PICTURE NAMING AND LEXICAL ACCESS IN ITALIAN CHILDREN AND ADULTS

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Abstract

Normative data are described and compared for 34 Italian-speaking children (5-6 years of age) and 50 Italian-speaking adults in a timed picture-naming task, with 250 pictures (simple line drawings). Dependent measures include overall nameability, percent agreement on the most frequent name (target), number of alternative names provided, overall reaction time and latency to produce the target name. Independent measures (characteristics of target words and pictures that might affect naming) include frequency (from both adult and child norms), age of acquisition (an objective measure from early lexical development norms, and a subjective measure based on adult ratings), length (in syllables and characters), animacy, semantic category, various word structure and grammatical category measures specific to Italian, and an objective measure of picture complexity. Although children were substantially slower and less accurate than adults, child and adult performance was highly correlated, and similar correlations were obtained for children and adults between lexical predictors and naming times. However, word complexity had effects on adults that were not seen in children, and grammatical gender had effects on children that were not seen in adults. Adult ratings of age of acquisition had strong effects on both children and adults (and reduced or eliminated effects of frequency in regression analyses), but an objective measure of age of acquisition only affected children (and did not eliminate frequency effects in regression analyses). Differences were also observed in the semantic categories that were easiest for children vs. adults.

Naming is a fundamental aspect of human language use (Brown, 1958; Terrace, 1985), and it is one of the first linguistic functions mastered by small children (Bates, Camaioni, & Volterra, 1975). There is a long tradition of research aimed at understanding how people retrieve and produce names for things (Cattell, 1886), and how children achieve this competence (DeLaguna, 1927; Dromi, 1987; Greenfield & Smith, 1976; Leonard, 1998). In research with adults, timed picture-naming tasks are often used to investigate the naming process (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999), including comparisons between picture naming and word reading (Paivio, Clark, Digdon, & Bons, 1989; Potter, Kroll, Yachzel, Carpenter, & Sherman, 1986), effects of sentential and grammatical structure on word retrieval (Bentrovato, Devescovi, D’Amico, & Bates, 1999; Jacobsen, 1999; Wicha, Bates, Hernandez, Reyes, & Gavaldón de Barreto, 1997), and the effects of congruent or incongruent word distracters on picture-naming times (Glaser, 1992).

Both pictures and words are thought of as symbols, standing for referents that may not be physically present when the symbols are used. Because pictures bear a transparent iconic relationship to their referents, it is generally assumed that they should be readily interpretable by children. “Recognizing pictures does not require particular steps of learning or development beyond learning to know the represented objects… [whereas] the relation between a noun and the corresponding class of objects is determined during the centuries of evolution of a language” (Glaser, 1992). In fact, pictorial stimuli have been used with considerable success in studies of word production and comprehension in young children (e.g. Bates, Bretherton, & Snyder, 1988). Indeed, looking at picture books is a normal activity in young children's daily life, even in early infancy. Many authors report that children from the first year of their life are interested in this activity, and start to name two-dimensional representations of well-known objects as early as 12 months of age, at the same time that they begin to name those objects in real life (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Ninio & Bruner, 1988).

Presumably, the naming process in young children involves many (perhaps all) of the basic processes that have been studied with adults using timed picture-naming tasks, but for a variety of reasons (most of them practical), reaction times studies of picture naming in children are relatively rare (Berman, Friedman, Hamberger, & Snodgrass, 1989; Cycowicz, Friedman, & Rothstein, 1997; Johnson, 1992; Roe et al., in press). The underlying cognitive process of naming a picture has been articulated by Johnson, Paivio, and Clark (1996) in three broad stages. The first step includes the identification of the object as a member of a particular class of objects; the second consists in name activation of the object from among thousands of words known by users; and finally, in the last step, articulatory commands for a specific response must be prepared and executed. These sophisticated operations must occur rapidly and efficiently in fluent speech (Johnson et al., 1996).

One approach to the study of this process has been to vary individual characteristics of both the picture and the word, and to observe which characteristics affect the choice of a particular name as a target, and the time taken to do this (Cattell, 1886), in an effort to tease apart the stage in picture naming at which each variable has its effect. A large body of research conducted with this intent has shown that picture naming by adults is affected by frequency, familiarity, the age at which the word was learned (called Age of Acquisition, or AoA, measured various ways), length (in syllables, characters or phonemes), imageability (although by definition all pictures can be imaged to some degree), and degrees of abstractness or concreteness. In many of these studies, subjective ratings of age of acquisition by independent samples of adults have proven to be a more powerful and reliable predictor of adult picture-naming latencies than such word attributes as frequency and familiarity (Carroll & White, 1973; Morrison, Chappell, & Ellis, 1997). This finding raises interesting but still unresolved questions regarding the relationship between acquisition by children and retrieval by adults. For example, are the effects of AoA really due to developmental differences in the point at which a word was acquired, or are they the by-products of other processes that adults engage in when they make their subjective ratings of AoA? Although the latter explanation has not been eliminated, it is at least clear that subjective ratings of AoA by adults are correlated significantly with objective measures of vocabulary development in school-age children (Morrison et al., 1997).

One way to approach the relationship between word acquisition in children and word retrieval in adults would be to conduct parallel studies of timed picture naming in both children and adults, and compare performance across the usual predictors of naming efficiency, including AoA. In an untimed picture-naming study, Berman et al. (1989) collected name agreement, familiarity and visual complexity norms from 7-10-year-old English children for the Snodgrass and Vanderwart set (Snodgrass & Vanderwart, 1980) and for 61 pictures from the Peabody Picture Vocabulary Test (Dunn & Dunn, 1981). They found substantial similarities between children and adults on all the measures with regard to the effect of lexical predictors on name agreement, and they conclude that published effects of familiarity judgments, complexity judgments and name agreement for simple line drawings reflect facts about information processing that are already in place by age 7. In a recent study, Cycowicz et al. (1997) provide normative data for 5-6-year-old English children in a timed picture-naming study. Comparing younger children with older children and adults, this study revealed large developmental differences in naming accuracy (agreement) and in naming latency. Furthermore, the measures of familiarity that were collected from both children and adults revealed a smaller range and less variation in ratings by young children, compared to adults and to older children in other studies. In contrast with these developmental changes in familiarity ratings, visual complexity ratings by children were similar to ratings by adults. Johnson (1992) found that name uncertainty (pictures with multiple possible names) affects children's accuracy and latency. All these authors agree that an unequivocal interpretation of age-related differences in cognitive functions can be made only when age-appropriate pictorial stimuli are chosen.

The present study has four goals: (1) to provide normative data for timed picture naming in Italian-speaking children between 5-6 years of age, establishing the feasibility and utility of this method for future studies of the development of lexical access; (2) to compare performance by Italian-speaking children and adults on the same items; (3) to investigate similarities and differences between children and adults in the lexical factors that influence picture naming, including an objective measure of early lexical development; (4) to determine whether word characteristics that have not been studied in English (e.g. effects of grammatical gender) have an influence on the word retrieval process in children and/or adults.

METHODOLOGY

Participants

Thirty-four young Italian children between 5 and 6 years of age participated in the study, 15 female and 19 male. All were native speakers of Italian, and were attending a kindergarten or primary school in the periphery of Rome. None of the children had history of visual problems and/or language disorders (as determined by teacher report).

For comparison with performance by children, we used the norming data for 50 adult native speakers of Italian from the Center for Research in Language International Picture Norming Study (CRL-IPN, research in progress). All adult participants were university students who volunteered, or were paid a small sum (5,000 Italian lire) for their participation.

Materials

For children, a set of 250 pictures consisting of simple line drawings in black and white format, depicting mostly household objects, animals, fruits and vegetables and persons, was used in the experiment, selected from a larger corpus of 520 images used in the cross-linguistic norming study of adults. The full set of 520 pictures was assembled from various published collections and diagnostic instruments (Abbate & La Chapelle, 1984; Dunn & Dunn, 1981; Kaplan, Goodglass, & Weintraub, 1983; Snodgrass & Vanderwart, 1980).

Because the full set of 520 picture-naming trials takes approximately 45 minutes for adults to complete, and because the risk of fatigue or loss of attention and interest is greater in children, we decided to administer only half the corpus. Based upon our results for the 50 Italian adults in the international norming study (CRL-IPN), items for the child study were selected according to the following criteria. First, we eliminated all items that (a) elicited a valid response less than 80% of the time (i.e. a response with a valid reaction time, which could be coded as target name, synonym, morphological variant, or other/naming error), (b) elicited more than 7 alternative names, or (c) elicited a mean reaction time at the RT ceiling (4000 milliseconds in the adult norming study). Then we also eliminated all pictures whose target name (i.e. the name given by the largest number of Italian adults) involved more than one word (e.g. 'sedia a rotelle' or 'wheel chair'). Finally, based on our own intuitions, we eliminated a small set of items that were deemed especially inappropriate for Italian culture (e.g. cowgirl, sixpack). This brought the set of items for the child picture-naming study down to 250, listed in Appendix 1 (in alphabetic order according to the target name in English, accompanied by the target name in Italian).

Procedure

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

Each child was tested individually, in one session, in a quiet room at the school he/she attended. Children were instructed to name the pictures with the first name that came to mind. Children were also exhorted to speak clearly, to name a picture with a single word, and not to emit any other sounds (no clearing of the throat, no preparatory sounds like "uhmmm", no article). In order to make children more confident with the experiment, a practice set of pictures depicting geometric forms like a triangle, a circle, and a square were given as examples. The practice items could be repeated if the Experimenter felt that the child did not yet understand the procedure.

On each trial, the target picture remained on the screen for a maximum of 5 seconds (5000 ms). The picture disappeared from the screen as soon as a vocal response was registered by the voice key; if there was no response, the picture disappeared at the end of the 5000-ms window. In contrast with the adult experimental procedure (in which pictures were advanced automatically at the end of each trial), the experimenter advanced to the next trial manually for children, when s/he was sure that the child was attending to the task.

Participants were randomly assigned to one of four random orders of picture presentation. During the session, the experimenter held a list of stimuli corresponding to the random order for that child, on which the experimenter wrote the child's response (if it differed from the expected name), and indicated any failures to respond or other artifacts.

Scoring

The target name for each picture was determined empirically for children, following the same procedure used to determine the target name in the norming study for adults. This was done in two steps.

First, the data were subjected to error coding to determine which responses could be retained for both naming and RT analyses. Three error codes were possible:

(1) Valid response refers to all the responses with a valid (codable) name and usable, interpretable response times (no coughs, hesitations, false starts, or prenominal verbalization like "that's a ball").

(2) Invalid response refers to all the responses with an invalid RT (i.e. coughs, hesitations, false starts, prenominal verbalizations) or a missing RT (the participant did produce a name, but it failed to register with the voice key).

(3) Nonresponse refers to any trial in which the participant made no verbal response of any kind.

Only the valid responses were used for determining the target name, and for further analyses. Once the set of valid responses had been determined, the target name was defined as the "dominant response", i.e. the name that was used by the largest number of subjects.

Second, all valid responses were coded into different lexical categories in relation to the target name, using the same criteria adopted for the adult study. Examples are provided in English (although they are of course realized differently in Italian).

Lexical Code 1: The target name (dominant response, empirically derived).

Lexical Code 2: Any morphological alteration of the target name, defined as a variation that shares the word root or a key portion of the word without changing the word's core meaning. Examples would include diminutives (e.g. 'bike' for 'bicycle'; 'doggie' for 'dog), plural/singular alternations (e.g. 'cookies' when the target word was 'cookie'), reductions (e.g. 'thread' if the target word was 'spool of thread') or expansions (e.g. 'truck for firemen' if the target word was 'firetruck').

Lexical Code 3: Synonyms for the target name (which differ from Code 2 because they do not share the word root or key portion of the target word). Example might include 'couch' for 'sofa', or 'chicken' for 'hen'.

Lexical Code 4: This included all names that could not be classified in codes 1-3, including hyponyms (e.g. 'animal' for 'dog'), semantic associates that share the same class but do not have the target word's core meaning (e.g. 'cat' for 'dog'), part-whole relations at the visual-semantic level (e.g. 'finger' for 'hand'), and all frank visual errors or completely unrelated responses.

For our purposes here, five dependent variables were derived for each picture, based only on the valid responses: (1) degree of nameability of the picture (percent of all subjects who were able to produce a codable response with a valid RT), (2) percent name agreement (percent target names produced out of all codable responses with a valid RT), (3) number of different names (alternatives) provided on valid trials (including the target name), (4) mean reaction times across all valid trials (i.e. mean latency for all subjects who produced a valid response on that item), (5) mean reaction times on target naming (i.e. mean latency only for those subjects who produced the target name for that item).

In addition to these measures of performance, the target names produced for each item were coded along a number of dimensions that are believed to affect accuracy and/or latency in studies of lexical access. The following variables were used for this study, including some that are applicable across languages and others that only apply to a subset of languages (in this case, Italian).

1. Word length, measured in two ways: number of characters, and number of syllables.

2. Presence/absence of a fricative or affricate in the initial consonant (0 = no fricative or affricate; 1 = fricative or affricate) was included because this variable has been reported to influence the time required for a response to register on the voice key.

3. Complex Word Structure is a dichotomous variable that was assigned to any item on which the dominant response was a plural or a compound word.

4. Phonological opacity refers to the relationship between the grammatical gender of the word and its final vowel (all Italian content words are vowel final, in both singular and plural form, except for foreign loan words). Transparent words are those that end in the characteristic masculine marking ‘ -o’ or feminine marking ‘-a’ . Opaque words are those that end with the gender-ambiguous vowel ‘-e’ (transparent = 0; opaque = 1). This variable was included because it is an Italian variant of the regular-irregular dimension that has been shown to affect reaction times in some studies of lexical access.

5. Grammatical gender is a dichotomy in Italian, a property of all nouns that is only loosely correlated with biological gender (0 = feminine; 1 = masculine). Because masculine is the default/unmarked gender in Italian (and more Italian word types are masculine than feminine), we included this variable to determine whether this aspect of lexical/morphological markedness has any influence on lexical access (nameability or reaction times).

6. Because animacy has been shown to influence word retrieval latencies in some studies, word targets were coded as animate (for persons or animals) or inanimate (all other referents including plants, body parts, foodstuffs). (0 = animate; 1 = inanimate.)

7. Pictures were further grouped into one of 6 lexical categories, to explore possible differences between children and adults in word retrieval: objects, food, animals, persons, mobile objects, body parts.

8. Frequencies of the target names were extracted from two different sources. Spoken adult frequencies for words are extracted from the De Mauro norms for Italian, and are based on the overt form of the word (e.g. singular and plural forms were not conflated for this count -- De Mauro, Mancini, Vedovelli, & Voghera, 1993). Child frequencies are taken from a large corpus including written and read words of Italian children attending elementary school (Marconi, Ott, Pesenti, Ratti, & Tavella, 1993). All the frequencies reported are calculated as natural log transforms [ln(1 + raw frequency)].

9. An objective measure of age of acquisition (AoA) was derived from published norms for the Italian version of the MacArthur Communicative Inventory (Caselli & Casadio, 1995; cf. Fenson et al., 1994), a parental report form that provides valid and reliable data about lexical development in Italian infants from 8-30 months. The MacArthur CDI is based on concurrent parent report of vocabulary development in very large samples of children, collected in a recognition-memory format with a large checklist of words that are likely to be acquired between 8-30 months. For our purposes here, the CDI yields a simple 3-point scale: 1 = words acquired (on average) between 8-16 months; 2 = words acquired (on average) between 17-30 months; 3 = words that are not acquired in infancy (> 30 months).

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

11. In addition to predictor variables associated with the target names, a rough estimate of visual complexity was also obtained for the picture itself, based on the number of pixels in each digitized image.

Table 1 summarizes mean values (collapsed across items) for each of these predictor variables.

RESULTS AND DISCUSSION

In the first stage of lexical coding, in which the target name for each picture is empirically derived, we found that children and adults provided the same target name for 230 of the 250 items (the 20 items for which children and adults used a different target name are reported in bold in Appendix 1). In order to focus on adult/child differences when the target names are held constant, these 20 items were excluded; all analyses are based on the remaining 230 pictures (except for the analyses of fatigue effects reported below).

Fatigue effects in children and adults

Snodgrass and Vanderwart were concerned that a single picture-naming session with 260 items would be too difficult for college students, much less 5-6-year-old children, and for that reason they broke their experiment into two halves (administered to separate subjects). In pilot studies preparing for our international picture-naming project, it became clear to us that the brisk timing parameters adopted in our study would indeed permit efficient administration of all 520 items in a single session (averaging 45 minutes) for college students, and we ascertained that 5-6-year-old children would be able to complete the 250 items administered here in a substantially shorter session (averaging 30 minutes). Nevertheless, we felt it would be important to determine whether there were fatigue effects toward the end of the session. Towards this end, we computed separate Pearson product-moment correlations for children and adults, examining the relationship between the order in which pictures were presented (‘event order’) and two of our primary dependent variables, target RT and name agreement. Because four different random orders were used, these analyses conflate across the four pictures that were present at each position in the list of 250 items. For both children and adults, we found no correlation between order of administration and name agreement (children: $r = -.01$, n.s.; adults: $r = -.05$, n.s.). However, there were small but significant positive correlations between event order and latency to produce target names (children: $r = +.22$, $p < .001$; adults: $r = .35$, $p < .001$). Hence there is a tendency for both age groups to slow down across the course of the session, but with no apparent drop in accuracy.

Comparing mean performance by children and adults

Table 2a provides descriptive statistics for children and adults on all dependent variables, computed over subjects. Table 2b compares adult and child performance on the same variables calculated over items. Simple one-way analyses of variance over subjects and over items indicate that adults have a large and significant advantage over children on all measures ($p < .0001$).

Although children were slower and less accurate than adults, all child participants enjoyed and completed the task. No participants were eliminated on the basis of their performance, though there were some cases that fell more than 2 standard deviations from the mean for their group on one or more dependent variables. Similarly, no items were eliminated from the analyses even though some items fell more than 2 standard deviations from the child or adult means (for RTs and/or naming scores). We retained outlying items and participants because the primary purpose of a norming study is to assess exactly how well our stimuli work with young children as well as adults. For that reason, we wanted to obtain an assessment of both the worst and the best cases.

In analyses over items, adults produced a valid response (providing a codeable name, on items with a valid and usable RT) on 98% of all trials, while for children the valid-response rate was only 75%. Results are similar in analyses over subjects, although the ranges differ. For adults, invalid responses and non-responses were exceedingly rare (1% each), while children produced an invalid response on 18% of all trials, and failed to respond at all on another 10%. The variable “nameability” refers to the proportion of all trials for which a valid and usable response was recorded. The range over items for adults on this measure is relatively small (86%-100%), although it is important to remember that this truncated range is the result of the selection procedures that we used to reduce the full set of 520 items to the final set of 250 administered to children in this (and to the final set of 230 items on which children and adults shared a common target name, used in all statistical analyses below). By contrast, the range over items for children was very large (12-100%), reflecting the great difficulty that children experience with the most difficult items.

Restricting our attention only to valid responses, analyses over items show that children were also less consistent than adults in production of the target name, although the age difference is smaller here than it was for overall nameability. Within the valid responses that they did manage to produce (the denominator for these percent scores), degree of agreement about the “majority name” averaged 86% for children, compared with 93% for adults. Morphological variants (Lexical Code 2) were relatively rare in both groups (2% for children, 3% for adults), as were synonyms (Lexical Code 3, 1% for children vs. 2% for adults). Hence the adult/child difference in name agreement is coming primarily from the heterogeneous “other/error” category (Lexical Code 4, 12% for children vs. 2% for adults). In principle, this might mean that children are producing a greater variety of alternative responses. In fact, Table 2 shows that children produced a mean of 3 alternatives for every picture, compared with a mean of 2 for adults (a significant difference).

As expected based on previous timed picture-naming studies in children and adults (e.g. Johnson et al., 1996; Roe et al., in press), children were much slower than adults in this task: a mean overall RT of 1313 (360 ms slower than adults), and a mean RT to produce the target word of 1291 (372 ms slower than adults). The RT ranges are very large on both these measures, for both age levels, whether they are calculated over subjects or over items.

Relationships among the dependent variables

To examine the relationships among naming and RT measures, correlations across the dependent variables were calculated (all correlations are calculated over items). The resulting coefficients are reported in Table 3a for children, Table 3b for adults, and Table 3c for correlations between children and adults.

We expected a high correlation among the dependent variables within each age group. This was certainly true for children, but less so for adults, due to the truncation of range that resulted from our item selection criteria. The direction of these correlations was the same in adults and children, but correlations differed markedly in strength (compare Tables 3a and 3b). First, overall nameability (percent valid responses) and name agreement (percent production of the target name) were significantly and positively correlated, as we would expect, but the value of this correlation was +.47 for children ($p < .01$) compared with only +.16 for adults ($p < .05$). Second, nameability and name agreement were significantly and negatively correlated with the number of alternative responses produced by children ($-.37$, $p < .01$); this relationship was in the same direction for adults but did not reach significance

(–.07, n.s.). Third, high nameability and high name agreement were associated with faster naming latencies (overall, and target only) at both age levels, and the number of alternative names was associated with slower naming latencies (both overall RT, and target RT only), again at both age levels. However, all these correlations were substantially higher in children (compare Tables 3a and 3b). In fact, the correlation between rates of target production and target RT was a nonsignificant –.11 in adults, compared with a substantial –.52 ($p < .001$) in children. Interestingly, these correlations for children are in the range that has been reported in previous timed picture-naming studies of adults (e.g. Snodgrass & Yuditsky, 1996), further evidence that the lower correlations that we have observed here for adults are due to truncation of range.

For reasons that will also become clear below (lexical predictor effects), this ceiling effect in adults only applies to the name production measures, and not to naming latencies. Consider Table 3c, which presents correlations between dependent variables for children and the corresponding variables for adults. Cross-age correlations for the name production measures are relatively low (from +.14 for percent name agreement, to +.33 for percent nameability), but cross-age correlations for the RT measures are high (+.60 for overall RT, +.56 for target RT). Table 3c also shows that child naming measures are reasonably good predictors of adult RT (between –.43 and –.51), but adult naming measures are poor predictors of child RT (between –.01 and –.21).

Relationships among the predictor variables

Pearson product-moment correlations among the twelve predictor variables were calculated over items, summarized in Table 4. These correlations are largely similar to those reported in other studies of lexical access (keeping in mind that much of that literature is based upon English). Significant relationships include a long-noted association between length and frequency (i.e. longer words tend to be less frequent). Not surprisingly, complex target names tend to be longer, less frequent and acquired later. There is also the expected negative relationship between AoA and log frequency (both child and adult frequency norms), although these frequency correlations are substantially higher for the subjective AoA ratings than the objective CDI measure. Picture complexity appears to be largely independent of the lexical variables in Table 4, although pictures of animate referents tend to be higher visual complexity.

The remaining relationships in Table 4 revolve around word structure variables that are particularly important for Italian, and have not been considered in English-language studies. For example, grammatically masculine words tend to be longer than feminine words, and masculines are also more likely to refer to animate referents (perhaps because the masculine form is more common -- though not universal -- as the default name for animals). Words that end in a gender-transparent vowel (-o for masculine, -a for feminine) are also more likely to be animate, to have masculine gender, and to be represented by a picture high in visual complexity. Because there are multiple confounds among these predictor variables, correlational analyses of the effects of lexical predictors on naming behavior need to be supplemented by regression analyses examining the independent contributions of each predictor when the other variables are controlled.

Relationships among dependent variables and predictor variables

Table 5 summarizes correlations among the different predictor variables and (for the sake of economy) three of our most important measures of naming behavior: percent name agreement (i.e. percent production of the target), mean RT to produce that target, and the number of alternative responses produced for each item. Dependent variables for children and adults are presented side by side, to facilitate comparison. Although there are some important similarities, Table 5 also suggests some interesting developmental differences.

For adults, name agreement was negatively correlated with word length (in syllables and in characters), and word complexity. In contrast, length and complexity had no effect on name agreement in children (who are less likely to produce those complex forms in the first place). For children, the significant predictors of naming agreement were frequency (more agreement for more frequent words, with both adult and child frequency measures) and age of acquisition (lower agreement for later-acquired words, on both the objective and subjective AoA measures), factors that had no influence on name agreement in adults. In addition, there was a significant positive correlation for children between name agreement and grammatical gender, suggesting that children are more likely to agree on the name for a picture if that name is in the masculine gender (the ‘default’ gender in Italian, containing more word types).

For adults, there were no significant correlations between predictor variables and number of alternative names. For children, there were four significant effects: higher-frequency targets were associated with fewer alternative names (by both adult and child frequency norms), words that were acquired later had more alternative names (significant only for the adult AoA ratings), and pictures that are high in visual complexity elicited significantly more alternative names.

Finally, recall that reaction time measures for adults did not suffer from the same truncation-of-range problem that we have for our adult naming measures, and adult RTs were also highly correlated with reaction times for children. Because child and adult RTs are highly correlated over items, we would expect more similarities than differences in the relationship between RT and lexical predictors. This was generally the case, but there were also some interesting exceptions. For both children and adults, higher word frequencies (both child and adult norms) were associated with faster RTs, and high visual complexity was associated with slower RTs. Aside from these similarities, Table 5 also suggests some developmental differences in the factors that influence naming latency. First, the effect of a word-initial fricative reached significance for adults, but not for children. This may reflect the fact that adults are responding much faster, within an RT range in which a small disadvantage for initial fricatives really does matter. Second, the objective age-of-acquisition measure had a significant effect on RTs in children, but not in adults. By contrast, the subjective AoA ratings had large and significant effects on reaction times at both age levels. This last finding is compatible with the claim that adult AoA ratings reflect a combination of factors, including effects of frequency as well as age of acquisition itself (Ellis & Morrison, 1998). We will return to this point later.

In order to control for potential confounds among these predictors, twelve stepwise regression analyses were also conducted (separately for children and adults) in which the contribution of each variable on the final step was assessed after the other 11 predictors were entered into the equation. For the sake of economy, these analyses were conducted on only two major outcome variables: percent name agreement, and RT to produce the target name. Table 6 summarizes the total variance accounted for by all predictors together, and the amount of variance contributed uniquely by each predictor after the other variables are controlled.

For adults, the overall equation failed to reach significance for name agreement, with the 12 predictors accounting for only 8% of the variance. In the 12 stepwise regressions looking at unique variance on the last step, only one measure reached significance for adult naming: word complexity added 1.9% ($p < .05$) to the equation when all other measures were controlled.

On the corresponding analyses of adult target RTs, the 12 predictors together accounted for 28% of the variance ($p < .001$). This included unique contributions on the last step of 10% from adult ratings of age of acquisition ($p < .001$), and 2.5% from visual complexity ($p < .01$). The unique contribution from initial frication just missed significance (1.2%, $p < .10$). Note that the significant effects of frequency uncovered in the raw correlations disappear when adult ratings of AoA are entered into the equation first, a finding that has also been reported in other studies of AoA effects.

For children, the overall equation reached significance for name agreement, with the 12 predictors together accounting for 22% of the variance ($p < .001$). Unique contributions on the last step come from the following sources: 4.1% from child frequency ($p < .001$), 4.1% from adult ratings of AoA ($p < .001$), and 1.5% from visual complexity of the pictures ($p < .05$). The contribution from grammatical gender just missed significance (1.3%, $p < .10$). Two aspects of these results for children are noteworthy: frequency survives the regression with AoA taken into account, but this is true only for the child frequency norms.

On the corresponding analyses of child target RTs, the 12 predictors together accounted for 33% of the variance ($p < .001$). However, the only predictors that contributed significant unique variance on the last step were adult ratings of AoA (16%, $p < .001$) and visual complexity of the picture (1.9%, $p < .05$). The unique contribution from child frequency norms just missed significance (1.3%, $p < .10$).

Although the objective and subjective AoA measures both affected results for children in the raw correlations, the objective measure (taken from CDI norms) did not survive regression analyses with adult AoA ratings entered first. However, as we have just noted, the adult measure reflects a combination of factors including both AoA and frequency. To determine whether it might be possible to separate the contributions of frequency and age of acquisition, we repeated the above analyses dropping the adult AoA ratings as a factor. Results of this second wave of analyses are also reported in Table 6.

For adults, this second set of regressions changed relatively little. In analyses of name agreement, the overall prediction once again failed to reach significance, accounting for a total of 7% of the variance (n.s.). There was still a significant unique contribution from word complexity on the final step (2.1%, $p < .01$), but no other individual predictors made unique contributions. In analyses of target RTs, the overall variance accounted for dropped markedly, from 28% with 12 predictors to 18% with 11 predictors, although the overall equation was still significant ($p < .001$). Visual complexity continued to affect adult performance on both measures when entered on the last step (3.5%, $p < .01$). The only interesting change in patterning occurred for target RTs, where removal of adult AoA as a predictor resulted in the emergence of a significant frequency effect on the last step. Interestingly, this effect came from child frequency norms, which contributed a unique 2.7% to the adult RT variance ($p < .01$), compared with a smaller trend for adult frequency (1.3%, $p < .10$).

For children, the second set of regressions changed the pattern of unique contributions in several ways. In the analyses of child name agreement, the total variance accounted for was a significant 18% ($p < .001$), compared with 22% when adult ratings of AoA are included in the equation. Unique contributions on the last step come from four sources: child frequency (8.7%, $p < .001$, compared with only 4% when adult AoA is controlled), the objective measure of age of acquisition (1.8%, $p < .05$), grammatical gender (1.5%, $p < .05$) and visual complexity (2.0%, $p < .05$). Of these four independent contributors, three are lost when adult AoA ratings were controlled in the first wave of regression analyses (objective AoA, child frequency, grammatical gender). A weaker variant of this pattern obtains in the analyses of child target RT. The total variance accounted for with 11 predictors was a significant 17% ($p < .01$), compared with a much larger 33% when adult AoA was included. Unique contributions on the last step came from two sources: child frequency (7.0%, $p < .001$) and visual complexity (3.1%, $p < .01$). There was also a trend toward a unique contribution from the objective AoA measure (1.3%, $p < .10$).

To summarize results for these two sets of regression analyses, some variables continue to make the same unique contributions whether or not adult AoA ratings are included in the equation. In particular, visual complexity slows RTs for both children and adults (and also decreases naming agreement for children), and word complexity reduces name agreement for adults (but not for children, who are less likely to produce such names in the first place). However, there are other variables that make unique contributions when adult AoA ratings are excluded, but disappear when these subjective ratings are controlled. These include significant effects of grammatical gender and objective AoA on name agreement in children, and significant effects of frequency (especially child frequency norms) on reaction times in both children and adults. The contrast between these two sets of analyses provides support for the claim that adult AoA ratings reflect multiple factors, including frequency as well as the age at which a word is actually acquired. We can detect separate contributions from frequency and our objective measure of AoA only if the adult AoA ratings are dropped from the analysis.

Semantic category cffects

All of the above correlations and regressions pertain to dichotomous or scalar variables. In our final comparison of children and adults, we looked at the contribution of semantic category (a nominal variable that could not be included in scalar analyses). Recall that pictures were divided into six semantic categories: household objects (the largest category by far, with 144 items), food (13 items), animals (35 items), persons (12 items), vehicles (14 items) and body parts (12 items). These categories have also been used in neuropsychological studies of brain-injured adults, and there are numerous reports of selective sparing or impairment in these six categories (for a review, see Goodglass, 1993). In view of various findings in the literature regarding the effects of age of action on naming in both normal and brain-injured adults, we thought it would be useful to determine whether responses differ across these categories in our child and adult samples. Table 7 compares mean target-name reaction tims within each category, for children and adults, expressed both as raw scores and as z-scores (to facilitate comparisons across age groups that differ massively in overall RT). The raw scores were entered into a 2 x 6 analysis of variance over items treating age group as a between-subjects variable and the six semantic categories as levels of a within-subject variable. There were significant main effects of age [$F(1, 224) = 228,16$, $p < .0001$] and category [$F(5, 224) = 2,39$, $p < .039$]. Most important for our purposes here, the interaction between age and semantic category was also significant [$F(5, 224) = 76,82$, $p < .0001$]. Separate one-way analyses of variance within each age group confirmed that reaction times differed across these semantic categories both for adults ($F(5, 229) = 2.60$, $p < .028$) and for children ($F(5, 229) = 3.79$, $p < .003$).

The z-scores in Table 7 indicate the source of the age by category interaction. In particular, adults were especially fast in naming pictures depicting body parts, whereas they were relatively slow to name pictures of people and animals. Children give their best performance in naming animals, followed by body parts and vehicles, while they (like the adults) were relatively slow to name pictures of people. The difficulty that both age groups experience in person naming may reflect two factors: (a) the same individual can take on many different social roles, and (b) these variations in roles are often difficult to depict. The source of the interaction between age and semantic category seems to be coming primarily from pictures of animals and vehicles, which may be especially easy for 5-6-year-old children (relative to their overall RTs) because these represent toys and images that are an important part of their daily lives (reflecting frequency and recency effects that are not operative for adults). To confirm these impressions, we conducted simple analyses of variance comparing child and adult z-scores within each of the six categories. The only effect to reach significance was a robust difference between children and adults in the animal category ($p < .0001$), although there were trends toward a child advantage for vehicles ($p < .06$) and an adult advantage for body parts ($p < .07$).

SUMMARY AND CONCLUSIONS

The study had multiple aims. First, we wanted to establish the feasibility of timed picture naming for the study of lexical access in 5-6-year-old children (the point at which most children enter the school system). Second, we wanted to compare performance by children and adults on the same items, based on a large international norming study of picture naming (CRL-IPN, research in progress). Third, we wanted to investigate similarities and differences between children and adults in the lexical factors that influence picture naming, including two different measures of frequency (from adult norms vs. child norms) and two different measures of age of acquisition (an objective estimate based on norms for lexical development in the first three years of life, and a subjective estimate based on adult AoA ratings). Finally, we wanted to determine whether word characteristics that have not been studied in English (e.g. effects of grammatical gender) have an influence on the word retrieval process in children and/or adults.

With regard to the first goal, we verified that all of these 5-6-year-old children were able to complete the task without difficulty, even though the number of items tested (250 images) was very large. As a group, our child participants produced a valid response on 75% of the items, enough to build a standard data base for children at the point of school entry. Moreover, when children were able to produce a valid response, there was high consistency in agreement on the target name (83%). Fatigue effects were evident (though very small) for child reaction times, but children and adults maintained the same level of name agreement across the entire session.

Second, although this method does seem to work for children, we found large differences between children and adults in nameability, agreement on the target name, and (above all) on reaction times. On average, children were 300-400 ms slower than adults in naming the same pictures, even when they agreed on the name to be retrieved. This finding is in line with previous studies of picture naming in children (e.g. Cycowicz et al., 1997; Roe et al., in press). The fact that children and adults are answering in different time frames may shed light on some of the differences that we also observed in the factors that influence naming and naming times.

Turning to our third goal, we confirmed a number of effects that have been reported in the literature, including interacting contributions from frequency and age of acquisition. With regard to frequency, the child and adult norms produced somewhat different effects. In general, the child norms were better predictors of picture naming (both name agreement and naming latency) at both age levels, although this was especially true for children. However, almost all the frequency effects disappeared in regression analyses using subjective ratings of AoA, a result that has been reported by other investigators (Ellis & Morrison, 1998). The only exception to survive after partialling out subjective AoA was a significant effect of child frequency norms on child name agreement. The adult AoA measure also absorbed all the variance associated with our objective measure of AoA. We were able to detect significant and independent contributions of frequency and objective AoA only when regressions were repeated excluding the adult AoA ratings. These results support the contention that adult AoA ratings reflect more than one factor, including a combination of frequency and real information about the age at which words are acquired.

Although we did not have subjective ratings of visual complexity of the sort that have been used in previous studies (e.g. Snodgrass & Yuditsky, 1996), we obtained an approximate but objective estimate of picture complexity by calculating the number of pixels in each digitized image. Controlling for 11 different properties of the target names, picture complexity added unique variance to name agreement scores in children, and it added unique variance to naming latencies in both age groups, slowing down their response. In the future, it would be useful to compare this novel complexity measure with subjective ratings of visual complexity, to determine whether subjective and objective complexity measures have the same effect.

With regard to our fourth goal, we also found some small but promising effects of morphophonology and word structure that have not been reported in picture-naming studies based on English.

In the raw correlations, adults showed significant effects of length and word complexity on name agreement that did not reach significance for children. They also showed a significant effect of initial frication on target name RTs that did not appear for children. The length and frication effects did not hold up in regression analyses controlling for other variables, but a significant and unique word complexity effect remained for adult name agreement. As can be seen in Table 1 (which provides a breakdown of lexical predictors across items), this complexity effect is coming from a very small number of the items, so its generalizability is questionable. However, related effects of word structure have been reported in other studies (Liu, 1996; Lu et al., submitted), and merit further consideration. The fact that some morphophonological effects reached significance for adults but not for children may be due to the fact that adults are responding much more quickly, so that it may be possible to observe effects of word-form characteristics that are washed out by other factors in the longer RTs observed in children. This possibility could be addressed with delayed-naming studies in adults.

Children appeared to be unaffected by word length or initial frication. However, these Italian-speaking children showed a significant positive effect of grammatical gender on name agreement that did not appear in adults. In particular, they were more likely to agree on the target name if that name is masculine gender, the default gender class in Italian (i.e. the class with the largest number of word types, and the gender more often given to foreign loan words). Because gender was confounded with other factors like length, animacy, transparency/opacity of gender marking and visual complexity in this stimulus set, it is important that this gender effect held up in regression analyses. In theories of word production (e.g. Levelt, 1989), it has been argued that grammatical gender is represented in the lemma, a level of organization midway between conceptual meaning and word form at which significant and language-specific aspects of semantics and grammar are encoded. This result (which will require much more extensive investigation) suggests that there may be developmental differences in the efficiency of lemma retrieval for children and adults, providing a small but reliable advantage for words in the default gender class.

Finally, we compared the effects of semantic category on child vs. adult naming times, using z-scores to determine whether there are developmental differences in the categories that are "hard" or "easy" for children vs. adults. For both children and adults, the "person" category was especially slow, perhaps reflecting the multiple roles that an individual human can take (e.g. a policeman is also a man), and/or the difficulty we have in unambiguous depiction of people in these roles. The most interesting finding, accounting for the significant interaction between age and semantic class, comes from the category "animal", which was the fastest category for children but one of the slowest for adults. We speculate that this result is due to frequency and recency, reflecting the importance of toys and other images of animals and books and play for 5-6-year-old children.

To conclude, timed picture naming is a method for the study of lexical access that works well for children in this age range, producing effects that are largely similar to those that are observed in adults (Cycowicz et al., 1997; Roe et al.1997). However, there are also small but intriguing differences in the factors that facilitate lexical access across this broad age range, factors that should be taken into account in future studies using this method.

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Table 1: Characteristics of the Dominant Responses for 230 Items

SCALAR VARIABLES	Mean	Minimum	Maximum	Standard Deviation
Number of Characters	6.68	2	13	1.86
Number of Syllables	2.75	2	6	0.81
Adult Spoken Frequencies	1.56	0	6.20	1.53
Child Written Frequencies	3.62	0	8.12	1.78
Adult Ratings of Age of Acquisition (AoA)	3.40	1.50	6.13	0.95
ORDINAL & NOMINAL VARIABLES	**Coding**	**Number of Items**	**Percent of Items**	
Objective Age of Acquisition (AoA) from MacArthur CDI Parent Reports	8-17 months = 1 18-30 months = 2 > 30 months = 3	97 17 116	42% 8% 50%	
Word-Initial Fricative	No = 0 Yes = 1	174 56	76% 24%	
Word Complexity	Simple = 0 Complex = 1	217 13	94% 6%	
Grammatical Gender	Feminine = 0 Masculine = 1	109 121	47% 53%	
Phonologically Transparent gender marking (-o/a ending) Phonologically Opaque gender marking (-e ending)	Transparent = 0 Opaque = 1	192 38	84% 16%	
Animacy	Inanimate = 0 Animate = 1	191 39	83% 17%	
Semantic Category	Artifacts Food Animals Person Vehicles Body Parts	144 13 35 12 14 12	63% 6% 15% 5% 6% 5%	

Table 2a: Summary Statistics of Dependent Variables in Children (CH) and in Adults (AD) (over participants)

	Error Codes (in percents)						Lexical Codes (in percents)								Reaction Time (in milliseconds)			
	Valid		Invalid		Non-Response		Target		Morph. Variants		Synonyms		Other/Error		Target Names		All Names	
	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD
Mean	75	97	5	1	20	1	84	93	2	3	1	2	12	2	1250	950	1295	965
Std Dev	10	3	3	2	9	2	7	3	1	1	1	1	6	2	212	103	229	106
Min	51	87	0	0	6	0	57	77	1	0	0	1	2	0	885	779	930	789
Max	90	100	16	12	46	13	94	97	5	8	3	4	37	17	1857	1180	1919	1201

Table 2b: Summary Statistics of Dependent Variables in Children (CH) and in Adults (AD) (over items)

	Error Codes (in percents)						Lexical Codes (in percents)								Reaction Time (in milliseconds)			
	Valid		Invalid		Non-Response		Target		Morph. Variants		Synonyms		Other/Error		Target Names		All Names	
	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD	CH	AD
Mean	76	98	5	1	18	1	86	93	2	3	1	2	12	2	1291	943	1313	957
Std Dev	18	3	4	2	17	2	16	10	5	7	5	7	15	3	286	136	292	141
Min	12	86	0	0	0	0	25	43	0	0	0	0	0	0	855	694	855	694
Max	100	100	18	8	85	10	100	100	28	57	50	51	75	11	2629	1324	2962	1343

Table 3a: Correlations among Dependent Variables for Children

	% Valid Responses	% Target Names	# Alternative Names	RT-Target Names
% Valid Response	-----			
% Target	+.47***	-----		
#Alternatives	-.37***	-.76***	-----	
RT-Target	-.64***	-.52***	+.49***	-----
RT-All Valid	-.68***	-.51***	+.54***	+.94***

* = p < .05 ** = p < .01 *** = p < .001

Table 3b: Correlations among Dependent Variables for Adults

	% Valid Responses	% Target Names	# Alternative Names	RT-Target Names
% Valid Response	-----			
% Target	+.16**	-----		
#Alternatives	n.s.	-.53***	-----	
RT-Target	-.40***	n.s.	+.31***	-----
RT-All Valid	-.40***	-.21***	+.39***	+.99***

n.s. = non-significant * = p < .05 ** = p < .01 *** = p < .001

Table 3c: Adult-Child Correlations for Dependent Variables

	CHILD MEASURES				
ADULT MEASURES	% Valid Responses	% Target Names	# Alternative Names	RT-Target Names	RT-All Valid Names
% Valid Response	+.33***	n.s.	-.13**	-.15**	-.21***
% Target	n.s.	+.14**	-.16**	n.s.	n.s.
#Alternatives	n.s.	-.28***	+.26***	+.17**	+.17**
RT-Target	-.51***	-.43***	+.44***	+.56***	+.61***
RT-All Valid	-.50***	-.44***	-.45***	+.56***	+.60***

n.s. = non-significant * = p < .05 ** = p < .01 *** = p < .001

Table 4: Correlations among the 12 Predictor Variables
(Numbers above columns refer to variable numbers in Column 1)

Variables Names & Numbers	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1. # Characters	-----										
2. # Syllables	.86***	-----									
3. Initial Fricative (0,1)	ns	-.14**	-----								
4. Word Complexity (0,1)	.32***	.35***	n.s.	------							
5. Phon.Opacity (0,1)	n.s.	n.s.	n.s.	n.s.	-----						
6. Gender (M=1; F=0)	.15**	.17**	n.s.	n.s.	.26***	-----					
7. Animacy (0,1)	n.s.	n.s.	n.s.	-.11~	.14*	.15*	-----				
8. Adult Frequency	-.32***	-.28***	n.s.	-.23***	n.s.	n.s.	-.15*	-----			
9. Child Frequency	-.33***	-.35***	n.s.	-.39***	n.s.	n.s.	n.s.	.52***	-----		
10. Objective AoA	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	ns	-.14**	ns	-----	
11. Subjective AoA	.27***	.29***	n.s.	.18**	n.s.	n.s.	ns	-.47***	-.53***	-.23***	-----
12. Visual Complexity	n.s.	n.s.	n.s.	n.s.	.14*	n.s.	.22***	n.s.	n.s.	n.s.	n.s.

n.s. = non-significant   ~ = $p < .10$ * = $p < .05$ ** = $p < .01$ *** = $p < .001$

Table 5: Correlations between Predictor Variables and Dependent Variables

PREDICTOR VARIABLES	% Production of Target Name		# Alternative Names		RT to Produce Target Name	
	CHILD	ADULT	CHILD	ADULT	CHILD	ADULT
# Characters	n.s.	-.16**	n.s.	n.s.	n.s.	n.s.
# Syllables	n.s.	-.17**	n.s.	n.s.	n.s.	n.s.
Initial Fricative (0,1)	n.s.	n.s.	n.s.	n.s.	n.s.	.15**
Word Complexity (0,1)	n.s.	-.19***	n.s.	n.s.	n.s.	n.s.
Phonological Opacity of Gender Ending (0,1)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Grammatical Gender (M=1; F=0)	.14**	n.s.	-.12~	n.s.	-.13*	n.s.
Animacy (0,1)	n.s.	n.s.	n.s.	n.s.	n.s.	.12~
Adult Frequency	.16**	n.s.	-.17***	n.s.	-.19***	-.29***
Child Frequency	.34***	n.s.	-.26***	n.s.	-.34***	-.26***
Objective AoA	-.15**	n.s.	n.s.	n.s.	.14**	n.s.
Subjective AoA	-.37***	n.s.	.36***	n.s	.53***	.44***
Visual Complexity	n.s.	n.s.	.16**	n.s.	.14**	.22**

n.s. = non-significant ~ = p < .10 * = p < .05 ** = p < .01 *** = p < .001

Table 6a: Regression Analyses for Name Agreement in Children and Adults (zero-order partial correlations & unique variance on the last step; ~ = p < .10; * = p < .05; ** = p < .01; *** = p < .001; n.s. = non-significant; ---- = not applicable)

PREDICTORS	With Subjective AoA				Without Subjective AoA			
	Adult		Child		Adult		Child	
	partial corr	unique variance	partial corr	unique variance	partial corr	unique variance	partial corr	unique variance
Adult Frequency Norms	- .02	n.s.	- .07	n.s.	- .03	n.s.	- .01	n.s.
Child Frequency Norms	+.00	n.s.	+.22	.041***	- .02	n.s.	+.31	.087***
(Adult & Child Frequency together)	-----	n.s.	-----	.041***	-----	n.s.	-----	.106***
Subjective AoA Ratings	+.07	n.s.	- .22	.041***	-----	-----	-----	-----
Objective AoA	+.05	n.s.	- .10	n.s.	+.07	n.s.	- .14	.018*
(Subjective & Objective AoA Together)	-----	n.s.	-----	.058***	-----	-----	-----	-----
Length in Characters	- .06	n.s.	+.00	n.s.	-.01	n.s.	+.04	n.s.
Length in Syllables	- .02	n.s.	+.05	n.s.	- .06	n.s.	- .00	n.s.
(Length in Characters & Syllables Together)	-----	n.s.	-----	n.s.	-----	n.s.	-----	n.s.
Word-Initial Fricative (no = 0; yes = 1)	+,04	n.s.	+.08	n.s.	+.03	n.s.	+.09	n.s.
Word Complexity (no = 0; yes = 1)	- .14	.019*	+.06	n.s.	- .15	.021*	+.07	n.s.
Gender (M=1; F=0)	+.04	n.s.	+.13	.013~	+.04	n.s.	- .15	.021*
Phonologically Opaque Gender Marking (transparent=0; opaque=1)	- .11	n.s.	+.02	n.s.	-.10	n.s.	+.22	n.s.
Animacy (no = 0; yes = 1)	+.02	n.s.	+.05	n.s.	+.02	n.s.	+.06	n.s.
Picture Complexity	+.06	n.s.	- .14	.015*	+.06	n.s.	- .15	.02*
TOTAL: Multiple R and Total Variance from All Predictors Together	.27	**.08**	.47	**.22*** **	.27	**.07**	.42	**.18*** **

Table 6b: Regression Analyses for Reaction Times in Children and Adults (zero-order partial correlations & unique variance on the last step; ~ = p < .10; * = p < .05; ** = p < .01; *** = p < .001; n.s. = non-significant; ---- = not applicable)

PREDICTORS	With Subjective AoA				Without Subjective AoA			
	Adult		Child		Adult		Child	
	partial corr	unique variance	partial corr	unique variance	partial corr	unique variance	partial corr	unique variance
Adult Frequency Norms	- .05	n.s.	+.11	n.s.	- .13	.013~	+.00	n.s.
Child Frequency Norms	- .05	n.s.	- .14	.013~	- .18	.027**	- .29	.074***
(Adult & Child Frequency together)	-----	n.s.	-----	.015~	-----	.075***	-----	.095***
Subjective AoA Ratings	+.34	.100***	+.44	.158***	-----	-----	-----	-----
Objective AoA	+.00	n.s.	+.04	n.s.	+.07	n.s.	+.12	.013~
(Subjective & Objective AoA Together)	-----	.102***	-----	.171***	-----	-----	-----	-----
Length in Characters	- .01	n.s.	- .00	n.s.	+.02	n.s.	- .03	n.s.
Length in Syllables	- .03	n.s.	-.05	n.s.	- .02	n.s.	+.01	n.s.
(Length in Characters & Syllables Together)	-----	n.s.	-----	n.s.	-----	n.s.	-----	n.s.
Word-Initial Fricative (no = 0; yes = 1)	+.13	.012~	- .02	n.s.	+.11	n.s.	- .01	n.s.
Word Complexity (no = 0; yes = 1)	- .06	n.s.	- .00	n.s.	- .08	n.s.	- .04	n.s.
Gender (M=1; F=0)	- .07	n.s.	- .11	n.s.	- .09	n.s.	- .12	.011~
Phonologically Opaque Gender Marking (transparent=0; opaque=1)	- .06	n.s.	- .07	n.s.	-.03	n.s.	- .02	n.s.
Animacy (no = 0; yes = 1)	+.11	n.s.	- .05	n.s.	+.08	n.s.	- .07	n.s.
Picture Complexity	+.18	.025**	+.17	.019*	+.20	.035**	+.19	.031**
TOTAL: Multiple R and Total Variance from All Predictors Together	.52	**.28*** **	.58	**.33*** **	.42	**.18*** **	.42	**.17*** **

Table 7: Effects of Semantic Category on Child vs. Adult Reaction Times

Lexical Category	Child Target RT	Adult Target RT	Child Z-score Target RT	Adult Z-score Target RT	Significance of Adult/Child Difference
Artifacts	1321.9	933.5	0.1	-0.07	p < .06
Food	1294.4	941.9	0.01	-0.01	n.s.
Animal	1155.5	990.3	-0.47	0.34	p < .0001
Person	1494.4	1011.4	0.71	0.5	p < .10
Vehicles	1212.0	941.8	-0.27	-0.01	n.s.
Body parts	1202.5	860.1	-0.31	-0.61	p < .07