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On recognizing proper names: The orthographic cue hypothesis

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Abstract

Five experiments investigated the recognition of proper names and common nouns using the lexical decision paradigm. In Experiments 1–3 the case of the initial letter of written stimuli was systematically varied. An advantage was consistently found for proper names written with the first letter in capital. Crucially, response times to proper names with the first letter in lowercase and to common nouns irrespective of the case of the first letter did not differ from each other. No difference between proper names and common nouns emerged in Experiment 4 where the stimuli were presented auditorily, and in Experiment 5 where a visual lexical decision task was performed with illegal non-words. The pattern of results shows that the proper name advantage is orthographic in nature and rules out an account in terms of semantic, morphological or other lexical variables. A model is proposed in which information about the case of the first letter is specified in the abstract multidimensional orthographic representation mediating written word recognition.

1. Introduction

Many linguistic distinctions concerning lexical knowledge are assumed to be associated with different processing mechanisms. Such claim has been advanced for the

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distinction between closed vs. open word classes (e.g., Bradley, Garret, & Zurif, 1980; Garrett, 1976; Shillcock & Bard, 1993; Silverberg, Vigliocco, Insalaco, & Garret, 1998), nouns vs. verbs (e.g., Caramazza & Hillis, 1991; Denes & Dalla Barba, 1998; Feldman, 1994), count vs. mass nouns (e.g., Macnamara & Reyes, 1994; McPherson, 1991; Semenza, Mondini, & Cappelletti, 1997), and concrete vs. abstract nouns (e.g., Breedin, Saffran, & Coslett, 1994; Paivio, 1991; Strain, Patterson, & Seidenberg, 1995), among others. The distinctions may be ascribed to differences in the type of representation underlying the lexical classes, or to the actual processing in comprehension and/or production tasks. In this paper we present some new empirical data on the distinction between proper names[1] and common nouns, and propose a model detailing the processes of the early visual recognition of the two classes of words.

Proper names differ from common nouns on a number of dimensions. At the semantic-conceptual level, proper names are assumed to lack sense and to be characterized only by reference, while common nouns entail both reference and sense (Kripke, 1980). Also, proper names, generally access semantic information specific to individuals, as do faces, (Valentine, Brédart, Lawson, & Ward, 1991). At the lexical level, proper names and common nouns may differ as regards to gender information, since proper names, at least people's names, are gender specific while common nouns may have grammatical gender (as in Italian) or they may not (as in English). Furthermore, gender assignment for people's names is semantically based, whereas it may be completely arbitrary for common nouns (Corbett, 1991). At the morphological level, differences may exist between common nouns and proper names for number and case information, since proper names usually are not marked for such information. At the syntactic level, common nouns take determiners, while proper names usually do not (Longobardi, 2001). Finally, at the orthographic level, proper names have the first letter capitalized by default, while for common nouns (in Italian as in many other languages) capitalization of the first letter depends on the context of usage (e.g., after a full stop or at the beginning of a sentence).

Beside the differences at the linguistic level, relevant differences in the processing of proper names and common nouns have been reported. In many studies, it has been shown that common nouns are recalled better than proper names. To illustrate, Cohen (1990), Cohen and Faulkner (1986), and McWeeny, Young, Hay, and Ellis (1987) have described the *baker–Baker* paradoxical effect, in which the word "baker" was recalled more often when it stood for the name of a profession than when it stood for the name of a person. The authors discussed this difference in terms of the size of the semantic network (i.e., the number of associated information) characterizing proper names and common nouns: A common noun would activate a wider semantic network than that activated by a proper name. The experimental evidence on the TOT (tip-of-the-tongue) phenomenon is also consistent with this view, as

[1] People's proper names can refer to specific individuals that may be famous (e.g., Chelsea Clinton, Ernest Hemingway) or not (e.g., John Tilburg, Mary Brown). They may also be "generic" labels referring to the class of actual or potential individuals having that name (e.g., Bill, Ernest, or John). In this paper we consider only the latter alternative.

TOT states are more frequent with a proper name than with a common noun (Burke, MacKay, Wortheley, & Wade, 1991).

Neuropsychological studies of individual patients with acquired brain damage report cases in which the processing of either common nouns or proper names is selectively impaired. The deficit involved either the production or the comprehension processes. There is a large number of cases with a selective deficit in the production of proper names (e.g., Fery, Vincent, & Brédart, 1995; Lucchelli & De Renzi, 1992; Semenza & Zettin, 1988, 1989), but very few studies reporting a selective sparing of this category of nouns (Hittmair-Delazer, Denes, Semenza, & Mantovani, 1994). For comprehension, there is a number of cases showing a selective preservation of proper names (e.g., Van Lanker & Klein, 1990; Warrington & McCarthy, 1987), but only one case has been reported in which the comprehension of proper names was selectively impaired (Ellis, Young, & Critchley, 1989).

The asymmetry between proper names and common nouns in the production tasks might be interpreted as the result of the different complexity of the corresponding semantic descriptions. As pointed out by Brédart, Brennen, and Valentine (1997), proper names' description is characterized by a relatively small number of semantic features with respect to the semantic description of common nouns, in virtue of the fact that only the latter can be considered "conceptual units" (i.e., they have a sense). The multiplicity of links between a large set of semantic features and the word level makes the common nouns easier to access and, therefore, more resistant to a cerebral damage.

According to a different view, proper name retrieval difficulty can be accounted for in terms of neighborhood density. In the Hyperspace Analogue Language model of memory (Burgess & Conley, 1999), proper names are shown to have a denser semantic space in which close neighbors tend to be other proper names. The denser proper name neighborhoods are likely to increase the probability of a retrieval error.

A number of studies on face recognition have also addressed some issues about the recognition of proper names. Even if these studies were focused on recognition of known people's names, some of the observations stemming from them may be useful for understanding the processing of proper names in general. Bruce and Young (1986) postulated that the recognition of visually presented proper names and common nouns is carried out by a common mechanism subserving the early visual and orthographic analyses and the access to the stored lexical representations. After this stage, written names of known people may activate semantic information about specific individuals by means of two differential pathways: Directly, as familiar faces do, or throughout general semantic knowledge. The latter is accessed also by common nouns (Valentine et al., 1991; Valentine, Hollis, & Moore, 1998, 1993). According to this view, the comprehension of proper names is more resistant to brain damage since semantic information about known people can be accessed through two parallel routes.

Valentine et al. (1991) distinguished two levels of long-term lexical representation: The Word Recognition Units, which allow to decide whether an actual letter string is a known word, and the Name Recognition Units, which allow to decide whether a full name, e.g., Marilyn Monroe, is a familiar name. Whereas the latter are specific to proper name processing and allow accessing the associated semantic information, the formers are involved in the recognition of all written words, irrespective of the grammatical category.

According to the proposals so far reviewed, any difference that may arise between proper names and common nouns should originate at the semantic level and/or in activating such level. No differences are postulated between the two categories of nouns as far as the orthographic recognition processes are concerned.

The present research focuses on such early recognition processes when proper names and common nouns are presented in written form. Our aim is to investigate the format of the computed orthographic representation and to ascertain whether the visual and/or orthographic characteristics of the written stimuli have a differential effect on the recognition of proper names and common nouns. This issue is relevant to theories of visual word recognition since it may enlighten about information specified at the abstract level of word representation.

Most word recognition models assume that the identification and/or naming of a letter string requires its translation into an abstract description containing information about the identity of the individual letters (Abstract Letter Identities, ALIs) and their position in the string (Brigsby, 1988; Caramazza & Hillis, 1990; Coltheart, 1981). This representation is assumed to be independent from the size, orientation, case, and style of the actual letter strings, and needs to be matched with the long-term orthographic descriptions stored in memory, i.e., the reader's lexicon. These assumptions are congruent with the results of a number of experimental studies showing that word recognition processes are "insensitive" to the visual format of the stimuli. Indeed, recognition accuracy does not vary when the letter case changes during saccade (Rayner, McConkie, & Zola, 1980), or when the letter string is presented in case-alternated format (Adams, 1979; Besner, 1990; Besner & McCann, 1987; Friedman, 1980; but see Brown & Carr, 1993). Also, orthographic priming studies have shown that the size of the effect is not reduced when the letter case of the prime is different from that of the target (Evett & Humphreys, 1981; Forster & Davis, 1984; Humphreys, Besner, & Quinlan, 1988; Peressottti & Grainger, 1999). Finally, neuropsychological studies on pure alexia have shown that the inability to derive abstract letter identities prevents normal reading. For example, the patient described by Miozzo and Caramazza (1998) was able to process letter shape and letter orientation but was unable to decide whether two letters with different shapes corresponded to the same grapheme (e.g., a A), or not (e.g., e A). This dissociation between the ability to access visual shape information of letters but not their graphemic identity can account for the inability to process orthographic information.

This class of theories suggesting an "abstract" level of written word representation would thus predict that in the recognition of proper names and common nouns the response time should be insensitive to the format of the first letter.

A different prediction can be derived from episodic theories of word recognition (e.g., Logan, 1988, 1990; for a review see Tenpenny, 1995), according to which words are identified by retrieving specific prior episodes that include those words. In experiments in which the same item was repeated, it has been found that recognition performance is higher when items were re-presented in their original case format (Graf & Ryan, 1990; Jacoby, Levy, & Steinbach, 1992).

According to these theories, the details of the episodic representation may constitute relevant cues for the identification process, so words should be recognized faster when presented in the most frequent visual format. It follows that recognition times should be faster for proper names written with the first letter capitalized and for common nouns written in lower-case.[2]

In the present paper, some of the predictions stemming form the two classes of theories have been tested using the lexical decision task. In the literature, this task is one of the most used to investigate visual word recognition (for a review see Grainger & Jacobs, 1996), which is generally assumed to be a multistage process which enables the orthographic information corresponding to a visual input to be matched with stored lexical knowledge. According to Caramazza and Hillis (1990), computing orthographic information from a visually presented string of letters requires three processing stages. A first stage, in which the relevant discontinuities of the image are computed directly from the spectrum of the light intensities, resulting in a retino-centric description of the edges of the image. A second stage, in which the spatial relations between the features extracted are analyzed, and a veridical representation of spatial arrangement of the line segments is computed. A third stage, at which the letter shapes are translated into a sequence of abstract units that do not retain information about size, font and orientation of the input letter string. The representation computed at this level is then used by lexical processing mechanisms for word recognition. Various models have been offered to account for these mechanisms, based either on activation or search procedures, or a combination of the two (for reviews see Balota, 1994; Carr & Pollatsek, 1985). These models differ in many aspects, but the distinctions are not relevant for the proposal we will entertain in this paper. The assumptions we need to make explicit here are the following. (1) The unit of representation for lexical access is a grapheme string (i.e., the episodic orthographic representation), specifying all information about the correct spelling of a word independently of the visual format. (2) Such episodic orthographic representation is computed from the perceptual features of the visual stimulus. (3) The computed episodic representation is used to contact the long-term orthographic representations of known words stored in the mental lexicon of the reader. The process that computes the visual stimuli to derive the corresponding orthographic representation is affected by the visual and spatial properties of the stimuli, while the process that compares the episodic orthographic representation to that stored in the lexicon is affected by lexical variables.

Following this line, distinguishing a written letter string that is a word from a letter string that is not a word (i.e., making a visual lexical decision) can be accomplished at one of several processing levels, depending on the nature of the string. Thus, when words are mixed with pronounceable pseudoword, an orthographic

[2] In Italian, common nouns have the first letter in capital only at the beginning of a sentence. Unlike English, Italian does not require capitalization after the colon, making the occurrence of a common noun with the first letter in capital even more rare.

description of the presented stimulus must be computed, and the level of stored orthographic descriptions of known words is activated in order to discriminate existing words from legal but meaningless pseudowords. On the other hand, in order to distinguish a written word from an illegal, not pronounceable non-word, a preliminary evaluation of some rapidly computable features allows a negative response to be made relatively early in the processing. As suggested by some studies in the literature (e.g., James, 1975; Peressotti, Job, Rumiati, & Nicoletti, 1995), the abstract orthographic description of a written stimulus contains enough information to reject all candidates whose properties (visual/orthographic/phonological) are such that they cannot be words. As an example, Carr, Posner, Pollatsek, and Snyder (1979) showed that the sequences FBI and IBF, even if meaningful, are rejected more accurately and quickly then legal but meaningless sequences like BIF. This result clearly shows that illegal non-words are decided upon at a level preceding the activation of lexical information.

Thus, the lexical decision task taps different levels of representation, depending on the nature of the experimental conditions. Also, it can be performed with auditorily presented material, allowing for a direct comparison across modalities. These features render it particularly suited for the investigation reported in the present paper which focuses on the role of case information in proper name recognition. In a series of. In Experiments 1–3, we compared lexical decision times to proper names and common nouns using visually presented words and pseudowords written either in lowercase, in uppercase or with the first letter capitalized. In Experiment 4, spoken proper names and common nouns were presented for an auditory lexical decision task. In Experiment 5, a visual lexical decision task was used with written words and illegal non-words (i.e., random consonant strings).

2. Overview of the method

2.1. Participants

The experimental data were collected at the University of Padova. One hundred and seventy-three students, aged from 19 to 32 years, participated (32 took part in each of Experiments 1–3 and 5, 45 to Experiment 4). They had Italian as their first language and normal or corrected to normal view and audition. They all volunteered to participate in the study.

2.2. Stimuli

In Experiments 1–4, the stimuli were sets of proper names and common nouns and corresponding pseudowords derived from different proper names and common nouns by changing one or two letters in each word. In Experiment 5 the pseudowords were replaced by random strings of consonants. In Experiments 1–3 and in Experiment 5 the stimuli were presented visually, each experiment using a combination of two of these different scripts: UPPERCASE, lowercase, First Letter Uppercase. In order to avoid repetitions, two experimental lists were constructed for each experiment, so that a given item was presented written in a case condition in one list, and in the alternative case condition in the other list. Each participant was presented with only one list. In Experiment 4 the stimuli were presented auditorily. In all experiments, the sets of proper names and common nouns were matched for a number of variables reported in further detail in the method sections of each experiment. The proper names and common nouns used are reported in the Appendix.

2.3. Procedure

Participants were given written instructions explaining that the task was a lexical decision. In Experiments 1–3 and in Experiment 5 the stimuli were presented visually. Participants were instructed to answer *irrespectively* of the case of the stimuli, i.e., considering only the lexical content of the string. Each participant was randomly assigned to one of the experimental lists and the stimuli within the list were presented in a different random order for each participant. Each trial started with the presentation of a cross at the center of the screen for 300 ms followed by the stimulus which remained in view either until participants responded by pressing a response key, or for a maximum time of 1000 ms. The intertrial interval was 1000 ms.

In Experiment 4, the task was an auditory lexical decision. Each trial started with a 300 Hz beep lasting 300 ms followed, after 200 ms of silence, by the spoken stimulus. From the onset of the stimulus, participants had 2000 ms to respond. After the response, the experimenter coded the accuracy of the response while the recorded response time was displayed on a computer screen for 400 ms. The next trial started 1000 ms after the end of this interval.

Participants were trained with a list of 20 stimuli in Experiments 1–3 and 5, and 40 stimuli in Experiment 4. The training stimuli were half words and half pseudowords in Experiments 1–4, and half words and half illegal non-words in Experiment 5. The training stimuli were not part of the experimental lists.

2.4. Apparatus

Participants were tested one at a time in an isolated and dimly illuminated room. For Experiments 1–3 and 5, the stimuli were presented using PsychLab (Gum, 1996) with a Macintosh Quadra 700. The participant sat in front of the computer screen placed at a distance of about 60 cm from his/her eyes. The words and the pseudowords were displayed in black Geneva print 24 points on a white background. Responses were recorded through the keyboard. The keys selected for the responses were Command and Control.

In Experiment 4, items were recorded in a digital format with a PC Digital Venturis 575 using Wave Studio 2.0, and stored by in the computer with Soundblaster 16 at 11,025 Hz sampling rate. The stimuli were presented and the responses were recorded using MEL2 (Schneider, 1988). The participant sat in front of a table with a computer screen and a button box in front of him/her, wearing headphones to hear the stimuli which were presented at a comfortable listening level.

In all Experiments, participants were instructed to respond to the word stimuli with the index finger of the preferred hand and to the non-word stimuli with the index finger of the other hand.

3. Experiment 1

In the first experiment proper names and common nouns were presented to participants under two case conditions with: (a) only the first letter in capital (e.g., Giovanni, (*John*),[3] Fabbrica, (*Factory*)) and (b) all the letters capitalized (GIOVANNI, FABBRICA). No differences between the response times for proper names and for common nouns should be expected, since, as claimed by Bruce and Young's (1986) model, proper names and common nouns should not differ at the lexical level. Furthermore, if the orthographic format of the string does not interfere with word processing, as claimed by the Abstract Letter Identity theory, no differences between the case conditions should be observed. If, on the contrary, memory of prior episodes affects recognition, we should expect faster reaction times for proper names with the first letter capitalized than for common nouns with the first letter capitalized, because of the higher familiarity of proper names written in this format.

3.1. Method

3.1.1. Stimuli

A set of 32 proper names was selected from the Spoken Italian Frequency Count (De Mauro, Mancini, Vedovelli, & Voghera, 1993) that lists the frequency of both proper names and common nouns. The mean frequency was 17.25. The length ranged from 4 to 10 letters (mean = 6.65 letters). Half of the stimuli were names of geographical sites (mean frequency = 11.94; mean length = 6.6 letters), while the other half were person names (mean frequency = 22.13, mean length = 6.8 letters). Using the same frequency count, 32 common nouns matched with the proper names for frequency and length (frequency = 17.28, length = 6.65 letters, ranging from 4 to 10 letters) were selected.

Since the De Mauro et al.'s (1993) frequency norms concern spoken language, we collected familiarity ratings for the written forms of the stimuli. Each stimulus, written in capital letters, was presented to 17 students not participating to the main experiment. The participants—tested individually—were asked to judge word familiarity by giving a value along a 7-point scale in which 1 corresponded to a very low level of familiarity and 7 corresponded to a very high level of familiarity. The mean values obtained were 3.9 for proper names and 4.4 for common nouns, indicating a small but significant difference ($t = 2.34$, $p = .022$).

[3] English translations of the examples are provided in brackets.

In the experiment, each experimental list contained 32 proper names, 32 common nouns, and 64 pseudowords. Half of the stimuli had the first letter capitalized, half had all letters capitalized.

3.2. Results

The mean correct response times (RTs) and error percentages are reported in Table 1. Separate analyses were carried out on words and pseudowords RTs. On the word data, outliers were individuated. For each subject, limit values were set to two standard deviations plus or minus the mean. RTs longer or shorter than the limit value were replaced with the limit value itself (4.7% of the data).

The word data were then submitted to both ANOVAs by participants and by items (throughout the paper *F*1 and *F*2, respectively) with Name Type and Case Type as factors. The significance level was set to $\alpha = .05$. A significant effect of Name Type was found ($F1(1,23) = 100.24$, $MSE = 672.74$, $p < .001$; $F2(1,62) = 42.26$, $MSE = 2178.42$, $p < .001$). Neither Case Type ($F1(1,23) = 2.85$ $p > .1$; $F2(1,62) = 1.57, p > .2$) or the interaction (*F*1 and $F2 < 1$) were significant. As reported in Table 1, independently of the format of the printed stimuli, proper names were responded to faster than common nouns (581 vs. 634 ms).

The error distribution paralleled the RTs data. Since quite few errors were made to the word stimuli and most cells would contain the values 0 or 1, no ANOVAs were conducted on the error rates.

Although proper names and common nouns were matched for frequency, they could not be matched for number of neighbors. Since such a variable may affect lexical decision time, a post hoc ANOVA by items was conducted on a subset of items (18 common and 18 proper) matched for the number of neighbors (Coltheart's N count). The results were the same as for the ANOVA on the entire set of items. Proper names were responded to 62 ms faster than common nouns ($F2(1,36) = 32.32$, $MSE = 2227.5$, $p < .001$) and there was no effect of case.

An ANOVA on pseudoword RTs was performed with subjects as the random variable and with the same factors as the ANOVA on words. Name Type in this context refers to the pseudowords derived from common nouns and pseudowords derived from proper names. Neither the factors nor the interaction were significant (all Fs < 1; Name Type $F(1,23) = 1.23$, $p > .2$).

Table 1
Mean RTs (in ms) and error percentages (in parenthesis) obtained in each experimental condition of Experiment 1

	Words			Pseudowords		
	First capital	All capital	Diff.	First capital	All capital	Diff.
Common names	639 (5.5)	629 (5.2)	10	741 (4.7)	748 (6.5)	−7
Proper names	584 (1.6)	578 (2.6)	6	736 (8.1)	747 (4.4)	−11
Diff.	56	51		5	1	

3.3. Discussion

Proper names were recognized faster than common nouns, irrespective of the way the strings were written, i.e., with all the letters capitalized or with only the first letter capitalized. The absence of case effect supports theories that postulate an abstract level of word representation since the format of the stimulus did not affect the recognition times. Nevertheless, the advantage for the proper names is inconsistent with the hypothesis according to which the early processing of written words from different lexical classes is the same, i.e., it capitalizes on the same perceptual and orthographic mechanisms. The present results then suggest that processing of proper names and common nouns might differ at the semantic-lexical level; alternatively, they might be differentially sensitive to the format of the stimuli, with the first letter capitalized facilitating the recognition of proper names.

Before further discussing such a question, we would like to control for an alternative interpretation that would explain the difference obtained in terms of a response bias and/or a response strategy effect. In this experiment, proper names, which constitute a relatively homogeneous class of nouns, belonging only to two semantic categories (people's and geographical names), were contrasted with a set of common nouns drawn from many different categories (e.g., vegetables, emotions, body parts, and furniture). Thus, proper names had a higher relative frequency of occurrence within the set of stimuli as a whole, i.e., they might have been over-represented as a semantic category. In order to control for these possible category-related effects we run Experiment 2 in which we equated the number of categories from which the stimuli were drawn.

4. Experiment 2

To control for category heterogeneity, the common nouns for Experiment 2 were selected from two categories, i.e., emotions and occupations. If the advantage found for proper names depended on a category effect related to within-class homogeneity and/or to the relative frequency of the elements from each category, the advantage should disappear in the present experiment.

4.1. Method

4.1.1. Stimuli

The proper names used in the present experiment were those of Experiment 1. For the common nouns, 16 names were selected from each of the two semantic categories of emotions and occupations. The emotions' names were matched for length (mean number of letters = 6.63) and frequency (mean = 22.3) to the people's names, while occupations' names were matched for length (mean number of letters = 7.1) and frequency (mean = 12.3) to the geographical sites' names. The set of common nouns used in the present experiment was also tested for familiarity with the same procedure as in Experiment 1. The mean familiarity value obtained is 4.4. Again, this value was greater than that of 3.9 reported in Experiment 1 for proper names ($t(62) = 2.004$, $p = .049$). Thirty-two new pseudowords were constructed. Sixteen were derived from names of emotions and 16 from names of occupations.

As in Experiment 1, each stimulus was presented under two case conditions (a) with only the first letter in capital (e.g., Giovanni (*John*), Amicizia (*Friendship*)) and (b) with all the letters capitalized (GIOVANNI, AMICIZIA), giving the two levels of the factor Case Type.

In the written instructions, participants were informed about the four semantic categories the word stimuli belonged to.

4.2. Results

Mean correct RTs and error percentages obtained in each condition are reported in Table 2. The outliers (3.9% of the data) were individuated and replaced with the corresponding limit values using the same procedure of Experiment 1.

The word RTs were then submitted to ANOVAs by participants and by items with Name Type and Case Type as factors. Only the main effect of Name Type was significant ($F1(1,31) = 30.86$, $MSE = 1278.93$, $p < .001$; $F2(1,62) = 17.99$, $MSE = 2266.06$, $p < .001$), with a 35 ms advantage for proper names. Again, neither the effect of Case ($F1(1,31) = 1.65$, $p > .2$; $F2(1,62) = 1.92$, $p > .5$) or the interaction ($F1$ and $F2 < 1$) proved significant.

Error percentage in each condition reflected the RTs pattern, and did not suggest any speed-accuracy trade-off. Since a large number of cells would have contained the values 0 or 1, no statistical analyses were performed on these data.

The ANOVA on pseudowords with the factors Name Type (i.e., pseudowords derived from proper names vs. pseudowords derived by common nouns) and Case Type (first letter capital vs. all letter capital) showed no significant effects (all Fs < 1).

4.3. Discussion

The results showed again the difference between common nouns and proper names observed in Experiment 1. It follows that the processing advantage of proper names did not depend on the intracategory homogeneity of the set of

Table 2
Mean RTs (in ms) and error percentages (in parenthesis) obtained in each experimental condition of Experiment 2

	Words			Pseudowords		
	First capital	All capital	Diff.	First capital	All capital	Diff.
Common names	622 (4.1)	629 (3.5)	−7	757 (4.7)	756 (4.3)	1
Proper names	588 (3.5)	592 (2.1)	−4	752 (6.2)	753 (5.7)	−1
Diff.	34	37		5	3	

stimuli. When both common nouns and proper names were selected from only two semantic categories (emotions and professions, and people and places, respectively), response times for the common nouns were still slower than that for proper names.

We might interpret such an effect either as a disadvantage for common nouns, or, alternatively, as an advantage for proper names. Let us consider the former interpretation first. Common nouns are more frequently encountered in lower case than with the first letter in capital. According to the episodic accounts of word recognition (Logan, 1988), words are identified through the use of specific prior episodes and, thus, while proper names would be recognized faster when presented with the first letter capitalized, common nouns would be recognized faster when presented in lowercase. Therefore, in the present experiment, the decisions about common nouns could have been slowed down with respect to proper names because of the case condition (i.e., first letter capitalized) in which they were presented. If this interpretation were correct, then common nouns in lower case should show no delay with respect to proper names with the first letter capitalized.

According to the alternative view, we might consider the difference obtained between proper names and common nouns as a genuine advantage for proper names. There are several hypotheses that can be put forward to account for such effect. First, we might hypothesize that the difference obtained reflects a difference in the morphological representation of proper names and common nouns. In Italian, common nouns are always suffixed words, while proper names usually are not. In particular, common nouns, but not proper names, are always suffixed for their singular/plural form. In addition, while for names of people the feminine and the masculine derived forms may both occur (e.g., Francesco and Francesca, masculine and feminine, respectively), the names of places are invariant. Thus, we can hypothesize that the advantage of proper names could be due to their generally simpler morphological representation. To shed light on this issue, we re-examined a subset of items used in the Experiment. An ANOVA was thus performed on the 15 out of 32 proper names marked for gender on the suffix and 15 matched common nouns. The results show that, even when the morphological complexity was equated, the difference between the two noun categories was still significant ($F2(1,29) = 13.16$; $MSE = 248.1$; $p < .01$).

A further, potential source of the proper names advantage is the semantic status of this category of words. It might be that proper names constitute a peculiar semantic category that allows faster access at the lexical level, or a better response availability. If this were true, we might predict that case information does not play a role on recognition time and that the advantage of proper names should be obtained even in a condition in which the stimuli are presented in lowercase.

Alternatively, it might indeed be the case that the orthographic format of the stimuli is a relevant variable in the processing of proper names. The fact that in Experiments 1 and 2 no differences emerge between stimuli with the first letter in capital and stimuli with all letters in capital indicates that the only relevant processing information concerns the case of the first letter. If this were the case, then the advantage should disappear when the stimuli are presented in lowercase. To test among these alternative predictions we ran the next experiment.

5. Experiment 3

Participants were presented with common nouns and proper names that had either the first letter capitalized or all letters in lower case (for example, Giovanni vs. giovanni (*John vs. john*), Amicizia vs. amicizia (*Friendship vs. friendship*)). If the proper names were to be responded to faster in the former condition, while the common nouns were to be responded to faster in the latter condition, we might conclude that the episodic component has a relevant role in the effect obtained in Experiments 1 and 2. Alternatively, if there is no difference in response times between proper names and common nouns when both are presented in lowercase, we might conclude that case is a relevant cue for proper name recognition, since proper names are faster than common nouns only when written with the first letter in capital. Finally, if proper names were faster than common nouns in both conditions, i.e., when presented with the first letter in capital or in lowercase, we might conclude that the advantage does not depend on orthographic features, but more likely on lexical-semantic factors.

5.1. Method

5.1.1. Stimuli

The stimuli were the same as in Experiment 2. Each letter string was presented either with the first letter capitalized (e.g., Giovanni, Amicizia) or with all letters in lower case (e.g., giovanni, amicizia).

5.2. Results

Mean correct RTs and error percentages are reported in Table 3. Among correct word RTs, outliers were individuated and replaced with the corresponding limit values (3.8% of the data), using the same procedure described in the previous experiments. The data were then submitted to ANOVAs with the Name Type and Case Type as factors. A main effect of both factors was found: Name Type ($F1(1,31) = 10.98$, $MSE = 1034.47$, $p = .002$; $F2(1,62) = 5.87$, $MSE = 1912.06$, $p = .02$; and Case Type $F1(1,31) = 8.35$, $MSE = 484.24$, $p = .007$; $F2(1,62) = 3.61$, $MSE = 1030.35$, $p = .062$). Also the interaction was significant ($F1(1,31) = 21.27$; $MSE = 642.24$, $p < .001$; $F2(1,62) = 11.16$, $MSE = 1030.35$, $p = .001$). No

Table 3
Mean RTs (in ms) and error percentages (in parenthesis) obtained in each experimental condition of Experiment 3

	Words			Pseudowords		
	First capital	Lower case	Diff.	First capital	Lower case	Diff.
Common names	615 (3.7)	605 (2.3)	10	710 (4.5)	705 (3.9)	5
Proper names	575 (3.4)	607 (3.4)	−32	721 (4.5)	703 (3)	18
Diff.	40	−2		−11	2	

difference was obtained between proper names and common nouns when they were written in lower-case. However, the two classes differed considerably when the names had the first letter capitalized (simple effect of Case on Name Type: $F1(1,31) = 19.93$, $MSE = 1253.12$, $p < .001$; $F2(1,144) = 15.44$, $MSE = 1471.2$, $p < .001$). Proper names were responded to 32 ms faster when they had the first letter capitalized than when they were written in lower-case (simple effect of Case Type on proper names: $F1(1,32) = 23.6$, $MSE = 690.03$, $p < .001$; $F2(1,62) = 13.73$, $MSE = 1030.35$, $p < .001$). The effect of case on common names (a 10 ms delay for stimuli with the initial letter capitalized) was marginally significant in the subject analysis ($F1(1,31) = 3.25$, $MSE = 690.03$, $p = .081$) and not significant in the item analysis ($F2(1,62) = 1.04$, $MSE = 1030.35$).

Error percentages were low and were not analyzed statistically, but their distribution did not suggest any speed-accuracy trade-off.

The ANOVA on pseudowords with the factors Name Type and Case Type showed a marginally significant effect of Case Type ($F1(1,31) = 3.79$, $MSE = 1135.44$, $p = .06$). Pseudowords with the first letter capitalized tended to be responded to more slowly than pseudowords in lower case (715 vs. 704 ms).

5.3. Discussion

Again, proper names were responded to faster than common nouns, but only when the first letter was capitalized. When the strings were written with all the letters in lower case, RTs to proper names and common nouns did not differ. Thus, there was a facilitation for proper names with the first letter capitalized with respect to the three other experimental conditions.

Two main considerations are in order at this point. First, the fact that the proper name advantage disappeared when the stimuli were written in lower case strongly suggests that case information was a relevant variable in the proper name recognition processes. Second, the fact that the advantage was just eliminated—and not reversed—suggests that the low familiarity (or the illegality) of proper names in lowercase is not the crucial variable. If so, in fact, we should have observed slower responses to proper names in lowercase than to common nouns in lowercase.

The fact that RTs to common nouns were a little faster (10 ms, marginally significant by subjects) when presented in lowercase than when presented with the first letter in capital might suggest the additional effect of an episodic component, which, however, could not account for the total pattern of results.

The advantage of proper name seems to depend crucially on the case of the first letter: The format of the first letter is relevant information coded by the visual system and used to recognize words. If this is true, we must assume that: (a) the information about first letter case is coded in the abstract orthographic representation used to contact the lexicon; and (b) word units in the orthographic input lexicon contain information about first letter case.

These two claims may be viewed as inconsistent with the original proposal of ALIs (Caramazza & Hillis, 1990; Coltheart, 1981), according to which the access code in word recognition is an abstract representation of letter identities that does not specify information about the actual form of the individual letters. Several empirical results indicate that such representation is indeed computed (e.g., Adams, 1979; Caramazza & Hillis, 1990; Coltheart, 1981; Miozzo & Caramazza, 1998) following earlier visual processing of the orthographic string. Thus, according to this view, two distinct types of letter representation are computed in reading. First, a letter shape map is constructed in which letters are encoded, preserving information about their actual form and orientation. Next, a graphemic map is derived, that specifies the identity and order of the letters, independently of their visual shape.

We propose that the results obtained here can be easily integrated within the ALI's theoretical framework. The main idea would be that information about the format of the first letter is coded in the abstract orthographic description that addresses recognition units in the orthographic input lexicon corresponding to proper names. This is based on the appreciation of the special status of the first letter, and assigns to it a specific role in lexical access. To motivate this claim, let us start by noting that information about the first letter case is specified in the orthographic output system, as the standard orthography for proper names requires the first letter in capital. Furthermore, information about the first letter case would become useful in those cases in which a letter sequence is ambiguous, being both a common noun and a proper name (i.e., rose–Rose). Thus, it is not implausible to postulate that the orthographic input system, analogously to the orthographic output system, contains information specifying that the uppercase first letter is the appropriate format for proper names.

According to this view, then, in computing graphemes from letter shapes, information about the case of the first letter is maintained and, in the case of an uppercase letter, an orthographic cue would mark the first grapheme. Lexical access processes would then use this orthographic cue to pre-activate those lexical units sharing the same marker specifying the uppercase format of the first letter, i.e., units corresponding to proper names.

This orthographic cue hypothesis explains both the advantage of proper names over common nouns when they are written with the first letter in capital, and the absence of any difference between proper names and common nouns when they are written in lowercase. In the latter condition, the graphemic map would not contain any orthographic information about the format of the first letter, and the letter sequence would be recognized on the basis of the identity and the relative position of each grapheme, as it happens for any kind of words. In this condition, thus, *ceteris paribus*, no difference between proper names and common nouns is expected.

The explicative hypothesis we offer for the pattern of results so far reported rests crucially on the notion that the graphemic map computed from the stimulus, as well as the long-term orthographic representation of proper names, are marked for information about the case of the first letter. According to this view, then, the advantage in written proper name recognition observed in the previous Experiments depends on the information about the case of the initial letter. Therefore, this advantage should not be observed when case information is neither available nor relevant to the task. As for the former, the modality in which the stimuli are presented is crucial, so that it can be predicted that when the lexical decision is required with auditorily presented stimuli, no proper name advantage should be obtained. As for the latter, we may predict that even in visual lexical decision there may not be a proper name advantage when the response can be computed on the basis of coarse and rapidly processed characteristics of the letter string. This would be the case of the lexical decision with random letter strings, as the rejection of random letter strings can be performed very rapidly and accurately, without retrieving lexical information (Carr et al., 1979; James, 1975; Peressotti et al., 1995). These predictions were tested in Experiments 4 and 5, respectively.

6. Experiment 4

Assuming that in the auditory lexical decision task there is no need to activate case information to access the lexicon, we predict no difference between RTs to proper names and common nouns.

6.1. Method

6.1.1. Stimuli

The stimuli were 96 words and 96 pseudowords. The words were 48 proper names (24 personal names and 24 geographical names) and 48 common nouns (24 household articles and 24 body parts). Half of the stimuli in each category were high frequency words and half were low frequency words. The frequency was derived from the Spoken Italian Frequency Count (De Mauro et al., 1993). High frequency proper names and common nouns were matched for frequency (mean frequency = 25.88, and mean frequency = 26, respectively, ranging form 7–129). Low frequency proper names and common nouns have both a nominal frequency of 0, since none of them was reported in the frequency count. Proper names and common nouns were also matched for length in letters (mean length = 6.3 and mean length = 6.2, respectively) and for the initial phoneme. Spoken pseudowords were derived from 48 new words, belonging to the same four semantic categories, by changing one phoneme. We changed phonemes in all position within the words in order to prevent the use of ad-hoc strategies by the participants. Words and pseudowords were matched for length.

6.2. Results

Table 4 reports mean RTs and error percentages. Separate analyses were carried out for words and pseudowords. The word data were screened for outliers using the procedure described by Van Selst and Jolicoeur (1994). Through this procedure 1.2% of the data was eliminated. The data were then submitted to ANOVAs with Frequency and Name Type as factors. The main effects and the interaction were significant: Frequency ($F1(1,44) = 556.3$, $MSE = 1533.08$, $p < .001$; $F2(1,92) = 52.89$, $MSE = 12022.22$, $p < .001$); Name Type ($F1(1,44) = 88.8$, $MSE = 1212.58$, $p < .01$; $F2(1,92) = 5.03$, $MSE = 12022.22$, $p < .01$); Frequency $\times$ Name Type

Table 4
Mean RTs (in ms) and error percentages (in parenthesis) obtained in each experimental condition of Experiment 4

	Words			Pseudowords		
	Frequency high	Low	Diff.	Frequency high	Low	Diff.
Common names	805 (0.4)	898 (9.3)	−93	968 (3.0)	988 (3.8)	−20
Proper names	803 (0.7)	985 (24.9)	−182	979 (4.9)	996 (3.2)	−17
Diff.	2	−87		−11	−8	

($F1(1,44) = 68.2$, $MSE = 1273.44$, $p < .001$; $F2(1,92) = 4.42$, $MSE = 12022.22$, $p < .05$). High frequency words were responded to faster than low frequency words (804 and 942 ms, respectively). The effect of Name Type was qualified by the interaction. While there was no difference between proper names and common nouns in the high frequency condition, common nouns were responded to faster than proper names in the low frequency condition. The ANOVA performed on accuracy rates confirmed this pattern. Both the main effects and the Interaction were significant (Frequency: $F1(1,44)$ 153.32, $MSE = .008$, $p < .001$; Name Type: $F1(1,44) = 109.23$, $MSE = .0026$, $p < .001$; Interaction: $F1(1,44) = 91.16$, $MSE = .0029$, $p < .001$).

As previously pointed out, the low frequency items were words that did not appear in the frequency count. These words, thus, could actually vary over an unspecified range for frequency and/or familiarity. In other words, it might be the case that the selected low frequency proper names were lower in frequency (or familiarity) than the selected low frequency common nouns. Given the crucial role of familiarity in word recognition (Suprenant et al., 1999), we collected familiarity ratings for the word stimuli used in the experiment. We asked 30 people to judge each word on a 7 point scale (1 = low familiarity, 7 = high familiarity). The mean familiarity rate obtained for each word was included as a covariate in a further analysis. The result showed that partialling out familiarity, the difference between low frequency proper names and low frequency common nouns was no longer significant ($F < 1$). The RT distribution for each stimulus category as a function of stimulus familiarity is shown in Fig. 1.

The ANOVA on pseudowords with the factors Name Type (i.e., pseudowords derived from proper names vs. pseudowords derived by common nouns) and Frequency (pseudowords derived from high frequency words vs. pseudowords derived by low frequency words) showed a significant effect of Frequency ($F1(1,44) = 8.98$, $MSE = 1696.6$, $p < .05$) and a marginally significant effect of Name Type ($F1(1,44) = 3.12$, $MSE = 1226.6$, $p = .084$). Pseudowords derived from high frequency words were responded to faster than pseudowords derived from low frequency words (974 and 992 ms, respectively). Pseudowords derived from proper names were responded slightly more slowly than pseudowords derived from common nouns (987 and 978 ms, respectively). To assess the reliability of these results, on the same data we performed an ANOVA with items as the random factor. No significant effects were obtained (all Fs < 1).

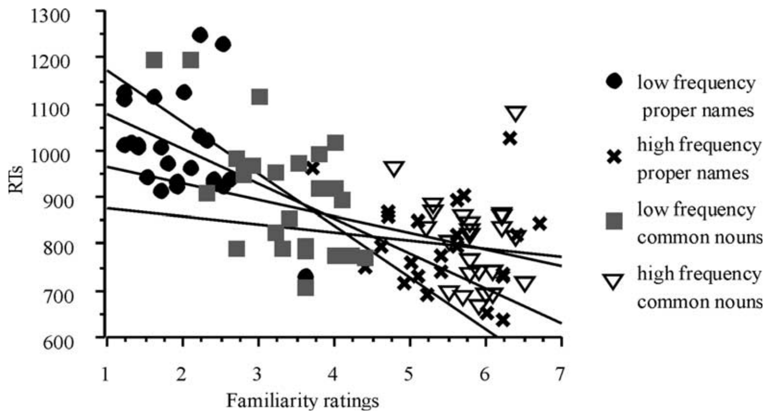

Fig. 1. Scattergram with regression lines as a function of Name Type and Familiarity rating for each of the stimuli of Experiment 4. While high frequency proper and common names were almost overlapping, low frequency common nouns were evaluated more familiar than proper names.

6.3. Discussion

The results of this experiment showed that when the stimuli were presented auditorily, the proper name advantage disappeared. Mean RTs varied as a function of the frequency of the word, but when words were matched for frequency and/or familiarity, mean RTs did not vary according to word type.

The fact that the advantage for proper names was observed only with written words positively rules out the hypothesis that the difference we report in the recognition of proper names and common nouns reflects differences at the lexical-semantic level. Rather, it suggests that the proper name advantage observed in the previous experiments arises at a processing level specific to reading, i.e., orthographic processing.

7. Experiment 5

In the present experiment the same material as in Experiment 3 was used, but the legal pseudowords were replaced by illegal random combinations of consonants of the same length.

Assuming that the presence of illegal non-words (i.e., random consonant strings) in the experimental list allows performing the visual lexical decision task without the need to retrieve full-fledge lexical information, we predict no difference between proper names and common nouns.

7.1. Method

7.1.1. Stimuli

The word stimuli were the same 32 proper names e 32 common nouns used in Experiment 3. The non-word stimuli were 96 random consonant strings of the same

Table 5
Mean RTs (in ms) and error percentages (in parenthesis) obtained in each experimental condition of Experiment 5

	Words			Illegal non-words		
	First capital	Lower case	Diff.	First capital	Lower case	Diff.
Common names	427 (1.6)	438 (3.1)	−11	430 (3.6)	421 (2.2)	9
Proper names	421 (1.6)	433 (1.7)	−12			
Diff.	6	5				

length as the words. In the same way as in Experiment 3, each letter string was presented either with the first letter capitalized or with all letters in lower case.

7.2. Results

Mean correct RTs and error percentages are reported in Table 5. Among correct word RTs, outliers were individuated and removed (1.6% of the data), using the procedure described by Van Selst and Jolicoeur (1994). The data were then submitted to ANOVAs with Name Type and Case Type as factors. No difference was obtained between proper names and common nouns in the two case conditions ($F1(1,31) = 1.7$, $p > .2$; $F2(1,62) = 1.8$, $p = .18$). A main effect of Case was found ($F1(1,31) = 7.71$, $MSE = 571.1$, $p = .009$; $F2(1,62) = 14.23$, $MSE = 266.95$, $p < .001$), as words with the first letter in capital were responded to faster than words in lowercase (424 vs 436 ms). The interaction was not significant either by participant or by items (both Fs < 1).

Error percentages reflected the RTs pattern, and did not suggest any speed-accuracy trade-off. Since errors were very few, they were not analyzed statistically.

In the ANOVA on the non-words, the factor Case Type was significant ($F1(1,31) = 8.36$, $MSE = 148.52$, $p = .007$). Non-words with the first letter capitalized were rejected more slowly than non-words in lowercase.

7.3. Discussion

The pattern obtained accords well with that expected: The first letter capitalized does not enhance recognition of proper names with respect to common nouns when illegal non-words are used. There is a small but significant advantage for words with the first letter capitalized, irrespective of the proper name/common noun status, which may be attribute to these stimuli being more word-like than lower case stimuli. This proposal accords well with the finding that non-words, even though illegal, are rejected more slowly when written with the first letter in capital.

Since the logic underlying this experiment was to show that replacing pseudowords with illegal non-words would have eliminated the proper name advantage, we compared latencies to word stimuli obtained in the present experiment with those of Experiment 3, as the same proper names and common nouns were presented in the same case conditions in the two experiments. ANOVAs by participants and by items were performed with Experiment, Name Type, and Case Type as factors. All three main effects were significant: Experiment ($F1(1,62) = 115.58$, $MSE = 16154.28$, $p < .001$; $F2(1,62) = 1857.57$, $MSE = 985.44$, $p < .001$), Name Type ($F1(1,62) = 11.719$, $MSE = 818.74$, $p = .001$; $F2(1,62) = 6.49$, $MSE = 1411.47$, $p = .013$), and Case Type ($F1(1,62) = 16.02$, $MSE = 527.67$, $p < .001$; $F2(1,62) = 11.33$, $MSE = 663.41$, $p = .001$). As for the second order interactions, Name Type × Case Type was significant ($F1(1,62) = 13.99$, $MSE = 507.80$, $p < .001$; $F2(1,62) = 9.47$, $MSE = 663.41$, $\text{p} = .003$), and Name Type × Experiment was marginally significant ($F1(1,62) = 3.41$, $MSE = 818.74$, $p = .061$; $F2(1,62) = 2.97$, $MSE = 985.45$, $p = .090$). Finally, and more interestingly for our hypothesis, the third order interaction Experimen × Name Type × Case Type was significant ($F1(1,62) = 12.92$, $MSE = 507.82$, $p < .001$; $F2(1,62) = 8.26$, $MSE = 633.89$, $p = .006$).

Two results should be singled out. First, latencies to the same word stimuli were consistently faster in Experiment 5 than in Experiment 3. Second, the interaction between Name Type and Case type (i.e., the interaction showing the proper name advantage) obtained in Experiment 3 disappears in Experiment 5, where proper names were not responded to faster than common nouns.

The interpretation we would like to offer for this pattern of response is that when words and non-words can be distinguished on the basis of the coarse visual and/or orthographic structure, no access to detailed lexical information is required to mediate lexical decision; however, when words and non-word stimuli cannot be distinguished on the basis of such visual/orthographic characteristics, higher order mechanisms requiring the retrieval of lexical information are needed to perform the task (for a discussion see Carr, 1986). It is only in this latter condition that the case of the first letter becomes relevant for the recognition of proper names. The lack of a proper name advantage in this experiment further supports the hypothesis that the effects reported in Experiments 1–3 were due to the orthographic information about the first letter having an effect in activating lexical units.

8. General discussion

The proper name advantage we have documented can be appreciated considering that proper names with the initial letter capitalized are recognized consistently faster than common nouns written in the same format. Further, proper names with the first letter capitalized are recognized faster than proper names and common nouns with the first letter in lower case. Crucially, recognition times for the latter two sets of stimuli do not differ from each other, and are as fast as those for common nouns written with the first letter capitalized. This pattern is best explained as a facilitation effect for proper names with the first letter capitalized, rather than an inhibition in the other experimental conditions. The advantage for proper names disappears when words are presented auditorily (Experiment 4) and this invites the conclusion that the facilitation effect for written proper names occurs at the orthographic (rather than at the semantic) level of representation. The advantage for proper names also disappears when participants have to discriminate between visually presented words and illegal non-words, consistent with the hypothesis that the case of the first letter has a role only when lexical processing is required.

In terms of models distinguishing between lemma and lexeme, such as Levelt, Roelofs, and Meyer's (1999) WEAVER++, the effects we are reporting concern the lexeme, the level of lexical representation that specifies information about phonological/orthographic form and morphological structure. Since the effect we report is an orthographic effect, Caramazza's (1997) distinction between two autonomous modality-specific lexemes, phonological (P-lexeme) and orthographic (O-lexeme), is particularly relevant. In fact, the abstract representation level specifying case information corresponds to the O-lexeme, which can be activated independently from the corresponding P-lexeme. Finally, with respect to the distinction, drown by Valentine, Brennen, and Brédart (1996); (see also Hollis & Valentine, 2001), between two levels of word form representation, i.e., output lexicon and word recognition units, the level of representation specifying first letter case information, and allowing the recognition of familiar words, corresponds to the visual word recognition unit.

8.1. Abstract letter identities and case information

The initial capital letter is associated with a categorical distinction between proper names and common nouns. Our results show that this distinction brings about processing consequences. While the orthographic nature of the distinction is uncontroversial, no existing theoretical account can explain the pattern we obtained in a straightforward way. On the one hand, our data suggest that the form of the initial letter influences lexical access by speeding up the word recognition process when associated to a proper name. This is *prima facie* counter-evidence for a level of orthographic representation based on abstract letter identities. On the other hand, the present results do not support an account based on the frequency (or familiarity) of a given letter pattern. Indeed, contrary to the predictions of episodic theories of word recognition, recognition times do not vary as a function of the word visual forms we are usually exposed to. Thus, common nouns with the first letter capitalized and proper names with the first letter in lowercase are not recognized more slowly than common nouns with the first letter in lower case.

Most models of visual word recognition assume that the orthographic code used to access long-term stored representation of words is abstract in nature, i.e., independent from the physical features of the actual stimuli. When a letter string is processed, information about the identity and position of the constituent letters is computed and then matched with the orthographic description of known words stored in the mental lexicon. Given that an individual word can be recognized as familiar even when written in a new style, it is very plausible to postulate some abstraction processes in order to deal with different types of letter fonts having quite different shapes. If information about the letter shape is assumed not to be relevant for the reading process and not specified at the abstract level of orthographic representation, no difference in recognition times for letter strings in lower or upper case should be expected. Several empirical results, partly reviewed in the introduction of this paper, are congruent with this prediction (e.g., Adams, 1979; Caramazza & Hillis, 1990; Coltheart, 1981; Henderson, 1982; Peressotti et al., 1995). In particular, Evett and Humphreys (1981) reported a pure effect of abstract (non-visual) graphemic features in a four-field masking priming paradigm, and Friedman (1980) showed that for both pseudowords and single letters case was often reported incorrectly when letter identity was reported correctly.

Apparently, the empirical data we have presented are in contrast with the assumption of an abstract level of letter identity. However, in the following section we argue that this is not the case, and that the advantage of the proper names with the first letter capitalized is best explained hypothesizing that abstract letter identities mediate word recognition.

8.2. The orthographic cue hypothesis

In this section we propose a theoretical framework within which it is possible to account for the advantage of the proper names with the first letter capitalized. The main assumption underlying our proposal is that case information is coded at the orthographic description level. Our claim is that while size, font and style (cursive or print) affect the visual shape of letters, the uppercase-lowercase distinction is abstract in nature since it is an intrinsic property of letters. All letters can be realized in uppercase or lowercase format, independently from any contingent visual features. Also, case is relevant orthographic information whose functions may differ in different written languages: The initial letter in capital distinguishes words of different grammatical classes (proper names vs. common nouns in Italian, nouns vs. verbs in German), and it is used in specific sentential contexts (following full stop in Italian, following either full stop or colon in English).

We propose that information about the first letter case is represented at the graphemic level. The case of the initial letter is a relevant orthographic information, that, when associated with other abstract properties, informs about the correct way to write a given word. When computing the abstract graphemic description from the letter shapes, information about the case of the first letter would be automatically coded. Such representation is marked for one of the two possible levels of the feature, i.e., the uppercase. As shown in Fig. 2, the marker does not retain information about the physical feature of the letter, but analogously to other markers, enables to specify the actual value on the relevant dimension. This information would be incorporated into the structure of the graphemic representation.

Converging experimental evidence supports the view that the orthographic representations of words are multidimensional structures in which different types of information are independently specified, and not simple linear sequences of letter tokens. For example, Berent and Perfetti (1995) showed the existence of different processing cycles for consonant and vowels in reading, and suggested that the distinction between consonants and vowels could be represented at the graphemic level. Also, several studies supported the idea that sub-lexical clusters, such as syllables, are relevant processing units in word recognition and they are assembled at the orthographic

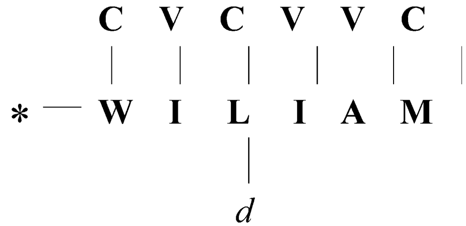

Fig. 2. The assumed structure of the orthographic representation of the word "William." C, consonant; V, vowel; *d*, doubling feature; *, marker for capital letter.

level (Perea & Carreiras, 1998; Rapp, 1992; Taft, 1979). Most evidence supporting the multidimensional structure of orthographic representations comes from neuropsychological studies on acquired dysgraphia (e.g., Caramazza & Miceli, 1990; Tanturier & Rapp, 2001). The analysis of the errors made by dysgraphic patients suggests that information about letter doubling and consonant/vowel status is coded at representational levels different from that specifying letter identity and order. Patients have been described showing the selective impairment (Miceli, Benvegnù, Capasso, & Caramazza, 1995; Venneri, Cubelli, & Caffarra, 1994) or the selective sparing (Tanturier & Caramazza, 1996) of the production of double letters, and suggesting the independence of letter identity and letter quantity information. Furthermore, several patients have been reported (Caramazza & Miceli, 1990; Cubelli, 1991; McCloskey, Badecker, Goodman-Shulman, & Aliminosa, 1994), making substitution and transposition errors that respected the status of the target letters, with consonants involving consonants and vowels involving vowels. These error patterns suggest that information about letter identity can be selectively lost but the knowledge of the consonant/vowel status of the letters could be preserved. In sum, a large amount of neuropsychological evidence indicate that orthographic representations may be viewed as having a multidimensional structure, in which different features of a word's orthography are encoded at functionally distinct levels.

The present proposal rests crucially on the notion that the first letter of proper names has a relevant role in the recognition process. This motivates the question whether the first letter of *any* word enjoys a relevant role. Two recent models are relevant on this issue as they aim at explaining how letter position is coded in printed word perception. Interestingly, both predict a special status of the first letter, even though the models are qualitatively very different.

In the model proposed by Grainger, Granier, Farioli, van Heuven, and Peressotti (submitted) visual word recognition requires, among others, three levels of representation: the alphanumeric array, the relative position map, and the whole-word orthographic representation. The alphanumeric array provides a retinotopic map of all characters in a given string. Each character detector computes information about the identity of a given character at a specified retinal location. This information then provides character-in-string position information at the relative position map level, in which letters directly next to a space are coded as outer letters while the other letters are coded as inner clusters. This map is fully connected by bi-directional excitatory and inhibitory connections to the orthographic level, which contains all words whose spelling is known. According to this framework, then, a specific letter identity is assigned to the first and the last letters of a string, while minimal positional information about inner letters is postulated.

Whitney (2001) also proposes a multilevel recognition system. The main idea in her proposal is that the relative order of letters in a word is achieved by an activation gradient that decreases monotonically from the beginning to the end of a word. At the letter level, activation from the feature level is converted into a temporal firing pattern across letter nodes, in which the firing order tags position. Thus, feature nodes corresponding to the first letter attain the highest level of activation and the letter node receiving the highest level of input fires first because it reaches threshold before the others.

Apart from the obvious and theoretically relevant differences between the two models, both assign a special status to the first letter, and this is in line with our assumption that identity and position of the first letter are strongly intertwined, and constitute anchoring points for processing. It is for this letter that case is coded, and becomes relevant for recognition when it is diagnostic, as in the case of proper names.

At the processing level, we might distinguish the effect of the first letter in word recognition as occurring either pre- or post-lexically. Consider the latter case first. In order to consider the post-lexical alternative, according to which the orthographic cue has a post-encoding effect, we analyze the predictions of a model that distinguishes explicitly pre- and post-lexical stages in word recognition. According to the verification model (Paap & Johansen, 1994; Paap, Newsome, McDonald, & Schvaneveldt, 1982), a word is recognized through a verification stage that involves a comparison between the bottom-up representation built from the perceived letter string and the orthographic representation retrieved from a word unit in the lexicon. When the match criterion between these two representations is reached, a word is recognized. More specifically, verification is usually described as a serial comparison process in which candidates produced by the early visual analyses are verified according to their frequency. High frequency candidates would be the first to be submitted to the comparison and, thus, would be recognized faster than low frequency candidates. In order to account for proper name advantage within this model, two hypothetical mechanisms can be proposed. Proper names are recognized faster because of the full match between the visually computed representation and the lexically retrieved representation, both marked with the cue for the initial letter capitalized. Alternatively, the presence of the cue could affect the order with which the candidates queue for verification. In other words, when the visually computed representation is marked for the first letter case, proper name candidates are pushed toward the top of the verification queue, speeding up their recognition time, in a way similar to what is hypothesized for high frequency words. In both cases, however, the model would predict equally fast RTs to proper names in capital and to common nouns in lowercase. Indeed, in both cases there is a full match between the visually computed and the lexically retrieved representations, and in both cases, the correct target is at the top, or near the top, of the verification list. On the other hand, recognition should be equally slow for both proper names in lowercase and common nouns in uppercase. These items do not provide a perfect match between the visually computed and the lexically retrieved representations and do not produce a verification list with the target word at the top. Proper names in lowercase would be verified following a queue which contains also common nouns similar to the target word, potentially placed at the top positions; common nouns in uppercase would be verified following a queue containing proper names similar to the target word, placed at the top positions. The pattern predicted by the verification model would thus be the following: Both common nouns in upper case and proper names in lowercase should be slower than common nouns in lowercase and proper names in uppercase. Clearly, this is not the pattern we obtained.

Let us now consider the pre-lexical alternative. For this to be tenable, we must assume that the units corresponding to proper names in the lexicon, in addition to information about constituent graphemes, such as identity and order, contain information about first letter case. The abstract information about the capital format of the first letter is a crucial orthographic cue for proper name identification. The cue constraints the recognition processes among those words units corresponding to proper names. This mechanism could be thought as a selective pre-activation of proper name word nodes. The cue would affect the encoding stage by influencing the resting level of activation, which in turn determines the set of candidates. A model with these characteristics would account for the entire pattern of results in terms of a processing advantage for proper names when written with the first letter in capital, without postulating any penalty for proper names written in lowercase. For these stimuli, the activation resting level would not be modified by absence of the orthographic cue and proper names would be recognized at the same rate as comparable common nouns (i.e., common nouns matched for frequency and length).

In summary, our findings strongly suggest that information about first letter case is coded in the episodic, bottom-up representation of the actual stimulus and specified in the word units corresponding to proper names in the orthographic input lexicon. We have proposed that the capitalized first letter is a crucial orthographic cue able to speed up recognition of written words, and that information about the first letter case has to be considered as an abstract orthographic property.

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Appendix A

Experimental stimuli and their translation in brackets.

A.1. Proper names

A.1.1. Experiments 1, 2, 3, and 5

Alessandro (*Alexander*), Anna (*Ann*), Antonio (*Anthony*), Daniele (*Daniel*), Elisa (*Liza*), Filippo (*Philip*), Francesca (*Frances*), Giovanni (*John*), Giuseppe (*Joseph*), Lorenzo (*Lawrence*), Luciano, Maria (*Mary*), Matteo (*Matthew*), Maurizio, Paolo (*Paul*), Piero (*Peter*), Albania (*Albania*), America (*America*), Bergamo, Bologna, Cina (*China*), Europa (*Europe*), Francia (*France*), Genova, Giappone (*Japan*), Lazio, Lombardia, Parigi (*Paris*), Russia (*Russia*), Torino (*Turin*), Toscana, (*Tuscany*), Venezia (*Venice*).

A.1.2. Experiment 4

High frequency: Antonio (*Anthony*), Barbara (*Barbara*), Carlo (*Charles*), Claudia (*Claude*), Francesca (*Frances*), Luciano, Marco (*Marc*), Maria (*Mary*), Paolo (*Paul*), Piero (*Peter*), Roberto (*Robert*), Sandro, Albania (*Albania*), America (*America*), Europa (*Europe*), Firenze (*Florence*), Francia (*France*), Genova (*Genoa*), Italia (*Italy*), Milano (*Milan*), Roma (*Rome*), Russia (*Russia*), Venezia (*Venice*).

Low frequency: Alcide, Bonifacio, Casimiro, Cirillo, Leonia, Moira, Poldo, Serafino, Siro, Tecla, Teresa (*Theresa*), Berna (*Bern*), Burundi (*Burundi*), Chieti, Coimbra (*Coimbra*), Foligno, Granada (*Granada*), Matera, Panama (*Panama*), Patrasso (*Patrai*), Rodi (*Rhodes*), Sofia (*Sofia*), Termoli.

A.2. Common nouns

A.2.1. Experiment 1

Amicizia (*Friendship*), Animale (*Animal*), Assenza (*Absence*), Attore (*Actor*), Carne (*Flesh*), Cartello (*Board*), Cifra (*Digit*), Cliente (*Client*), Confine (*Border*), Contrario (*Contrary*), Costa (*Coast*), Fabbrica (*Factory*), Lista (*List*), Mancaza (*Lack*), Materia (*Matter*), Meccanismo (*Mechanism*), Mercato (*Market*), Offerta (*Offer*), Parente (*Relative*), Patata (*Potato*), Piano (*Floor*), Reparto (*Sector*), Resto (*Change*), Ricordo (*Remembrance*), Salute (*Healh*), Scatola (*Box*), Sincero (*Sincere*), Soldato (*Soldier*), Stile (*Style*), Tappeto (*Carpet*), Vendita (*Sale*), Viso (*Face*).

A.2.2. Experiments 2, 3, and 5

Aiuto (*Help*), Amicizia (*Friendship*), Bene (*Goodness*), Colpa (*Fault*), Curiosità (*Curiosity*), Dolore (*Pain*), Fastidio (*Bother*), Fatica (*Fatigue*), Mancanza (*Lack*), Miseria (*Misery*), Pace (*Peace*), Paura (*Fear*), Pazienza (*Patience*), Piacere (*Pleasure*), Riguardo (*Regard*), Speranza (*Hope*), Artista (*Artist*), Attore (*Actor*), Dirigente (*Manager*), Dottore (*Doctor*), Giudice (*Judge*), Guardia (*Guard*), Maestro (*Teacher*), Ministro (*Minister*), Notaio (*Notary*), Operaio (*Worker*), Pittore (*Painter*), Regista (*Director*), Scrittore (*Writer*), Sindaco (*Mayor*), Soldato (*Soldier*), Vigile (*Policeman*).

A.2.3. Experiment 4

High frequency: Braccio (*Arm*), Capelli (*Hair*), Corpo (*Body*), Faccia (*Face*), Fianco (*Flank*), Fronte (*Forehead*), Lingua (*Tongue*), Occhio (*Eye*), Orecchio (*Ear*), Pancia (*Belly*), Spalla (*Shoulder*), Testa (*Head*), Appartamento (*Apartment*), Bagno (*Bathroom*), Camera (*Bedroom*), Cucina (*Kitchen*), Finestra (*Window*), Lenzuolo (*Sheet*), Muro (*Wall*), Piatto (*Dish*), Porta (*Door*), Radio (*Radio*), Sala (*Hall*), Scala (*Stairway*).

Low frequency: Bicipite (*Biceps*), Busto (*Bust*), Ciglia (*Eyelash*), Cranio (*Skull*), Falange (*Phalanx*), Gengiva (*Gum*), Milza (*Spleen*), Perone (*Fibula*), Plasma (*Plasma*), Rotula (*Knee-cap),*Sterno (*Sternum*), Timpano (*Tympanum*), Atrio (*Entrance Hall*), Ballatoio (*Open gallery*), Catino (*Bacin*), Colino (*Strainer*), Culla (*Cradle*), Lavabo (*Washstand*), Madia (*Kneading-through*), Pomello (*Cheek-bone*), Scansia (*Bookcase*), Stipite (*Jamb*), Teglia (*Baking pan*), Tegola (*Tile*).

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