Behavior Research Methods, Instruments, & Computers
2004, 36 (1), 140-155

Predictors of picture naming speed

F.-XAVIER ALARIO
Université René Descartes, Paris, France

LUDOVIC FERRAND
CNRS and Université René Descartes, Paris, France

MARINA LAGANARO
Université de Genève, Genève, Switzerland

BORIS NEW
Université René Descartes, Paris, France

ULI H. FRAUENFELDER
Université de Genève, Genève, Switzerland

and

JUAN SEGUI
CNRS and Université René Descartes, Paris, France

We report the results of a large-scale picture naming experiment in which we evaluated the potential contribution of nine theoretically relevant factors to naming latencies. The experiment included a large number of items and a large sample of participants. In order to make this experiment as similar as possible to classic picture naming experiments, participants were familiarized with the materials during a training session. Speeded naming latencies were determined by a software key on the basis of the digital recording of the responses. The effects of various variables on these latencies were assessed with multiple regression techniques, using a repeated measures design. The interpretation of the observed effects is discussed in relation to previous studies and current views on lexical access during speech production.

Articulating the name that corresponds to the picture of a common object is a fast, efficient, and relatively effortless cognitive skill. These aspects of naming performance obscure the complexity of the processes involved in this behavior (see Glaser, 1992; Johnson, Paivio, & Clark, 1996). The aim of the present study was to investigate the representations and processes involved in picture naming by examining the individual contribution of nine predictors (e.g., printed frequency, age of acquisition, name agreement, etc.) to naming latencies. An attempt was made to locate the influence of each predictor in a standard model of picture naming.

In the present study, 388 pictures were named by 46 participants whose immediate naming latencies and delayed pronunciation latencies were measured. Similar studies have already been conducted in American English (Snodgrass & Yuditsky, 1996), Welsh (Barry, Morrison, & Ellis, 1997), British English (Ellis & Morrison, 1998), Spanish (Cuetos, Ellis, & Alvarez, 1999), Italian (Dell'Acqua, Lotto, & Job, 2000), and even French (Bonin, Chalard, Méot, & Fayol, 2002; Bonin, Peereman, Malardier, Méot, & Chalard, 2003).[1] Critically, the present study makes a number of methodological improvements over previous studies. First, we tested a larger number of pictures (388 pictures). Second, we started by familiarizing participants with the materials, as is commonly done in language production studies using the picture naming paradigm. This allowed us to assess the impact of the familiarization process on the effects that the different variables have on naming latencies. Third, we used a repeated measures design in the regression analysis, following the methodology advocated by Lorch and Meyers (1990; see below). Finally, we recorded the actual naming responses, which allowed us to check the accuracy of voice key measurements against the naming onset measured on the digital recording of the response. Together, these characteristics of the present study contribute to an increase in the amount of information gathered in the experiment as well as in the precision of its analysis. This directly improves the reliability of the effects that are reported.

According to current models of picture naming (e.g., Glaser, 1992; Humphreys, Riddoch, & Quinlan, 1988;

Part of the work reported in this article was presented at the 41st Annual Meeting of the Psychonomic Society held in New Orleans, November 2000. Correspondence should be addressed to F.-X. Alario, now at Laboratoire de Psychologie Cognitive – Case 66, CNRS and Université de Provence, 3 place Victor Hugo, 13331 Marseille Cedex 3, France (e-mail: alario@up.univ-mrs.fr).

Levelt, Roelofs, & Meyer, 1999), this basic task is accomplished by a sequence of at least four processes—namely, (1) activation of stored structural knowledge about the object's appearance, (2) activation of semantic information, (3) name retrieval, and (4) articulation (see Figure 1). We investigated the different processing stages by assessing the independent effects of the nine different predictors described below. The investigation of these potential effects can contribute to our understanding of the processes involved at each stage.

Predictors of Picture Naming Speed

In what follows, we will briefly discuss empirical findings related to predictors of picture naming speed. We will start with visual factors such as visual complexity and image agreement, then we will discuss semantic factors such as concept familiarity and imageability (or image variability), and then we will discuss lexical factors such as name agreement, frequency, and age of acquisition. We will finish with phonological factors such as number of phonemes and number of syllables.

Visual complexity refers to the number of lines and detail in the drawing. It is thought to determine the ease of processing before or at the structural stage of object recognition. Visual complexity may affect such variables as naming latencies, tachistoscopic recognition thresholds, and memorizability. Early research that used pictorial stimuli established that more complex stimuli are more difficult to process than simple stimuli (Attneave, 1957; see also Ellis & Morrison, 1998, for a recent replication). However, other investigators have shown that complex objects are identified and named as readily as simple objects (Biederman, 1987; Paivio, Clark, Digdon, & Bons, 1989). The most recent view is that this factor does not have a major impact on naming latencies for simple black-and-white drawings, such as those used here.

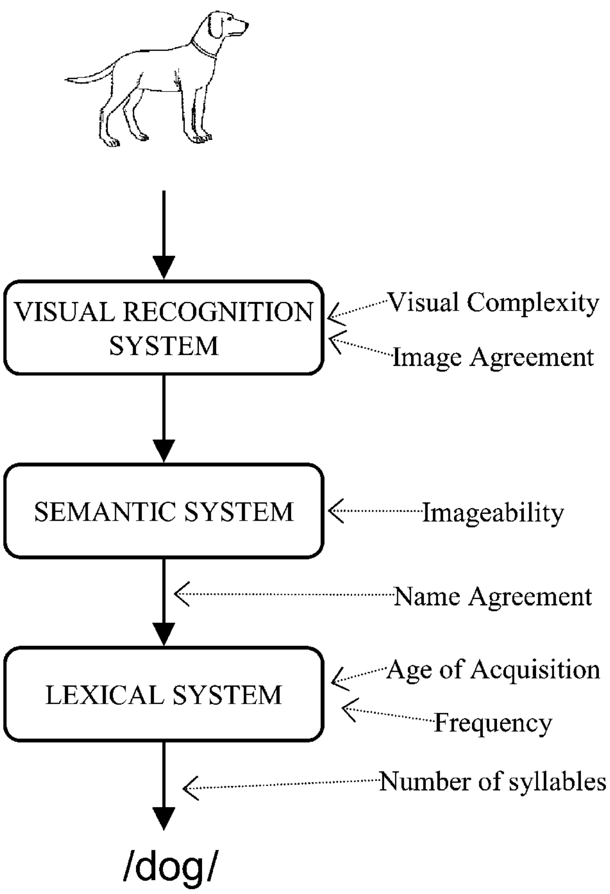

Figure 1. A general model of picture naming with suggested loci for the different variables investigated in this study.

Image agreement refers to the degree to which the images generated by participants to a picture's name agree with the actual picture. It might be thought of as a measure of the match or mismatch between the picture and a stored canonical representation of the object. Barry et al. (1997) showed that pictures with higher ratings of image agreement were named faster than were those with lower ratings. These results suggest that image agreement has its influence at the level of object recognition, so that the closer a picture is to one's mental image of an object, the faster the naming time for that picture will be.

Imageability (or *image variability*) is a measure of the extent to which an object name evokes few or many different images for a particular object. Effects of imageability have been reported in patients with deep dyslexia who are thought to read exclusively by means of semantic representations (Plaut & Shallice, 1993). Morrison, Ellis, and Quinlan (1992) failed to find a significant effect of imageability on picture naming speed. However, the range of imageability values used in this study was rather restricted. Using a wider range, Ellis and Morrison (1998) found a significant effect of that factor. Plaut and Shallice (1993) interpreted imageability in terms of number of semantic features, so that names with high imageability have "richer" semantic representations than do names with lower imageability. Under this interpretation, the sensitivity of the picture naming task to the imageability variable could be attributed to the fact that objects with high imageability names are easier to process at the semantic level (during object identification).

Concept familiarity refers to the familiarity of the depicted concept. Familiarity has been shown to have important effects on various memory and cognitive processing tasks. In particular, Ellis and Morrison (1998), Snodgrass and Yuditsky (1996), and Feyereisen, Van der Borght, and Seron (1988) showed that, in their experiments, rated familiarity was a significant predictor of picture naming latencies so that the more familiar a concept is, the faster the naming time for that item will be. Hirsh and Funnell (1995) reported that neuropsychological patients with progressive semantic dementia were able to name pictures with high concept familiarity better than those with low concept familiarity, even when other factors such as age of acquisition and frequency were taken into account. They suggested that concept familiarity for pictures is equivalent to frequency for words, and that concept familiarity affects the ease with which representations of pictures can activate their central semantic representations.

Name agreement (or *codability*) refers to the degree to which participants agree on the name of the picture. Name agreement is measured by assessing the number of different names given to a particular picture across participants. Pictures that elicit many different names have lower name agreement than do those that elicit a single name. This information is important for picture–name matching studies, recall memory studies, and recognition studies in which verbal encoding is manipulated. Name agreement is also a robust predictor of naming difficulty. Pictures with a single dominant response are named more quickly and accurately than those with multiple responses (Barry et al., 1997; Lachman, Shaffer, & Hennrikus, 1974; Paivio et al., 1989; Snodgrass & Yuditsky, 1996; Vitkovitch & Tyrrell, 1995). More importantly, name agreement affects naming latencies independently of the effects of correlated attributes such as word frequency and rated age of name acquisition (Lachman et al., 1974; Vitkovitch & Tyrrell, 1995).

Frequency is a measure of the degree of use of a given word, generally on the basis of counts of written corpora (e.g., Francis & Kučera, 1982, in English; Content, Mousty, & Radeau, 1990, or New, Pallier, Ferrand, & Matos, 2001, in French). A strongly correlated predictor is age of acquisition, which is an evaluation of the moment in life at which a particular word was first learned (see the next paragraph). It has generally been observed that picture naming latencies decrease as name frequency increases (Barry et al., 1997; Ellis & Morrison, 1998; Oldfield & Wingfield, 1965).

Age of acquisition refers to the age at which the words are learned. This measure can be obtained by asking adults to estimate this age (Morrison & Ellis, 1995; Morrison et al., 1992) or by the analysis of children's productions (both methods have been found to produce similar estimates; Ellis & Morrison, 1998; Morrison, Chappell, & Ellis, 1997). Some authors have suggested that the general influence of word frequency on learning, memory, and perception could be attributed solely to this factor, and that frequency effects are not found when age of acquisition is properly controlled (Bonin et al., 2002; Carroll & White, 1973; Morrison et al., 1997; Morrison et al., 1992). However, Barry et al. (1997), Snodgrass and Yuditsky (1996), and Ellis and Morrison (1998) found that the time taken to name a pictured object correctly was affected both by rated age of acquisition and by the frequency of the name (in accord with Lachman, 1973, and Lachman et al., 1974).

Number of syllables and *number of phonemes* are phonological factors. It is commonly assumed that the phonological encoding of a word involves filling a word frame with the different segments or syllables that compose that word (e.g., Fromkin, 1971; Shattuck-Hufnagel, 1979). The main evidence in support of this claim comes from speech errors, and particularly from the existence of cases in which words are produced with erroneous segments or segments are exchanged between words. This encoding description leads to the prediction that longer words take more time to be encoded than do short words, if either the retrieval or the encoding of the units is assumed to be sequential. Various studies have addressed the issue of the existence of a length effect in word production, but the results are inconsistent. For example, Klapp, Anderson, and Berrian (1973) found a small but significant difference between monosyllabic and bisyllabic words in a picture naming task. This result was recently replicated by Santiago, MacKay, Palma, and Rho (2000). Syllabic length effects were also found by Cuetos et al. (1999) in a study similar to the present one. However, Dell'Acqua et al. (2000) and Snodgrass and Yuditsky (1996) did not find the effect, nor did Bachoud-Lévi, Dupoux, Cohen, and Mehler (1998) in a study involving various factorial design experiments.

As was noted previously, our experiment comprised two phases. First, there was a familiarization phase during which participants named all the pictures and received feedback on the names. The experiment proper was conducted during a second phase. We used this procedure because most psycholinguistic experiments that use the picture naming paradigm include familiarization of this type. In the presentation of the predictors used in our study, we have not included a systematic discussion of the impact of the familiarization phase on the effects of the different variables. Indeed, our primary interest lies on the second (postfamiliarization) naming session, whose results can be compared with those of other studies (e.g., language production studies). As a general prediction concerning the effects of familiarization on the participants' performance, one can expect that naming times will be shorter and less variable in the second than in the first session. Consequently, the effects of the manipulated factors will probably be somewhat attenuated. Besides this general point, it could be the case that the effect of a particular variable is specifically affected by the familiarization and the repetition of the items. In this study we did not have a priori hypotheses concerning this possibility for any particular variable.

EXPERIMENT

In order to evaluate the independent contribution of the nine variables included in the study to the process of single-word production, we conducted a large-scale picture naming experiment. The experiment we conducted comprised two sessions. During the first session, the participants named the pictures, which they had not seen before. The collected responses provided naming times without prior familiarization. Furthermore, in each trial of this session, the expected modal name of the picture was written on the computer screen after the naming response had been recorded. This feedback was intended to familiarize the participants with the picture names that they were asked to use in the second session. During the second session, the participants named each picture twice; first in a classic immediate naming procedure and then in a delayed pronunciation task. In each trial, the participants first named the picture as fast as possible upon its appearance on the screen (*immediate naming*). Shortly after, a prompt—a question mark—appeared on the screen and triggered the second production of the name of the picture (*delayed pronunciation*). In this article, we will concentrate on the immediate naming latencies obtained in the first (familiarization) phase and in the second phase. We conducted various multiple regression analyses on this data set. The inclusion of delayed repetition in the study was originally motivated to address issues about the peripheral process of articulation (Balota & Chumbley, 1985; Forster & Chambers, 1973; Monsell, Doyle, & Haggard, 1989; Savage, Bradley, & Forster, 1990) and will be described in detail elsewhere.

Method

Stimuli

Three hundred eighty-eight black-and-white pictures were selected from among the picture database of Cycowicz, Friedman, Rothstein, and Snodgrass (1997), which included the 260 pictures of Snodgrass and Vanderwart (1980). The full database comprised 400 pictures, but we excluded 12 of them that had the same modal name as a more common object in the corpus. For example, the picture of a *verre a pied* (wineglass) was excluded because it has the same modal name as the picture of a *verre* (glass). The pictures used, which have previously been normed in French by Alario and Ferrand (1999), span a wide range of values in each of the relevant dimensions under consideration (see Table 1). Pairwise correlations between these variables can be found in Table 2. Eighteen additional pictures were selected to be used as training and warm-up trials during the experiment. All pictures were presented as black outlines on a white screen in the center of the computer screen.

Definitions of the Independent Variables

The normed values of most of the variables used in the present study are those of Alario and Ferrand (1999). In this section, we recall briefly how the norms were collected in that study.

Visual complexity (from Alario & Ferrand, 1999). Participants were asked to rate the complexity of the black-and-white drawings of objects. They were told that complexity is a measure of the amount of detail or the intricacy of the lines in a picture, and they rated each picture on a 5-point scale (1, *drawing very simple*, 5, *drawing very complex*).

Image agreement (from Alario & Ferrand, 1999). Participants were asked to judge how closely each picture resembled their mental image of the object by "comparing" their mental image of the object with the representation adopted in the pictorial stimuli. Participants rated the degree of agreement between their image and the picture by using the 5-point scale: A rating of 1 indicated *low agreement, the picture provided a poor match to their image*, and a rating of 5 indicated *high agreement*.

Imageability (from Alario & Ferrand, 1999). Participants were instructed to rate on a 5-point scale (1, *few images*, 5, *many images*) whether a given picture name evoked few or many different images for that particular object.

Concept familiarity (from Alario & Ferrand, 1999). Participants rated the degree to which they come in contact with or think about the concept on a 5-point scale (1, a *very unfamiliar object*, 5, a *very familiar object*).

Name agreement (from Alario & Ferrand, 1999). Name agreement was evaluated by calculating the H statistic on the naming outcomes in an off-line task. H measures the dispersion of the responses provided; its value is zero if all participants provide the same name for the picture, and it increases with the number of different responses.

Printed frequency (from New et al., 2001). Frequency values were taken from the new French database LEXIQUE (New et al., 2001). The values used are expressed in terms of occurrences per million words. This recent corpus is based on texts published from 1950 to 2000 and contains 31 million words.

Age of acquisition (from Alario & Ferrand, 1999). Participants were asked to estimate the age at which they thought they had learned each of the names in its written or oral form on a 5-point scale (1, *learned at 0–3 years*, 5, *learned at age 12+, with 3-year age bands in between*).

Number of phonemes and syllables. These were taken from the French lexical database LEXIQUE (New et al., 2001).

Participants

Forty-six students at the University of Geneva, Switzerland, participated in the experiment for course credit. All were native speakers of French with normal or corrected-to-normal vision.

Procedure

The experiment was divided into two sessions that were run at an interval of 1 week. Each session lasted for about 1 h and included three pauses. During the first session, the participants were familiarized with the materials. In each experimental trial, they were asked to name as quickly as possible a picture that appeared on the screen. Their response was recorded during a 2,000-msec period. As soon as articulation started and the voice key was triggered, the

Table 1
Summary of the Nine Independent Variables Tested in the Experiment

Variable	*M*	*SD*	Min	1/4 Percentile	Median	3/4 Percentile	Max	Skew
Name agreement (*H*)	0.29	0.38	0.00	0.00	0.15	0.47	1.87	1.46
Image agreement	3.49	0.73	1.00	3.03	3.60	4.03	4.90	−0.73
Concept familiarity	2.78	1.21	1.07	1.80	2.47	3.87	4.97	0.39
Visual complexity	3.09	0.93	1.00	2.38	3.10	3.76	5.00	0.00
Imageability	2.82	0.62	1.43	2.33	2.67	3.21	4.70	0.70
Age of acquisition	2.44	0.74	1.12	1.87	2.38	2.96	4.62	0.39
Written frequency	25.3	55.0	0	2	8	21	477	4.72
Number of phonemes	4.7	1.6	2	3	5	6	10	0.66
Number of syllables	1.9	0.7	1	1	2	2	4	0.54

Note—This summary is based on the 329 items that were included in the regression analysis.

Table 2
Pairwise Correlations Between the Predictors Used in This Study

Predictors	NA	IA	Fam	V. Comp.	IV	AoA	W. Freq.	Number of Phonemes
Name agreement (H)	1							
Image agreement	−0.286*	1						
Concept familiarity	−0.131	−0.099	1					
Visual complexity	0.083	−0.007	−0.436*	1				
Imageability	−0.188	−0.200*	0.610*	−0.248*	1			
Age of acquisition	0.325*	−0.032	−0.589*	0.254*	−0.623*	1		
Written frequency	−0.085	−0.056	0.432*	−0.153	0.369*	−0.380*	1	
Number of phonemes	−0.024	0.091	−0.128	0.144	−0.139	0.292*	−0.219*	1
Number of syllables	−0.039	0.095	−0.182	0.176	−0.164	0.251*	−0.251*	0.817*

Note—The data are based on the 329 items used in the multiple regression. Correlations significant to the .01 level, Bonferroni corrected, are marked with an asterisk. NA, name agreement; IA, image agreement; Fam, concept familiarity; V. Comp, visual complexity; IV, image variability (imageability); AoA, Age of acquisition; W. Freq, printed word frequency.

picture disappeared from the screen. It was replaced by the modal name of the picture written in capital letters. The participants were instructed to check their response against that provided by the computer and, if the two differed, to use only the name provided by the computer during the next session. The appearance of the following trial was self-paced. This feedback procedure was modeled from familiarization procedures used in previously reported picture naming experiments. Each experimental trial of the second session comprised an immediate naming and a delayed pronunciation response. The participants were asked to name the picture as quickly as possible when it appeared on the computer screen. Their response was recorded during a 2,000-msec period, although as soon as they started to articulate it, the target disappeared from the screen. A prompt (question mark) appeared 750 msec after the end of the fixed recording period. The participants then had to repeat the picture name they had previously produced. Each session lasted for approximately 1 h. The participants were given short breaks between blocks (see the Design section below).

The experiment was piloted by the program DMDX (Forster & Forster, 2003). This program recorded a digital version of the participant's responses. It also provided naming times evaluated by a software voice key. In order to test the reliability of the voice key measurements, we selected 7 participants at random to conduct a comparative analysis of the response onset times obtained with the software voice-key and those obtained by visual inspection of the recorded waveform of the responses. The correlation between these two measures was always very high (all correlation coefficients $>.84$, all r^2s $>.71$), indicating a high degree of consistency between the two measures. In the analysis reported below, we always used the times provided by the software voice key.

Design

Every participant named all 388 pictures during both sessions. During the first (familiarization) session, the pictures were presented in a random order. For the second session, four pseudo-random lists were created, in which two consecutive items were neither semantically nor phonologically related. Each participant received one of the experimental lists. The experiment began with a practice block of four items. The 388 experimental items were then presented in four blocks of 97 items. The first four trials that started a block were warm-up trials.

Results

The following procedures were followed for the analysis of the two naming sessions. The data of the 46 participants were first screened for errors and outliers. We considered as errors and excluded those trials in which the voice key malfunctioned, those in which the participants stuttered, hesitated noisily, or gave an incorrect response, and trials in which naming latencies were more than three standard deviations from the mean of the participant (outliers). We also excluded from the analysis all items that led to less than 40% correct responses. We also excluded a few items (mainly compounds such as *pomme de terre* [*potato*]) that could not be found in the French database LEXIQUE (New et al., 2001). This left 329 items.

We conducted separated single-equation multiple regression analyses on the immediate naming latency data of the first and second sessions. The experimental design we used included repeated measures by participants. Most often picture naming studies that have analyzed this type of data sets have used response times averaged over subjects (see the references cited earlier). This method yields one data point per item on which the regression is conducted. The problem with this averaging procedure is that by reducing all data points for a given item to a single measure, it loses valuable information in the original data set. In particular, the averaging does not allow us to partial out any participant effect (Lorch & Myers, 1990). In our analysis of the data set, no averaging was done: The regression was conducted directly on the individual naming latencies ($46 \times 329 =$ 15,134 data points, from which errors and outliers were excluded). The variables included in the analysis were the nine factors described earlier, in addition to participants coded as dummy variables.[2] Owing to the high number of degrees of freedom and of tests conducted in these analyses, we adopted an α criterion of 0.01.

First Session

The average naming latency was 883 msec, with a standard deviation of 289 msec. There were errors or outliers on 27% of the trials (4,079 out of 15,134). The overall regression equation was significant, and the model accounted for 27% of the variance in the data [$F(54,11000) = 76.6$, root $MS_e = 247.4$, $p < .001$; $R^2 = .27$]. The results show that the following factors made significant independent contributions toward predicting naming speed: name agreement ($p < .001$), image agreement ($p < .001$), familiarity ($p < .01$), imageability ($p < .001$), age of acquisition ($p < .001$), and printed frequency ($p < .001$). There was no significant contribution of visual complexity ($p = .58$). Number of syllables was not significant ($p = .58$), and number of phonemes was marginally significant ($p = .04$). Note, however, that these two variables have a high correlation between them. If only one of them was included in the analysis, then its effect was significant (number of syllables, $p < .01$, or number of phonemes, $p < .01$). This observation suggests that the length of the items influenced naming latencies in this task, although its effect was weak.

Second Session

The average naming latency was 844 msec, with a standard deviation by participants of 255 msec. There were errors or outliers on 16% of the trials (2,417 out of 15,134). The improvement of performance between the first and the second naming session was shown to be significant by participants and by items [naming latencies, $t_1(45) = 4.46$, $p < .01$, and $t_2(328) = 14.2$, $p < .01$; error rates, $t_1(45) = 6.68$, $p < .01$, and $t_2(328) = 18.7$, $p < .01$]. Table 3 shows the results of the simultaneous multiple regression analysis on the immediate naming data. The overall regression equation was significant, and the model accounted for 29% of the variance in the data [$F(54,12662) = 96.15$, root $MS_e = 215.5$, $p < .001$; $R^2 = .29$]. The results show that name agreement (H), image agreement, visual complexity, imageability, age of acquisition, and printed frequency made significant independent contributions toward predicting naming speed. Number of syllables was significant. The β coefficients for concept familiarity and number of phonemes were not significant.

Further Analysis of the Second Session Data

All but one of the reported effects were in the expected direction. For example, the significant positive β coefficient for the age of acquisition indicates that pictures with names acquired later produced longer naming latencies than did pictures with names learned earlier. Somewhat surprisingly, the marginally significant β coefficient reported for the number of syllables predictor was negative. Under a standard interpretation, this would indicate faster naming times for longer words—a counterintuitive result. This effect was similarly observed whether the variable that is most highly correlated to the number of syllables (the number of phonemes) was included in the analysis or not, suggesting that the counterintuitive β coefficient cannot be readily attributed to colinearity between the predictors. Furthermore, we conducted a post hoc exploration of the effect of syllabic length by randomly selecting 60 pictures, 20 with monosyllabic names, 20 with bisyllabic names, and 20 with trisyllabic names. These three groups of items were matched for nearly all other dimensions available in our study [all Fs < 1 but for the predictors name agreement for which $F(2,57) = 1.21$, $p = .31$, and image complexity for which $F(2,56) = 1.51$, $p = .23$]. The three groups of pictures could not be matched for length in phonemes while matching for the other factors (on average, pictures with monosyllabic names had 3.0 phonemes, those with bisyllabic names had 4.5 phonemes, and those with trisyllabic names had 6.5 phonemes). The analysis of these data showed the following naming times for the three groups: monosyllabic, 841 msec; bisyllabic, 841 msec; trisyllabic, 821 msec. These results suggest that the length effect might be limited to a (still counterintuitive) faster naming for trisyllabic items [$F_1(2,90) = 2.49$, $p = .09$; $F_2(2,57) < 1$]. This unexpected outcome will be discussed further in the General Discussion section.

The effect of the training session can be assessed by comparing the pattern of results in the first and second naming sessions. It can also be assessed by comparing, within the second session, naming times for items that were successfully named in the first session and naming times for items for which an incorrect response was provided in the first session. Note that most of the responses in the first session were correct; therefore, there are many more data points in the first subset (first session correct, 10,590 data points) than in the second subset (second session correct, 2,785 data points). The post hoc analysis of this second set must therefore be interpreted carefully. The analyses revealed that the pattern of performance on the actual naming session (Session 2) was not critically influenced by the nature of the response in the first session. In other words, multiple regression analysis yielded similar levels of significant β coefficients of similar signs for the different predictors. Overall, β coefficients and t values were smaller in the second subset than in the whole data set, probably because of the smaller number of data. The only notable difference between the two data sets concerns the predictors that index item length (in phonemes and in syllables). Whereas only syllabic length contributed (marginally) to predicting naming latencies in the first subset, both length in sylla-

Table 3
Simultaneous Multiple Regression Analysis on the Picture Naming Latencies, Second Session (After Familiarization)

Predictor	β Coeff.	Standard Error	t Value	p
Name agreement	121.4	6.05	20.1	.000
Image agreement	−33.3	2.83	−11.8	.000
Concept familiarity	−.91	2.28	−.40	.688
Visual complexity	7.27	2.24	3.25	.001
Imageability	−52.3	4.31	−12.1	.000
Age of acquisition	69.4	3.70	18.8	.000
Printed frequency	−.19	.038	−4.97	.000
Number of phonemes	−.73	2.12	.34	.731
Number of syllables	−12.2	4.53	−2.70	.007

bles and phonemes (marginally) contributed to the prediction of naming latencies in Subset 2 (see the General Discussion section for details about the interpretation of length effects).

Comparison of the Naming Data With Previous Studies

In order to tease apart the independent contribution to naming latencies of different closely related factors, we included in this study a large number of items named by many participants. Although this high number of observations argues for the robustness of the effects we report, it remains important to compare our results with those of previous studies.

Table 4 provides a summary of the multiple regression analysis results obtained in the present study (conducted in French) as well as in other studies conducted in American English (Snodgrass & Yuditsky, 1996), Welsh (Barry et al., 1997), British English (Ellis & Morrison, 1998), Spanish (Cuetos et al., 1999), Italian (Dell'Acqua et al., 2000), and French (Bonin et al., 2002; Bonin et al., 2003). As can be seen, frequency, age of acquisition, name agreement, and image agreement emerged as the most robust predictors of picture naming speed across the eight studies considered. The other effects contributed significantly only in a fraction of the reported studies, although not all studies investigated all effects.

A notable difference between the results of the present study and those of the study conducted in French by Bonin et al. (2002) is that we found a clear effect of frequency, whereas Bonin et al. failed to find such an effect (although see Bonin et al., 2003). This difference in the results is of importance in the current debate about the relationship between frequency and age-of-acquisition effects. One of the various minor differences between their study and ours could be responsible for this difference: for example, the fact that the two studies used different frequency counts, or the difference in the number of items (203 in their analysis, 329 in ours). Because the original collection of pictures used in both studies was the same, we were able to make a direct comparison between the data collected in the two studies by conducting various post hoc regression analyses on our data. In these analysis, we included only the items used by Bonin et al. (2002), and we used as predictors those tested in their study. We conducted four different analyses, which differed in the frequency count used: LEXIQUE frequency (New et al., 2001), log(LEXIQUE + 1), BRULEX frequency (Content et al., 1990), and log(BRULEX + 1). In all these analyses, we found significant effects of the frequency factor (all $ps < .01$). Although we cannot be sure why Bonin et al. (2002) did not find an effect of frequency, we can be confident that frequency contributed significantly as a robust predictor of naming latency in our experiment, even when the potential contributions of age of acquisition and concept familiarity were partialed out (thus confirming the results obtained by Barry et al., 1997; Ellis & Morrison, 1998; Snodgrass & Yuditsky, 1996; and the more recent results reported by Bonin et al., 2002).

GENERAL DISCUSSION

In this study, we investigated the cognitive processes involved in the picture naming task by assessing the independent roles of different predictor variables on picture naming latencies. We improved on a methodology introduced in previous studies by familiarizing participants with the experimental materials, by using a very large sample of data, and by analyzing it in a repeated measures, multiple regression analysis. Naming latencies were measured by a software voice key. These measurements were shown to be reliably similar to the measurements obtained by analyzing the actual acoustic onset on the digital recordings of the responses. These characteristics of our study argue in favor of the reliability of the reported effects.

Table 4
Summary Table of the Multiple Regression Results Obtained in the Present Study (in French) and in Studies Conducted in American English (Snodgrass & Yuditsky, 1996), in Welsh (Barry et al., 1997), in British English (Ellis & Morrison, 1998), in Spanish (Cuetos et al., 1999), in Italian (Dell'Acqua et al., 2000), and Two Other Studies Conducted in French (Bonin et al., 2002; Bonin et al., 2003)

Language	This Study $N = 329$	American $N = 250$	Welsh $N = 195$	British $N = 220$	Spanish $N = 140$	Italian[1] $N = 266$	French1[1] $N = 203$	French2 $N = 299$
Frequency	✓	✓	✓	✓	✓	n.s.	n.s.	✓
Age of acquisition	✓	✓	✓	✓	✓	✓	✓	✓
Name agreement	✓	✓	✓	✓	✓	✓	✓	✓
Image agreement	✓	✓	✓	–	✓	–	✓	✓
Imageability	✓	–	n.s.	✓	–	–	✓	n.s.
Number of syllables	✓[2]	n.s.	–	–	✓	n.s.	–	–
Number of phonemes	n.s.	✓	n.s.	n.s.	✓	–	n.s.	n.s.
Number of letters	–	n.s.	–	–	–	n.s.	n.s.	–
Concept familiarity	n.s.	✓	n.s.	✓	✓	n.s.	n.s.	n.s.
Visual complexity	✓	n.s.	n.s.	✓	n.s.	–	n.s.	n.s.

Note—✓, significant effect; –, not available; n.s., effect not significant. [1]Contrary to the other studies, these pictures were not taken from Snodgrass and Vanderwart (1980) or from Cycowicz et al. (1997). [2]This effect was in the unexpected direction (negative β coefficient).

A first point that our research helps to establish is the impact of the familiarization phase on performance in a psycholinguistic picture naming experiment. The data sets obtained in the two naming phases were very comparable. Although the significance level of the reported effects is somewhat lower in the second session, the same overall pattern is observed in the two sessions. The major difference between the data sets of the first and the second session concerns the average naming latencies and their variability, as well as on the number of errors.[3] As could be expected, performance was better in the second session, with an overall priming effect of 39 msec on naming latencies and of 11% on error rates. The values of the standard deviations computed on the naming latencies data set showed less variability in the second than in the first session (first session, 289 msec; second session, 255 msec). Furthermore, a separate analysis of second naming trials for which the corresponding response in the familiarization phase (same item, same participant) was correct versus incorrect revealed no relevant differences. These expected results provide a clear motivation for the current practice of familiarizing participants with experimental materials before conducting a picture naming experiment. The resulting data set is more homogeneous, without a major influence on effects of the size reported here.

In the following section, we will briefly discuss the implications of the major effects that we observed in relation to previous studies and current views on lexical access during speech production.

Visual Complexity and Image Agreement

Visual complexity was a significant predictor of picture naming speed in the second naming session, a result also obtained by Ellis and Morrison (1998). These authors have suggested that the complexity of a drawing influences the time taken to recognize the image as the representation of a familiar object. However, many immediate naming studies have failed to find such an effect (Barry et al., 1997; Bonin et al., 2002; Bonin et al., 2003; Cuetos et al., 1999; Snodgrass & Yuditsky, 1996). This absence of an effect is consistent with the view that this factor does not have a major impact on naming latencies for simple black-and-white drawings such as those used here (Biederman, 1987; Paivio, Clark, Digdon, & Bons, 1989).

Image agreement was a significant predictor of picture naming speed, indicating that pictures with higher ratings of image agreement were named faster than those with lower ratings. Barry et al. (1997) suggested that this variable relates to the ease with which a particular drawing is recognized as a positive instance of the object for which the entry level representation is established. They further suggested that image agreement has its influence relatively early during picture naming at the level of the stored structural descriptions. Processing at this level would be faster for items whose pictures closely resemble the stored structural description than for items whose pictures fit more poorly with its stored representation.

Imageability and Concept Familiarity

Imageability contributed significantly to naming latencies in the present study (see also Bonin et al., 2002; Ellis & Morrison, 1998). The presence of an imageability effect is particularly notable given the restricted range of values available in this type of study, since the words used are all names of concrete objects. Ellis and Morrison (1998) suggested a semantic locus for this effect—that is, the meaning of a picture to be named becoming available faster the more imageable the object is.

Concept familiarity was not significant in the experimental session of the present study, although it had a significant effect during the familiarization phase. The effect of this factor has been reported only in three of the eight studies summarized on Table 4 (it was obtained by Cuetos et al., 1999; Ellis & Morrison, 1998; Snodgrass & Yuditsky, 1996). The lack of robustness of the familiarity effect with repetition and its observation only in some of the studies reported in the literature suggests that this variable has at most a weak effect on picture naming latencies. Concept familiarity is defined as a measure of the frequency with which participants use or encounter a given object. The absence of a familiarity effect could therefore suggest that the process of object identification involved in picture naming is not very sensitive to frequency of occurrence (as we will see below, the process of word retrieval seems sensitive to frequency of use).

Name Agreement

Replicating robust effects observed in previous studies (e.g., Barry et al., 1997; Bonin et al., 2002; Bonin et al., 2003; Cuetos et al., 1999; Dell'Acqua et al., 2000; Ellis & Morrison, 1998; Lachman et al., 1974; Paivio et al., 1989; Snodgrass & Yuditsky, 1996; Vitkovitch & Tyrrell, 1995), we found that the factor name agreement emerged as the strongest predictor of picture naming latencies. This effect was found despite the fact that in our study participants benefited from a first phase of familiarization with the pictures, in which they were given the opportunity to identify and study the names of the experimental pictures. This effect signals the importance of the "strength" of the relationship between a given depicted concept and its corresponding name. Presumably, processing objects with low name agreement produces the activation of more lexical candidates than does the processing of objects with high name agreement. The effect of name agreement would reflect the competition between alternative responses and additional time required to select between them. Other studies have found that name agreement decreased naming but not object decision reaction times for the same pictures, suggesting that it affected a postidentification stage unique to naming (name retrieval, response generation, or both; Johnson et al., 1996).

Frequency and Age of Acquisition

These two predictors are highly correlated and have triggered important discussions in the field of psycholinguistics. Various studies have tried to determine whether one is responsible for the effect attributed to the other. Some studies of picture naming found effects of age of acquisition but not frequency on picture naming speed (e.g., Gilhooly & Gilhooly, 1979; Morrison et al., 1992). However, more recent investigations involving larger numbers of items and more up-to-date frequency measures have tended to find independent contributions of both variables (e.g., Barry et al., 1997; Ellis & Morrison, 1998; Snodgrass & Yuditsky, 1996). Thus, the object pictures that are named the fastest are acquired early and of high frequency of use, whereas those that are named slowest are acquired late and are of low frequency. In the present study, we observed clear effects of both printed frequency and age of acquisition. Therefore, the results we report clearly indicate that both frequency *and* age of acquisition play independent determinant roles in picture naming (but see Bonin et al., 2002; Bonin et al., 2003).

It has also been shown that the age-of-acquisition factor does not affect object classification speed (Morrison et al., 1992). This suggests that the effect of age of acquisition is located at the level of name retrieval itself. Barry et al. (1997) proposed that both frequency and age of acquisition affect the same essential process—namely, how a word's phonological representation is activated for its production in speech. They suggested that frequency and age of acquisition have their effect after the semantic level but prior to the articulation level: the level of name retrieval or the phonological encoding level (see Figure 1). This view is somehow strengthened by the fact that we did not observe an independent effect for concept familiarity in the second session of our experiment and by the fact that concept familiarity is not a robust predictor of naming latencies across studies. If concept familiarity is taken as a measure of object use frequency—as opposed to word use frequency—the absence of an effect of familiarity suggests that in this type of experiment the process that is sensitive to the frequency of use dimension is word retrieval rather than object identification.

Number of Phonemes and Syllables

Number of phonemes did not contribute significantly to predicting naming latencies. This absence of effect was also observed in most studies examining this variable (see Table 4). Number of syllables contributed marginally to naming latencies. However, this effect was not in the expected direction. The negative β coefficient indicates shorter naming latencies for longer words. A post hoc analysis conducted on a subset of the items showed that trisyllabic items were named, on average, faster than mono- or bisyllabic items. We can consider this result in light of previous attempts to demonstrate effects of the number of syllables. In studies similar to this one, Cuetos et al. (1999) found the effect, but Snodgrass and Yuditsky (1996) and Dell'Acqua et al. (2000) failed to find them (see Table 4). As was mentioned in the introduction, the effect of the number of syllables has proved elusive in picture naming experiments (compare Bachoud-Lévi et al., 1998, with Santiago et al., 2000). This does not mean that length in syllables does not affect any level of processing during picture naming or that syllables play no significant role during phonological encoding. It could be that certain specific conditions have to be met for the effect to be observed. Recent evidence provided by Meyer, Roelofs, and Levelt (2003) suggests such a conclusion. These authors found effects of the number of syllables in blocked designs (i.e., when the number of syllables of a given experimental block was held constant) but not in mixed designs. Another possibility is that the syllable length effect interacts with printed frequency, so that the effect is observed only for low frequency names but not for high frequency names (see Ferrand, 2000, for such a result obtained in a word naming task). Clearly, further investigation of this potentially important effect is required. Indeed, the results observed for this latter factor provide an example of the limitations of the methodology used here, in which experimental factors are not explicitly manipulated.

CONCLUSION

The processes involved in the production of the name of a picture are sensitive to a variety of factors. Our study provides converging and new evidence on these effects. On the methodological side, the present study has shown the reliability of naming latency measurements obtained with a software voice key. It also provides an example of the application of a repeated measures design in a multiple regression analysis, a recommended methodology that is seldom used for this type of experiment.

The main conclusions that can be drawn from our study are as follows. Visual complexity, image agreement, and name agreement are major determinants of naming speed. Frequency and age of acquisition both make *independent* contributions to naming times. This conclusion is different from that reached in some other studies in which frequency effects disappeared when age of acquisition was controlled for. Also, the reliable effect observed for word frequency contrasts with the absence of an effect of the object familiarity factor, which could be taken as a measure of frequency of object use. Finally, our results indicate that the nature of the effect of word length still requires a more thorough study.

REFERENCES

Alario, F.-X., & Ferrand, L. (1999). A set of 400 pictures standardized for French: Norms for name agreement, image agreement, familiarity, visual complexity, image variability, and age of acquisition. *Behavior Research Methods, Instruments, & Computers*, **31**, 531-552.

Attneave, F. (1957). Physical determinants of the judged complexity of shapes. *Journal of Experimental Psychology*, **53**, 221-227.

Bachoud-Lévi, A.-C., Dupoux, E., Cohen, L., & Mehler, J. (1998). Where is the length effect? A cross-linguistic study of speech production. *Journal of Memory & Language*, **39**, 331-346.

Balota, D. A., & Chumbley, J. I. (1985). The locus of word frequency effects in the pronunciation task: Lexical access and/or production? *Journal of Memory & Language*, **24**, 89-106.

Barry, C., Morrison, C. M., & Ellis, A. W. (1997). Naming the Snodgrass and Vanderwart pictures: Effects of age of acquisition, frequency, and name agreement. *Quarterly Journal of Experimental Psychology*, **50A**, 560-585.

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review*, **94**, 115-147.

Bonin, P., Chalard, M., Méot, A., & Fayol, M. (2002). The determinants of spoken and written picture naming latencies. *British Journal of Psychology*, **93**, 89-114.

Bonin, P., Peereman, R., Malardier, N., Méot, A., & Chalard, M. (2003). A new set of 299 pictures for psycholinguistic studies: French norms for name agreement, image agreement, conceptual familiarity, visual complexity, image variability, age of acquisition, and naming latencies. *Behavior Research Methods, Instruments, & Computers* **35**, 158-167.

Carroll, J. B., & White, M. N. (1973). Age-of-acquisition norms for 220 picturable nouns. *Journal of Verbal Learning & Verbal Behavior*, **12**, 563-576.

Content, A., Mousty, P., & Radeau, M. (1990). BRULEX: Une base de données lexicales informatisée pour le français écrit et parlé [Brulex: A computerized lexical database for the French language]. *L'Année Psychologique*, **90**, 551-566.

Cuetos, F., Ellis, A. W., & Alvarez, B. (1999). Naming times for the Snodgrass and Vanderwart pictures in Spanish. *Behavior Research Methods, Instruments, & Computers*, **31**, 650-658.

Cycowicz, Y. M., Friedman, D., Rothstein, M., & Snodgrass, J. G. (1997). Picture naming by young children: Norms for name agreement, familiarity, and visual complexity. *Journal of Experimental Child Psychology*, **65**, 171-237.

Dell´Acqua, R., Lotto, L., & Job, R. (2000). Naming times and standardized norms for the Italian PD/DPSS set of 266 pictures: Direct comparisons with American, English, French, and Spanish published databases. *Behavior Research Methods, Instruments, & Computers*, **32**, 588-615.

Ellis, A. W., & Morrison, C. M. (1998). Real age-of-acquisition effects in lexical retrieval. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **24**, 515-523.

Ferrand, L. (2000). Reading aloud polysyllabic words and nonwords: The syllabic length effect reexamined. *Psychonomic Bulletin & Review*, **7**, 142-148.

Feyereisen, P., Van der Borght, F., & Seron, X. (1988). The operativity effect in naming: A re-analysis. *Neuropsychologia*, **26**, 401-415.

Forster, K. I., & Chambers, S. M. (1973). Lexical access and naming time. *Journal of Verbal Learning & Verbal Behavior*, **12**, 627-635.

Forster, K. I., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers*, **35**, 116-124.

Francis, W. N., & Kučera, H. (1982). *Frequency analysis of English usage: Lexicon and grammar.* Boston: Houghton Mifflin.

Fromkin, V. A. (1971). The non-anomalous nature of anomalous utterances. *Language*, **47**, 27-52.

Gilhooly, K. J., & Gilhooly, M. L. (1979). Age-of-acquisition effects in lexical and episodic memory tasks. *Memory & Cognition*, **7**, 214-223.

Glaser, W. R. (1992). Picture naming. *Cognition*, **42**, 61-105.

Hirsh, K. W., & Funnell, E. (1995). Those old, familiar things: Age of acquisition, familiarity and lexical access in progressive aphasia. *Journal of Neurolinguistics*, **9**, 23-32.

Humphreys, G. W., Riddoch, M. J., & Quinlan, P. T. (1988). Cascade processes in picture identification. *Cognitive Neuropsychology*, **5**, 67-103.

Johnson, C. J., Paivio, A., & Clark, J. M. (1996). Cognitive components of picture naming. *Psychological Bulletin*, **120**, 113-139.

Klapp, S. T., Anderson, W. G., & Berrian, R. W. (1973). Implicit speech in reading reconsidered. *Journal of Experimental Psychology*, **100**, 368-374.

Lachman, R. (1973). Uncertainty effects on time to access the internal lexicon. *Journal of Experimental Psychology*, **99**, 199-208.

Lachman, R., Shaffer, J. P., & Hennrikus, D. (1974). Language and cognition: Effects of stimulus codability, name-word frequency, and age of acquisition on lexical reaction time. *Journal of Verbal Learning & Verbal Behavior*, **13**, 613-625.

Levelt, W., Roelofs, A., & Meyer, A. (1999). A theory of lexical access in speech production. *Behavioral & Brain Sciences*, **22**, 1-75.

Lorch, R. F., & Myers, J. L. (1990). Regression analyses of repeated measures data in cognitive research. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **16**, 149-157.

Meyer, A. S., Roelofs, A., & Levelt, W. J. M. (2003). Word length effects in object naming: The role of a response criterion. *Journal of Memory & Language*, **48**, 131-147.

Monsell, S., Doyle, M. C., & Haggard, P. N. (1989). Effects of frequency on visual word recognition tasks: Where are they? *Journal of Experimental Psychology: General*, **118**, 42-71.

Morrison, C. M., Chappell, T. D., & Ellis, A. W. (1997). Age of acquisition norms for a large set of object names and their relation to adult estimates and other variables. *Quarterly Journal of Experimental Psychology*, **50A**, 528-559.

Morrison, C. M., & Ellis, A. W. (1995). The roles of word frequency and age of acquisition in word naming and lexical decision. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **21**, 116-133.

Morrison, C. M., Ellis, A. W., & Quinlan, P. T. (1992). Age of acquisition, not word frequency, affects object naming, not object recognition. *Memory & Cognition*, **20**, 705-714.

New, B., Pallier, C., Ferrand, L., & Matos, R. (2001). Une base de données lexicales du français contemporain sur Internet: LEXIQUE [A lexical database of contemporary French on Internet: LEXIQUE]. *L'Année Psychologique*, **101**, 447-462. Available at http://www.lexique.org.

Oldfield, R. C., & Wingfield, A. (1965). Response latencies in naming objects. *Quarterly Journal of Experimental Psychology*, **17**, 273-281.

Paivio, A., Clark, J. M., Digdon, N., & Bons, T. (1989). Referential processing: Reciprocity and correlates of naming and imaging. *Memory & Cognition*, **17**, 163-174.

Plaut, D. C., & Shallice, T. (1993). Deep dyslexia: A case study of connectionist neuropsychology. *Cognitive Neuropsychology*, **10**, 377-500.

Santiago, J., MacKay, D. G., Palma, A., & Rho, C. (2000). Sequential activation processes in producing words and syllables: Evidence from picture naming. *Language & Cognitive Processes*, **15**, 1-44.

Savage, G. R., Bradley, D. C., & Forster, K. I. (1990). Word frequency and the pronunciation task: The contribution of articulatory fluency. *Language & Cognitive Processes*, **5**, 203-326.

Shattuck-Hufnagel, S. (1979). Speech errors as evidence for a serial-ordering mechanism in sentence production. In W. E. Cooper & E. C. T. Walker (Eds.), *Sentence processing: Psycholinguistic studies presented to Merrill Garrett* (pp. 295-342). Hillsdale, NJ: Erlbaum.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning & Memory*, **6**, 174-215.

Snodgrass, J. G., & Yuditsky, T. (1996). Naming times for the Snodgrass and Vanderwart pictures. *Behavior Research Methods, Instruments, & Computers*, **28**, 516-536.

Vitkovitch, M., & Tyrrell, L. (1995). Sources of disagreement in object naming. *Quarterly Journal of Experimental Psychology*, **48A**, 822-848.

NOTES

1. We were not aware of the work by Bonin et al. (2003) during the preparation of our study.

2. An attempt was made to code both participants and items with dummy variables. This involved using 10 + 45 + 328 = 383 predictors, and it led our statistical program to drop many item predictors. Therefore this item coding was abandoned.

3. There was no effect of the variable visual complexity during the familiarization phase, although it had an effect during the experimental phase. This point is discussed below, in the section devoted to this variable.

APPENDIX
Mean Naming Latencies (*M*), Standard Deviations (*SD*), and Percentage of Correct Responses (%) in the Immediate Pronunciation Tasks for the 329 Items Used in the Analyses

No.	No. (A&F)	French	English	Immediate Naming *M*	*SD*	%
1	1	accordéon	accordion	841	287	89
2	2	gland	acorn	961	224	65
3	3	avion	airplane	671	161	98
4	4	crocodile	alligator	815	258	96
5	5	ancre	anchor	888	224	80
6	6	fourmi	ant	993	234	89
7	8	enclume	anvil	883	190	57
8	9	pomme	apple	735	205	100
9	11	bras	arm	856	196	96
10	13	flèche	arrow	746	149	98
11	14	artichaut	artichoke	941	279	65
12	15	cendrier	ashtray	892	219	96
13	16	asperge	asparagus	949	256	78
14	17	avocat	avocado	935	212	74
15	18	hache	axe	834	218	91
16	19	landau	baby carriage	879	243	54
17	20	ballon	ball	711	167	96
18	21	ballon	balloon	675	153	98
19	22	banane	banana	648	172	100
20	24	tonneau	barrel	801	260	80
21	26	panier	basket	766	255	98
22	27	chauve-souris	bat	903	261	96
23	28	ours	bear	793	162	98
24	29	lit	bed	628	122	98
25	30	abeille	bee	1,029	241	65
26	32	cloche	bell	745	224	96
27	33	ceinture	belt	720	159	98
28	34	banc	bench	725	186	98
29	35	vélo	bicycle	688	181	89
30	36	jumelles	binoculars	847	308	85
31	37	oiseau	bird	852	263	72
32	38	cage	bird cage	857	183	93
33	39	nid	bird nest	852	145	96
34	40	dirigeable	blimp	1,222	226	41
35	42	livre	book	640	140	93
36	43	botte	boot	786	172	96
37	44	bouteille	bottle	744	209	98
38	45	nœud	bow	773	192	67
39	46	bol	bowl	934	302	78
40	47	boîte	box	905	264	80
41	48	cerveau	brain	853	201	98
42	49	pain	bread	794	191	61
43	50	balai	broom	814	257	93
44	51	brosse	brush	787	194	96
45	52	bison	buffalo	1,089	261	61
46	53	bus	bus	828	202	78
47	54	papillon	butterfly	674	157	93
48	55	bouton	button	910	252	87
49	56	cactus	cactus	798	200	93
50	57	caddie	caddy	846	199	46
51	58	gâteau	cake	745	159	93
52	59	chameau	camel	932	306	72
53	62	bougie	candle	702	142	91
54	63	canon	cannon	798	160	96
55	64	casquette	cap	795	189	93
56	65	voiture	car	690	175	93
57	66	carotte	carrot	636	130	98
58	67	chat	cat	636	125	100
59	68	chenille	caterpillar	965	316	74

APPENDIX (Continued)

No.	No. (A&F)	French	English	Immediate Naming *M*	*SD*	%
60	69	céleri	celery	1,109	210	41
61	70	chaîne	chain	756	187	91
62	71	chaise	chair	608	131	98
63	73	cerise	cherry	775	160	98
64	74	malle	chest	1,004	268	48
65	75	poule	chicken	925	265	87
66	76	cheminée	chimney	794	173	96
67	78	église	church	724	139	96
68	79	cigare	cigar	984	215	96
69	80	cigarette	cigarette	854	156	98
70	81	horloge	clock	891	244	78
71	84	nuage	cloud	953	276	87
72	85	clown	clown	679	87	96
73	86	manteau	coat	928	289	70
74	88	passoire	colander	923	296	74
75	89	peigne	comb	760	194	98
76	90	boussole	compass	1,025	194	80
77	91	maïs	corn	842	152	93
78	92	canapé	couch	878	250	65
79	93	vache	cow	858	171	89
80	94	crabe	crab	921	269	87
81	95	couronne	crown	830	164	96
82	96	tasse	cup	730	161	98
83	98	fléchette	dart	930	167	72
84	99	cerf	deer	1,115	290	72
85	100	bureau	desk	965	236	72
86	101	dinosaure	dinosaur	1,078	275	96
87	102	chien	dog	689	152	100
88	103	niche	doghouse	873	246	80
89	104	poupée	doll	782	172	98
90	105	dauphin	dolphin	724	178	98
91	106	âne	donkey	858	251	100
92	107	porte	door	703	181	91
93	108	poignée	doorknob	1,179	232	72
94	109	libellule	dragonfly	932	273	85
95	110	robe	dress	866	262	100
96	111	commode	dresser	984	238	76
97	112	tambour	drum	891	260	96
98	113	canard	duck	813	180	93
99	115	aigle	eagle	1,027	280	87
100	116	oreille	ear	631	96	98
101	118	anguille	eel	1,161	234	67
102	119	éléphant	elephant	633	103	100
103	120	enveloppe	envelope	733	220	80
104	121	oeil	eye	658	165	98
105	122	éventail	fan	948	264	70
106	123	robinet	faucet	864	230	93
107	124	plume	feather	762	188	98
108	125	barrière	fence	783	200	87
109	126	fougère	fern	984	260	78
110	128	doigt	finger	725	242	87
111	129	poisson	fish	672	133	96
112	130	aquarium	fishbowl	1,060	229	61
113	131	hameçon	fishhook	1,082	241	54
114	134	drapeau	flag	706	122	91
115	135	flamand	flamingo	1,040	274	41
116	137	fleur	flower	746	219	100
117	139	mouche	fly	1,003	225	87
118	140	pied	foot	646	143	100
119	141	fourchette	fork	747	190	100
120	142	renard	fox	976	318	91

APPENDIX (Continued)

No.	No. (A&F)	French	English	Immediate Naming *M*	*SD*	%
121	143	croissant	French croissant	735	107	100
122	145	grenouille	frog	785	273	80
123	146	poêle	frying pan	968	206	70
124	147	entonnoir	funnel	855	295	93
125	148	poubelle	garbage can	759	178	93
126	149	girafe	giraffe	684	168	100
127	150	verre	glass	706	194	96
128	151	lunettes	glasses	632	132	93
129	152	mappemonde	globe	891	218	65
130	153	gant	glove	747	118	96
131	154	chèvre	goat	986	288	76
132	156	gorille	gorilla	934	267	83
133	157	raisin	grapes	840	269	91
134	158	sauterelle	grasshopper	1,045	263	50
135	159	barbecue	grill	1,003	208	65
136	160	guitare	guitar	727	188	100
137	161	pistolet	gun	829	193	80
138	162	cheveux	hair	899	204	93
139	164	marteau	hammer	919	273	96
140	165	hamac	hammock	1,042	231	89
141	166	main	hand	631	138	100
142	167	cintre	hanger	774	196	89
143	168	harmonica	harmonica	931	258	76
144	169	harpe	harp	779	158	89
145	170	chapeau	hat	621	128	100
146	172	cœur	heart	608	104	100
147	173	hélicoptère	helicopter	694	176	100
148	174	casque	helmet	702	141	98
149	175	hippopotame	hippopotamus	904	242	83
150	177	cheval	horse	692	173	98
151	179	maison	house	774	236	93
152	180	hyène	hyena	1,087	272	80
153	181	igloo	igloo	732	139	100
154	183	veste	jacket	1,042	325	57
155	184	bocal	jar	984	220	67
156	185	méduse	jellyfish	1,057	308	57
157	186	kangourou	kangaroo	790	227	93
158	187	bouilloire	kettle	1,175	296	41
159	188	clef	key	660	115	98
160	189	cerf-volant	kite	800	185	93
161	190	couteau	knife	728	215	98
162	191	koala	koala	878	198	93
163	192	échelle	ladder	699	191	96
164	193	louche	ladle	911	258	89
165	194	coccinelle	ladybug	905	230	85
166	195	agneau	lamb	1,050	347	41
167	196	lampe	lamp	701	145	93
168	197	tondeuse	lawnmower	1,065	299	67
169	198	feuille	leaf	913	272	98
170	199	jambe	leg	928	244	87
171	200	citron	lemon	717	198	100
172	201	léopard	leopard	1,033	267	52
173	203	ampoule	light bulb	734	151	80
174	204	interrupteur	light switch	1,021	267	78
175	205	lion	lion	805	196	96
176	206	bouche	lips	728	252	83
177	208	lézard	lizard	867	243	87
178	209	lama	llama	1,006	254	83
179	211	cadenas	lock	898	217	91
180	212	b°ches	logs	1,163	318	50
181	213	poumons	lungs	1,075	273	93

APPENDIX (Continued)

No.	No. (A&F)	French	English	Immediate Naming *M*	*SD*	%
182	214	maracas	maracas	924	232	63
183	215	microscope	microscope	1,081	228	61
184	216	moufle	mitten	910	176	46
185	217	singe	monkey	831	234	93
186	218	lune	moon	729	203	98
187	219	élan	moose	1,089	277	57
188	220	moto	motorcycle	789	227	93
189	221	montagne	mountain	872	228	96
190	222	souris	mouse	866	215	85
191	223	champignon	mushroom	670	103	96
192	224	clou	nail	958	258	89
193	225	lime	nail file	978	307	78
194	226	collier	necklace	740	208	100
195	227	aiguille	needle	947	262	80
196	228	nez	nose	671	100	98
197	229	écrou	nut	941	288	48
198	230	poulpe	octopus	1,177	288	48
199	231	oignon	onion	980	288	87
200	232	orange	orange	944	271	85
201	233	autruche	ostrich	922	264	70
202	234	hibou	owl	855	257	96
203	236	pinceau	paintbrush	766	209	93
204	237	palmier	palm tree	751	157	96
205	239	pantalon	pants	659	135	100
206	240	parachute	parachute	1,201	295	78
207	241	perroquet	parrot	1,033	294	78
208	242	pêche	peach	1,118	259	52
209	243	paon	peacock	962	245	89
210	244	cacahouète	peanut	795	206	93
211	245	poire	pear	722	212	93
212	247	pélican	pelican	995	309	65
213	248	stylo	pen	868	215	87
214	249	crayon	pencil	668	160	96
215	250	pingouin	penguin	855	257	96
216	251	poivron	pepper	1,029	247	72
217	252	piano	piano	743	163	93
218	253	tableau	picture	761	179	91
219	254	cochon	pig	883	217	100
220	255	flipper	pinball machine	1,097	219	70
221	256	ananas	pineapple	732	172	100
222	257	pipe	pipe	689	146	96
223	260	pince	pliers	1,034	256	74
224	261	prise	plug	935	250	87
225	262	sac	pocketbook	800	230	78
226	263	casserole	pot	913	290	91
227	264	pomme de terre	potato	1,013	286	43
228	265	hélice	propeller	842	261	96
229	266	citrouille	pumpkin	890	269	72
230	267	pyramide	pyramid	840	201	100
231	268	lapin	rabbit	638	141	100
232	270	râteau	rake	867	262	96
233	271	rat	rat	857	185	80
234	272	raie	ray	1,111	311	63
235	273	tourne-disque	record player	916	244	85
236	275	rhinocéros	rhinoceros	842	218	91
237	276	bague	ring	875	216	96
238	277	fusée	rocket	787	159	96
239	280	coq	rooster	854	226	78
240	281	corde	rope	836	254	98
241	282	règle	ruler	790	236	93
242	283	selle	saddle	898	227	91

APPENDIX (Continued)

No.	No. (A&F)	French	English	Immediate Naming *M*	*SD*	%
243	284	coffre-fort	safe	1,067	213	70
244	285	voilier	sailboat	902	220	46
245	286	salière	salt shaker	1,053	293	52
246	287	sandwich	sandwich	837	209	98
247	288	scie	saw	755	215	91
248	289	saxophone	saxophone	1,095	319	76
249	290	balance	scale	745	134	100
250	291	ciseau	scissors	673	151	100
251	292	pelle	spatula	1,074	294	54
252	293	scorpion	scorpion	1,053	292	74
253	294	vis	screw	945	242	83
254	295	tournevis	screwdriver	864	255	83
255	296	hippocampe	sea horse	939	302	70
256	297	phoque	seal	1,138	329	63
257	298	requin	shark	881	267	91
258	299	mouton	sheep	1,062	338	67
259	300	chemise	shirt	942	277	85
260	301	chaussure	shoe	649	123	89
261	302	douche	shower head	876	210	91
262	303	squelette	skeleton	736	150	98
263	304	ski	ski	854	199	93
264	305	jupe	skirt	897	266	83
265	306	crâne	skull	909	285	80
266	307	putois	skunk	1,061	308	43
267	308	luge	sled	822	234	91
268	309	escargot	snail	734	188	98
269	310	serpent	snake	697	157	98
270	312	chaussette	sock	644	132	98
271	314	araignée	spider	857	192	96
272	316	rouet	spinning wheel	993	238	46
273	318	cuillère	spoon	722	208	96
274	320	écureuil	squirrel	794	197	93
275	321	étoile	star	639	177	98
276	323	stéthoscope	stethoscope	1,080	228	74
277	324	tabouret	stool	779	207	93
278	325	cuisinière	stove	1,129	299	57
279	326	fraise	strawberry	762	243	89
280	327	valise	suitcase	733	182	98
281	328	soleil	sun	648	191	100
282	329	cygne	swan	786	220	93
283	332	balançoire	swing	799	188	98
284	333	espadon	swordfish	952	308	41
285	334	seringue	syringe	819	157	93
286	335	table	table	667	132	98
287	337	téléphone	telephone	620	104	100
288	339	télévision	television	760	175	70
289	341	thermomètre	thermometer	762	218	89
290	342	thermos	thermos	1,071	315	57
291	344	pouce	thumb	896	204	74
292	345	cravate	tie	757	253	93
293	346	tigre	tiger	880	254	89
294	347	pneu	tire	906	239	65
295	348	grille-pain	toaster	1,093	339	54
296	349	orteil	toe	1,155	189	48
297	350	tomate	tomato	829	240	93
298	352	toupie	top	802	162	91
299	353	totem	totem pole	912	274	85
300	355	tracteur	tractor	799	241	96
301	356	feu	traffic light	918	223	80
302	357	train	train	785	237	93
303	358	oeuf	tram car	1,246	186	41

APPENDIX (Continued)

No.	No. (A&F)	French	English	Immediate Naming *M*	*SD*	%
304	359	arbre	tree	715	228	100
305	360	camion	truck	704	121	100
306	361	trompette	trumpet	799	231	93
307	362	dindon	turkey	1,058	273	50
308	363	tortue	turtle	697	213	100
309	364	parapluie	umbrella	662	155	100
310	365	vase	vase	778	177	100
311	366	gilet	vest	981	235	57
312	367	violon	violin	967	274	72
313	368	vautour	vulture	1,135	314	43
314	370	morse	walrus	1,064	230	52
315	372	montre	watch	684	162	96
316	373	arrosoir	watering can	755	195	96
317	374	pastèque	watermelon	891	219	85
318	375	girouette	weather vane	1,108	251	59
319	376	puits	well	922	287	91
320	377	baleine	whale	985	265	87
321	378	roue	wheel	826	307	93
322	379	fouet	whip	1,074	277	76
323	380	sifflet	whistle	766	164	96
324	381	moulin	windmill	832	229	83
325	382	fenêtre	window	904	195	93
326	383	loup	wine glass	823	191	93
327	385	clé	wrench	1,138	295	48
328	386	yo-yo	yo-yo	1,008	228	89
329	387	zèbre	zebra	791	185	96

(Manuscript received February 19, 2002;
revision accepted for publication May 28, 2003.)