WORD READING AND PICTURE NAMING IN ITALIAN

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ABSTRACT —

Results from two separate norming studies of lexical access in Italian were merged, permitting a comparison of word-reading and picture-naming latencies and the factors that predict each one for an overlapping subsample of 128 common nouns. Factor analysis of shared lexical predictors yielded four latent variables: a frequency factor, a semantic factor, a length factor, and a final factor dominated by presence of a word-initial fricative. Age of acquisition (AoA) loaded highly on the first two factors, suggesting that it can be split into separate sources of variance. Regression analyses using factor scores as predictors showed that word reading and picture naming are both influenced by the frequency/AoA factor. The semantics/AoA factor only influenced picture naming, while the length and frication factors only influenced word reading. Generalizability of these results to other languages is discussed, including cross-language differences in orthographic transparency.

Word reading and picture naming are tasks with a long history in psycholinguistic research (Cattell, 1886), including studies comparing reaction times in each modality for the same target words (Federmeier, 1999; Federmeier & Kutas, 1999a,b, 2000; Federmeier, Segal, Lombrozo, & Kutas, 1999; Potter & Faulconer, 1975; Potter, Kroll, Yachzel, Carpenter, & Sherman, 1986). All studies to date have reported shorter latencies for word reading (at least in adults), and various proposals to account for this RT difference have been advanced. For example, Potter and colleagues have suggested that picture naming requires obligatory lexical access, while word reading could (at least in principle) be accomplished without accessing the full semantic and grammatical representation of the word (both lemma and concept). However, some studies have shown that word reading is affected by factors like imageability or concreteness, especially for low-frequency words. Such results necessarily reflect activation of both the lemma and the concept associated with those words (see Balota, Ferraro, & Connor, 1991; Strain, Patterson, & Seidenberg, 1995). Furthermore, visual word naming has been used successfully in dozens of semantic and/or grammatical priming studies, suggesting that readers do access multiple levels of lexical representation while they are reading target words. Picture naming is used less often in priming paradigms, but the few studies that have used picture naming for this purpose have also reported robust effects of semantic and/or grammatical context (Bentrovato, Devescovi, D'Amico, & Bates, 1999; Federmeier & Bates, 1997; Jacobsen, 1999; Lu et al., 2000; Wicha et al., 1997), including a recent study showing effects of sentence context on picture naming from 3-87 years of age (Roe et al., in press). Finally, effects of both word frequency and word age of acquisition (AoA) have been reported for visual word naming and for picture naming, although the locus of these effects is still controversial (Barry, Morrison, & Ellis, 1997; Brysbaert, Lange, & van Wijnendaele, 2000; Ellis & Morrison, 1998; Gerhand & Barry, 1998; Gilhooly & Logie, 1981; Morrison, Chappell, & Ellis, 1997; Morrison & Ellis, 1995; Morrison & Ellis, in press; Morrison, Ellis, & Quinlan, 1992).

In this report, we will compare reaction time results for word reading and picture naming in Italian-speaking adults, based on 128 overlapping items (all common nouns) from two separate norming studies in the Italian language. The picture-naming data are drawn from the Italian component of a large international picture-naming norming study involving 520 object pictures, 50 participants per language (Bates et al., 2000; see also D'Amico, Devescovi, & Bates, 2000). The word-reading data are drawn from a norming study of word reading in Italian, involving 516 common nouns, and 30 participants (Burani, Barca, & Arduino, 2000). These data are part of a larger study in which normative data for various lexical and sublexical variables were collected (from 44 participants for each variable), for 626 Italian simplex nouns (Burani, Barca, & Arduino, in press).

Although results are certainly preliminary, this comparison of word reading and picture naming in Italian provides information that could not be derived from comparable modality comparisons in English (e.g., Federmeier, 1999; Federmeier & Kutas, 1999a,b; Federmeier & Kutas, 2000; Potter et al., 1986). In contrast with English, which has a complex orthographic system involving many irregular forms, the Italian system of grapheme-to-phoneme correspondence is extremely transparent. In Italian, word stress is the only aspect of pronunciation that cannot always be predicted directly from the written form of the word. Hence, in principle, it should be easier to pass directly from graphemic input to oral pronunciation in Italian, without passing through the lexicon, and without accessing either the concept or the lemma (at least if words are presented in isolation).

In fact, lexical effects have been found in Italian word pronunciation studies, for words (Colombo & Tabossi, 1992; Tabossi & Laghi, 1992) and pseudowords (Burani, Dovetto, Spuntarelli, & Thornton, 1999; Burani & Laudanna, in press; Job, Peressotti, & Cusinato, 1998). So it is already clear that Italians do pass through the lexicon during word reading. However, we can offer the more conservative hypothesis that reliance on lexical reading may be weaker for Italian compared to languages with deeper orthographies like English (Arduino & Burani, 2000; Brysbaert et al., 2000; Frost, 1994; Frost, Katz, & Bentin, 1987). In this regard, a recent neural imaging study by Paulesu et al. (2000) compared word reading in monolingual speakers of English vs. Italian, and found distinct patterns of activation. In Italian, word reading elicited activation primarily in superior temporal regions, which the authors attribute to phonemic processing. In English, the corresponding words (matched to Italian in length and complexity) elicited greater activation in frontal and inferior temporal sites, which the authors attribute to word retrieval. Regardless of how one chooses to interpret these frontal-temporal differences, the Paulesu et al. results provide support for the hypothesis that word

reading processes may differ in fundamental ways for English and Italian.

In this brief report, we will compare the two modalities (i.e., word reading and picture naming) in analyses over items, looking for similarities and differences in the factors that affect lexical access times. Results for Italian serve as the motivation for a larger study (now in progress) comparing word reading, auditory word repetition and picture naming for the same (translation equivalent) items in Italian, English and Chinese.

METHOD

Word reading

Participants. Participants in the reading study were 30 university students (15 male, 15 female) between 20 and 30 years of age. All were native speakers of Italian. Some were volunteers, others were paid small sums for their participation.

Materials. The materials employed in this report are based on results for a large reading time study (Burani et al., 2000) of 516 simple Italian nouns (morphologically uninflected nouns, 4 to 9 letters in length, with a frequency between 1 and 2253 based on a written corpus of 1,500,000 words (Istituto di Linguistica Computazionale del CNR, Pisa, 1989). This sample of 516 words was taken, in turn, from a large database reported by Burani et al. (in press), available on the authors' website (http://www.ip.cnr.it/database). In the analyses presented below, we will restrict our attention to a subset of 128 words in the word-reading study that overlap with items in the picture-naming study (described below).

Procedure. Participants were tested individually in a quiet room. They were asked to read aloud a series of words that would appear on the computer screen in front of them. The words were divided into blocks, and presented in a single session. The order of words within blocks was individually randomized. The order of block presentation was also randomized. Before beginning the task, participants read printed instructions, in which they were asked to respond as quickly as possible but to avoid making mistakes. Reaction times from word onset to the beginning of each vocalization were collected by a voice key connected to the computer, within the MEL Professional 2.0 experimental control shell. A microphone was attached to the voice key and to a tape recorder for recording the session. The experimenter registered all the stimuli incorrectly pronounced, and those were eliminated from subsequent analyses.

The stimuli appeared in capital letters in the center of the computer screen, preceded by a fixation point (400 ms). They stayed on the computer screen for a maximum of 1 sec (1000 ms). If the participant did not produce any answer within that time, the feedback "Fuori tempo" (Out of time) appeared on the screen. The experiment was preceded by a brief practice session to familiarize participants with the task; items in the practice session did not occur in the main experiment.

Predictor variables for word reading. All of the words in the reading database were coded to reflect the following predictor variables:

- Age of acquisition, defined as the estimated age at which the word and its meaning were first learned, either in the auditory or the written modality.
- Familiarity, defined as the estimated frequency of occurrence of the word, in written or spoken form, in the raters' own daily lives or the daily lives of other people like themselves (Connine, Mullennix, Shernoff, & Yelen, 1990; Gernsbacher, 1984; Noble, 1953).
- Imageability, defined as the ease and speed with which the target word evokes a mental image (a visual representation, a sound or any other sensory experience—Paivio, Yuille, & Madigan, 1968).
- Concreteness, defined as a property of words referring to objects, animate beings, actions or materials that can be experienced directly by the senses (Paivio et al., 1968).

Values for these four variables were gathered in subjective ratings (on a 1–7 scale) by 176 students (44 students, half male and half female, for each variable). All raters were native speakers of Italian between 20 and 30 years of age, students at one of several universities in the Rome area. None of the students in the reading study had participated in these ratings.

In addition to these ratings, the following measures were taken:

- Written adult word frequencies taken from the CNR Institute of Computational Linguistics database (1989), based on a corpus of 1,500,000 words in contemporary written Italian texts.
- Written child word frequencies taken from the *Lessico Elementare* (Elementary Lexicon) by Marconi, Ott, Pesenti, Ratti, & Tavella (1993). These norms are based on materials written by adults for children, and on writings by children. The corpus includes 500,000 word tokens adopted from readers, fairy tales, school newspapers, comic books and textbooks written for children between the first and fifth grades; another 500,000 tokens are taken from essays written by first- to fifth-grade children. Of the various indices available, our word-reading study used absolute word frequency (unweighted tokens of the citation form from the entire corpus).
- Spoken adult word frequencies were taken from the Lessico di frequenza dell'italiano parlato (Lexical frequencies in spoken Italian) by De Mauro, Mancini, Vedovelli, & Voghera (1993), based on a corpus of 500,000 words from samples of contemporary spoken Italian. Our reading study used the frequency of the singular word form.
- Number of orthographic neighbors, or density is defined as the number of words that can be obtained by substituting one letter at a time within the target

(Coltheart, Davelaar, Jonasson, & Besner, 1977; for a review of effects of orthographic density on recognition of written words, see Andrews, 1997). Density values for these Italian words were taken from Baldi & Traficante (2000), adjusted to exclude word neighbors that are highly unfamiliar.

- Word length in letters was based on a simple orthographic count (for orthographic word length effects on reading, see Weekes, 1997).

Picture naming

Participants. For comparison with performance in the reading study, we made use of data for 50 adult native speakers of Italian, taken from the Center for Research in Language International Picture Norming Study (CRL-IPN, Bates et al., 2000; see also D'Amico et al., 2000). All participants were university students who volunteered, or were paid a small sum (5,000 Italian lire) for their participation.

Materials. Picture stimuli for object naming were black-and-white line drawings of common objects from various sources, including 174 pictures from the original set by Snodgrass & Vanderwart (1980). (For further details, see Bates et al., 2000.) All stimuli were scanned and stored digitally for presentation within the PsyScope Experimental Control Shell, in 10 different randomized orders.

Procedure. The digitized picture images were set in black outline on a white background and were presented on the monitor of a Macintosh laptop computer. Participants wore headphones with a sensitive built-in microphone (adjusted to optimal distance from the participant's mouth) that were connected to the Carnegie Mellon button box, a measuring device with 1-ms resolution design for use with Macintosh computers. Response times were collected by a voice key using the CMU button box, which was connected to the computer. The PsyScope Experimental Shell, a program developed to administer experimental presentation (presentation of stimuli, storing data, recording time and response, etc.) was used (Cohen, MacWhinney, Flatt, & Provost, 1993).

Each participant was tested individually in a quiet room, in a single session. They were instructed to name the pictures with the first name that came to mind, as quickly as possible without making a mistake. They were urged to speak clearly, to name each picture with a single word if possible, and not to emit any other sounds (no clearing of the throat, no preparatory sounds like "uhmmm" no articles before the noun). To familiarize them with the procedure, they were given a practice period with pictures depicting geometric forms (circle, triangle, etc.) that did not appear in the main experiment. On each trial, the target picture remained on the screen for a maximum of 5 seconds (5000 ms). The picture disappeared from the screen as soon as a vocal response was registered by the voice key; if there was no response, the picture disappeared at the end of the 5000-ms window. Participants were randomly assigned to one of ten random orders of picture presentation. During the session, the experimenter held a list of stimuli corresponding to the random order for that participant, on which the experimenter wrote the participant's response (if it differed from the expected name), and indicated any failures to respond or other artifacts.

Scoring. The target name for each picture was determined empirically, in two steps. First, the data were subjected to error coding to determine which responses could be retained for both naming and RT analyses. Responses were eliminated if there were failures to respond, or reaction time artifacts (coughs, hesitations, false starts, or prenominal verbalization like "that's a ball"), or if the participant did produce a name, but it failed to register with the voice key. Based on the remaining trials, the target name was defined as the dominant response, i.e. the name that was used by the largest number of subjects. Various lexical codings were given for alternatives to the dominant response (morphological variants, synonyms, other). For present purposes, we will restrict our analyses to reaction times for those trials on which participants produced the dominant response, corresponding to the target words that were also used in the reading time study.

In addition to some of the variables outlined above for the reading time study, the following variables were used in the picture-naming study:

- Word length in syllables.
- Presence/absence of a fricative or affricate in the initial consonant (0 = no fricative or affricate; 1 = fricative or affricate), included because this variable has been reported to influence the time required for a response to register on the voice key (for fricatives and affricates being slower in triggering the voice key, see e.g., Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995, Part 2).
- Written child word frequencies were used in the picture-naming study, from the same source adopted for the word-reading study (Marconi et al.,1993). Whereas the reading study had taken the absolute frequency of the citation form across the entire corpus as the basis for these counts, the picture-naming study had adopted an adjusted frequency measure that took into account the distribution of the word across various corpora within the Marconi et al. database. In this comparative study, we will use both indices, for both modalities.
- Spoken adult word frequencies were also taken from the same source adopted for the word reading study (De Mauro et al., 1993). While the reading study had used the frequency of the singular word form, the picture-naming study had adopted the cumulative frequency of both singular and plural. In this comparative study, we will use both indices, for both modalities.
- An objective measure of age of acquisition was derived from published norms for the Italian version of the MacArthur Communicative Inventory (Caselli & Casadio, 1995; cf. Fenson et al., 1994), a parental report form that provides valid and reliable data about lexical development in Italian infants from 8-30 months. The MacArthur CDI is based on concurrent

parent report of vocabulary development in very large samples of children, collected in a recognition-memory format with a large checklist of words that are likely to be acquired between 8-30 months. For our purposes here, the CDI yields a simple 3-point scale: 1 = words acquired (on average) between 8-16 months; 2 = words acquired (on average) between 17-30 months; 3 = words that are not acquired in infancy (> 30 months).

- We also obtained subjective ratings of age of acquisition for 520 target words from a sample of 37 college students, based on the same 9-point scale that has been used in other studies.

RESULTS

All of the analyses presented below are based on the 128 items that overlapped between the word-reading and picture-naming studies, and are conducted over items. Naming latencies for words in each modality were combined in a single database, together with the predictor variables from each study. All word frequency indices are based on log transforms. The full list of items is listed in the Appendix, which also includes mean latencies for each item, in each modality (raw RTs averaged over subjects), as well as z-score reaction times for each item (based on the mean over items). Z-scores are included to facilitate cross-modality comparisons.

Comparison of dependent variables

Table 1 summarizes descriptive statistics for naming latencies in each modality. Not surprisingly, reaction times for picture naming are substantially longer than reaction times for word reading.

We had anticipated that the correlation between modalities for naming latencies would be relatively low, but we assumed that the 128 words would share a certain degree of item difficulty across modalities, resulting in RT correlations somewhere in the +.30 - +.40 range. To our surprise, the correlation was virtually zero: $r = +.03$, n.s. Although it will be important to determine whether this degree of independence replicates across other samples of items and participants, this result suggests that the processes governing word access really are quite different for word reading and picture naming—at least in this language.

Correlations among predictors

Table 2 summarizes correlations of word-reading and picture-naming latencies with each other, and with all of the predictor variables described in the introduction (a total of 15). Table 3 summarizes correlations of the same 15 lexical predictors with each other. The predictors all bear a sensible theoretical relationship to word access in both modalities. Of course some of the correlations in Table 2 and 3 are virtual tautologies, reflecting the relationship between closely related measures of the same construct (e.g., absolute vs. adjusted child frequency scores; two different ratings of age of acquisition). We include them here to maximize comparability between the respective word-reading and picture-naming norming studies from which these shared items were drawn, since each study had made slightly different choices of predictors. Other correlations reflect more interesting relationships similar to those reported in previous studies, including the oft-cited correlations among frequency, familiarity and age of acquisition. Although most of the latter correlations are modest, Table 3 shows that there is a substantial degree of collinearity among these various predictors, requiring a multivariate approach in which the contribution of each predictor can be compared with variance from overlapping variables controlled.

Factor analysis

In order to reduce the number of variables in Tables 2-3 to a more manageable and coherent subset, we conducted a factor analysis (principal-components analysis). Four factors with eigenvalues greater than 1.0 emerged from this analysis. Factor loadings are summarized in Table 4.

The first factor accounts for 42.7% of the variance, and loads heavily on all the frequency measures, plus familiarity ratings, and two independent ratings of age of acquisition (both based on subject ratings by adults). Hence this factor seems to unite the variance obtained with objective frequency norms and subjective ratings of both familiarity and AoA.

The second factor accounts for 14.1% of the variance. It loads heavily on all three age-of-acquisition measures (including the objective measure taken from the MacArthur norms), plus familiarity ratings, and the two semantic variables (ratings of imageability and concreteness). The contrast between Factor 1 and Factor 2 is convenient, because it permits us to dissociate two aspects of both AoA and familiarity that have been confounded in most studies: frequency-related variance, and variance related to word meaning and the actual age at which the word was acquired.

The third factor accounts for 9.8% of the variance and loads primarily on length, including positive loadings for both length in characters and length in syllables, and a large negative loading for orthographic neighborhood density.

Finally, the fourth factor accounts for 7.3% of the variance, and is defined almost exclusively by presence of an initial fricative, with very small and heterogeneous loadings from other factors.

Regression analyses with factors as variables

With these four latent variables in hand, all with a relatively straightforward interpretation, we conducted stepwise regression analyses of naming latencies for each modality, assessing the contribution of each factor when it was entered into the equation on the last step. Results of these analyses are presented in Tables 5a and 5b.

For word reading, the four factors together accounted for 28.6% of the reaction time variance (multiple-$r = .53$, $p < .00001$). Three of the four factors made significant contributions when they were entered on the last step. The frequency-dominant factor added 7.5% ($p < .0005$), with a partial correlation of –.31 indicating that frequency, AoA and familiarity jointly facilitate word-naming times. The length/neighborhood density factor added a large and significant 17.5% ($p < .00001$), with a partial correlation of +.44 indicating that length slows down naming times when other factors are controlled. The semantics/AoA/familiarity factor had no effect at all on reading times when the other

factors were controlled, but the fourth factor (presence of an initial fricative) increased the variance accounted for by a small but significant 3.1% ($p < .023$), with a partial correlation of +.20 indicating that RTs are slower for words with an initial fricative when other factors are controlled.

For picture naming, the four factors together accounted for 27.1% of the variance (multiple-r = .52, $p < .00001$). Only two of the four factors made a unique and significant contribution when the other factors were controlled. The first factor added 9.7% ($p < .0001$), with a partial correlation of –.34, indicating that frequency, familiarity ratings and that aspect of AoA that overlaps with frequency converge to facilitate picture-naming latencies. The second factor added a large and significant 15.9% on the last step ($p < .00001$), with a partial correlation of –.42 indicating that early acquisition, familiarity and semantics (imageability and concreteness) jointly facilitate the time required to identify and name a picture. The third factor (length/neighborhood density) and fourth factor (initial fricative) had no effect on picture-naming times when the other factors were controlled.

DISCUSSION

In view of the low correlation that we observed between word-reading and picture-naming latencies, it is noteworthy that word access in these two modalities seems to be governed by different factors. Although both modalities are facilitated by word frequency (and those aspects of familiarity and age of acquisition that overlap with frequency), the remaining contributions are distinct and complementary. Word reading in Italian (at least for these words) is strongly affected by length, neighborhood density and initial frication, but it seems to be unaffected by semantic factors (imageability and concreteness) and/or those aspects of age of acquisition and familiarity that remain when frequency is controlled. Picture naming in Italian (again, for these words) is strongly affected by semantic factors and frequency-independent aspects of familiarity and age of acquisition, but it is unaffected by length, neighborhood density or an initial fricative.

To interpret these results, we need to take into account differences between tasks as well as differences between languages. For example, the strong impact of semantics on picture naming and the negligible effect of this factor on word reading may reflect inherent differences between the two processes (see also Lambon Ralph, Cipolotti, & Patterson, 1999). In picture naming, semantics is a crucial source of lexical activation. By contrast, word reading is fed by two main sources, one semantic and one orthographic-phonological. In reading, the latter source of activation is inherently strong, and may be even stronger in languages with transparent orthographies like Italian. Indeed it has been already observed that the effects of age of acquisition and frequency in more transparent languages are smaller than the effects usually reported in English (see, e.g., Brysbaert et al., 2000, for Dutch). The present data from Italian, a language with transparent orthography, indicate that semantic effects can disappear altogether when related variables are controlled (for additional evidence suggesting null effects of age of acquisition on Italian word reading after other factors are controlled, see Burani et al., 2000). And yet word reading does show effects of frequency when other factors are accounted for in a regression design. These unique contributions from frequency suggest that word reading in Italian does involve lexical access. In this regard, Burani et al. (2000) provided additional evidence for a role of frequency variables when related sublexical measures like bigram frequency (see Gernsbacher, 1984) are accounted for. The presence of frequency effects in the absence of semantic effects contributes to the view that lexical reading does occur in Italian, with purely lexical reading potentially dissociable from lexical-semantic reading (see Burani et al., 1999: Burani & Laudanna, in press; Peressotti & Job, 2000; see also Buchanan & Besner, 1993, for the reading of the shallow Japanese Kana scripts).

The pattern differs for picture naming, which is significantly affected by semantics when other variables are controlled. It is especially interesting in this regard that we were able to break both age of acquisition and familiarity down into two kinds of variance, one loading on frequency and the other loading on semantics. The first aspect (frequency dependent, independent of semantics) affects both word reading and picture naming. The second aspect (frequency independent, but correlated with semantics) affects picture naming but has no effect on reading. We may have been successful in isolating two different kinds of AoA variance also because we included an objective AoA measure in the data set, based on parent report of first words in infancy (see also D'Amico et al., 2000).

We also found effects of word form (length and frication) on word reading but not on picture naming (for the absence of length effects on picture naming in English, see also Ellis & Morrison, 1998, and their reanalyses of data from Barry et al., 1997 and Snodgrass & Yuditsky, 1996). Why was this the case? At this point we can only speculate, but it is worth pointing out that word-reading times are substantially faster than picture-naming times for the same words in this study (and in other studies). It is possible that factors like frication and word length have their greatest effects at the early stages of speech planning, independent of the factors involved in comprehension of the picture and the associated concept that must be named. Because word-reading times are so fast, they may be affected by speech-planning factors that are no longer detectable in the reaction time range tapped by picture naming. It would be interesting to determine whether speeded picture-naming studies, in which participants are placed under even greater pressures to name pictures based on minimal visual input, might yield effects of word structure (including phonological properties and length) that are not evident in the picture-naming time represented here, but are detected in reading times. Up to now, speeded picture naming has been used mainly to induce higher error rates, thus supporting the conclusion that this task limited processing time primarily at the level of word selection (Vitkovich & Humphreys, 1991; Vitkovitch, Humphreys, & Lloyd-Jones, 1993). If reaction times were taken as the dependent variable in speeded picture naming, the effects of variables having to do

with the activation and production of phonological word forms might appear. While leaving intact or even enhancing lexical-semantic effects, speeded picture naming might shed further light on more peripheral components involved in the naming process.

A different processing component, namely an orthographic input component (present in word reading but not in picture naming) might also be involved in the word length effect that we found for reading but not for picture naming. Indications that length affects the visual recognition of words come from studies, conducted on both English and less opaque languages like Dutch and Italian, in which analogously strong effects of word length were found in both word naming and visual lexical decision, a task in which no verbal output is involved (see, e.g., Butler & Hains, 1979; Gilhooly & Logie, 1981; 1982, for English; Hudson & Bergman, 1984, for Dutch; Burani, Marcolini, & Stella, 2000; Burani et al., 2000, for Italian).

In short, these results point to a dissociation between tasks, highlighting the different processes involved in word reading and picture naming: word form effects (orthographic-phonological) for word reading, and semantic-conceptual effects (which also load on age of acquisition and familiarity) for picture naming. These results are compatible with the neural imaging findings reported by Paulesu et al. (2000), who found evidence for differential profiles of neural activity in Italian word reading (primarily in superior temporal regions) and English (greater frontal and inferior temporal activation).

Of course these results must be replicated with larger samples of items and languages, including within-subjects designs that permit a comparison of modality effects in the same subjects. We have recently initiated such cross-linguistic comparisons of reading and picture naming in three languages, with three different writing systems: English (an opaque alphabetic system), Italian (a transparent alphabetic system) and Chinese (a logographic system).

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APPENDIX A: INSTRUCTIONS FOR SUBJECTIVE RATINGS. READING STUDY.

- ***Age of acquisition ratings.*** *Instructions* (Subjective Adult AoA (1)):

In this study, we need your estimates of the age at which you think you first learned each of a series of words, that is, first learned the word and its meaning, either in spoken or written form.

In the following pages you will find a list of words.

learned at the ages of

0-2 years	**3-4 years**	**5-6 years**	**7-8 years**	**9-10 years**	**11-12 years**	**13 + years**
1	**2**	**3**	**4**	**5**	**6**	**7**

Your task is to indicate the age at which you think you learned each word.

Rate each word by crossing the number that best indicates the age at wich you think you learned that word.

If you think you learned a word at the age of 7 years, then you would cross the "4" on the scale beside that word; if you think you learned a word at the age of 1 year, then you would cross the "1" on the scale beside that word; and so on.

Feel free to use all the numbers on the scale, and do not be concerned about how often you use a number.

- ***Familiarity ratings***. ***Instructions***

In the following pages you will find a list of words.

Each word has an accompanying scale. The scale ranges from 1 to 7, as follows:

very little known **very well known**

1 2 3 4 5 6 7

Your task is to rate how well you think each word is known by students like you.

Rate each word by crossing the number that best indicates your judgment.

Keep in mind that the "1" corresponds to very little-known words, and the "7" to the words that you think are very well known by students like you. Use the intermediate numbers for intermediate degrees of knowledge.

Feel free to use all the numbers on the scale.

Rate each word only once. Remember to rate every word.

- ***Imageability ratings. Instructions***

Words differ in their capacity to arouse mental images of things or events. Some words arouse a sensory experience, such as a mental picture or sound, more quickly and easily than others.

In the following pages you will find a list of words.

Each word has an accompanying scale. The scale ranges from 1 to 7, as follows:

hardly imageable **highly imageable**

1 2 3 4 5 6 7

Your task is to rate each word. The words that arouse a mental image very quickly and easily should be given a high rating; words that arouse images with the greatest difficulty or not at all should be given a low rating.

Feel free to use all the numbers on the scale, and do not be concerned about how often you use a number.

Rate each word by crossing the number that best indicates your judgment.

- ***Concreteness ratings. Instructions*:**

The words that refer to objects, living beings, actions and materials that can be experienced by the senses, can be considered as "concrete". Words that refer to concepts that cannot be experienced by the senses, can be considered as "abstract".

In the following pages you will find a series of words.

Each word has an accompanying scale. The scale ranges from 1 to 7, as follows:

highly abstract **highly concrete**

1 2 3 4 5 6 7

Your task is to rate each word for its degree of concreteness or abstractness.

Rate each word, considering that the high ratings should be given to concrete words, and the low ratings to abstract words. When you rate a word as being neither fully concrete nor fully abstract, give it an intermediate value.

Feel free to use all the numbers on the scale, and do not be concerned about how often you use a number.

Rate each word by crossing the number that best indicates your judgement.

APPENDIX B: INSTRUCTIONS FOR SUBJECTIVE RATINGS. PICTURE-NAMING STUDY.

- ***Age of acquisition. Instructions*** *(Subjective Adult AoA (2)):*

You will see a list of words presented one at a time on the computer screen. We need your estimate of when in your life you think you first learned the meaning of each of the words that you see, i.e., first learned the word and its meaning either in spoken or written form. We are aware that it might be difficult to remember exactly. Therefore please give us your best estimate of when you think you learned the meaning of the word, even if you have to guess.

You are provided with a 9-point scale to give your best estimate of the age you acquired the word.

The 9-point scale is:

Age	**Grade**	**Keyboard Code**
2 years (and under)	Prenursery	1
3 years	Prenursery	2
4 years	Nursery	3
5 years	Kindergarten	4
6 years	First Grade	5
7-8 years	Second, Third	6
9-10 years	Fourth, Fifth	7
11-12 years	Sixth, Seventh	8
13+ years	Eighth and above	9

Respond to each word by pressing any of the nine keys specified on the keyboard. Try and respond as quickly as you can. Also, since you won't be able to change your responses, be careful that the response you give is what you wanted to choose.

You may take a break whenever you wish. Press the space bar to pause the experiment and press the space bar again to resume the experiment.

APPENDIX C: RESULTS FOR INDIVIDUAL ITEMS
English Translations, RT Word Reading (RT-WR), RT Picture Naming (RT-WR), Z-score Word Reading (Z-WR), Z-score Picture Naming (Z-PN)

	Italian	English	RT-WR	RT-PN	Z-WR	Z-PN		Italian	English	RT-WR	RT-PN	Z-WR	Z-PN
1	aquila	eagle	501	1257	–0.92	0.95	31	cucchiaio	spoon	577	849	1.89	–0.9
2	aragosta	lobster	513	1545	–0.49	2.26	32	cuore	heart	516	694	–0.38	–1.61
3	balcone	balcony	518	1192	–0.3	0.66	33	cuscino	pillow	574	1043	1.76	–0.02
4	banana	banana	545	770	0.69	–1.26	34	divano	sofa	505	870	–0.78	–0.81
5	barba	beard	515	1050	–0.4	0.01	35	doccia	shower	520	1039	–0.23	–0.04
6	bastone	cane	507	1156	–0.7	0.49	36	donna	woman	502	1142	–0.89	0.43
7	bicchiere	wineglass	559	835	1.23	–0.97	37	drago	dragon	520	1047	–0.23	0
8	bocca	lips	483	814	–1.58	–1.06	38	elefante	elephant	504	879	–0.8	–0.77
9	bomba	bomb	512	1167	–0.54	0.54	39	fantasma	ghost	508	937	–0.67	–0.5
10	burro	butter	531	1413	0.18	1.66	40	farfalla	butterfly	516	736	–0.37	–1.41
11	calamita	magnet	562	1179	1.34	0.6	41	faro	light-house	527	1107	0.03	0.27
12	camino	chimney	530	1208	0.13	0.73	42	finestra	window	551	942	0.93	–0.48
13	cammello	camel	537	962	0.4	–0.39	43	foca	walrus	526	1218	–0.02	0.77
14	candela	candle	534	786	0.31	–1.19	44	frate	monk	516	1344	–0.37	1.35
15	cane	dog	507	768	–0.72	–1.27	45	freccia	arrow	549	859	0.84	–0.86
16	canguro	kangaroo	542	888	0.58	–0.72	46	fucile	rifle	536	895	0.37	–0.69
17	capra	goat	517	1203	–0.33	0.71	47	fulmine	lightning	535	1032	0.32	–0.07
18	carciofo	artichoke	545	1046	0.69	–0.01	48	fuoco	fire	536	953	0.36	–0.43
19	carota	carrot	527	971	0.02	–0.35	49	gabbia	cage	507	974	–0.71	–0.33
20	casa	house	505	835	–0.77	–0.97	50	gatto	cat	515	834	–0.43	–0.97
21	castello	castle	508	1029	–0.66	–0.08	51	genio	genie	537	1272	0.38	1.02
22	cavallo	horse	500	839	–0.97	–0.95	52	giacca	jacket	524	1122	–0.08	0.34
23	cervo	deer	534	1231	0.29	0.83	53	giraffa	giraffe	578	836	1.93	–0.96
24	chiesa	church	536	1026	0.36	–0.1	54	gonna	skirt	526	880	0	–0.76
25	chitarra	guitar	564	798	1.39	–1.13	55	granchio	crab	553	1291	1	1.1
26	ciliegia	cherry	585	1210	2.18	0.74	56	gufo	owl	528	1048	0.08	0
27	coltello	knife	506	941	–0.74	–0.48	57	imbuto	funnel	532	938	0.2	–0.5
28	coniglio	rabbit	534	852	0.31	–0.89	58	incudine	anvil	592	1384	2.45	1.53
29	cravatta	tie	556	866	1.1	–0.82	59	lampada	lamp	493	1042	–1.23	–0.03
30	cubo	cube	514	1436	–0.44	1.76	60	libro	book	504	770	–0.8	–1.26

Appendix C (continued)

	Italian	English	RT-WR	RT-PN	Z-WR	Z-PN		Italian	English	RT-WR	RT-PN	Z-WR	Z-PN
61	limone	lemon	503	896	–40.85	-0.69	91	pinguino	penguin	591	1157	2.38	0.5
62	lucchetto	lock	523	1166	–0.13	0.54	92	pioggia	rain	523	926	–0.13	–0.55
63	lucertola	lizard	548	1322	0.79	1.25	93	pipa	pipe	504	773	–0.81	–1.25
64	lumaca	snail	502	1020	–0.91	–0.13	94	piramide	pyramid	538	947	0.44	–0.46
65	luna	moon	492	757	–1.25	–1.32	95	piscina	pool	538	990	0.44	–0.26
66	lupo	wolf	482	1299	–1.65	1.14	96	pistola	gun	548	803	0.8	–1.11
67	maiale	pig	496	1122	–1.11	0.34	97	piuma	feather	549	1006	0.83	–0.19
68	mano	hand	516	742	–0.37	–1.39	98	pollice	thumb	513	1231	–0.49	0.83
69	matita	pencil	523	885	–0.13	–0.74	99	ponte	bridge	506	1069	–0.74	0.1
70	medaglia	medal	513	1164	–0.49	0.53	100	racchetta	tennis-racket	588	915	2.28	–0.6
71	mela	apple	494	904	–1.20	–0.65	101	ragno	spider	506	978	–0.76	–0.32
72	moneta	coin	483	1019	–1.59	–0.13	102	rana	frog	533	899	0.27	–0.67
73	mucca	cow	482	1018	–1.64	–0.13	103	rubinetto	faucet	570	1166	1.63	0.54
74	mulino	windmill	490	1109	–1.32	0.28	104	scimmia	monkey	553	1041	1.01	–0.03
75	naso	nose	495	728	–1.13	–1.45	105	secchio	trashcan	540	1364	0.52	1.44
76	nave	ship	493	978	–1.23	–0.32	106	sedia	chair	555	771	1.07	–1.26
77	nido	nest	513	1137	–0.50	0.41	107	serpente	snake	548	849	0.8	–0.9
78	nodo	knot	526	1211	–0.01	0.74	108	spada	sword	591	1056	2.41	0.04
79	nuvola	cloud	520	1335	–0.23	1.30	109	statua	statue	583	1059	2.08	0.05
80	orso	bear	474	906	–1.93	–0.64	110	tamburo	drum	513	827	–0.48	–1
81	pacco	package	521	1123	–0.18	0.34	111	tappeto	rug	531	895	0.2	–0.69
82	padella	pan	517	1042	–0.32	–0.03	112	tartaruga	turtle	542	836	0.6	–0.96
83	pala	shovel	502	1043	– 0.89	–0.02	113	tetto	roof	561	1035	1.28	–0.06
84	palma	palmtree	509	1050	–0.65	0.01	114	topo	mouse	505	1036	–0.76	–0.05
85	pane	bread	494	1123	–1.18	0.34	115	torta	cake	516	925	–0.39	–0.56
86	parrucca	wig	531	1062	0.19	0.07	116	trappola	mouse-trap	524	1580	–0.08	2.42
87	patata	potato	516	1369	–0.38	1.46	117	treno	train	525	951	–0.04	–0.44
88	pecora	sheep	513	1297	–0.5	1.13	118	tromba	trumpet	509	981	–0.63	–0.3
89	pentola	pot	541	1097	0.54	0.22	119	uomo	man	487	1110	–1.43	0.28
90	pettine	comb	529	709	0.11	–1.54	120	uovo	egg	499	783	–0.99	–1.2

Appendix C (continued)

	Italian	English	RT-WR	RT-PN	Z-WR	Z-PN		Italian	English	RT-WR	RT-PN	Z-WR	Z-PN
121	valigia	suitcase	532	855	0.23	–0.87	125	vulcano	volcano	490	1180	–1.32	0.6
122	vasca	bathtub	510	1076	–0.6	0.13	126	zampa	paw	527	1573	0.01	2.38
123	verme	worm	519	1501	–0.28	2.06	127	zanzara	mosquito	549	1428	0.85	1.73
124	volpe	fox	486	1183	–1.47	0.61	128	zebra	zebra	556	993	1.11	–0.25

Table 1

Descriptive statistics for RT Word Reading and RT Picture Naming

	Mean	St.dev	Min	Max
Word Reading	525 ms	26	474 ms	592 ms
Picture Naming	1036 ms	198	694 ms	1580 ms

Table 2

Correlations of Word-Reading and Picture-Naming Reaction Times With Each Other and with 15 Lexical Predictors

Variable Names	Word Reading RT	Picture Naming RT
Picture-naming RT	.03	-----
Subjective Adult AoA (1)	.22**	.39**
Objective AoO	.12~	.21**
Subjective Adult A0A (2)	.25**	.44***
Familiarity Ratings	–.22**	–.37***
Written Adult Frequencies	–.33**	–.34***
Spoken Adult Frequencies (1)	–.24**	–.32***
Spoken Adult Frequencies (2)	–.26**	–.30***
Written Child Frequencies (1)	–.43***	–.30***
Written Child Frequencies (2)	–.42***	–.31***
Number of Orthographic Neighbors	–.38***	–.03
Length in Characters	.49***	–.02
Length in Syllables	.29***	–.04
Initial Fricative	.26**	.15*
Imageability Ratings	–.11	–.46***
Concreteness Ratings	–.02	–.26**

(1) = Predictor variables for word reading

(2) = Predictor variables for picture naming

~ p <.10 *p <.05 **p <.01 ***p <.001

Table 3
Correlations among Predictor Variables

	Lexical Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	**Subjective Adult AoA (1)**	-----													
2	**Objective AoA**	.33***	-----												
3	**Subjective Adult AoA (2)**	.90***	.29***	-----											
4	**Familiarity Ratings**	–.79***	–.25***	–.78***	-----										
5	**Written Adult Frequencies**	–.38***	n.s.	–.47***	.49***	-----									
6	**Spoken Adult Frequencies (1)**	–.44***	n.s	–.44***	.52***	.65***	-----								
7	**Spoken Adult Frequencies (2)**	–.46***	n.s	–.47***	.54***	.62***	.95***	-----							
8	**Written Child Frequencies (1)**	–.69***	–.19**	–.70***	.67***	.69***	.59***	.58***	-----						
9	**Written Child Frequencies (2)**	–.69***	–.18**	–.70***	.68***	.70***	.61***	.60***	.99***	-----					
10	**Number of Orthographic Neighbors**	–.22**	n.s.	.28***	n.s	.28***	.25***	.24***	.37***	.37***	-----				
11	**Length in Characters**	.29***	.20***	.25**	n.s	–.30***	–.31***	–.29***	–.45***	–.44***	–.62***	-----			
12	**Length in Syllables**	.28***	.18**	.26***	–.21*	–.32***	–.29***	–.27***	–.45***	–.45***	–.52***	.80***	-----		
13	**Initial Fricative**	n.s.	n.s.	n.s.	n.s	n.s	–.17~	–.16~	n.s	n.s	n.s	n.s.	–.16~	------	
14	**Imageability Ratings**	–.59***	–.30***	–.57***	.58***	.17**	.29***	.29***	.33***	.33***	n.s.	n.s.	n.s.	n.s.	-----
15	**Concreteness Ratings**	–.31***	n.s.	–.27***	.19**	n.s	n.s	n.s	n.s	n.s	n.s	n.s.	n.s	n.s	.38***

(1) Predictor variables for word reading; (2) Predictor variables for picture naming.
~ p <.10 *p <.05 **p <.01 **

Table 4
Results of Factor Analysis across Predictor Variables

	Factor 1 (42.7%)	**Factor 2 (14.1%)**	**Factor 3 (9.8%)**	**Factor 4 (7.3%)**
Subjective AoA (1)	**–.50**	**–.75**	.15	–.15
Objective AoA	.08	**–.56**	.26	.06
Subjective AoA (2)	**–.55**	**–.70**	.14	–.13
Familiarity Ratings	**.64**	**.60**	.00	.16
Written Adult Freqs	**.84**	–.03	–.17	.01
Spoken Adult Freqs (1)	**.85**	.07	–.14	–.29
Spoken Adult Freqs (2)	**.84**	.09	–.12	–.28
Written Child Freqs (1)	**.78**	.31	–.34	.21
Written Child Freqs (2)	**.80**	.30	–.32	.20
Orthographic Neighbours	.17	.07	**–.76**	–.13
#Characters	–.19	–.04	**.91**	.00
#Syllables	–.22	–.03	**.85**	–.19
Initial Fricative	–.07	–.12	–.02	**.87**
Imageability Ratings	.22	**.79**	.11	–.12
Concreteness Ratings	–.01	**.54**	.03	–.10

(1) see Predictor variables for word reading;
(2) see Predictor variables for picture naming.

Table 5a

Regression of Factor Scores on RT for Word Reading

	% Variance	Zero-order partial correlation	p<
TOTAL (Joint Variance)	**28.6*** **	**.53**	**.0001**
Factor 1: Frequency, AoA & Familiarity	**7.5*** **	**–.31**	**.0005**
Factor 2: Semantics, AoA & Familiarity	n.s	–.11	n.s
Factor 3: Length & Density	**17.1*** **	**.44**	**.0001**
Factor 4: Initial Frication	**3.1***	**.20**	**.023**

Table 5b

Regression of Factor Scores on RT for Picture Naming

	% Variance	Zero-order partial correlation	p<
TOTAL (Joint Variance)	**27.1*** **	**.52**	**.0001**
Factor 1: Frequency, AoA & Familiarity	**9.7*** **	**–.34**	**.0001**
Factor 2: Semantics, AoA & Familiarity	**15.9*** **	**–.42**	**.0001**
Factor 3: Length & Density	n.s	–.07	n.s
Factor 4: Initial Frication	n.s	.13	n.s