* derived from *serpe*) required longer times to be read than late diverging non-words (e.g. *folbo* derived from *folto*). Mulatti, Peressotti and Job explained these results within the DRC model, where the non-lexical route operates serially, and a non-word deriving from a word by changing a letter in final positions should be more positively influenced by lexical knowledge than a non-word deriving by changing a letter in initial positions. The output of the non-lexical route is consistent with the one of the lexical route until the diverging letter is encountered: when the output of the two routes is consistent, the phonological lexicon reinforces the non-lexical activation in the phonemic buffer. Once the diverging letter is processed, the output of the non-lexical route becomes inconsistent with the information sent by the lexical route, thus decreasing the activation of the corresponding word unit and consequently the activation of the non-lexical route output itself: "it follows that the earlier the non-lexical route processes the diverging grapheme, the slower the lexical activation rises, and the smaller the lexical contribution to name the pseudoword will be"(*Zeading and Reazing: which is faster? The position of the diverging letter in a pseudoword determines reading time*. The quarterly journal of experimental psychology, 2007, p. 1006).

CHAPTER 3

3.1. Introduction

In this chapter I will describe the different tasks used to analyse the influence of the orthographic neighbourhood on the word recognition processes. I will focus on the reasons why researchers have based their studies on different experimental tasks to investigate the neighbourhood size and the neighbourhood frequency as keys for the comprehension of the mechanisms underlying the lexical access processes. I will consider the points of strength and weakness of each experimental task to conclude that, in the absence of a consensus as to which task provides the "purest" measure of the mental lexicon access, the best solution would be to obtain converging evidence on neighbourhood effects in a variety of task contexts. Finally, I will point out that the neighbourhood size and the neighbourhood frequency effects have to be distinguished from other relevant factors that influence the word recognition processes and, consequently, the underlying lexical access mechanisms.

3.2. A comparison between the different experimental tasks

The effects of neighbourhood structure have been investigated in a variety of tasks and using several dependent measures ranging from the standard measures of reaction times and accuracy to measures of eye-fixation durations and even-related potential waveforms. The tasks include perceptual identification, lexical decision, word naming and semantic categorization. The perceptual identification task requires that degraded stimuli are identified by subjects either through successive attempts or through a single identification response. Grainger and Segui (1990) for instance, have used a "progressive demasking" procedure, in which subjects made a single identification response to a display consisting of interleaved presentations of a target word and a mask where the length of the target exposure was progressively increased. They replicated in French the inhibitory neighbourhood frequency effect found in other languages, like English (Snodgrass and Minzer, 1993) and Spanish (Carreiras, Perea and Grainger, 1997) using the same methodology. Some researchers noticed that perceptual identification task could be subject to response-bias-effects: they have attributed the inhibitory neighbourhood frequency effect to the guessing strategies of participants. In particular, they have explained the inhibitory neighbourhood frequency effect observed in the perceptual identification task based on a single identification response (but not on that based on successive attempts at identifying the stimulus) by affirming that: "subjects guessed high-frequency neighbours because they had no opportunity to eliminate them in previous responses as they did when multiple successive responses were allowed" (Snodgrass and Minzer, p. 262). Contrary to this interpretation, Grainger and Jacobs (1996), have argued for the importance of the perceptual identification task as a direct reflection of the visual word recognition processes: in their view, single-response in perceptual identification task relies on the activation of individual word detectors rather than on the overall lexical activity. Most of the earlier research on lexical access processes has been based on the lexical decision task that requires subjects to classify stimuli as real words or non-words. The reason for its frequent use is the assumption that classification times provide the "purest" measure of the time necessary to retrieve an entry in the lexical memory. This assumption, however, has been rejected by some researchers who detected differences in the effects of different variables on the lexical decision task as compared with other tasks also requiring lexical access (Balota and Chumbley, 1984). In particular, word frequency effects have been demonstrated to be larger in lexical decision than in word naming or category verification: these differences in terms of magnitude of the effect have called in question the validity of lexical decision times as measure of lexical access. Moreover, lexical decision performances have been considered strongly influenced by strategic processes related to the decision stage, rather than "normal" lexical retrieval. Grainger and Jacobs (1996) have explained the heterogeneity of the lexical decision results by hypothesizing that lexical decision latencies sometimes might be based on overall lexical activity rather than single word identification; in particular, they have attributed the facilitatory neighbourhood size effects to lexical decision's specific processes They have concluded that unique word identification is best indexed by performances in perceptual identification tasks which generally reveal inhibitory neighbourhood influences, while lexical decision task performances can provide insight in word identification processes only in discrimination conditions where decisions cannot be based on overall lexical activity. Differently from the lexical decision task, the word naming task has gained in popularity because it requires a practiced skill that is normally part of the natural reading process, even though the fact that many stimuli can be accurately named without any lexical retrieval means that in some conditions naming could not reflect lexical access mechanisms. Indeed, while Balota and Chumbley (1984) claim that "decision processes having little to do with lexical access accentuate the word frequency effect in the lexical decision task" (p. 340), Paap et al. (1982) attribute the smaller frequency effect in naming to the involvement of non-lexical processes, and conclude that "the naming task severely underestimates the role of frequency….the lexical decision task remains the best paradigm for studying word recognition" (p. 232). However, as already reminded Chapter 2, Peereman and Content (1995) evaluated neighbourhood size effects in word naming performances as a function of whether or not words were mixed with non-words, and their analysis seems to reject the hypothesis that neighbourhood activation effects in this task do not reflect lexical retrieval but simply effects of orthographic structure (e.g., bigram or trigram frequency). Finally, Forster and Shen (1996) have focused on the semantic categorization task by arguing that this task requires lexical-semantic retrieval without the involvement of any decisional process. In particular, they have hypothesized that semantic categorization provides the critical evidence that neighbourhood effects reflect lexical retrieval processes because, while lexical decision and naming imply the use of familiarity or non-lexical procedures respectively, it requires both identification and access to meaning. Even this assumption has been confuted by other students, who have underlined that this task can be largely influenced by sophisticated guessing strategies or at least by its own specific decision processes. The fact that all of these methods for investigating lexical access may be contaminated by task-specific requirements implies that the only plausible solution is in finding convergent evidence form data obtained across different task contexts. All the above mentioned tasks might involve lexical retrieval, but they contemporarily require other processes: the critical evidence that neighbourhood structure influences lexical access processes should be provided by the fact that it exerts similar effects across a variety of tasks independently of the specific requirements of each particular task.

3.3. **A comparison between the different languages**

As already showed in Chapter 2, the heterogeneity of the results on neighbourhood effects found in different research works may be considered only apparent and is explainable by considering the peculiarities of the different languages. In particular, the degree of orthographic depth seems to be a relevant variable to be considered in order to explain the different neighbourhood effects found. All languages with a deep orthography, like English, entail that grapheme-phoneme correspondence rules have to be contextualized in specific words, while languages with shallow orthographies, like Italian and Spanish, display consistent print-to-sound mapping units: graphemes are regularly translated into the same phonemes, irrespective of word contexts. These differences in terms of spelling-to-sound systems have a relevant implication: the majority of Italian or Spanish orthographic neighbours share both the orthography and pronunciation of the common segment. So, the neighbourhood of a given Italian or Spanish stimulus, differently from English, rarely includes words with inconsistent pronunciations: the orthographic neighbours of a given stimulus are often phonological neighbours. Although French has more opaque mapping relationship, it has been estimated that 95% of French words are consistent, in the sense that they could be correctly pronounced using grapheme-phoneme corresponding rules. Facilitatory neighbourhood size effects in English could be accounted for by considering the role of orthographic bodies that play a more important role in lexical retrieval than they do in languages with a more consistent orthography-to-phonology mapping. Body units are more consistently pronounced than either vowels alone or CV units: in English orthographic body units are useful functional units because they provide systematic cues to inconsistent pronunciations. Since most neighbours are body neighbours, the neighbourhood advantage may reflect the functional status of body units in word identification. In languages with shallow orthographies other units seem to be relevant in word identification processes such as bigrams, trigrams, syllables and morphemes. Many studies have been conducted on Italian in order to account for the role of syllabic and morphemic structures on word recognition processes, but these effects cannot always be clearly distinguished from those deriving by the orthographic structures. Two morphologically related words are often orthographically similar: the existence of morphologic and syllabic relations is often mistaken for orthographic similarity. Some connectionist models hypothesize that morphological and syllabic properties are not explicitly represented in the mental lexicon but they are simply emerging properties from a lexical system that provides relationships between orthographic and phonological properties of words on the one hand and their lexical meanings on the other hand (Seidenberg and Gonnerman, 2000). Other models maintain that morphological and syllabic representations cannot be reduced to simple emerging properties from the orthographic structure and they attribute an independent status to these representations in the mental lexicon (Laudanna, Badecker and Caramazza, 1992). This question does not constitute the object of our study; we have decided to focus our attention exclusively on the orthographic structure and, in particular, on the effects of orthographic neighbourhood on word identification processes. In this chapter, we have limited ourselves to underline the complexity of results obtained on neighbourhood effects, which are also due to the differences in terms of experimental tasks used, of natural properties of the investigated languages, and of the potential confusion with other relevant variables, such as distributional and morphological factors.

3.4. **The priming paradigms**

The complexity of the results found on neighbourhood effects makes it difficult to take the role of orthographic structure out of other factors like morphology and semantics. The priming paradigm is widely used for distinguishing the relative contribution of those factors in the word recognition process. In the priming paradigm a pair of stimuli is displayed with a varying interval of time among them and the subjects have to respond (for instance by naming or by giving a lexical decision) to the second target stimulus. The first stimulus, the prime, can be identical to the target, unrelated, or related along one or more dimensions, so allowing to isolate the contributions of different factors to the processes under investigation. The use of the form (or orthographic) priming paradigm has shown that responses to word targets are influenced by the previous presentation of a prime that differs only for one letter. The most common explanation for this phenomenon is that a prime stimulus sharing letters with the target elicits activation for both word representations. Forster, Davis, Schoknecht and Carter (1987) have claimed that form priming can be considered a particular case of repetition priming. In the orthographic priming, the two words share only orthographic material (for instance, *ponte*/*conte*, bridge/count): the results obtained by using this paradigm, have shown that the orthographic neighbours compete for the recognition, especially if the presentation of the stimuli occurs under conditions that do not allow a conscious identification (Humphreys, Besner and Quinlan, 1988). Evett and Humphreys (1981) have found orthographic priming with both lexical decision and naming when associated with the masked priming: for instance, perceptual identification scores to *white* are facilitated by the prior presentation of *while*. As already noticed in Chapter 2, Colombo (1986) argued that when the prime is consciously identified, then inhibitory and not only facilitatory effects can be observed in target processing: in particular, inhibitory effects are linked to the presence of high frequency targets. Grainger and Segui (1990) have challenged this hypothesis by emphasizing that the relative frequency of the prime and the target is the relevant variable. Starting from the evidence that in single word recognition performances an interference is observed when the stimulus word is orthographically similar to a more frequent neighbour, they have hypothesized that the strong competitor must be inhibited, via an intra-level inhibition, in order to correctly identify the stimulus word. They have shown that, in a priming lexical decision task with conscious prime identification, if the target is a higher frequency neighbour (*char-CHAT)* it requires slower recognition latencies relative to an unrelated condition (*foin-CHAT*) because the target representation must be inhibited for the prime to be identified. If the target is a smaller frequency neighbour (*chat-CHAR*) it is not a strong competitor in prime identification and it does not require inhibition: in this case, target recognition latencies are not slower than in unrelated condition. Grainger and Segui have inferred that during prime word identification, selection processes operate to isolate the prime word from competing representations and remove any higher frequency competitor: this inhibitory mechanism acts only on strong competing representations. Grainger and Segui have shown completely opposite results in a masked priming lexical decision task, where there is not a conscious prime identification. In this case, if the prime is a higher frequency neighbour it determines longer target recognition latencies relative to the unrelated condition while the inhibition disappears when the prime is a lower frequency neighbour. These results are explained in terms of pre-activation of all orthographic neighbours of the prime determined by the unconscious presentation of the prime itself: when the prime is a higher frequency neighbour of the target, this could increase overall interference in target processing while with lower frequency neighbour primes this pre-activation may not be sufficient to render it competitive enough during target processing. Many studies have supported the hypothesis that the masked priming technique allows to observe priming effects in absence of any conscious identification of the prime-target relationship (Forster & Davis, 1984; Forster et al., 1987). Forster, Mohan and Hector (2003) have observed that the participants cannot even refer some properties of the prime they have been exposed to. The little time of exposure may not allow the working memory to maintain the information, so the prime would be 'forgotten' (Lachter, Durgin & Washington, 2000). By using event-related potentials and functional magnetic resonance, Dehaene, Naccache, Cohen, Bihan, Mangin, Poline & Riviere (2001) have showed that masked words produce different patterns of activation if compared with unmasked words: the unmasked words produce a largely distributed activation in multiple sites, while the masked words produce a more limited effect. It has been argued that masked priming is particularly sensitive to orthographic effects (Bowers, Vigliocco & Haan, 1998; Bodner & Masson, 1997), and that masked priming works at a prelexical level. According to the 'open entry' hypothesis, the prime acts only on orthographic grounds (Forster,1987; 1989): the presentation of a masked prime pre-activates the material that it shares with the target. On the contrary, the unmasked priming allows the identification of prime words, it is conscious and it is more sensitive to individual differences between subjects. The identification of the prime activates the working memory, and contributes to the formation of an episodic trace of the prime: for these reasons, before the target is presented, the subject might create personal expectations.

At the beginning of this chapter it was underlined that one of the most relevant problems of the single-word paradigms is represented by the difficulty to distinguish the respective influences of multiple variables on the word recognition processes: it has been shown that the priming paradigm allows isolating the individual contributions of different variables by experimentally manipulating one of them and by holding the others constant. We have reported how the priming paradigm is particularly appealing in the research on neighbourhood effects because presenting a prime stimulus, neighbour of the target provides a direct representation of the co-activation of neighbours that is presumed to occur when we identify a single word. This hypothesis is seductive but potentially misleading because the priming paradigm can provide insights about how co-activation of a neighbour might influence the identification of a target, but it does not permit to conclude that neighbours are activated by presentation of a single target word and that they affect its retrieval. An exhaustive research on neighbourhood effects in word recognition cannot set aside a cross-analysis of the results obtained by using both single-word and priming paradigms.

CHAPTER 4

Introduction

In this chapter we report three experiments on single stimuli, carried out to investigate neighbourhood size and neighbourhood frequency effects in recognition of Italian written words. We have kept the classic definitions both of neighbourhood size (the number of words that may be generated by changing one letter of the target word, preserving letter positions) and neighbourhood frequency (the relationship between the frequencies of neighbours and the frequency of the stimulus word). In the previous chapters, the review on experiments based on different experimental tasks and concerning different languages revealed a great heterogeneity of results. Starting from the study of Coltheart et al. (1977), that found an inhibitory neighbourhood size effect on non words, but no effect on English words, successive studies (e.g., Andrews, 1989) showed a neighbourhood size effect even on English word recognition, or a neighbourhood frequency effect more marked than the neighbourhood size effect – in other languages like French (Grainger and Segui, 1990; Grainger and Jacobs, 1996) and Spanish (Carreiras et al., 1997). In Italian, the research usually focused on non-word reading aloud in order to verify the influence of lexical variables in a language with shallow orthography. Arduino and Burani (2004) found a facilitatory neighbourhood size effect on non-words in the naming task and an inhibitory neighbourhood frequency effect in the lexical decision task. Our research aimed at establishing reliable data set of reference on the role of the orthographic neighbourhood structure in Italian word recognition process. Three experiments were carried out in order to test the neighbourhood size and the neighbourhood frequency effects, as well as the possible interaction between them.

Experiment 1

- Introduction

In the first experiment we have used the word naming task, according to the main trend of research on Italian. Our aim was to verify if and how a lexical factor as the neighbourhood structure affects word reading processes in a language characterized, differently from English, by a very regular print-to-sound mapping. Evidence from experiments on English and French have showed a facilitatory neighbourhood size effect: words with a large neighbourhood elicit faster reading times than words with a small neighbourhood. Arduino and Burani (2004) have reported a facilitatory neighbourhood size effect on Italian non-word reading: non-words with many neighbours are read more rapidly than non-words with few neighbours. But what does it happen for Italian words? According to the Dual Route Cascaded Model (Coltheart et al., 2001), we should expect a facilitatory neighbourhood size effect, because the lexical activation level of each phonemic unit is determined by the number of the neighbours of the input and, in a language with shallow orthography like Italian, in the phonemic buffer the outputs of lexical route non-lexical routes should coincide very often.

- Method

Stimuli

A 2x3 factorial design was employed, where the two variables were neighbourhood size (small vs large) and neighbourhood frequency (no higher frequency neighbour vs one higher frequency neighbour vs many higher frequency neighbours). The critical stimuli were five-letter bi-syllabic Italian words. In particular, 72 target words balanced for initial phoneme, syllabic structure and frequency within small and large neighbourhood conditions, were subdivided in 6 groups of words:

1) *furto* (small neighbourhood/no higher frequency neighbour);
2) *farsa* (small neighbourhood/one higher frequency neighbour);
3) *firma* (small neighbourhood/more than one higher frequency neighbour);
4) *finta* (high neighbourhood/no higher frequency neighbour);
5) *forma* (high neighbourhood/one higher frequency neighbour);
6) *fonte* (high neighbourhood/more than one higher frequency neighbour).

The whole experimental list is reported in the Appendix A**.** 72 filler words were also included: they belonged to the same categories, but they were not balanced for initial phoneme and syllabic structure.

Neighbourhood size was defined by counting the number of words that could be formed by changing one letter of each target word. For example, the word *furto* has the neighbours *fusto, furbo* and *furti* while the word *fonte* has the neighbours *conte, monte, ponte, fante, forte, finte, folte, fotte, fonde* and *fonti.* Words classified as "large neighbourhood" had at least 7 neighbours, while those classified as "small neighbourhood" had a maximum of 4 neighbours. The boundaries to distinguish words with a small neighbourhood from those with a large neighbourhood was different from the one used by Andrews (1989) (in her experiment, words with a large neighbourhood had at least 9 neighbours while those with a small neighbourhood had no more than 5 neighbours). Our criterion was determined by the different distributional properties of the two sets of stimuli: differently from the English four-letter mono-syllabic words used by Andrews, our words were all five-letter long, and had a bi-syllabic structure. The word frequency was determined on the basis of the CoLFIS (Corpus e Lessico di frequenza dell'Italiano Scritto, Bertinetto, Burani, Laudanna, Marconi, Ratti, Rolando and Thornton, 2005): in particular, we considered the surface frequency of words, since we focused exclusively on orthographic factors rather than on possible influences of semantic and/or morphological factors.

Experimental session

The whole experiment was arranged in only one session containing all the 72 targets and the 72 fillers. The session was divided in three blocks: each block was composed by 48 items, 24 targets and 24 fillers perfectly balanced in terms of the underlying categories. Six randomizations were created for the order of presentation of the blocks and each block was shown in each of the six possible positions.

Participants

Twenty participants, all students of the University of Salerno and native speakers of Italian, took part into the experiment. They were between 18 and 28 years old.

Equipment

Microphone connected to an IBM PC running the E-Prime software (version 1.1)

Procedure

A reading aloud task was used as experimental paradigm. Participants were all tested individually and were asked to read the words at a fixed distance from a microphone. The experiment was preceded by a practice session where participants were asked to give their responses in a fast and accurate way. When the participants reached the 70% of responses given in the expected time the experiment started. All the stimuli appeared in Courier New font, 18 point size, in the centre of the computer screen preceded by a "+" and accompanied by an acoustic stimulus: this fixation point lasted 250 ms and was followed by a pause of 200 ms. The targets remained on the computer screen for a maximum of 1 second. If the participants did not produce any answer within the deadline, the feedback "Fuori tempo" (Out of time) appeared on the screen; if they produced a response a confirmatory "!" appeared (Table 1).

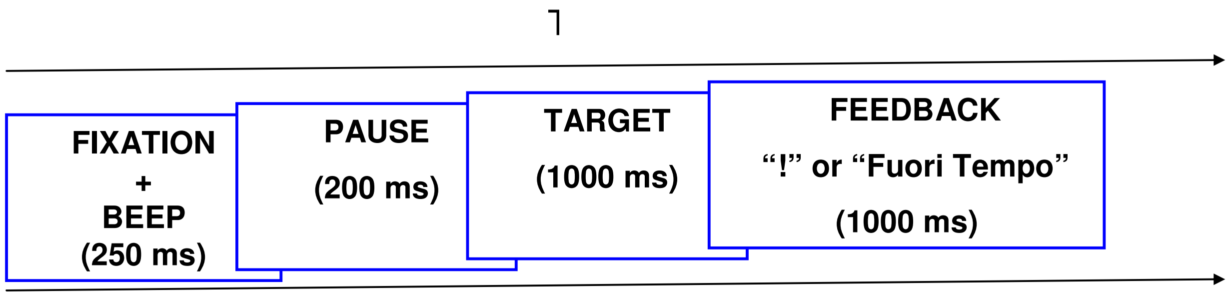

Table 1 Procedure: word naming

Reaction times were recorded from word onsets to participants' responses, the lack of a response was scored as an error. The experimenter listened to responses and recorded all the errors in order to exclude these trials from the analysis of reaction times.

- Results

Mean reaction times and percentage of errors are shown in Table 2.

	N small 0 frequency	N small 1 frequency	N small > 1 frequency	N large 0 frequency	N large 1 frequency	N large > 1 frequency
Reaction Times	491	464	469	467	463	461
Errors	2,1%	0,8%	2,1%	0,4%	1,2%	0,4%

Table 2 Mean reaction times and percentage of errors

Analyses of variance on reaction times and errors were carried out both by participants and by items. The ANOVA on reaction times showed a facilitatory neighbourhood size effect both in the analysis by participants [$F_{(1,19)}$=14,96; *p<.001*] and, marginally, in the analysis by items [$F_{(1,64)}$=3,34; *p<.07*]. The ANOVA on errors confirmed this facilitatory neighbourhood size effect in the analysis by participants [$F_{(1,19)}$=3,70; *p<.06*] while it did not reveal any significant result in the analysis by items [$F_{(1,64)}$=2,68; *p<.1*]. Moreover, the ANOVA on reaction times in the analysis by participants showed a facilitatory neighbourhood frequency effect only in the small neighbourhood condition [Fs(2.38)=7.96; *p<.001*] (Table 3), with shorter reaction times on words having few neighbours or at least one higher frequency neighbour. No cumulative neighbourhood frequency effect was found: the presence of at least one higher frequency neighbour seemed to be sufficient to speed the word reading times in the condition of small neighbourhood and the presence of more than one higher frequency neighbour did not seem to further improve performances.

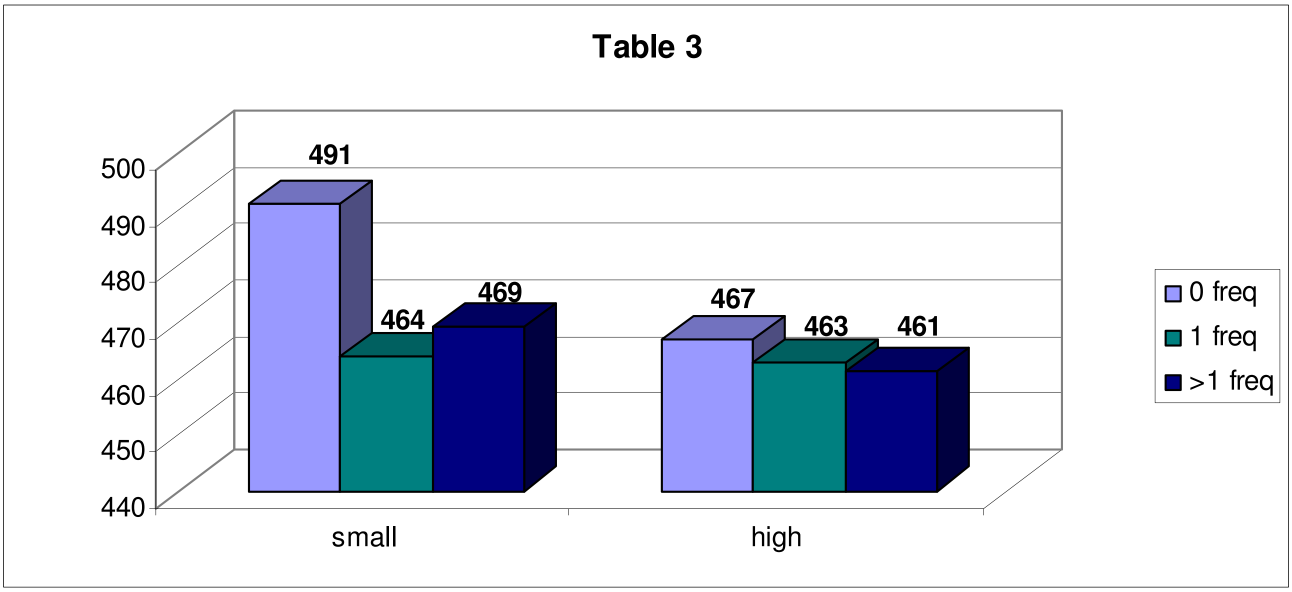

Table 3 Mean reaction times

To verify whether the facilitatory neighbourhood size effect was simply due to a difference in terms of word frequency between the small neighbourhood condition and the high neighbourhood condition we carried out a regression analysis by considering the words frequencies as the predictor, and the mean reaction times as the criterion. We found a negative correlation between these two factors but not significant (R = - 0,033; $p = .8$) We carried out a post-hoc analysis by selecting 60 words arranged in four categories obtained by varying word frequency (low vs high) and neighbourhood size (small vs high). The analysis of variance on reaction times by subjects showed a significant facilitatory effect of neighbourhood size only for low frequency words [Fs(1.19)=4.30; $p=.05$] (Table 4).

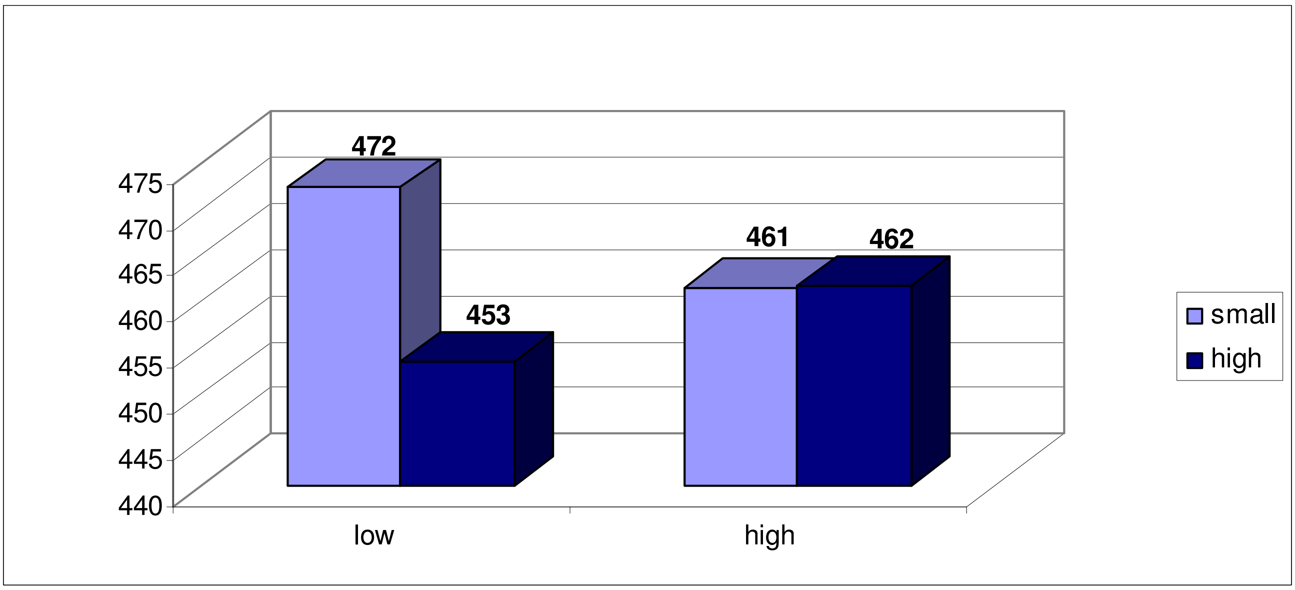

Table 4 Mean reaction times obtained replying the experimental design of Andrews (1989).

Experiment 2

- Introduction

In the second experiment we used the simple lexical decision task in order to verify the presence of neighbourhood effects even in a task different from the one (word naming) that attracted great part of interest on Italian. The studies carried out by using this task have revealed a great heterogeneity of results among the different languages. The first study on neighbourhood size by Coltheart et al. (1977) did not detect any effect on recognition of English words, while it revealed an inhibitory effect on non-word rejection process: English non-words with a large neighbourhood had longer decisional latencies than those with a small neighbourhood. Andrews (1989) failed to replicate these results: she underlined that when varying orthogonally neighbourhood size (small vs large) and word frequency (low vs high) the presence of a neighbourhood size effect was clear not only on non-words, but even on English words. In particular, her results showed a facilitatory neighbourhood size effect for low frequency words but not for high frequency words. Grainger and Jacobs (1996), Grainger and Segui (1990) and Carreiras et al. (1997) in their studies on French and Spanish, respectively reported a significant influence of neighbourhood frequency rather than of neighbourhood size in the lexical decision task. They showed an inhibitory neighbourhood frequency effect, such that words with at least one higher frequency neighbour had longer decisional latencies than words without any higher frequency neighbour. Furthermore, no cumulative effect was found: the presence of only one higher frequency neighbour was sufficient to lengthen reaction times and to reduce the accuracy of performances. But what does it happen in Italian? As already shown up, the lexical decision task has been almost ignored: in our experiment, in accordance with the Multiple Read-out Model (Grainger & Segui, 1996), an inhibitory neighbourhood frequency effect was predicted, because the presence of at least one higher frequency neighbour should raise the total activation of the lexicon and lengthen the recognition times for the input.

- Method

Stimuli

The same experimental design of Experiment 1 was used. We added 18 target words to the 72 target stimuli of Experiment 1, grouped in the six categories – obtained by varying neighbourhood size and neighbourhood frequency – and 90 target non-words balanced for initial phoneme and syllabic structure. Non-words were classified as non-words having one or more than one high frequency neighbour if they had one or more than one neighbour with frequency >50. The 6 groups of non words were defined as follows:

1) *curbo* (small neighbourhood/no high frequency neighbour);
2) *culva* (small neighbourhood/one high frequency neighbour);
3) *carba* (small neighbourhood/more than one high frequency neighbour);
4) *cance* (high neighbourhood/no high frequency neighbour);
5) *colca* (high neighbourhood/one high frequency neighbour);
6) *calto* (high neighbourhood/more than one high frequency neighbour).

The whole experimental list is reported in the Appendix B**.** 54 filler words and 54 filler non words were also included: they were subdivided in the six categories but they were not balanced for initial phoneme and syllabic structure.

Experimental session

The whole experiment was arranged in only one session containing all the 180 targets and the 108 fillers. The session was divided in four blocks: each block was composed by 72 items, 45 targets and 27 fillers, perfectly balanced in terms of underlying categories. Eight randomizations were created for the order of presentation of the blocks and each block was shown in each of the eight possible positions.

Participants

Thirty participants, all students of the University of Salerno and native speakers of Italian, took part into the experiment. They were between 18 and 29 years old.

Equipment

Hand-held device connected to an IBM PC running the E-Prime software (version 1.1)

Procedure

A simple lexical decision task was used as experimental paradigm. Participants were instructed that they would have been presented with words and non-words and that they had to decide about the lexicality of the stimulus by pressing one of two response buttons. Word responses had to be given with the dominant hand, and participants were instructed to respond as quickly as possible, also keeping a reasonable level of accuracy. The experiment was preceded by a practice session: when the participants reached at least the 70% level of correct responses, the experiment started. All the stimuli appeared in Courier New font, 18 point size in the centre of the computer screen preceded by a "+" accompanied by an acoustic stimulus: this fixation point lasted 200 ms and was followed by a 300 ms pause. The targets remained on the computer screen for a maximum of 1 second. If the participants did not produce any answer within 1 second, the feedback “Fuori tempo” (Out of time) appeared in the screen (Table 5).

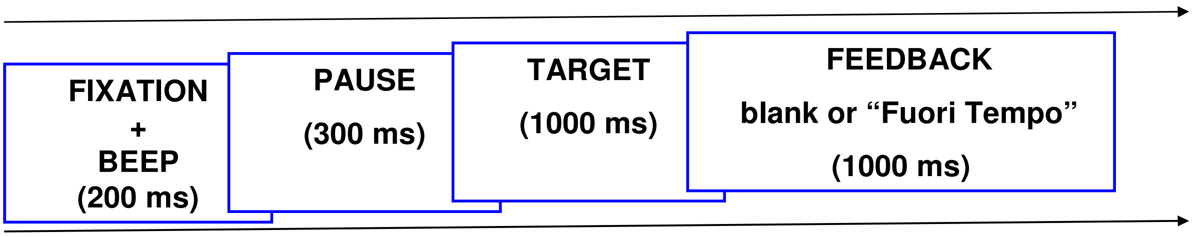

Table 5 Procedure: simple lexical decision

Reaction times were recorded from word onset to the response, the lack of a response was scored as an error and cumulated with incorrect responses. These trials were excluded from the analyses on reaction times.

- Results

Mean reaction times and percentage of errors on words and non-words are shown in Tables 6 and 7 respectively.

	N small 0 frequency	N small 1 frequency	N small > 1 frequency	N large 0 frequency	N large 1 frequency	N large > 1 frequency
Reaction Times	540	544	538	498	512	511
Errors	5,1%	4,4%	3,3%	1,7%	2,8%	3,3%

Table 6 Mean reaction times and percentage of errors on words

	N small 0 frequency	N small 1 frequency	N small > 1 frequency	N large 0 frequency	N large 1 frequency	N large > 1 frequency
Reaction Times	600	611	606	610	631	628
Errors	4%	3,5%	4,4%	3,7%	6%	6,4%

Table 7 Mean reaction times and percentage of errors on non-words

Analyses of variance on reaction times and errors were carried out both by participants and by items on words as well as on non-words. The ANOVA on reaction times on words showed a facilitatory neighbourhood size effect both in the analysis by participants [$F_{(1,29)}$=114,34; *p<.0001*] and in the analysis by items [$F_{(1,78)}$=12,52; *p<.001*] (Table 8). The ANOVA on errors confirmed this facilitatory neighbourhood size effect both in the analysis by participants [$F_{(1,29)}$ = 6,69; *p<.025*] and marginally by items [$F_{(1,78)}$ = 3,31; *p<.07*].

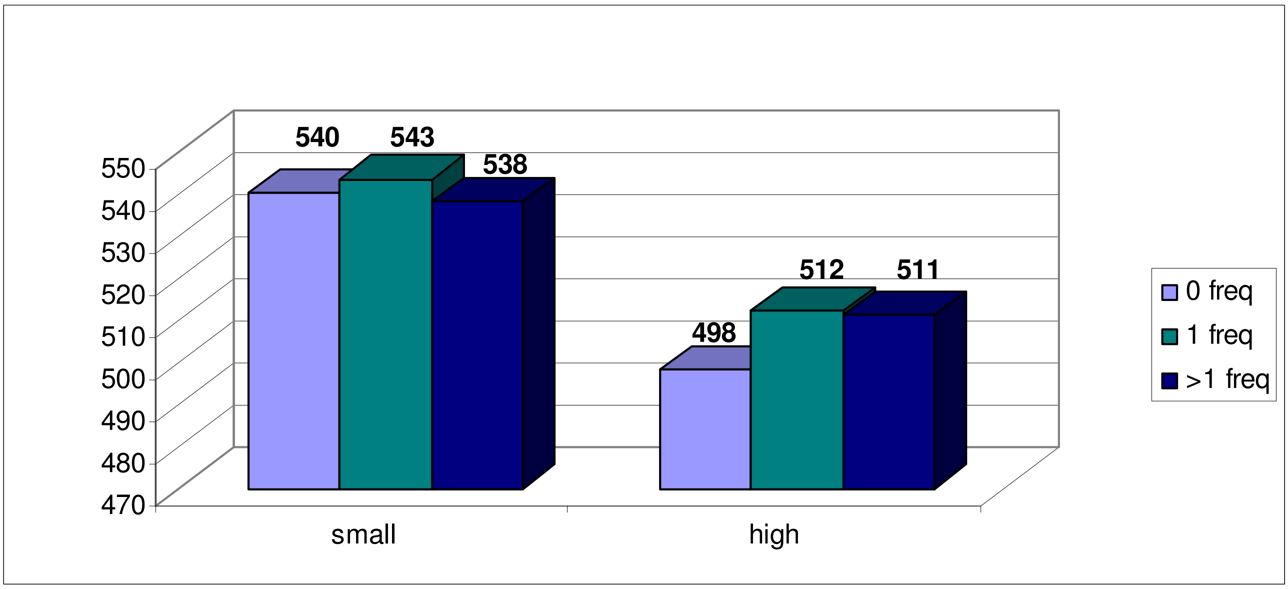

Table 8 Mean reaction times on words

Contrary to results on words, the ANOVA on reaction times on non-words showed an inhibitory neighbourhood size effect both in the analysis by participants [$F_{(1,29)}$=17,07; *p<.0001*] and in the analysis by items [$F_{(1,78)}$=6,98; *p<.001*] (Table 9). The ANOVA on errors confirmed this inhibitory neighbourhood size effect in the analysis by items [$F_{(1,78)}$=4,16; *p<.05*] while it did not reveal any significant result in the analysis by participants [$F_{(1,29)}$=2,06; *p<.2*] .

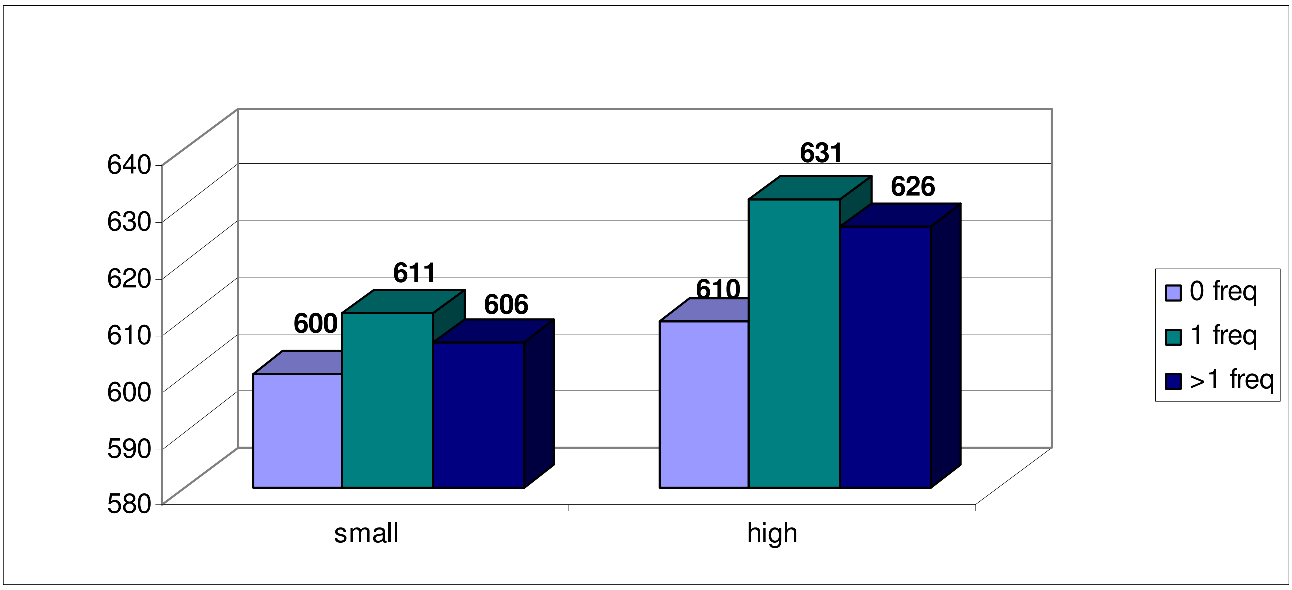

Table 9 Mean reaction times on non-words

Finally, the ANOVA on reaction times in the analysis by participants revealed an inhibitory effect of neighbourhood frequency only in the large neighbourhood condition both for words

[F(2.58)=3.12; *p<.05*] and non-words [Fs(2.58)=7.86; *p<.001*] (Tables 8 and 9), with slower reaction times on stimuli having a large neighbourhood and at least one higher frequency neighbour. No cumulative neighbourhood frequency effect was found.

As for word naming, even for lexical decision task, we carried out a regression analysis by considering as factors the words frequencies as the predictor, and the mean reaction times as the criterion, in order to ascertain whether the facilitatory neighbourhood size effect was simply due to a difference in word frequency between the small neighbourhood condition and the large neighbourhood condition. Differently from the word naming task, we found a significant negative correlation between these two factors (R = -0,34; *p<.0001*) (Table 10).

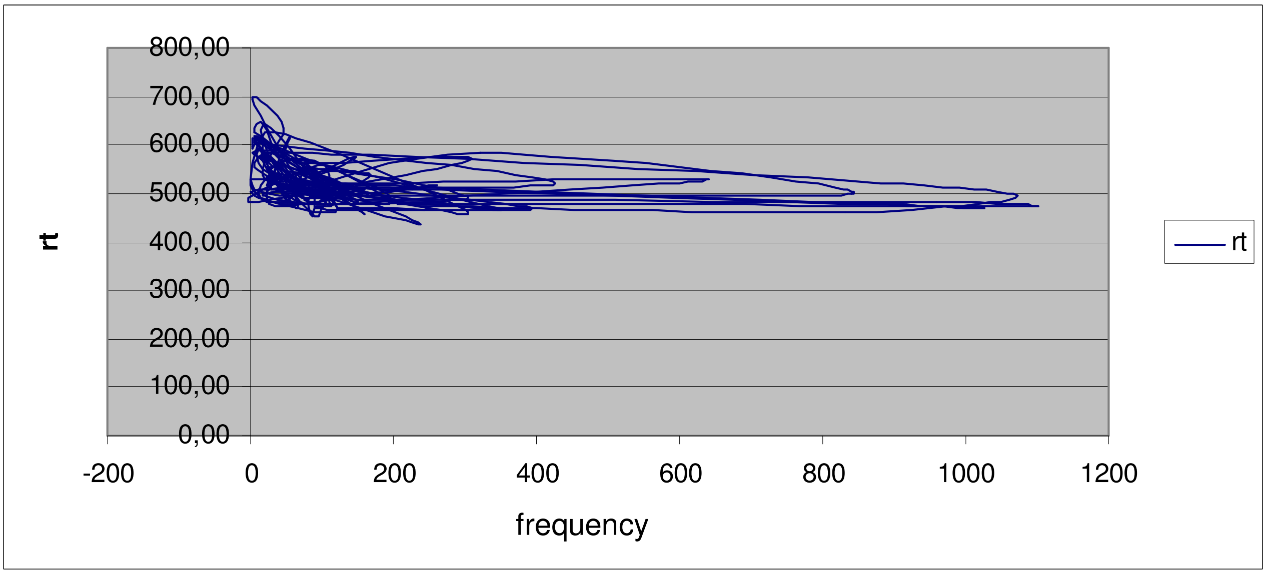

Table 10 The regression analysis between words frequencies and mean reaction times

We carried out a post-hoc analysis by selecting the same 60 words selected in the first experiment and arranged in the four categories obtained by varying word frequency (low vs high) and neighbourhood size (small vs high). The analysis of variance on reaction times by participants showed a significant facilitatory effect of neighbourhood size only for low frequency words [F(1.29) = 8,21; *p<.01*].

Experiment 3

- **Introduction**

In Experiment 3, based on a single word paradigm, we used the non-word naming task in order to verify the results on Italian previously found by other researchers. The interest in the analysis of non-word reading process has been stimulated by the need to verify the putative presence of lexical effects in a language with a shallow orthography. In particular, Arduino and Burani (2004) used a 2x2 factorial design where the two variables were neighbourhood size (large vs small) and neighbourhood frequency (one high frequency neighbour vs no high frequency neighbour). Their results were not completely compatible with those found in languages with deep orthographies: a facilitatory neighbourhood size effect was confirmed, with no effect of neighbourhood frequency, but, contrary to the data on non-word naming in English (Andrews, 1992), a contribution of bigram frequency to the speed of non-word naming was found. These data could be explained within the Dual-Route cascaded Model. Arduino and Burani suggested that even in Italian, where the novel letter-strings could easily and efficiently be read through non-lexical grapheme-to-phoneme conversion rules, non-word reading is positively influenced by the lexicon, while the supplementary contribution of the frequency of sub-lexical units, such as bigrams, provides further evidence for the parallel activation of lexical and non-lexical reading routes. But what does it happen in a non-word naming task when an enlarged design is used? And are there differences among the results obtained by using a fixed experimental list and a mixed one?

- Method

Stimuli

The same experimental design of Experiments 1 and 2 was used. We used 72 five-letter non-words, organized into six categories, obtained by crossing neighbourhood size and neighbourhood frequency and balanced for initial phoneme, syllabic structure and position of letter changed from initial real words. Like in Experiment 2, non-words were classified as non-words having one or more than one high frequency neighbour if they had one or more than one neighbour with frequency > 50. The 6 groups of non-words were defined as follows:

1) *dervo* (small neighbourhood/no high frequency neighbour);
2) *darza* (small neighbourhood/one high frequency neighbour);
3) *denza* (small neighbourhood/more than one high frequency neighbour);
4) *dampa* (high neighbourhood/no high frequency neighbour);
5) *dordo* (high neighbourhood/one high frequency neighbour);
6) *donte* (high neighbourhood/more than one high frequency neighbour).

We subdivided the experiment in two "sub-experiments": indeed these target non-words were included both in a fixed list, with 72 filler non-words, and in a mixed list with 72 filler words (for the most part, the same used in Experiment 1).

Experimental session

The whole experiment was arranged in two sessions, each containing 72 targets and 72 fillers. The difference among the two sessions was determined by the presence of different fillers: in one session target now-words were mixed with filler non-words while in the other session target non-words were mixed to filler words. Each session was divided in three blocks: each block was composed by 48 items, 24 targets and 24 fillers perfectly balanced in terms of underlying categories. Six randomizations were created for the order of presentation of the blocks and each block was shown in each of the six possible positions.

Participants

Forty participants, all students of the University of Salerno, and native speakers of Italian, took part into the experiment. Twenty of them were exposed to the fixed list while the others were submitted to the mixed list. Their age was between 18 and 29 years.

Equipment

Microphone connected to an IBM PC running the E-Prime software (version 1.1)

Procedure

A reading aloud task was used as experimental paradigm. Participants were all tested individually and were asked to read the words at a fixed distance from a microphone. The experiment was preceded by a practice session where participants were asked to give their responses in a fast and accurate way. When the participants reached the 70% of responses given in the expected time the experiment started. All the stimuli appeared in Courier New font, 18 point size, in the centre of the computer screen preceded by a "+" and accompanied by an acoustic stimulus: this fixation point lasted 250 ms and was followed by a pause of 200 ms. The targets remained on the computer screen for a maximum of 1 second. If the participants did not produce any answer within the deadline, the feedback "Fuori tempo" (Out of time) appeared on the screen; if they produced a response a confirmatory "!" appeared (Table 1).

- Results

Mean reaction times and percentage of errors within the fixed list and the mixed list are showed in Tables 11 and 12, respectively.

	N small 0 frequency	N small 1 frequency	N small > 1 frequency	N large 0 frequency	N large 1 frequency	N large > 1 frequency
Reaction Times	567	526	512	516	516	511
Errors	2,9%	5,4%	1,2%	3,3%	1,2%	1,2%

Table 11 Mean reaction times and percentage of errors within the fixed list

	N small 0 frequency	N small 1 frequency	N small > 1 frequency	N large 0 frequency	N large 1 frequency	N large > 1 frequency
Reaction Times	529	525	502	506	498	485
Errors	2,5%	4,6%	2,1%	3,7%	0,8%	1,2%

Table 12 Mean reaction times and percentage of errors within the mixed list

Analyses of variance on reaction times and errors were carried out both by participants and by items in the fixed list condition as well as in the mixed list condition. In the fixed list condition, the ANOVA on reaction times showed a facilitatory neighbourhood size effect both in the analysis by participants [$F_{(1,19)}$=27,86; *p<.0001*] (Table 13) and in the analysis by items [$F_{(1,66)}$=4,08; *p<.05*]. The ANOVA on errors was not significant in the analyses both by participants and by items. Moreover, the ANOVAs on reaction times revealed a facilitatory neighbourhood frequency effect only in the small neighbourhood condition [by partcipants: $F_{(2.38)}$ = 14,88; *p<.0001,* and by items $F_{(2.66)}$=3,18; *p<.05*] with faster reaction times on non-words having few neighbours and at least one high frequency neighbour. A lightly relevant cumulative neighbourhood frequency effect was found only in the analysis by participants [$F_{(2.38)}$=14,30; *p=.05*] but it did not result significant in the analysis by items [$F_{(2,66)}$=2,27; *p<.4*]. We may conclude that the presence of at least one high frequency neighbour is sufficient to reduce the non-word reading times in the condition of small neighbourhood and that the presence of more than one high frequency neighbour does not further improve performances.

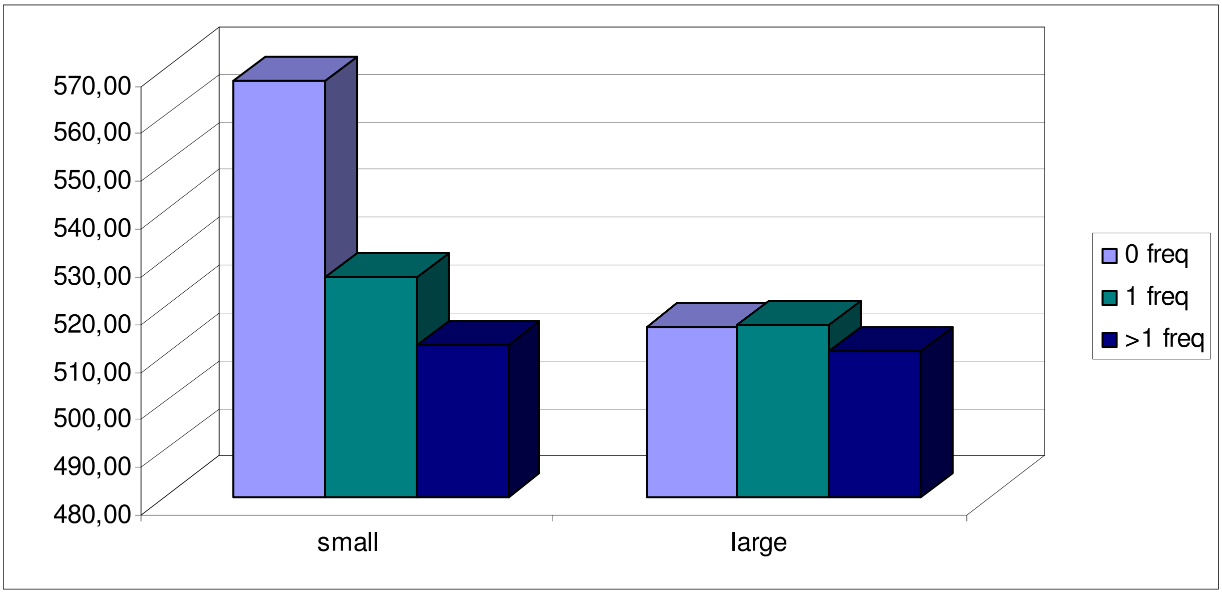

Table 13 Mean reaction times within the fixed list

In the mixed list condition, the ANOVA showed partially different results. The analysis on reaction times both by participants [$F_{(1,19)}$ = 31,23; *p<.0001*] and by items [$F_{(1,66)}$ =7,98; *p<.01*] confirmed a facilitatory neighbourhood size effect. The results of the ANOVA on errors were not significant both by participants and by items. The ANOVA on reaction times by participants did not show a significant interaction between neighbourhood size and neighbourhood frequency: a post-hoc LSD Test showed a facilitatory neighbourhood frequency effect but, differently from the fixed list condition, this effect was relevant both in the small neighbourhood and in the large neighbourhood conditions, and it seemed to emerge only in presence of more than one high frequency neighbour (Table 14).

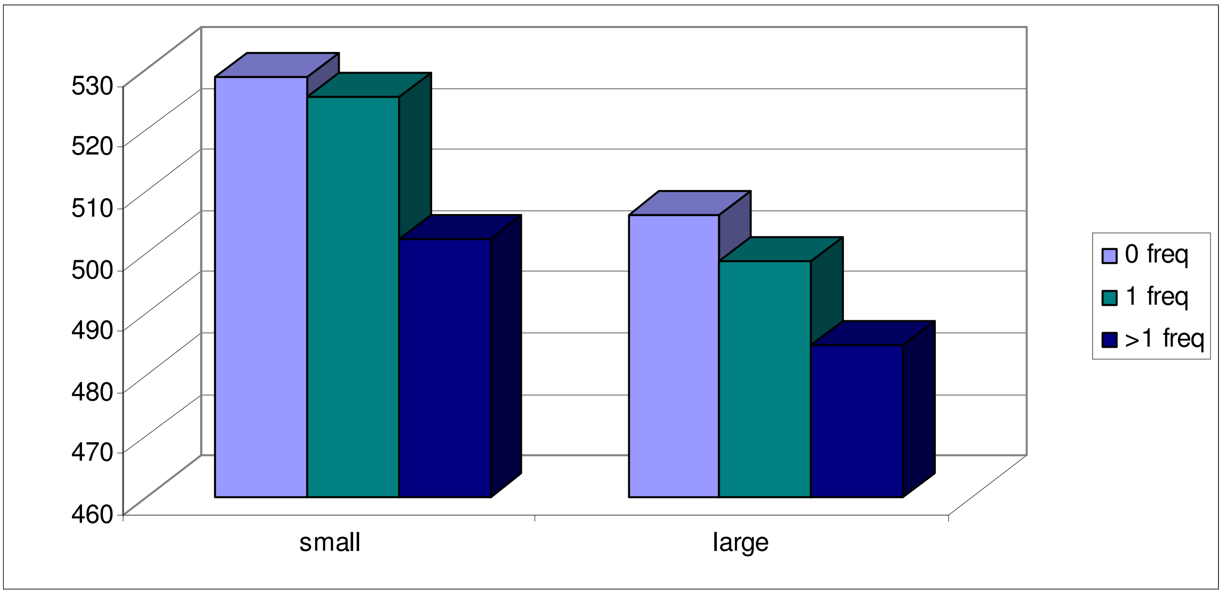

Table 14 Mean reaction times within the mixed list on non-words

Finally, we carried out an ANOVA also on the filler words (which were mostly the same words used in the first experiment) in order to verify the reliability of previous results: the analysis on reaction times by participants replicated the facilitatory neighbourhood size effect - even though it was weaker than the one found in the first experiment [$F_{(1,19)}$ = 3,16; *p<.09*] - and the facilitatory neighbourhood frequency effect only in the small neighbourhood condition [$F_{(2,38)}$ = 11,70; p<*.0001*] (Table 15).

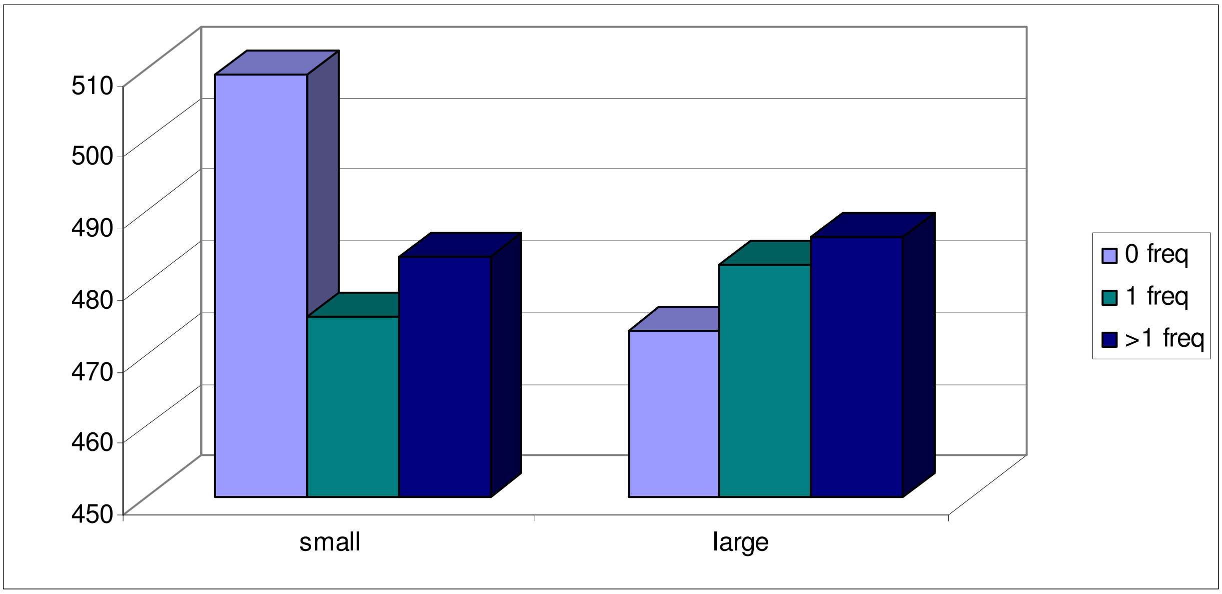

Table 15 Mean reaction times within the mixed list on words

In order to account for the different results found by using the same non-word targets in the fixed and in the mixed list, we carried out a regression analysis by considering the trigram frequency as the predictor, and the mean reaction times detected in the two sessions as the criteria. We started from the hypothesis that the different results obtained in the two sessions were determined by a greater influence of sub-lexical variables like trigram frequency in the fixed list condition due to a weaker activation of the lexical route in a context of only non-words. We found a significant negative correlation between these two factors both in the fixed list condition (R = - 0,38; *p*< *.001*) and in the mixed list condition (R= -0,29; *p*< *.025*) but, as predicted, the effect was stronger in the former condition (Tables 16 and 17, respectively).

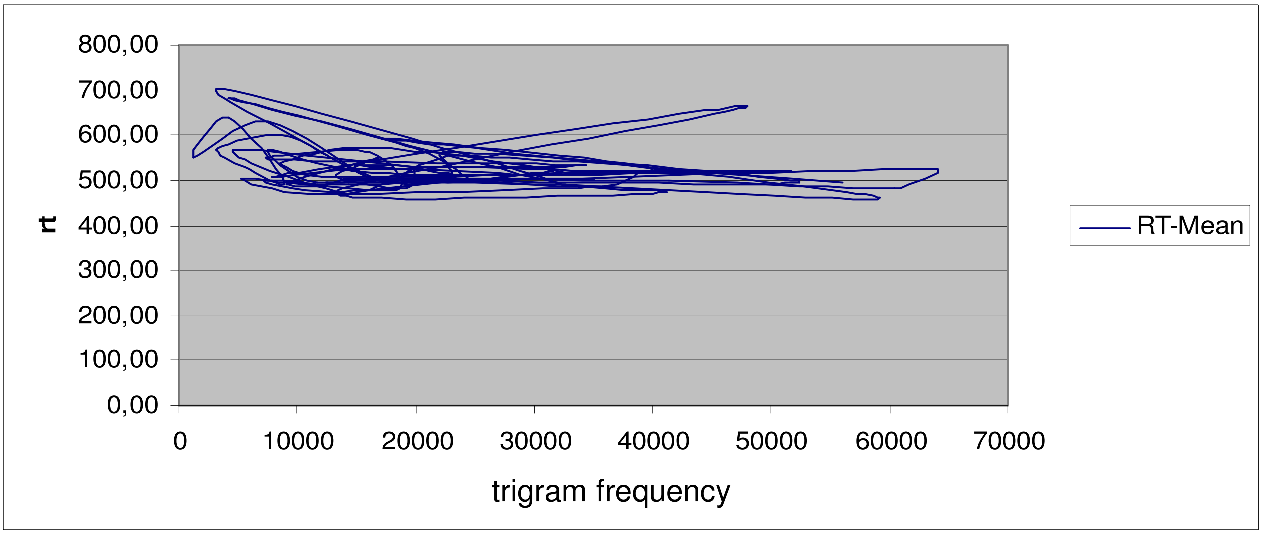

Table 16 Regression analysis in the fixed list

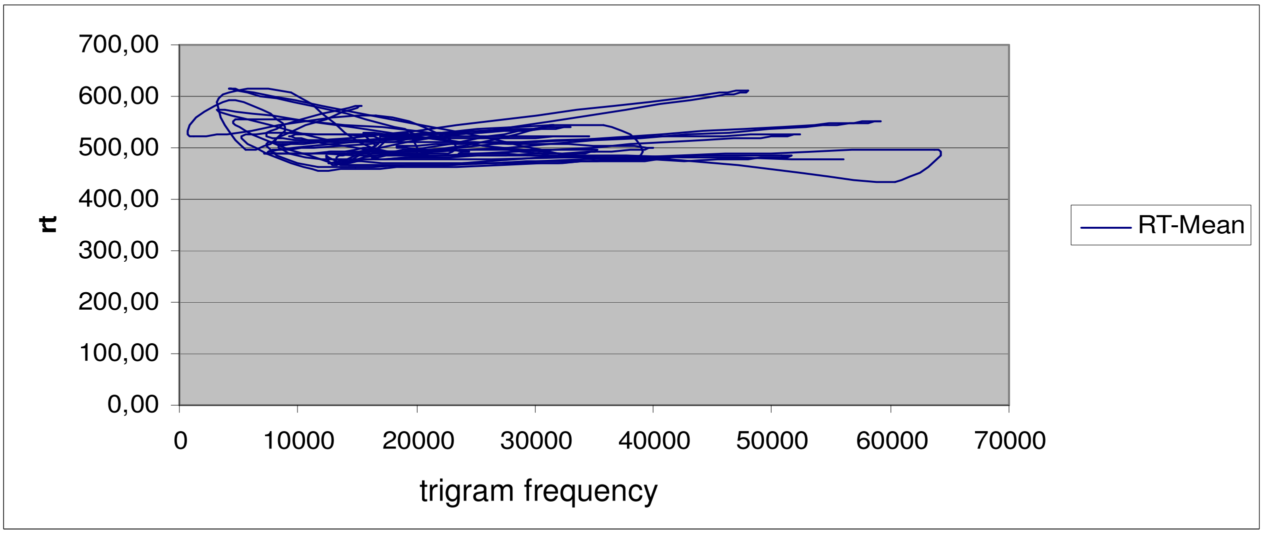

Table 17 Regression analysis in the mixed list

- Discussion and conclusions

Our results are compatible with those found by Andrews (1989): we have detected a significant inhibitory neighbourhood size effect on non-words in Experiment 2 – in agreement also with the data found by Coltheart et al. (1977) - and a significant facilitatory neighbourhood size effect exclusively on low-frequency words both in Experiment 1 and in Experiment 2 (contrary to Coltheart et al.'s results). Furthermore, in Experiment 1 we did observe a facilitatory non-cumulative neighbourhood frequency effect, limited to the "small neighbourhood" condition. Then, the inhibitory non-cumulative neighbourhood frequency effect in Experiment 2 replicates the data found by Grainger et al. (1989), even though our study showed that this effect is restricted to the large neighbourhood condition both for words and non-words and that a significant neighbourhood size effect still endures. The results of Experiment 2 are also partially compatible with those found by Arduino & Burani (2004), who showed a significant inhibitory effect of neighbourhood frequency for non-words in the lexical decision task, but no effect of neighbourhood size. Our data can be interpreted in light of the Multiple Read-Out Model (Grainger & Jacobs, 1996), which predicts and simulates reaction times to both words and non-words through the total activation of the lexicon: the total activation of the orthographic input is correlated with the number of its neighbours and with their frequencies. The absence of cumulative neighbourhood frequency effect can be explained within this model by assuming that, since the total lexical activation is determined by the number of neighbours of the input, a significant neighbourhood size effect is expected, but this effect is influenced by the number of higher and high frequency neighbours. In presence of only one neighbour of this kind, the strong activation of a unique lexical entry increases the total lexical activation and slows down the times for recognizing the input: the presence of two or more higher and high frequency neighbours does not elicit the inhibitory effect, because of the reduction of the lexical activation due to the lateral inhibition mechanisms. Moreover, the results of Experiment 3 in the mixed list condition, replicate those by Arduino & Burani on non-word naming in particular for the presence of a facilitatory neighbourhood size effect and for the absence of both a neighbourhood frequency effect in the "one high frequency neighbour" condition and of an interaction between neighbourhood size and neighbourhood frequency. Our data (based on a 2x3 design, which separated non-words with one high frequency neighbour from those with more than one high frequency neighbour) also reveal a facilitatory neighbourhood frequency effect in the latter condition. Furthermore, the different results obtained in the fixed list condition of Experiment 3 confirm that the composition of the experimental list is a relevant variable to be considered, as suggested by Job, Peressotti and Cusinato (1998). Differently from these results, however, our data showed that the influence of lexical variables, like the neighbourhood size, does not disappear in the fixed list condition: it seems to be only partially reduced, and this is easily explainable by considering the greater influence of sub-lexical factors, such as trigram frequency, in the fixed list condition, as showed by our post-hoc regression analysis involving trigram frequency and reaction times. The results of Experiments 1 and 3 also allow us to reject the hypothesis that the homogeneity of results found in literature on facilitatory neighbourhood effects on word and non-word naming is explainable in terms of a confounding with bigram or trigram frequency effects. We replicate on Italian the results found by Peereman and Content on French: if neighbourhood effects would actually be ascribed to sub-lexical variables, our data should reveal weaker neighbourhood size effects in word naming when the words are presented within a context of other words (Experiment 1) rather than when they are mixed with non-words (Experiment 3, mixed list condition). Thus, we may confirm that even in a language with shallow orthography, like Italian, the reading process of both words and non-words is influenced not only by sub-lexical factors (e.g., trigram frequency, as shown by our results, or bigram frequency, as shown by Arduino and Burani's results) but also by lexical factors, like neighbourhood size and neighbourhood frequency.

Summing up, our data on word and non-word naming corroborate the Dual-Route Cascaded Model predictions: the facilitatory neighbourhood size effect is explainable by considering that the information derived from grapheme-to-phoneme conversion rules and the information from the lexical pathway, where orthographically similar words receive some activation are combined together in the phonemic buffer. The non-cumulative neighbourhood frequency effect in word naming only in the small neighbourhood condition could be explained by assuming that the presence of just one higher frequency word among few neighbours reinforces the lexical route output in the phonemic buffer more weakly than when the higher frequency word is accompanied by other higher frequency words, or it is distributed over many neighbours. The different results obtained on neighbourhood frequency effects in non-word naming within the fixed vs mixed list condition is explainable in terms of different reading strategies used by participants. The Dual Route Cascaded Model implies the parallel use of lexical and non-lexical routes even in non-word naming but it is reasonable to hypothesize that in the fixed list condition the lexical route is less activated than in the mixed list condition. Hence, in the fixed list, the presence of only one high frequency word among few neighbours seems to be sufficient to activate the lexical route and to reduce non-word reading times. On the contrary, in the mixed list, the lexical route is already activated by the presence of words and the existence of just one high frequency neighbour seems to be not sufficient to improve non-word reading times: the presence of more than one high frequency neighbour is required in order to reinforce the non-lexical output in the phonemic buffer.

More generally, our study corroborates the interactive activation framework for lexical access which assumes both facilitatory and inhibitory neighbourhood size and neighbourhood frequency effects (Table 18).

	LEXICAL DECISION		WORD NAMING	NON-WORD NAMING	
	Words	Non-words		Fixed list	Mixed list
N-SIZE	Facilitation	Inhibition	Facilitation	Facilitation	Facilitation
N-FREQUENCY	Non-cumulative inhibition in large N	Non-cumulative inhibition in large N	Non-cumulative facilitation in small N	Non-cumulative facilitation in small N	Cumulative facilitation

Table 18 A synthesis of the neighbourhood size and the neighbourhood frequency effects found in our experiments

CHAPTER 5

EXPERIMENT 4

- Introduction

In this chapter, a fourth experiment carried out by using the priming paradigm will be described. In Chapter 3 it was argued that the use of the priming paradigm is aimed to isolate the respective contributions of the different factors that affect the word recognition processes. We have used the orthographic priming with the exclusive interest of evaluating the effects of the orthographic neighbourhood structure on lexical access mechanisms. We have previously observed that the results obtained in literature by using the masked priming paradigm are completely different from those derived by the unmasked priming. In particular, the conscious identification of the prime determines longer lexical decision latencies when the target is a neighbour of higher frequency than the prime, while the effect disappears when the target is a neighbour of lower frequency than the prime. In a masked priming condition, the effect is opposite: when the prime is a neighbour of higher frequency slower lexical decision latencies are observed, and the effect disappears when the prime is a lower frequency neighbour. Starting from these data we carried out Experiment 4 by using the unmasked priming paradigm in a lexical decision task.

- Method

Stimuli

We selected 72 pairs of five-letter Italian words that differed only by one letter in the same position and had contrasting frequencies. For each pair a control prime word was chosen that did not share any letter with the corresponding target word and was approximately of the same frequency as the experimental prime word. Thus, for instance, for the experimental pair *bordo/borgo* (*border/village*) the control pair *quota/borgo* (*share/village*) was created. 48 experimental pairs of words were characterized by the presence of a prime that was a higher frequency neighbour of the target while the remaining 24 pairs were characterized by the presence of a lower frequency prime than the target. The word pairs with a prime of higher frequency than the target were classified in four different categories obtained by varying neighbourhood size (small/large) and neighbourhood frequency (only one higher frequency neighbour/ more than one higher frequency neighbour) with respect to the target. The word pairs with a lower frequency prime were classified in two different categories, on the basis of the neighbourhood size of the target (small/large). The 6 classes of word pairs were balanced for syllabic structure, target frequency and the ratio between target frequency and prime frequency. Beyond these 72 experimental pairs, we selected 48 experimental nonword-word pairs, in order to verify the influence of non-words in lexical decision latencies on target words: these 48 pairs of stimuli were classified in four categories, analogous to those described for the word pairs with a higher frequency prime than target. Even in this case for each experimental pair, like **tadro/ladro* there was a control pair like **nuosa/ladro*. The list of the 72 experimental similar word-word pairs, 72 control pairs, 48 experimental similar nonword-word pairs, and 48 nonword-word control pairs was completed by filler pairs of stimuli: 36 dissimilar word-word pairs, 60 dissimilar nonword-word pairs, 36 similar word-nonword pairs, 72 dissimilar word-nonword pairs, 24 similar nonword-nonword pairs, 84 dissimilar nonword-nonword pairs.

The whole experimental list is reported in **Appendix D.**

Experimental session

The whole experiment was arranged in two different sessions: each session contained all the 72 target words preceded by words and all the 48 target words preceded by nonwords but each target was presented only once in one of the two experimental conditions (either preceded by a similar word/nonword or preceded by an unrelated word/nonword). The two different conditions were equally distributed in the two sessions. Each session was divided in six blocks and each block was composed of 72 pairs of items: 6 experimental similar word-word pairs, 4 experimental similar nonword-word pairs, 6 control unrelated word-word pairs, 4 control unrelated nonword-word pairs, 6 filler word-word pairs, 10 filler nonword-word pairs, 12 filler word-nonword pairs, 6 similar word-nonword pairs, 14 filler nonword-nonword pairs, 4 similar nonword-nonword pairs. Six randomizations were created for the order of presentation of the blocks and each block was shown in each of the six possible positions.

Participants

Forty-four participants, all students of the University of Salerno, and native speakers of Italian, took part into the experiment. Their age varied between 18 and 28 years. Each participant was submitted to a single experimental session.

Equipment

Response box connected to an IBM PC running the E-Prime software (version 1.1)

Procedure

The unmasked priming was used as experimental paradigm, with a lexical decision task. The experiment was preceded by a practice session and participants were asked to be as fast and accurate as possible. They had to press on two buttons: the one corresponding to their dominant hand for the decision "word", the other for the decision "non-word". When the participants reached the level of 70% of correct responses in the practice session, the experiment started. All the stimuli appeared in Courier New font, 18 point size in the centre of the computer screen preceded by a "+" and a contemporary acoustic stimulus: the fixation point lasted for 200 ms, followed by a 40 ms pause. This pause was followed by the presentation of the prime for 190 ms. After another pause of 50 ms, the target appeared and remained on the computer screen for a maximum of 1 second. If the participants did not produce any response within the 1 second limit, the feedback "Fuori tempo" (Out of time) appeared on the screen (Table 19).

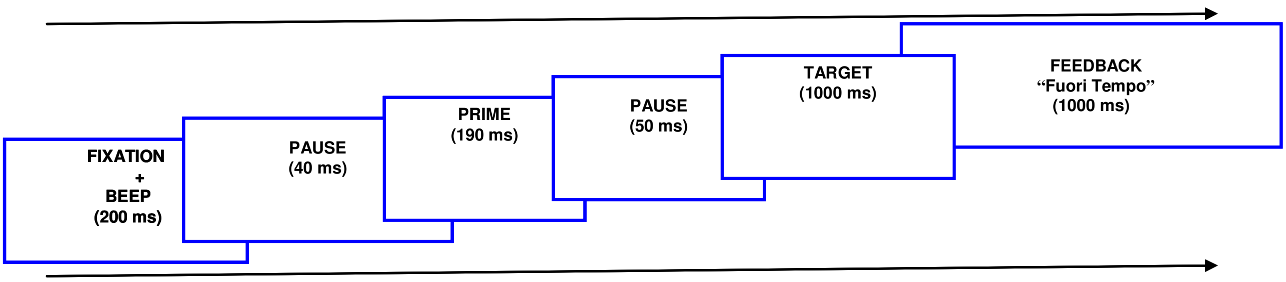

Table 19 Procedure: lexical decision task with unmasked orthographic priming

Reaction times and errors constituted the dependent variables. The reaction times were measured from the onset of the target to the response, and the lack of a response was scored as an error.

- Results

Mean reaction times and percentage of errors on targets preceded by word primes are reported in Tables 20 and 21.

	Control	Experimental
Reaction Times	517	543
Errors	1,9%	3,4%

Table 20 Mean reaction times and percentage of errors on targets preceded by word primes

	N small 0 frequency	N small 1 frequency	N small > 1 frequency	N large 0 frequency	N large 1 frequency	N large > 1 frequency
Reaction Times	510	562	547	513	529	519
Errors	1,3%	6,25%	2,8%	1,5%	1,3%	2,1%

Table 21 Mean reaction times and percentage of errors on targets preceded by word primes

Analyses of variance on reaction times and errors were carried out by participants and by items. The ANOVA on reaction times showed an inhibitory orthographic priming effect both in the analysis by participants [$F_{(1,43)}$ =38,44; $p<.0001$] and in the analysis by items [$F_{(1,66)}$ =23,95; $p<.0001$] (Table 22). The ANOVA on errors confirmed this effect both in the analysis by participants [$F_{(1,43)}$ =19,16; $p<.0001$] and in the analysis by items [$F_{(1,66)}$ =7,56; $p<.01$]. The ANOVA on reaction times showed a facilitatory neighbourhood size effect both in the analysis by participants [$F_{(1,43)}$ = 27,91; $p<.0001$] and in the analysis by items [$F_{(1,66)}$ = 8,94; $p<.005$]. This effect was also confirmed by ANOVA on errors only in the analysis by participants [$F_{(1,43)}$=29,47; $p<.0001$]. Finally, a non-cumulative inhibitory neighbourhood frequency effect both in small and large neighbourhood conditions was detected on reaction times in the analysis by participants [$F_{(2,86)}$=12,59; $p<.0001$] and by items [$F_{(2,66)}$=3,35; $p<.05$] (Table 23).

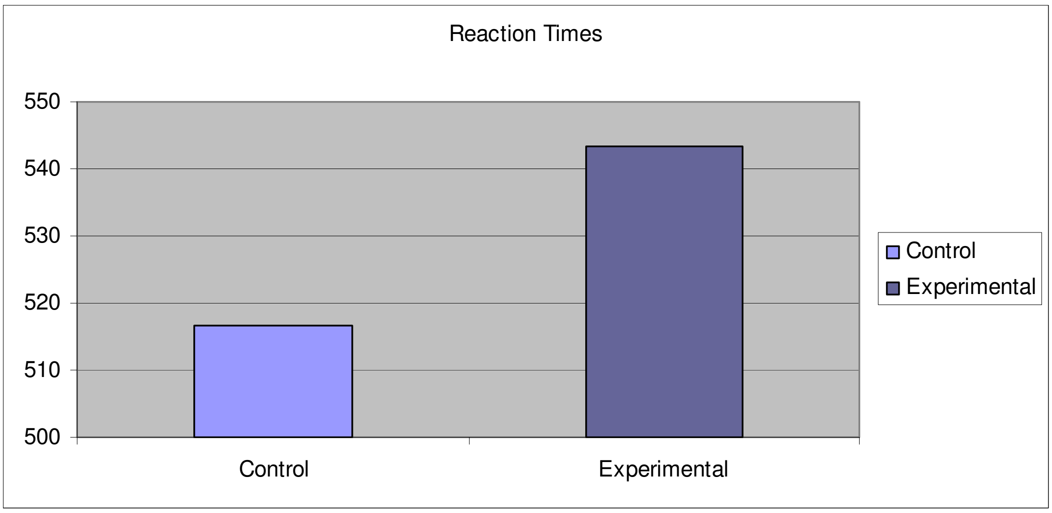

Table 22 Mean reaction times on targets preceded by word primes

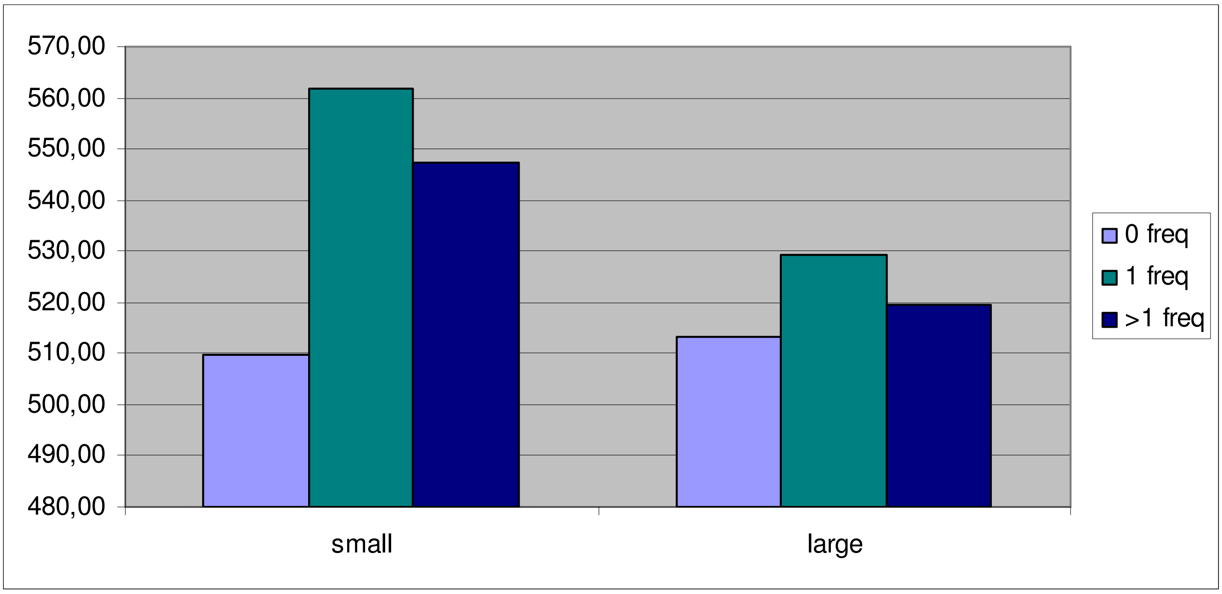

Table 23 Mean reaction times and percentage of errors on targets preceded by word primes

Mean reaction times and percentage of errors on targets preceded by non-word primes are reported in Tables 24 and 25.

	Control	Experimental
Reaction Times	526	521
Errors	1,6%	1,7%

Table 24 Mean reaction times and percentage of errors on targets preceded by non-word primes

	N small 1 frequency	N small > 1 frequency	N large 1 frequency	N large > 1 frequency
Reaction Times	526	537	521	511
Errors	1,8%	1,8%	2,1%	0,8%

Table 25 Mean reaction times and percentage of errors on targets preceded by non-word primes

Differently from the results obtained on targets preceded by word primes, reaction times and errors did not show any orthographic priming effect, in the analyses both by participants and by items (Table 26). Instead, a facilitatory neighbourhood size effect was significant on reaction times in the analysis by participants [$F_{(1,43)}$=17,06; $p<.0005$] (Table 27). The ANOVA on errors was not significant.

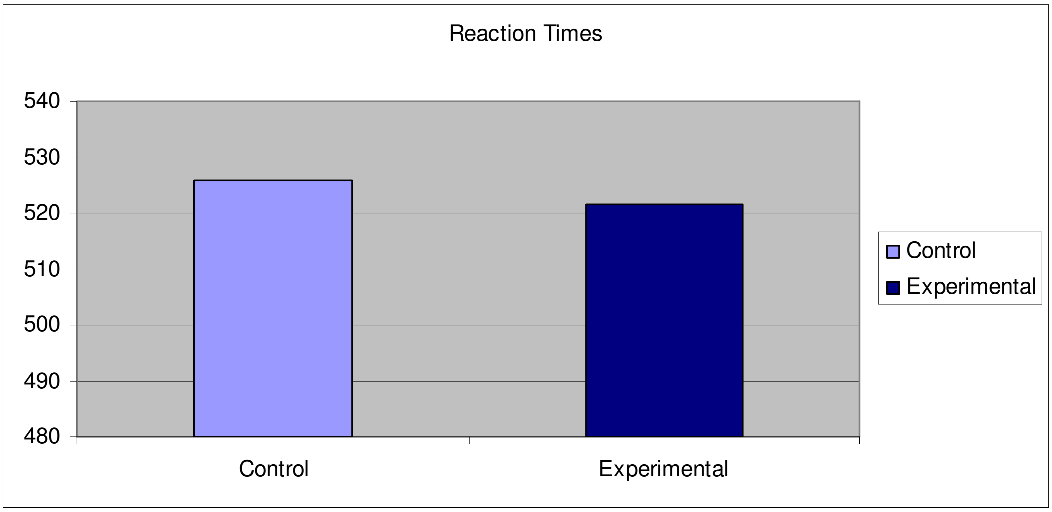

Table 26 Mean reaction times on targets preceded by non-word primes

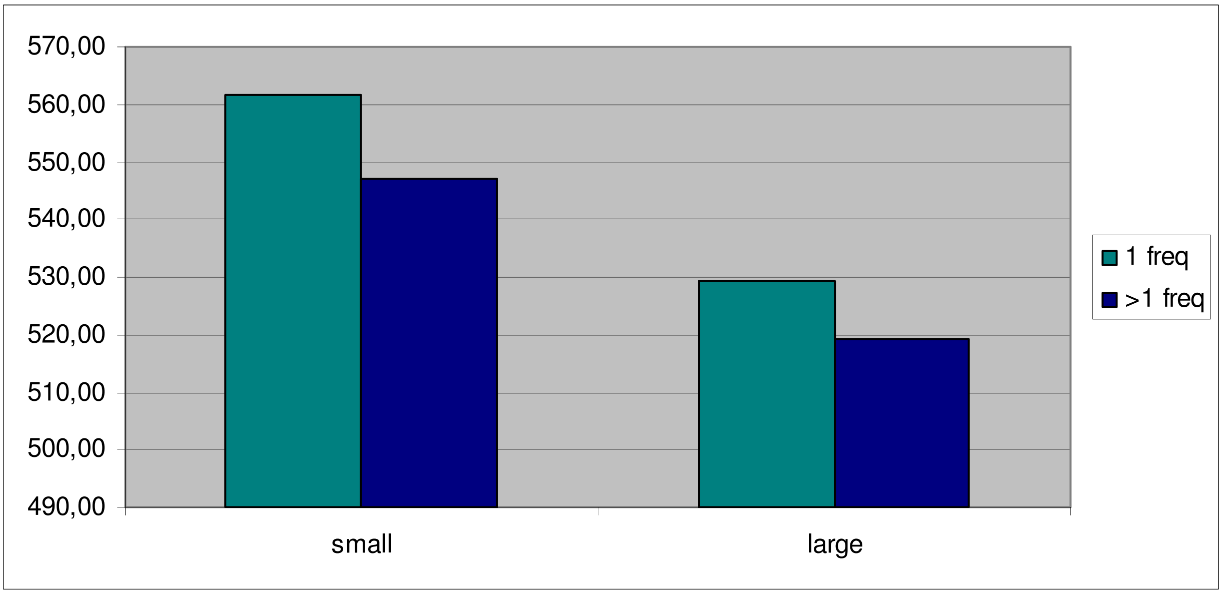

Table 27 Mean reaction times on targets preceded by non-word primes

- Discussion

The results of Experiment 4 showed a strong inhibitory orthographic priming in the experimental "word-word" condition: when a word is preceded by an orthographic similar neighbour it requires longer lexical decision latencies. Contrary to the results found by Grainger and Segui (1990) we did not observe differences due to an embalancing of frequency between primes and targets. If we consider the mean reaction times on targets preceded by lower frequency primes, we observe that there is a significant difference between the experimental and the control conditions (523 vs 499 ms): targets preceded by lower similar frequency primes (e.g., *tondo/fondo*) require lexical decision latencies that are longer than in the control condition (e.g., *selva/fondo*). If this result is analogous to the one obtained by Grainger and Segui (1990), we also find a difference between the experimental and the control conditions on targets preceded by higher frequency primes (552 vs 525 ms): here we observe decision latencies which are longer than when targets are preceded by orthographically unrelated primes. The inhibition exerted by the prime would be extended to all neighbours and not only to higher frequency ones. A possible explanation is that, during prime word identification, selection processes operate to identify the prime word and remove all competing representations, not only the stronger competitors. This inhibitory effect disappears when the prime is represented by a non-word: in this case there is no difference between control and experimental conditions. The presentation of a non-word prime before the target would not influence the identification processes of the target itself.

We have confirmed the results on simple lexical decision task even by using a priming paradigm: in particular, we found a facilitatory neighbourhood size effect when targets are preceded by both word and non-word primes, and a non-cumulative inhibitory neighbourhood frequency effect in the large as well as in the small neighbourhood condition.

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APPENDIX A

Neighbourhood size	Neighborhood frequency		
	No greater frequency neighbour	One greater frequency neighbour	Two or more greater frequency neighbours
SMALL	bonzo	borgo	Belva
	curva	calce	Conca
	dogma	dolci	Delta
	furto	farsa	Firma
	greco	grido	Greto
	mitra	madre	Macro
	mamma	muffa	Mucca
	milza	merce	Marmo
	plebe	prete	Prosa
	purga	pinza	Punta
	sfogo	scudo	Sposo
	tomba	talpa	Targa
LARGE	bordo	barba	Bando
	corso	corda	Corte
	danza	dorso	Dente
	finta	forma	Fonte
	grana	grata	Grano
	mosca	magro	Magra
	mezzo	messa	Mossa
	morte	morto	Monte
	prato	preda	Presa
	porta	palco	Porto
	spina	spesa	Scavo
	turno	turba	Torto

APPENDIX B

	TARGET WORDS		
	Neighborhood frequency		
Neighborhood size	No greater frequency neighbor	One greater frequency neighbor	Two or more greater frequency neighbors
SMALL	bonzo	borgo	Belva
	curva	calce	Curdo
	dogma	dolci	Delta
	furto	farsa	Firma
	greco	grido	Greto
	mitra	madre	Macro
	mamma	muffa	Mucca
	milza	merce	Marmo
	plebe	prete	Prosa
	purga	pinza	Punta
	sfogo	scudo	Sposo
	tomba	talpa	Targa
	croce	garza	Fibra
	golfo	lampo	Norma
	tigre	picco	Sedia
LARGE	bordo	barba	Bando
	corso	corda	Corte
	danza	dorso	Dente
	finta	forma	Fonte
	grana	grata	Grano
	mosca	magro	Magra
	mezzo	messa	Mossa
	morte	morto	Monte
	prato	preda	Presa
	porta	palco	Porto
	salsa	spesa	Scavo
	scala	turba	Torto
	crema	barca	busto
	tasca	legno	festa
	razza	torre	pasta

	TARGET NON-WORDS		
	Neighborhood frequency		
Neighborhood size	No great frequency neighbor	One great frequency neighbor	Two or more great frequency neighbors
SMALL	berda curbo dervo funzo glero mucra meffa menco plepe purbo scoba talba gando codra dorco	bolpa culva darza filta glado mibro madde melga pleda pelte slero tembo crace fopia golmo	Burto carba denza farza grodo mospa merro marvo prifo pelce speva talso pomba lorsa vorma
LARGE	balpa cance dampa folgo gromo migre merre malza pruna ponca scago tonza vardo panga zacca	benta colca dordo falma grace masco mutto mersa prote parpa spoga tonco folca parza ganna	banto calto donte farce Greno musto misso Morco Pramo palso stida tarto sonto baria cerno

APPENDIX C

Neighborhood size	Neighborhood frequency		
	No great frequency neighbor	One great frequency neighbor	Two or more great frequency neighbors
SMALL	berda	bolpa	burto
	curbo	culva	carba
	dervo	darza	denza
	funzo	filta	farza
	glero	glado	grodo
	mucra	mibro	mospa
	meffa	madde	momma
	menco	melga	marvo
	plepe	pleda	prifo
	purbo	pelte	pelce
	scoba	slero	speva
	talba	tembo	talso
LARGE	balpa	benta	banto
	cance	colca	calto
	dampa	dordo	donte
	folgo	falma	farce
	gromo	grace	greno
	migre	masco	musto
	merre	mutto	misso
	malza	mersa	morco
	pruna	prote	pramo
	ponca	parpa	palso
	scago	spoga	stida
	tonza	tonco	tarto

APPENDIX D

- **Word pairs with a prime of higher frequency than the target**:

SMALL N/1 HIGHER FREQUENCY N	
buffa	**muffa**
vizio	**tizio**
prove	**prole**
bordo	**borgo**
grado	**grido**
campo	**lampo**
pizza	**pinza**
falsa	**farsa**
scuro	**scudo**
costo	**cosmo**
morto	**morbo**
lungo	**luogo**

SMALL N/ >1 HIGHER FREQUENCY N	
magra	**sagra**
sacco	**succo**
frase	**frate**
media	**sedia**
causa	**pausa**
nuova	**nuora**
larga	**targa**
marzo	**Marmo**
coppa	**copia**
pieno	**fieno**
libro	**litro**
forma	**firma**

LARGE N/1 HIGHER FREQUENCY N	
tasca	**vasca**
barca	**barba**
parco	**palco**
colpa	**polpa**
basta	**busta**
corso	**dorso**
fonda	**sonda**
folla	**molla**
presa	**preda**
banca	**banda**
corsa	**corda**
visto	**misto**

LARGE N/ >1 HIGHER FREQUENCY N	
feste	**peste**
manca	**marca**
costa	**posta**
colpo	**colmo**
vanno	**vanto**
resto	**gesto**
torno	**corno**
salto	**sarto**
banco	**bando**
pista	**pasta**
letto	**petto**
gente	**dente**

- **Word pairs with a prime of lower frequency than the target:**

SMALL N	
benda	**tenda**
spago	**svago**
nuoto	**vuoto**
turco	**turno**
ferie	**serie**
russo	**rosso**
samba	**gamba**
limbo	**bimbo**
cuoco	**fuoco**
serra	**terra**
fisco	**disco**
lista	**vista**

LARGE N	
sorso	**sordo**
tondo	**fondo**
fiuto	**fiato**
palma	**calma**
freno	**treno**
torta	**porta**
panno	**fanno**
grata	**grana**
tasto	**pasto**
tazza	**razza**
saldo	**caldo**
festa	**testa**

- Nonword-word pairs

SMALL N/1 HIGHER FREQUENCY N	
garta	**garza**
toffo	**tuffo**
tadro	**ladro**
siele	**miele**
suota	**ruota**
lusco	**lusso**
tampa	**talpa**
sosco	**solco**
mulca	**multa**
mieve	**lieve**
frete	**prete**
piese	**piede**

SMALL N/ >1 HIGHER FREQUENCY N	
siega	**piega**
mibra	**fibra**
finso	**fisso**
coldo	**soldo**
sporo	**sposo**
norta	**norma**
tippo	**tappo**
crumo	**crudo**
polgo	**polso**
grota	**trota**
tarco	**varco**
tunta	**punta**

LARGE N/1 HIGHER	
porpa	**pompa**
falze	**calze**
furro	**furbo**
temme	**terme**
torle	**torre**
ponse	**ponte**
gampa	**zampa**
mapra	**capra**
fordo	**lordo**
dreca	**greca**
canga	**canna**
sfesa	**spesa**

LARGE N/ >1 HIGHER FREQUENCY N	
verle	**verme**
mervo	**servo**
zinta	**tinta**
torbo	**torto**
ronte	**conte**
sonto	**santo**
bolca	**bolla**
solpe	**volpe**
lenno	**lento**
frono	**trono**
gosta	**sosta**
zatto	**gatto**