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The determinants of spoken and written picture naming latencies

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The influence of nine variables on the latencies to write down or to speak aloud the names of pictures taken from Snodgrass and Vanderwart (1980) was investigated in French adults. The major determinants of both written and spoken picture naming latencies were image variability, image agreement and age of acquisition. To a lesser extent, name agreement was also found to have an impact in both production modes. The implications of the findings for theoretical views of both spoken and written picture naming are discussed.

Picture naming is a complex activity which is influenced by many factors (Kosslyn & Chabris, 1990). Consequently, a number of studies have attempted to identify the various factors that contribute to naming speed (e.g. Barry, Morrison, & Ellis, 1997; Cycowicz, Friedman, Rothstein, & Snodgrass, 1997; Ellis & Morrison, 1998; Lachman, Shaffer, & Hennrikus, 1974; Morrison, Ellis, & Quinlan, 1992; Snodgrass & Yuditsky, 1996; Vitkovitch & Tyrrell, 1995). To achieve this aim, these studies have used large databases of pictures standardized on a number of relevant variables.

In their pioneering study, Snodgrass and Vanderwart (1980) presented a set of 260 black-and-white drawings standardized on four variables of relevance—name agreement, image agreement, conceptual familiarity and visual complexity—for research on visual perception, language and memory. Other picture norming studies have since been published relating to different language communities (Alario & Ferrand, 1999; Barry *et al.*, 1997; Berman, Friedman, Hamberger, & Snodgrass, 1989; Cycowicz *et al.*, 1997; Martein, 1995; Pind, Jonsdottir, Tryggvadottir, & Jonsson, 2000; Sanfeliu & Fernandez, 1996; Vitkovitch & Tyrrell, 1995). Of importance here is Alario and Ferrand's (1999) recent normative French-language database.

Alario and Ferrand (1999) have provided normative measures for 400 line drawings taken from Cycowicz *et al.* (1997) which include the 260 line drawings from Snodgrass

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and Vanderwart (1980). Closely following Snodgrass and Vanderwart's (1980) procedures, the drawings have been standardized on: name agreement, image agreement, familiarity, visual complexity, image variability and age of acquisition (in the following, AoA_{AF}). Given their direct relevance for the present study, we briefly describe the norms collected by Alario and Ferrand (1999). We refer the reader to Alario and Ferrand's (1999) study for details.

Name agreement refers to the degree to which participants agree on the name of the picture. It was measured by taking into account the number of alternative names given to a particular picture across participants. *Image agreement* refers to the degree (evaluated using a 5-point scale) to which mental images generated by participants in response to a picture match the picture's visual appearance: A rating of 1 indicates that the picture provides a poor match for the image and a rating of 5 indicates a very good match. *Familiarity* refers to the familiarity of the concept depicted. This was also measured on a 5-point scale (1 = a very unfamiliar object, 5 = a very familiar object). *Visual complexity* corresponds to the number of lines and details in the drawing. In Alario and Ferrand (1999), the participants rated the complexity of each drawing on a 5-point scale (1 = drawing very simple, 5 = drawing very complex) rather than the complexity of the object it represented. *Image variability* was again rated on a 5-point scale. This measure indicates whether the name of an object evokes few or many different images for that particular object (1 = few images, 5 = many images). For this latter norming task, as well as for the estimations of age of acquisition (AoA), Alario and Ferrand (1999) presented the name of the pictures and not the pictures themselves. To rate AoA, the participants were asked to estimate on a 5-point scale the age at which they thought they had learned each of the names in its written or oral form, where 1 = learned at 0–3 years and 5 = learned at age 12+, with 3-year bands in between.

The present study explored the factors that contribute to the spoken and written picture naming onset latencies in 237 of the Snodgrass and Vanderwart (1980) pictures. Although a number of studies in spoken picture naming have revealed important factors that contribute to naming speed by means of multiple regression analyses, we are not aware of any written picture naming study of this kind.

Investigating written picture naming in addition to spoken picture naming is important from an empirical point of view. In effect, it makes it possible to identify the potential common and specific factors that contribute to the naming latencies in these production modes. Moreover, it provides response time (RT) data that will be useful for future research into spoken and written picture naming. Finally, it also makes it possible to shed light on the important issue of the nature of the processing components that are shared (and not shared) between writing and speaking (Ellis, 1988). Indeed, it was long assumed that writing borrowed from speech (Geschwind, 1969; Luria, 1970). Within this view, written production should primarily be based on the processes and the representations dedicated to speech production. However, this traditional view has not as yet received strong empirical support. Very few experimental studies in normals have investigated the extent to which the processes and the representations involved in written production resemble those involved in spoken production (Bonin & Fayol, 2000; Bonin, Fayol, & Gombert, 1997, 1998). However, if we are to elaborate views on written picture naming, it seems somewhat odd to build models of the writing process on what is a rather *a priori* basis. Our basic assumption is that the finding of similar effects in the two production modes would indicate that similar processes and representations are involved (Bonin & Fayol, 2000).

Factors that contribute to spoken naming speed

To investigate the processes and the representations underlying spoken picture naming, one approach has been to vary individual item characteristics and to observe which of them reliably affect picture naming performance. A number of studies have thus revealed some important factors that contribute to spoken picture naming speed.

Oldfield and Wingfield (1964, 1965) showed that the latencies required to say aloud the name of pictures are a linear function of the log printed word frequency of the picture names. Since then, the effect of word frequency on the time taken to name pictures has been regularly reported (Goodglass, Theurkauf, & Wingfield, 1984; Griffin & Bock, 1998; Humphreys, Riddoch, & Quinlan, 1988; Huttenlocher & Kubicek, 1983; Jescheniak & Levelt, 1994; Lachman, 1973; Lachman *et al.*, 1974; Levelt, Praamstra, Meyer, Helenius, & Salmelin, 1998; Oldfield & Wingfield, 1964, 1965).

AoA has been found to be an important determinant of performance in various lexical processing tasks (Barry *et al.*, 1997; Brown & Watson, 1987; Carroll & White, 1973a; Coltheart, Laxon, & Keating, 1988; Gerhand & Barry, 1998; Gilhooly & Logie, 1981; Hodgson & Ellis, 1998; Lachman, 1973; Lachman *et al.*, 1974; Morrison, Chappell, & Ellis, 1997; Morrison *et al.*, 1992; Yamazaki, Ellis, Morrison, & Lambon Ralph, 1997). Carroll and White (1973b) were the first to show that the estimated AoA of words is an important predictor of spoken picture naming speed in adults. Carroll and White (1973b) claimed that all or part of the differences in spoken picture naming speed that were attributed to word frequency might actually be related to differences in AoA. Some researchers have therefore cast considerable doubt on whether frequency effects are genuinely frequency effects or whether they might be more properly attributed to AoA. Some authors have strongly claimed that frequency effects are actually AoA effects in disguise (e.g. Morrison *et al.*, 1992). Morrison *et al.* (1992) reanalysed data reported by Oldfield and Wingfield (1965) and found that when AoA scores were taken into account in multiple regression analyses, only AoA was a significant independent determinant of naming latency. In addition, Morrison *et al.* (1992) have shown, using their own data, that only AoA and word length in phonemes had significant independent effects on spoken naming speed (see also Gilhooly & Gilhooly, 1979). Nevertheless, other studies have reported significant effects of both word frequency and AoA (Lachman, 1973; Lachman *et al.*, 1974; Snodgrass & Yuditsky, 1996). Interestingly, Barry *et al.* (1997) have shown that rated AoA and word frequency interacted. More precisely, a frequency effect was observed for late acquired words but not for early acquired words.

The degree of agreement among speakers concerning the name they use to refer to a pictured object (i.e. codability) has also been shown to be an important determinant of naming speed (Barry *et al.*, 1997; Ellis & Morrison, 1998; Gilhooly & Gilhooly, 1979; Lachman, 1973; Lachman *et al.*, 1974; Paivio, Clark, Digdon, & Bons, 1989; Snodgrass & Yuditsky, 1996; Vitkovitch & Tyrrell, 1995). Indeed, the codability of pictures has been put forward as the underlying factor in accounting for the longer naming time of pictures compared to words (Ferrand, 1999). In multiple regression analyses, Vitkovitch and Tyrrell (1995) reported that name agreement remained the strongest predictor of spoken naming latencies, even after any AoA, frequency and complexity effects were partialled out.

The visual complexity of the objects referred by the pictures has been found to affect the naming times (Humphreys *et al.*, 1988). Humphreys *et al.* (1988) have shown that items coming from structurally distinct categories, e.g. *tools*, were named faster than items coming from structurally similar categories, e.g. *animals*. Structural similarity is the degree to which members of a semantic category look alike. For instance, animals or vegetables are structurally similar categories whereas tools or furniture are structurally dissimilar categories. More precisely, Humphreys *et al.* (1988) observed that word frequency affected the naming times only for pictures coming from structurally distinct categories. However, the crucial observation for the present purpose is the observation that the visual complexity of the pictures themselves has not been found to contribute to the naming times in a systematic and robust manner (Barry *et al.*, 1997; Cycowicz *et al.*, 1990, but see Ellis & Morrison, 1998). The same holds true as regards the familiarity of the concept to be named (Ellis & Morrison, 1998; Jolicoeur, 1985). Ellis and Morrison (1998) reported a significant effect of concept familiarity in spoken picture naming in a multiple regression analysis using Lorch and Myers' (1990) procedure but not in a conventional simultaneous multiple regression. However, Hirsh and Funnell (1995) have found that patients with progressive semantic dementia achieved better naming performance with objects having a high concept familiarity than with objects having a low concept familiarity (see also Feyereisen, Van der Borght, & Seron, 1988, in aphasic patients).

Pictures with higher image agreement ratings are named faster than those with lower ratings (Barry *et al.*, 1997). So far, however, spoken picture naming studies have not systematically included image agreement as a predictor variable. Finally, we are not aware of any previous spoken picture naming study that included image variability as a predictor variable.

To sum up, a number of studies have indicated certain determinants of spoken naming speed. Among those that appear to have a major effect are the age at which names are first learned and, to a lesser extent, the degree of agreement between the names and the pictures. A major difficulty discussed below is to relate these effects to specific processing levels in speech production models.

Relating the impact of variables to processing levels involved in speech production

It is widely accepted that spoken picture naming involves a stage of object recognition (i.e. a computation of a visual representation of the object from the visual image, Levelt *et al.*, 1998, and access to stored structural representations, Davidoff & De Bleser, 1994; Humphreys *et al.*, 1988), conceptual activation (i.e. access to associative and functional properties of the object, Flores d'Arcais & Schreuder, 1987), and lexicalization and articulation (Bock & Levelt, 1994; Dell, 1986; Kempen & Huijbers, 1983; Levelt, 1989, 1991; Levelt, Roelofs, & Meyer, 1999; Schriefers, Meyer, & Levelt, 1990).

In some models of lexical access, it is further assumed that lexicalization entails two steps: lemma retrieval and access to lexeme representations. Lemmas are conceived as units which encode the meanings and the syntactic properties of words (Levelt, 1989), whereas lexemes correspond to the phonological form and the individual segments that comprise words (Schriefers *et al.*, 1990). The lemma-lexeme distinction is supported by a number of different empirical findings including speech errors, RT data, and results from simulations (see Bock & Levelt, 1994; Bonin, 1997; Ferrand, 1994; Roelofs, 2000, for reviews).

One aim of spoken picture naming studies has been to establish a relation between the factors that contribute to naming speed and certain specific processing levels. Accordingly, word frequency effects have been assumed to operate at the level of phonological lexemes (Jescheniak & Levelt, 1994; Levelt *et al.*, 1999) or in the links between semantic and phonological representations (Barry *et al.*, 1997; Wheeldon & Monsell, 1992). Indeed, a clear account of the locus and the mechanisms that underlie frequency effects in spoken word production remains a matter of debate.

AoA effects have been localized at the level of phonological representations (Morrison *et al.*, 1992; Morrison & Ellis, 1995, 2000) or in the links between semantic and phonological representations (Hirsh & Funnell, 1995). A commonly held explanation is that early acquired words would have more unitary phonological representations than late acquired words, with the result that the former would be encoded faster than the latter (i.e. the completeness hypothesis, Brown & Watson, 1987). As for frequency effects, there is as yet no detailed account of these effects (but see Ellis & Lambon Ralph, 2000).

As far as name agreement is concerned, two potential sources have been pointed out (Vitkovitch & Tyrrell, 1995). When the depicted objects are difficult to interpret, e.g. ant → spider, an effect of name agreement could arise as the consequence of competing incorrect responses at, or around, the level of stored structural representations. In contrast, when the objects can be given alternative correct names, e.g. couch → sofa, the effect might be related to a competitive process involving correct responses and the locus would therefore be lexical.

The visual complexity of the objects would affect the object recognition level, and more precisely the access to stored structural representations (Humphreys *et al.*, 1988). Also, the visual complexity of the drawings themselves would influence the object recognition level involved in picture naming (Ellis & Morrison, 1998). Barry *et al.* (1997) have proposed that image agreement would have an impact at the level of stored structural representations: Objects whose pictures closely resemble the stored structural representation would be processed faster than objects whose pictures fit more poorly with the stored representations. Finally, conceptual familiarity would be rooted at the semantic/conceptual level. It would affect the ease with which representations of objects can activate their semantic representations, with familiar objects contacting their semantic representations earlier than less familar ones.

The above discussion was not intended to provide an in-depth review of all the accounts that have been put forward in the literature regarding the locus of the effects of the various variables that have been found to affect spoken picture naming speed. We simply wanted to make it clear that, as yet, we certainly have no straightforward picture of the relationships between the factors that contribute to spoken naming speed and the processing levels at which they are supposed to act.

Written picture naming

As far as written picture naming is concerned, no study has addressed the issue of the various factors that might contribute to written picture naming speed by using large sets of items and multiple regression analyses. It is worth remembering that very few studies have focused on written picture naming in normals (Bonin & Fayol, 2000; Bonin, Fayol, & Chalard, 2001; Bonin *et al.*, 1997; Bonin, Fayol, & Gombert, 1998; Bonin, Fayol, & Peereman, 1998).

In an earlier study, Bonin, Fayol, & Gombert (1998) showed that printed word frequency affected naming latencies. The word frequency effect was interpreted as being a genuine lexical effect since it was found neither in an object recognition task nor in a delayed production task (assuming that these two tasks index conceptual and post-lexical levels respectively). However, in this study, AoA was not controlled for, with the result that the frequency effect might turn out to be an AoA effect.

In a recent study (Bonin, Fayol, & Chalard, 2001), it was found that AoA had an effect on written latencies (and also on spoken latencies) when word frequency was controlled for, whereas frequency had no reliable effect on the latencies when AoA was controlled for. However, in Bonin *et al.*'s (2001) study, the absence of word frequency effects in these experiments may have been due to three potential reasons. First, a small set of items was used and it has been argued that word frequency effects are mostly observed when large sets of items are used (Ellis & Lambon Ralph, 2000; Ellis & Morrison, 1998; Morrison & Ellis, 2000; Snodgrass & Yuditsky, 1996). Secondly, the participants were trained with the names of the pictures before the naming experiments proper. We cannot therefore exclude the possibility that this pre-exposure might have acted as a repetition effect which could have wiped out frequency but not AoA effects. Thirdly, given that word frequency effects are significantly captured on late acquired words only (Barry *et al.*, 1997), a potential flaw in the experiments examining word frequency was that a word frequency effect might not have been observable because a substantial proportion of the words employed were acquired early in life (Barry *et al.*, 1997). Therefore, in the present study, these possible shortcomings were taken into account by using a large set of items and no pre-exposure to the names of the pictures before the naming experiment proper.

As presented above, in spoken production research, there exist explicit accounts on the locus of the factors that have been found to affect naming speed. In contrast, in written production in normals, such accounts are pending on additional empirical findings. It is thus crucial to determine the various factors that might contribute to written picture naming latencies if we are to build a more precise model of lexical access in writing.

The study of Bonin *et al.* (2001) had already highlighted the primacy of AoA effects over word frequency effects in both written and spoken picture naming in French. However, since that study focused only on the impact of AoA and word frequency on picture naming using a semi-factorial design, many factors that might have contributed to the picture naming speed were controlled for (e.g. name agreement, visual complexity, image agreement). Therefore, the relative contribution of these factors to the naming speed was not assessed.

The primary goal of the present study was therefore to extend the contribution of Bonin *et al.* (2001) by attempting to delineate the relevant factors (see below) that might affect both written and spoken picture naming latencies in the French language by means of multiple regression analyses. Moreover, as just mentioned, it also re-examined the potential impact of word frequency over AoA on picture naming speed by taking into account the potential shortcomings of the study of Bonin *et al.* (2001).

Evidence from neuropsychological studies suggests that conceptually driven writing would involve the following processing levels: semantic activation, orthographic retrieval, allographic and graphic motor encoding (see Bonin, 1997, for a review). For instance, in Caramazza's (1997) independent network model, naming starts with the activation of semantic features. These, in turn, send activation to the orthographic lexeme level. In certain views, it is further assumed that handwriting requires a specification of the type of letters to be produced, i.e. the allographic level (De Bastiani & Barry, 1989; Ellis, 1982; Patterson & Wing, 1989; Weekes, 1994). Finally, this latter level is thought to serve as input for the activation of the graphic motor patterns required for the execution of the strokes that form letters (Baxter & Warrington, 1986).

An important issue concerning conceptually driven writing is whether phonological codes obligatorily contribute to orthographic encoding, i.e. the obligatory phonological mediation hypothesis (Geschwind, 1969; Luria, 1970), or whether orthographic codes can be accessed directly on the basis of semantic codes, i.e. the orthographic autonomy hypothesis (Miceli, Benvegnu, Capasso, & Caramazza, 1997; Rapp & Caramazza, 1997; Rapp, Benzing, & Caramazza, 1997). Evidence from brain-damaged patients (Assal, Buttet, & Jolivet, 1981; Bub & Kertesz, 1982; Rapp & Caramazza, 1997; Shelton & Weinrich, 1997), and from normals (Bonin, Fayol, & Peereman, 1998) favours the latter hypothesis. However, it must be stressed that the orthographic autonomy hypothesis does not preclude the influence of phonological codes in orthographic encoding (for related evidence see Bonin, Peereman, & Fayol, 2001; Miceli, Capasso, & Caramazza, 1999).

As stressed by Barry *et al.* (1997), it is important in multivariate studies of picture naming to include all the essential variables that might be expected to have some effect on naming times. Therefore, the various factors that we considered worth examining included: AoA_{AF}, word frequency (Fr), name agreement (NA), image agreement (IA), image variability (Ivar), conceptual familiarity (Fam) and visual complexity (VC).

The scores for AoA, NA, IA, Ivar, Fam and VC were all taken from Alario and Ferrand (1999). Word frequency values (given per 100 million) were taken from Imbs (1971). We also included word length defined as the number of phonemes and letters respectively. Since Bonin *et al.* (2001) discussed, but did not test, a possible orthographic origin of AoA effects in their written picture naming experiment, some regression analyses included, in addition to the AoA ratings from Alario and Ferrand (1999), estimated AoA of words in their written form (AoA_W) and estimated AoA of words in their spoken form (AoA_S). These last two ratings were collected by the second author from two independent groups of participants. In these rating tasks, the instructions strongly encouraged the participants to estimate the age at which they acquired each word in either its spoken or in its written form, depending on the group. Words were visually presented in a booklet (two different orders were prepared for each rating task). We used the same 5-point scale as Alario and Ferrand (1999). Finally, given the reported interaction between word frequency and AoA (Barry *et al.*, 1997), and since the experiments reported in Bonin *et al.* (2001) did not assess this interaction due to their use of a semi-factorial design, some analyses considered the multiplicative term of $AoA_{AF} \times$ word frequency.

In the experiment, the participants were presented with pictures which they had to name using the first bare noun that came into their minds. The participants were randomly assigned to the two production modes, namely writing versus speaking.

Method

Participants

A total of 72 undergraduate students (64 females and 8 males; mean age: 20 years; range: 18–39 years) from Blaise Pascal University (Clermont-Ferrand) participated in the experiment in order to fulfil a course requirement and were given course credit. All were native speakers of French with normal or corrected-to-normal vision. Half of the participants were randomly assigned to the spoken picture naming task and the remaining half to the written picture naming task.

Material

The stimuli consisted of 237 pictures selected from the Snodgrass and Vanderwart (1980) database. The French picture names were taken from Alario and Ferrand (1999). In addition, 10 pictures taken from Cycowicz *et al.* (1997) were used in the training phase. As described in Snodgrass and Vanderwart (1980), the orientation of the figures was as follows: the animals were presented side-on, the objects whose up-down orientation may vary were drawn with the functional end down and, finally, long, thin objects were oriented at a 45° angle. The visual dimensions of the pictures presented on the computer screen were 9.5×5.5 cm.

Apparatus

The experiment was run using PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993) on a PowerMacintosh. The computer controlled the presentation of the pictures and recorded the latencies. A graphic tablet (WACOM UltraPad A5) and a contact pen (SP-401) were used to record the graphic latencies. An AIWA CM-T6 small tie-pin microphone connected to a Button-Box was used to record the spoken latencies. The recording accuracy for the latencies was to the nearest millisecond.

Procedure

The participants were tested individually and randomly assigned to either the written or spoken picture naming task.

Spoken picture naming

The participants sat in front of the screen at a distance of about 60 cm. They were instructed to say aloud the name of any given picture presented on the screen as quickly as possible, and to avoid saying 'um' or 'er' before a name. The participants were told to say aloud 'I don't know' whenever they did not know the name to use to refer to a given picture. However, when participants felt they knew its name, but were not able to retrieve it immediately, they had to say aloud 'tip of the tongue'. The experimenter monitored the participants' responses and scored them for correctness.

Each trial had the following structure: A ready signal (*) appeared on the screen for 500 ms and was immediately followed by the picture. The next trial began 5000 ms after the participants had initiated their response. This inter-trial delay was established on the basis of similar studies (Bonin & Fayol, 2000; Bonin *et al.*, 2001). A short break was given to the participants after about every 45 trials.

Written picture naming

The procedure was the same as for spoken picture naming except that the participants had to write down the name of each presented picture as quickly as possible. The written responses were timed as follows: the participants sat with the stylus right above the tablet so that the latency was the time taken to make contact after picture onset. In order to avoid any variability in the positioning of the stylus before each word was written, a line was drawn and the participant was obliged to position the stylus directly above the start of the line. More precisely, we prepared response sheets (size: 21×29.7 cm) to enable us to gather all the written responses relating to the different words. These response sheets consisted of three columns of 15 lines each, with the different lines drawn one above the other at a constant interval of 1 cm. All of the lines were 5 cm long. The experimenter systematically ensured that the instructions were adhered to and always corrected the participants if they failed to observe them. Also, they were instructed to write down either 'I don't know' or 'tip of the tongue' when the name was not immediately available.

For both speaking and writing, 10 pictures were used as warm-ups. The entire session lasted about one hour.

Results

Scoring of the data

Items that had an error rate greater than 50% in speaking or writing were removed from the corresponding RT data. For the remaining items (203 in speaking and 201 in writing), the elimination of trials was performed as follows. Trials for which a name other than the intended dominant one was produced were discarded: 7.31% and 6.96% in spoken and written picture naming, respectively. Trials involving 'I don't know' and 'tip of the tongue' responses were set apart: 'I don't know' responses accounted for 2.04% of the data in speaking and 0.95% in writing, while 'tip of the tongue' responses accounted for 1.31% in speaking and 0.90% in writing. Trials in which technical problems occurred (with the voice key or the graphic tablet) were also removed: 1.96% in the spoken naming task and 0.84% in the written naming task. Moreover, for this latter task, words that were mis-spelled (2.34%) or written with an upper case initial letter (0.19%) were discarded. On the basis of this set of criteria, 12.31% of the trials in speaking and 12.19% in written naming were removed from the analyses. Finally, latencies exceeding two standard deviations above the participant and item means were excluded: 1.81% and 1.56% of the data in spoken and written production respectively. Overall, 14.42% of the trials were discarded in speaking and 13.75% in writing.

Analyses

Naming latency data for individual items in the stimulus set can be found in the Appendix.

In all the analyses, frequency measures were transformed to log(freq + 1) as in Barry *et al.* (1997).

Tables 1 and 2 show the intercorrelations between the variables (independent and dependent) for the spoken (Table 1) and written (Table 2) picture naming tasks. In both tasks, the independent variable that had the highest correlation with naming latencies was AoA_{AF}, followed by AoA_S and, to a lesser extent, image variability and AoA_W. With the exception of visual complexity and the two measures of word length, i.e. numbers of letters and phonemes, the remaining independent variables also correlated significantly with naming latency.

The differences between the two tasks appeared to be very weak (compare Tables 1 and 2). As far as the independent variables are concerned, this is not surprising since most of the items were common to both tasks. More interesting was the great proximity of the correlations between these independent variables and naming latencies in the two tasks.

As might be expected, two clusters of independent variables appeared:

1. The three measures of AoA correlated very highly, and particularly so in the case of the AoA_{AF} and the AoA_S measures (the correlations with AoA_W were about 0.1 below this value).
2. The two measures of word length also correlated very highly.

Table 1. Significant correlations ($p < .01$) between the variables in the spoken picture naming task

	SL	AoA_S	AoA_W	AoA_{AF}	Fr	NA	IA	Fam	VC	Ivar	L	P
AoA_S	0.42											
AoA_W	0.35	0.79										
AoA_{AF}	0.49	0.90	0.78									
Fr	−0.27	−0.45	−0.52	−0.50								
NA	−0.28											
IA	−0.21				−0.18	0.18						
Fam	−0.29	−0.42	−0.37	−0.51	0.41							
VC				0.19				−0.49				
Ivar	−0.40	−0.52	−0.46	−0.59	0.50		−0.36	0.60	−0.24			
L		0.28	0.48	0.25	−0.39							
P		0.29	0.43	0.26	−0.42						0.81	

Key. SL = spoken latencies; AoA_S = estimated spoken age of acquisition; AoA_W = estimated written age of acquisition; AoA_{AF} = estimated AoA taken from Alario and Ferrand (1999); Fr = word frequency; NA = name agreement; IA = image agreement; Fam = conceptual familiarity; VC = visual complexity; Ivar = image variability; L = number of letters; P = number of phonemes.

Word frequency and image variability correlated significantly with most of the other independent variables and, in particular, with the three measures of AoA. Their intercorrelation was also important and significant. Finally, familiarity also correlated with most of the independent variables and more specifically with image variability.

Multiple regression 1: General analysis with AoA_{AF} as a measure of AoA

Simultaneous regression analyses were performed separately for the two tasks. In these

Table 2. Significant correlations ($p < .01$) between the variables in the written picture naming task

	WL	AoA_S	AoA_W	AoA_{AF}	Fr	NA	IA	Fam	VC	Ivar	L	P
AoA_S	0.43											
AoA_W	0.33	0.78										
AoA_{AF}	0.49	0.90	0.78									
Fr	−0.26	−0.46	−0.54	−0.51								
NA	−0.26			−0.18								
IA	−0.27					0.18						
Fam	−0.25	−0.39	−0.35	−0.49	0.41							
VC								−0.50				
Ivar	−0.35	−0.52	−0.46	−0.59	0.51		−0.35	0.60	−0.24			
L		0.24	0.46	0.21	−0.38							
P		0.29	0.43	0.26	−0.42						0.81	

Key. WL = written latencies; AoA_S = estimated spoken age of acquisition; AoA_W = estimated written age of acquisition; AoA_{AF} = estimated AoA taken from Alario and Ferrand (1999); Fr = word frequency; NA = name agreement; IA = image agreement; Fam = conceptual familiarity; VC = visual complexity; Ivar = image variability; L = number of letters; P = number of phonemes.

regression analyses, among the three AoA measures, only the AoA_{AF} variable was considered.[1]

The two overall equations were significant ($p < .001$) and explained very similar proportions of variance in the two tasks (40.2% versus 39.5% in spoken and written picture naming, respectively). The variables that had significant effects were the same in both tasks, namely: image agreement, AoA_{AF}, image variability and name agreement (see Table 3). This latter variable appeared, however, to have a lesser effect than the other three variables. The remaining independent variables, and in particular word frequency, yielded no significant effect (using both two-tailed and one-tailed tests).

It should also be noted that the absence of significant effects of the two length variables—numbers of letters and phonemes—could be partly explained by their high redundancy (the correlation between them is high and their multiple R with all independent variables (including the second length characteristic) vary between .816 and .83) which leads to conservative tests and very imprecise estimations concerning their weights in the equations. However, the changes in R^2 when adding these variables as a set (e.g. Cohen & Cohen, 1983, p. 120) when other independent variables were already present in the equation were not significant: their values were .006 and .008 for the spoken and written picture naming task respectively.

Multiple regression 2: Analysis with two specific measures of AoA (AoA_S and AoA_W)

Simultaneous regression analyses were performed separately for the two tasks using both AoA_S and AoA_W. Multiple R were significant ($p < .001$) and virtually identical. The variables that had significant effects were the same in both tasks: image agreement, AoA_S, image variability and name agreement. Neither word frequency nor AoA_W yielded any significant effects. Note that, as in the previous analyses, the set of the two word length variables did not account for significant increases in explained variance (the changes in R^2 when hierarchically adding this set were equal to .007 for both tasks).

The two estimations of AoA—AoA_S and AoA_W—have high correlations and important multiple R (between .814 and .847) with all the other independent variables (including the second type of AoA). In order to ensure a better understanding of respective roles of these independent variables and to base our comparison with the previous analysis on better estimation weights, we also report in Table 4 the results of the two regression analyses using AoA_S and AoA_W separately. The R^2 PRESS (R^2_{PRESS}, e.g. Myers, 1990, p. 191)[2] measure was used as a supplementary guide in selecting between the three regression models, i.e. using both AoA_S and AoA_W, only AoA_S, or only AoA_W.

[1] The choice of this variable was motivated by the fact that, given the high level of redundancy between the three AoA measures, the effect estimations corresponding to these variables would be very imprecise and the tests of them very conservative if the three measures were entered in the regressions. Moreover, AoA_{AF} appears to be a measure which integrates both spoken and written dimensions (see multiple regression 2). It would therefore be very difficult to gain a clear picture of the role of these two dimensions if the three measures of AoA were entered in the analyses. However, when the three AoA measures are taken into account in the analyses, only AoA_{AF} has a significant impact on the latencies in both tasks. If we force AoA_W or AoA_S (or both) to enter in the regression model and then consider AoA_{AF} to enter in the regressions using a hierarchical procedure (simultaneous or stepwise), this latter variable turns out to be non-significant, a result which shows that the level of redundancy is so high that a choice between the three AoA measures is necessary if we are to gain a clearer view.

[2] This approach consists in computing, for each item, a prediction and a residual from the equation derived on the (N – 1) remaining items. The PRESS statistic is the sum of these squared residuals and the R^2_{PRESS} is given by: $R^2_{PRESS} = 1 - (PRESS)/TSS$ where TSS is the total sum of squares. It has the advantage over the classical R^2 that it is built on true prediction errors, since each item is not used for fit and model assessment.

As can be seen from Tables 3 and 4, whatever the task, the equation including only AoA_S explained a part of variance that was nearly equal to that explained by the equation including AoA_{AF} alone. Moreover (see Table 4), the global explanations were very close for both tasks. In contrast, the use of AoA_W alone led to an equation with weaker explanatory power than that using AoA_S alone. Compared with the model that included both AoA_W and AoA_S, the introduction of the AoA_W variable when the AoA_S variable was already in the equation yielded a very poor and non-significant improvement in overall prediction. The R^2 PRESS (R^2_{PRESS}) criterion also revealed that this latter equation had a poorer external prediction power than the one that used only AoA_S.

Finally, it is important to note that, whatever the equation, the same independent variables yielded significant effects, namely: image agreement, image variability, AoA (spoken or written) and name agreement. In addition, the number of letters also yielded a significant effect for the written picture naming task using only AoA_W (this model appeared, however, to possess the least explanatory power). Also, no significant effect of word frequency was observed.

Multiple regression 3: Does AoA interact with word frequency?

To examine whether AoA and word frequency interacted (Barry *et al.*, 1997), the multiplicative term formed by AoA_{AF} and word frequency [log(freq + 1)] was included in the regression. The choice of AoA_{AF} measures was motivated by the fact that these represent more classical and standardized measures of AoA and also, to a lesser extent, by the fact that the explanatory power of this variable was found to be greater than that of the AoA_S variable. In order to permit an interpretation of the coefficients in their standardized form (Aiken & West, 1991), these independent variables were standardized before calculation of the multiplicative term.

The results of the simultaneous regression analysis are presented in Table 5. The improvement in explanatory power resulting from the inclusion of the multiplicative

Table 3. Summary of multiple regression analyses in spoken and written picture naming

Multiple *R*	Spoken picture naming 0.634				Written picture naming 0.629			
	β	SE	*t*	*p*	β	SE	*t*	*p*
AoA_{AF}	.327	.076	4.30	.001	.341	.077	4.42	.001
Fr	−.040	.073	−0.55	.58	−.006	.075	−0.08	.94
NA	−.174	.058	−3.01	.001	−.118	.059	−1.99	.05
IA	−.326	.062	−5.23	.001	−.374	.063	−5.98	.001
Fam	.040	.082	0.49	.63	.075	.082	0.92	.36
VC	−.007	.065	−0.10	.92	.033	.066	0.50	.62
Ivar	−.323	.084	−3.83	.001	−.294	.086	−3.43	.001
L	−.112	.098	−1.14	.27	−.142	.097	−1.46	.15
P	.045	.100	0.45	.67	.151	.101	1.50	.14

Key. AoA_{AF} = estimated AoA taken from Alario and Ferrand (1999); Fr = word frequency; NA = name agreement; IA = image agreement; Fam = conceptual familiarity; VC = visual complexity; Ivar = image variability; L = number of letters; P = number of phonemes.

Table 4. Values of multiple *R*, R^2_{PRESS}, and beta weights for the significant independent variables in the two tasks as a function of the regression model (presence of the two age of acquisition measures versus only one of them) and the picture naming task (spoken versus written)

Models	AoA_S and AoA_W		AoA_S		AoA_W	
Tasks	Spoken	Written	Spoken	Written	Spoken	Written
Multiple *R*	.629	.628	.628	.627	.611	.593
R^2_{PRESS}	.317	.316	.325	.321	.297	.272
			Significant beta weights			
AoA_S	.260**	.360**	.282**	.307**		
AoA_W					.229**	.180*
Fr						
NA	−.188**	−.140*	−.190**	−.134*	−.178**	−.134*
IA	−.349**	−.397**	−.349**	−.398**	−.358**	−.407**
Fam						
VC						
Ivar	−.355**	−.323**	−.356**	−.320**	−.395**	−.384**
L						−.204**
P						

*$p<.05$; **$p<.01$.
Key. AoA_S = estimated spoken age of acquisition; AoA_W = estimated written age of acquisition; Fr = word frequency; NA = name agreement; IA = image agreement; Fam = conceptual familiarity; VC = visual complexity; Ivar = image variability; L = number of letters; P = number of phonemes.

Table 5. Summary of multiple regression analyses using Alario and Ferrand's (1999) AoA measures and the multiplicative term between word frequency and AoA in spoken and written picture naming

Multiple *R*	Spoken picture naming .638				Written picture naming .635			
	β	SE	*t*	*p*	*β*	SE	*t*	*p*
AoA_{AF}	.308	.077	3.98	.001	.314	.078	4.01	.001
Fr	−.069	.077	−0.90	.367	−.041	.078	−0.52	.602
$AoA_{AF} \times$ Fr	−.071	.055	−1.28	.203	−.089	.056	−1.61	.110
NA	−.178	.058	−3.07	.002	−.114	.059	−1.92	.056
IA	−.335	.063	−5.35	.001	−.385	.063	−6.14	.001
Fam	.036	.082	0.45	.657	.071	.081	0.87	.386
VC	−.011	.065	−0.17	.865	.034	.066	0.52	.607
Ivar	−.325	.084	−3.86	.001	−.296	.085	−3.48	.001
L	−.113	.098	−1.16	.248	−.130	.097	−1.33	.184
P	.040	.100	0.40	.691	.135	.101	1.35	.180

Key. AoA_{AF} = estimated AoA taken from Alario and Ferrand (1999); Fr = word frequency; NA = name agreement; IA = image agreement; Fam = conceptual familiarity; VC = visual complexity; Ivar = image variability; L = number of letters; P = number of phonemes.

term was very slight. More importantly, the multiplicative term was not significant. The independent variables that yielded significant effects were nearly the same as those in the equation that did not include this term. The only departure from this was that name agreement in the written picture naming task was only marginally significant on a two-tailed test ($p = .056$). None of the remaining independent variables reached significance (with either one-tailed or two-tailed tests).

Discussion

This study was undertaken in order to explore the various factors that might contribute to naming onset latencies in both written and spoken picture naming. The findings obtained through the use of various multiple regression analyses revealed that out of a set of nine factors, image variability, image agreement, age of acquisition and name agreement significantly influenced both written and spoken naming latencies. The similarity in terms of the percentage of variance explained by these factors in the two production modes is striking. From a methodological point of view, the present data indicate the variables that will have to be taken into account when conducting research into either the writing or speaking of isolated words from pictures. In addition, our study has provided RT data (see Appendix) that we think will be useful for future studies of picture naming.

Age of acquisition

Among the major determinants of naming onset latencies in both speaking and writing was the age at which words are first learned. As far as spoken picture naming is concerned, this latter finding replicates in French a number of other findings reported in the literature (e.g. Barry *et al.*, 1997; Carroll & White, 1973a, b; Morrison *et al.*, 1992; Snodgrass & Yuditsky, 1996). Regarding written picture naming, the observation that AoA was an important determinant of naming latencies builds on earlier observations reported by Bonin *et al.* (2001) that rated AoA had a significant impact on written onset latencies when word frequency was controlled for.

Bonin *et al.* (2001) have discussed the compatibility of this finding with the two hypotheses concerning access to written form representations (obligatory phonological mediation hypothesis; orthographic autonomy hypothesis). Both hypotheses claim that phonological codes contribute to the determination of orthographic codes. The obligatory phonological mediation hypothesis states that phonological codes are obligatorily accessed in order to derive orthographic codes. In contrast, the orthographic autonomy hypothesis claims that orthographic codes can be retrieved directly from semantics, with phonology playing a constraining role in orthographic encoding (Bonin, Peereman, & Fayol, 2001).

Since most accounts of AoA effects have localized them at the phonological level (Morrison & Ellis, 1995; Morrison *et al.* 1992), Bonin *et al.* (2001) have acknowledged the possibility that AoA effects in written picture naming may be phonologically based. However, Bonin *et al.* (2001) have also pointed out that AoA effects might be localized at a different level from that of phonological lexemes (for a similar claim in naming Japanese Kanji, see Yamazaki *et al.*, 1997). Therefore, Bonin *et al.* (2001) speculate that AoA effects might be orthographically based in written picture naming. Accordingly, they suggest that, if this latter account is accepted, estimated written AoA scores might be better predictors of written picture naming onset latencies (and conversely that estimated spoken AoA scores might be better predictors of spoken naming onset latencies).

The present findings indicate, however, that the best predictor of both spoken and written picture naming latencies were the AoA scores provided by Alario and Ferrand (1999). It should be recalled that these ratings are based on estimations of the age at which words are learned in either their spoken or written form. Moreover, the multiple regression analyses that used only the estimated AoA of words in their written form (AoA_W) showed that the AoA_W measures rested essentially on the spoken ones and that the independent part of them from the estimated spoken AoA scores was not predictive of naming latencies in either of the picture naming tasks. Such a finding could, therefore, be interpreted as casting doubt on the hypothesis of a genuine orthographic origin of AoA effects in written picture naming. It would thus incline us to favour a phonological source of AoA effects in writing. Nevertheless, the hypothesis that AoA effects might be orthographic in nature should not be discarded too swiftly. One may very well imagine that the written estimations of AoA do not adequately reflect the age at which words are acquired in their written form. The reason might be that when judging most words, participants are not able to distinguish specifically between the age at which they acquire words in their spoken form from the age at which they acquire the same words in their written form. It is indeed possible that, although the instructions strongly encouraged the participants to evaluate the age at which words were acquired in their *written form*, these estimations were somehow contaminated by the age of acquisition of the words in their spoken form. Some credence can be given to such an account, for instance on the basis of the observation of the raw correlations between the three AoA measures (AoA_{AF}, AoA_S, AoA_W). In effect, the correlation between AoA_{AF} and AoA_S was stronger than the correlation between AoA_{AF} and AoA_W. Given that in Alario and Ferrand (1999), the participants were told to evaluate the age of acquisition of words in either their spoken or written form, this latter result suggests that the participants indeed based most of their estimations on the spoken form of the words. However, we think that the use of *objective* spoken and written AoA measures respectively (not available for French so far), would probably help us to achieve a better understanding of this issue. Nevertheless, even if a phonological origin for AoA effects is accepted for both speaking and writing, our findings do not enable us to determine whether the locus of AoA effects is rooted at the level of the phonological representations themselves or in the links between semantic and phonological codes.

Some proposals have been made to explain AoA effects in terms of the quality of phonological representations (Brown & Watson, 1987). Thus, early acquired words may be stored in unitary form whereas the phonological representations of late acquired words may be more fragmentary in nature. However, further in-depth research is necessary if we are to achieve a clear understanding of the precise mechanisms that are responsible for the emergence of AoA effects in both speaking and writing (but see Ellis & Lambon Ralph, 2001).

Objective word frequency

Given the central role of word frequency in most theoretical accounts of word retrieval, a noticeable finding was that this variable did not emerge as a significant determinant of naming latencies in either speaking or writing.

It should be remembered that in Bonin *et al.* (2001), objective word frequency had no significant impact on either spoken or written picture naming onset latencies when

AoA was controlled for. We mentioned (see 'Written picture naming' above) that the lack of significant word frequency effects in Bonin *et al.*'s (2001) study could potentially be attributed to either (1) the use of a small set of items; (2) the pre-exposure of the names and the pictures before the naming experiments; or (3) the matching performed on early acquired words in the experiments examining word frequency. The present findings show that none of the reasons is likely to be correct. In effect, the present study clearly indicated that word frequency was neither shown to be a reliable predictor of naming latencies, nor did it interact significantly with AoA even though a large set of items was used without any pre-exposure to the names of the pictures before the naming experiment proper.

At first sight, these findings cast some serious doubts on the reliability of word frequency effects in both language production modes. However, in view of the fact that some studies have found a significant contribution of word frequency to naming speed (Lachman, 1973; Lachman *et al.*, 1974; Snodgrass & Yuditsky, 1996), the impact of this variable in picture naming cannot be dismissed. Nevertheless, it must be stressed that, so far, very few picture naming studies have found significant frequency effects when AoA is also taken into account. It is worth noting here that Lachman's (1973, 1974) studies, which are often cited as evidence for an influence of both word frequency and AoA effects in picture naming, used subjective ratings of word frequency and not objective word frequency measures.

At the very least, the present findings strongly suggest that true word frequency effects in picture naming studies are not easily detected when AoA is taken into account. Nevertheless, we acknowledge that a potential problem might be related to the objective word frequency measures available for French. As stressed by Ellis and Lambon Ralph (2000), more recent studies that have involved more items and *better* measures of word frequency have usually found effects of both word frequency and AoA (e.g. Barry *et al.*, 1997; Ellis & Morrison, 1998). Therefore, we cannot exclude the possibility that, to some extent, the measures of printed word frequency available for French (Imbs, 1971) do not adequately reflect the actual use of the French language. Thus, it remains to be seen whether more up-to-date word frequency measures for French would allow true word frequency effects to emerge on both spoken and written picture naming performance. Unfortunately, we are not aware of any more recent objective word frequency counts available for French.

Image variability and image agreement

As far as image variability is concerned, as we noted, this variable had not been taken into account in any of the previous studies into the determinants of spoken picture naming speed. However, this variable was found to be a major determinant of both written and spoken latencies. More precisely, we observed that pictures that evoke many different mental images are initiated faster than pictures that evoke few mental images. At first sight, this finding is a little surprising. In effect, one might have hypothesized that pictured objects that evoke many different images for a participant, e.g. a bird, would be less likely to match any one of his or her mental images and would therefore result in a more extended matching process than pictured objects that evoke few images. To account for the observation that image variability had a significant negative correlation with naming latencies, a tentative explanation would be that pictured objects having high image variability scores possibly possess richer structural/semantic representations than those having low image variability scores. Evidence would accumulate more rapidly for the former than the latter.

Image agreement was also a major determinant of both spoken and written naming latencies. Remember that to date only very few studies of spoken picture naming have included this factor as a predictor variable. It has been suggested that the locus of this variable lies at the level of stored structural representations (Barry *et al.*, 1997). The objects whose pictures closely resemble the stored structural representations would then be processed faster than those whose pictures fit more poorly with the stored structural representations.

Image agreement and image variability have thus been attributed to a preverbal level, i.e. the structural and semantic levels. The observation that both variables have an impact on the naming latencies in both speaking and writing can easily be accounted for since these processing levels have been assumed to be common to both production modes (e.g. Caramazza, Berndt, & Brownell, 1982).

Name agreement

Name agreement had a significant effect on the latencies in both production modes, but less so than the AoA, image agreement and image variability factors. As far as spoken picture naming is concerned, this finding is in line with other studies that have shown that this variable plays an important role (Barry *et al.*, 1997; Ellis & Morrison, 1998; Gilhooly & Gilhooly, 1979; Lachman, 1973; Lachman *et al.*, 1974; Paivio, Clark, Digdon, & Bons, 1989; Snodgrass & Yuditsky, 1996; Vitkovitch & Tyrrell, 1995).

In spoken picture naming studies, the impact of name agreement on the time taken to initialize the names of pictures has been ascribed either to difficulties in accessing stored structural representations when objects are difficult to identify, or to selection difficulties, occurring after semantic access, due to different potential correct names that can be assigned to a given object.

How can we account for the finding that this variable had an impact on both written and spoken picture naming performance? When the source of name agreement is related to difficulties in contacting stored structural representations then, since these representations are thought to be common to both speaking and writing, the impact of this factor on naming latencies is obviously observed in both production modes. In contrast, when objects are identified without any great difficulty but can be assigned alternative correct names, certain difficulties arise in selecting a unique name because different representations are activated and compete for output. Since both writing and speaking must incorporate a selection mechanism at the lexical level, the impact of name agreement, in this specific case, also shows up in both forms of language production.

In terms of the orthographic autonomy hypothesis, the nature of the representations that are activated and that truly compete for selection might be different in writing and in speaking. In effect, this latter hypothesis assumes that orthographic and phonological codes are activated in parallel on the basis of semantics. Even though some links are postulated between orthographic and phonological codes, orthographic codes can be directly activated from semantic codes; that is to say that phonological codes are not a prerequisite for orthographic encoding. Therefore, given that a specific written form must be selected for output in writing, this selection process might take place at the level of orthographic representations. For instance, in Caramazza's (1997) model, it is assumed that several orthographic representations in the orthographic network are activated from semantics and are in competition. In contrast, however, if it is assumed that written picture naming is obligatorily phonologically mediated, then the competition process would take place at the phonological level. Therefore, among the phonological representations that are activated from semantics, only the selected phonological representation would be further orthographically encoded.

Although the findings strongly suggest that speaking and writing share certain processing levels, we should not be too hasty in concluding that writing is *entirely* dependent upon speech representations and processes, as has been claimed in the past (Geschwind, 1969; Luria, 1970). Indeed, it is worth stressing that a growing body of evidence coming from analyses of brain-damaged patients (e.g. Rapp *et al.*, 1997) and from normals (Bonin, Fayol, & Peereman 1998; Bonin, Pacton, & Fayol, 2001) strongly suggests that writing is relatively 'autonomous' from speech.

To conclude, the present study has made it possible to identify certain major determinants of both written and spoken picture naming onset latencies. We have discussed how these variables could influence a variety of processing levels in the written and spoken picture naming process. The finding that the factors that significantly influenced the naming latencies were indeed common to both production modes provides clear empirical support for the view that writing and speaking involve some similar processes and representations (Bonin & Fayol, 2000). As Ellis (1988, p. 191) wrote 'An important task for cognitive psychologists is to elucidate which processes are common to both modalities and which are modality specific'. We think that our study has helped take us one step further towards this aim.

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Appendix

Mean spoken latencies (SL in ms) and standard deviations of these means (SD_S); mean written latencies (WL in ms) and standard deviations of these means (SD_W); number of observations (Nb Obs) used in the calculation of the means and standard deviations for the stimuli used in the experiment. An asterisk is used to indicate values corresponding to items that were not included in the spoken or written latency analyses.

Stimuli	English translation	Nb Obs	SL	SD_S	Nb Obs	WL	SD_W
Abeille	Bee	29	1144	346	26	1474	442
Accordéon	Accordion	33	915	173	30	1209	209
Aigle	Eagle	23	1252	276	30	1467	381
Aiguille	Needle	28	1074	390	29	1397	394
Ampoule	Light bulb	33	811	135	33	1136	199
Ananas	Pineapple	36	900	175	34	1068	165
Ancre	Anchor	26	1141	277	23	1444	446
Âne	Donkey	33	1055	267	32	1286	249
Araignée	Spider	33	1107	317	33	1326	347
Arbre	Tree	34	850	187	34	1108	199
Arrosoir	Watering can	34	965	333	20	1283	361
Artichaut	Artichoke	26	1204	405	17*	1788*	541*
Asperge	Asparagus	21	1627	494	28	1883	559
Autruche	Ostrich	27	1349	282	36	1800	420
Avion	Aeroplane	36	836	237	35	1155	287
Bague	Ring	30	1074	189	31	1451	498
Balai	Broom	36	936	287	28	1150	199
Balançoire	Swing	26	1292	295	34	1826	501
Ballon	Balloon	36	878	203	35	1300	443
Banane	Banana	35	754	122	36	1082	240
Boîte	Box	30	1102	356	31	1414	438
Botte	Boot	31	1023	287	30	1297	334
Bougie	Candle	35	896	251	34	1124	324
Bouteille	Bottle	34	974	301	35	1158	231
Bouton	Button	32	1026	229	36	1237	345
Bras	Arm	34	1134	393	32	1477	398
Brosse	Brush	34	1101	343	28	1447	433
Bureau	Desk	33	1163	306	33	1351	334

Stimuli	English translation	Nb Obs	SL	SD_S	Nb Obs	WL	SD_W
Bus	Bus	20	1076	263	10*	1295*	521*
Cacahuète	Peanut	32	1104	274	29	1375	288
Cadenas	Padlock	25	1283	297	21	1927	818
Camion	Truck	34	925	225	36	1245	354
Canapé	Couch	27	1040	213	28	1366	453
Canard	Duck	33	1077	268	31	1262	245
Canon	Cannon	26	1134	257	34	1657	462
Carotte	Carrot	35	817	137	36	1054	284
Casquette	Cap	32	1074	292	32	1266	472
Casserole	Pot	34	1065	293	34	1332	361
Ceinture	Belt	34	914	263	34	1167	191
Cendrier	Ashtray	31	1110	224	29	1722	591
Cerf	Deer	28	1317	425	34	1577	495
Cerise	Cherry	32	932	156	36	1169	225
Chaîne	Chain	34	1069	286	36	1427	340
Chaise	Chair	34	863	198	35	1060	277
Chameau	Camel	19	1251	414	21	1659	743
Champignon	Mushroom	36	858	111	34	1107	224
Chapeau	Hat	35	826	214	35	1051	204
Chat	Cat	33	855	103	36	1084	196
Chaussette	Sock	34	873	178	34	1061	202
Chaussure	Shoe	36	822	148	36	1100	232
Chemise	Shirt	34	1164	308	35	1376	393
Chenille	Caterpillar	27	1071	303	31	1400	329
Cheval	Horse	36	907	188	36	1167	288
Cheveux	Hair	30	1335	328	31	1699	348
Chèvre	Goat	25	1383	464	31	1420	281
Chien	Dog	35	896	128	36	1111	266
Cigare	Cigar	29	1273	241	30	1795	641
Cigarette	Cigarette	33	1163	298	35	1236	210
Cintre	Hanger	31	924	182	27	1152	219
Ciseau	Scissors	35	870	195	34	1007	180
Citron	Lemon	31	1048	303	36	1142	251
Citrouille	Pumpkin	29	1275	337	28	1461	473
Clé	Key	35	851	139	36	1077	181
Cloche	Bell	35	834	130	36	1175	287
Clou	Nail	19	1057	301	24	1288	278
Clown	Clown	36	898	106	35	1171	188
Cochon	Pig	34	987	235	32	1256	329
Coeur	Heart	35	802	106	36	1045	233
Collier	Necklace	34	936	166	32	1357	492
Commode	Dresser	23	1245	410	21	1739	501
Coq	Rooster	24	1036	231	32	1280	350
Couronne	Crown	36	1087	208	33	1356	307
Couteau	Knife	33	1019	331	36	1256	338
Cravate	Tie	36	995	201	32	1263	193
Crayon	Pencil	26	923	216	22	1264	230
Crocodile	Alligator	33	1077	379	36	1309	466
Cuillère	Spoon	35	885	210	29	1133	190
Cygne	Swan	33	1148	306	17*	1564*	591*

Stimuli	English translation	Nb Obs	SL	SD_S	Nb Obs	WL	SD_W
Doigt	Finger	30	860	182	29	1192	435
Drapeau	Flag	35	846	152	36	1226	223
Échelle	Ladder	35	858	199	35	1110	276
Écrou	Nut	16*	1535*	517*	19	1774	498
Écureuil	Squirrel	32	985	262	23	1345	362
Église	Church	33	1002	189	34	1352	498
Éléphant	Elephant	34	775	169	34	1124	321
Enveloppe	Envelope	28	892	248	30	1123	225
Escargot	Snail	35	844	199	34	1070	162
Étoile	Star	36	736	101	35	1041	226
Fenêtre	Window	22	1371	271	27	2023	791
Feu	Traffic light	24	1138	253	17*	1499*	408*
Feuille	Leaf	35	1029	290	31	1179	315
Flèche	Arrow	35	1018	259	35	1250	317
Fleur	Flower	34	882	140	35	1125	302
Fourchette	Fork	34	854	216	34	1082	247
Fourmi	Ant	31	1321	447	33	1618	364
Fraise	Strawberry	32	971	238	36	1128	242
Gant	Glove	32	997	259	35	1509	580
Gâteau	Cake	33	1067	320	35	1397	364
Girafe	Giraffe	36	890	204	30	1143	234
Gorille	Gorilla	21	1217	332	26	1389	333
Grenouille	Frog	31	923	303	30	1224	376
Guitare	Guitar	36	866	215	33	1051	316
Hache	Axe	28	1080	295	31	1503	522
Harpe	Harp	24	1152	380	25	1501	479
Hélicoptère	Helicopter	35	846	188	33	1175	310
Hibou	Owl	32	985	209	28	1217	224
Hippocampe	Sea horse	27	1282	407	10*	1829*	692*
Horloge	Clock	20	1169	355	21	1325	377
Interrupteur	Light switch	30	1307	351	26	1619	413
Jambe	Leg	27	1184	257	32	1517	545
Jupe	Skirt	29	1104	261	30	1284	323
Kangourou	Kangaroo	34	950	221	35	1345	456
Lampe	Lamp	32	872	228	34	1141	294
Landau	Baby carriage	17*	1144*	414*	25	1192	255
Lapin	Rabbit	36	737	101	36	1000	234
Lion	Lion	36	936	165	36	1202	324
Lit	Bed	36	794	152	36	1092	280
Livre	Book	36	830	156	36	1092	280
Luge	Sled	33	1138	245	34	1443	508
Lune	Moon	34	1043	392	36	1225	402
Lunettes	Glasses	36	755	115	34	994	196
Main	Hand	35	884	319	34	1058	230
Maïs	Corn	28	1109	283	28	1349	478
Maison	House	35	840	176	35	1301	329
Manteau	Coat	21	1018	205	20	1647	556
Marteau	Hammer	33	1018	317	29	1671	501
Montagne	Mountain	30	1222	360	32	1401	389
Montre	Watch	36	761	111	35	1151	244

Stimuli	English translation	Nb Obs	SL	SD_S	Nb Obs	WL	SD_W
Moto	Motorcycle	35	898	219	33	1211	639
Mouche	Fly	22	1316	318	31	1711	639
Moulin	Windmill	35	951	207	28	1289	376
Mouton	Sheep	28	1237	361	29	1771	694
Nez	Nose	35	830	173	33	1115	209
Noeud	Bow	29	958	282	31	1147	183
Nuage	Cloud	29	1114	281	31	1687	475
Œil	Eye	33	898	235	31	1220	370
Oignon	Onion	30	1153	279	30	1415	236
Oiseau	Bird	25	1124	380	32	1228	268
Orange	Orange	26	1289	413	33	1576	450
Oreille	Ear	35	802	116	36	1117	218
Ours	Bear	34	1053	258	35	1263	342
Panier	Basket	35	842	169	35	1137	234
Pantalon	Trousers	36	875	252	35	1114	243
Paon	Peacock	26	1250	388	32	1401	267
Papillon	Butterfly	36	806	141	35	1106	395
Parapluie	Umbrella	34	757	135	34	1069	261
Pastèque	Watermelon	20	1352	623	26	1737	563
Peigne	Comb	36	899	244	36	1108	190
Phoque	Seal	24	1272	332	25	1326	287
Piano	Piano	35	970	228	30	1137	235
Pied	Foot	35	863	206	36	1061	203
Pince	Pliers	24	1202	376	24	1661	634
Pinceau	Paintbrush	28	1006	245	35	1315	396
Pingouin	Penguin	30	1121	344	32	1426	371
Pipe	Pipe	35	865	153	33	1060	165
Poêle	Frying pan	29	1140	328	24	1377	377
Poignée	Doorknob	26	1501	477	19	1899	517
Poire	Pear	34	871	152	36	1026	274
Poisson	Fish	34	794	141	34	1042	268
Poivron	Pepper	17*	1687*	584*	28	1999	768
Pomme	Apple	35	992	287	36	1210	275
Porte	Door	32	987	321	34	1348	432
Poubelle	Dustbin	36	832	164	35	1121	193
Pouce	Thumb	25	1154	289	29	1412	281
Poule	Chicken	28	1044	218	35	1212	273
Poupée	Doll	19	1101	309	22	1473	733
Prise	Plug	26	1412	539	24	1911	973
Puits	Well	36	1085	252	6*	1232*	335*
Raisin	Grapes	26	1038	216	29	1380	405
Règle	Ruler	33	950	222	33	1250	232
Renard	Fox	30	1092	263	31	1470	498
Rhinocéros	Rhinoceros	32	1047	283	21	1324	317
Robe	Dress	33	1044	233	35	1482	481
Roue	Wheel	35	881	212	33	1221	341
Salière	Salt shaker	16*	1439*	409*	19	1779	554
Sandwich	Sandwich	32	1236	302	34	1576	423
Sauterelle	Grasshopper	14*	1914*	931*	21	1836	634
Scie	Saw	29	1081	154	31	1343	574

Stimuli	English translation	Nb Obs	SL	SD_S	Nb Obs	WL	SD_W
Serpent	Snake	35	878	213	35	1143	209
Sifflet	Whistle	34	1041	193	28	1190	315
Singe	Monkey	33	1108	180	34	1266	271
Soleil	Sun	34	838	178	36	992	160
Souris	Mouse	28	937	168	32	1119	189
Stylo	Pen	30	1104	173	32	1222	218
Table	Table	36	830	178	35	1079	326
Tabouret	Stool	32	964	243	35	1278	339
Tambour	Drum	31	1139	296	33	1354	311
Tasse	Cup	34	993	233	30	1157	253
Téléphone	Telephone	36	774	117	36	1033	199
Télévision	Television	26	881	152	31	1248	237
Tigre	Tiger	29	1310	369	33	1590	541
Tomate	Tomato	31	1136	302	32	1501	751
Tonneau	Barrel	27	965	233	28	1235	309
Tortue	Turtle	35	888	245	35	1078	274
Toupie	Top	30	1246	410	34	1461	340
Tournevis	Screwdriver	33	1080	285	32	1561	407
Train	Train	34	1084	292	33	1542	485
Trompette	Trumpet	34	1055	312	34	1381	432
Vache	Cow	33	1007	244	32	1350	233
Valise	Suitcase	31	967	319	31	1343	472
Vase	Vase	34	901	159	35	1225	217
Vélo	Bicycle	30	810	213	34	1209	445
Verre	Glass	34	846	234	35	1053	149
Veste	Jacket	30	1165	412	17*	1614*	421*
Violon	Violin	28	1180	225	29	1533	434
Vis	Screw	21	1194	290	26	1695	653
Voiture	Car	35	812	227	36	1089	232
Zèbre	Zebra	35	977	244	35	1232	287