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Multiple Influences on Vocabulary Acquisition: Parental Input Dominates

Dominic W. Massaro

Department of Psychology
University of California, Santa Cruz

Massaro@ucsc.edu

Abstract

How spoken language is acquired has been an active area of inquiry in linguistic, psychological, and speech science. New advances in this controversial field are promising given the recent accumulation of large databases of children's speech understanding and production, as well as various properties of words. This paper explores the contribution of a variety of potential influences on vocabulary acquisition including difficulty of articulation, iconicity, log parental input frequency, lexical category, and imageability. The influence of difficulty of articulation, iconicity ratings, and imagery ratings decreased more or less linearly with increasing age. Lexical category effects were fairly small. Parental input in terms of child directed speech has by far the largest influence. Multiple regressions with these variables give a fairly complete account of spoken vocabulary acquisition. The increasing availability of large databases promises progress in this area of inquiry.

Index Terms: vocabulary acquisition, speech difficulty, iconicity in speech, age of acquisition, parental input frequency, child directed speech

1. Introduction

A fundamental principle emerging from recent research is that language processing is a form of pattern recognition, is influenced by multiple cues or sources of information, and is quantitatively described by the Fuzzy Logical Model of Perception (FLMP) [1] and [2]. The model assumes the evaluation and integration of the multiple sources, and a decision based on all of the sources. These same processes also occur in language acquisition, not just in accomplished language users [3], [4], [5], and [1, Chapter 8].

An Emergentist Coalition Model also describes how children rely on multiple cues over development in the mapping of words onto referents [6] and [7]. The use of and the weight given to these cues change across development. For example, infants initially rely primarily on perceptual cues and gradually begin to use a speaker's intent and linguistic cues to determine word reference. The use of and the weight given to these cues change across development. As assumed by the FLMP [1] and [2], these cues and constraints are graded (not categorical) in nature, suggesting further that they must be combined to give a more reliable understanding of the input. Evidence to date indicates that this combination process is highly efficient or optimal, as described by a Bayesian-like process [8] and [9].

2. Influences on Vocabulary Acquisition

This framework sets the stage for the study of vocabulary acquisition. The goal is to evaluate various factors in word learning. I now describe some potential influences.

2.1. Parental Input (Child Directed Speech)

As noted in one of the keynote talks of this conference, there has been a resurgence of research and applied interventions on the importance of the quality and quantity of language directed at children from birth onward. It is well established that many of the words children know are those that they have heard, especially in child directed speech. Hart and Risley [10] first discovered that children before the age of 3 heard many more words in high than in low socioeconomic status (SES) families. Hoff [11] additionally revealed that the lexical richness and sentence complexity of mother's speech to their children also differed between these two types of families. Thus, it appears that quality as well as quantity of language is important in children's language development. Competence in word recognition is also a function of how frequently the word is encountered [12], [13], and [14]. In the current study, I operationalize this variable as parental input frequency and ask how word frequency of child directed speech influences vocabulary acquisition.

2.2. Adults Estimates of Age of Word Acquisition

There is also evidence that a word appears to be better learned the earlier a child learns it. Although this variable has not been explored systematically in children, age of acquisition and word frequency have very large and roughly equivalent correlations with adult's reaction time and accuracy in a lexical decision task [15] and [16]. Age-of-acquisition ratings accounted for a substantial percentage of variance after effects of log word frequency, word length, and similarity to other words were accounted for [12]. In another informative study, there was an advantage of high-frequency over low-frequency words acquired fairly late, but early acquisition of words eliminated any frequency advantage [17]. Thus, the sooner a child experiences a word might be more beneficial for vocabulary learning.

It should be noted, however, that age of acquisition ratings given by adult subjects should not be considered a sensitive of word learning in the first few years of life. Children's vocabulary changes dramatically in just a few months time but adults are asked to estimate their age of acquisition in whole

years. Many estimates of first hearing common words are older than preschool ages [12]. Thus, age of acquisition measures will not be used as a predictor of vocabulary growth.

2.3. Difficulty of Articulation

A child's production of words might relate to the difficulty of articulation of segments of the words. We might expect those words easier to articulate would tend to be produced (and perhaps understood) earlier than those more difficult to articulate. Massaro and Rowe [18] found that difficulty of articulation of words was negatively correlated with the likelihood of very young children between 8 and 18 months having those words in their expressive language.

2.4. Iconicity

Iconicity can be defined as a correspondence between the speech characteristics of a word and the characteristics of the object or event that the speech symbol represents [19]. Perlman and Cain [20] use "the term to refer, across modalities and media, to any sort of correspondence between the form of an expression and its meaning." [20, p. 320]. The hypothesis is that an iconic word is more easily learned because there is a correspondence between the symbolic form of the word and its meaning [21]. One possible example is the articulation of the word "lips" draws attention to the lips thus facilitating the association between the sound and the meaning. This correspondence putatively makes the relationship between sound and meaning more obvious. Perry et al. [19] found a positive contribution of rated iconicity on the proportion of children who produced words at 30 months of age, as determined by the MCDI checklist [22] and [23], even after log word frequency, concreteness, imageability, word length, and systematicity [24] were accounted for. A stronger bootstrapping hypothesis [25] claims that children tend to acquire iconic words as their first words. Only then do they acquire non-iconic words perhaps based on other variables such as familiarity caused by overall frequency of occurrence and words used frequently by their caregivers.

2.5. Imageability

There has been a long tradition in memory research that words high in imageability (and concreteness) are easier to learn and remember. Several investigators have also made the case for an influence of these highly correlated variables in vocabulary acquisition. McDonough et al [26] carried out a regression analysis on the age at which 50% of the children had a word in their production vocabulary, as measure by the MCDI: Words and Sentences [22]. They found that imageability accounted for about 10% of the variance, after syntactic category (noun or verb) and frequency were partialed out. Their sample was limited to just 120 words that had imageability ratings, however, so additional research is called for.

3. Empirical Investigation: Method

The present research involved mining an existing database of children's comprehension and production vocabulary to determine the potential influence of various properties of vocabulary. The two dependent measures were 1) from a checklist completed by parents and 2) from a frequency count of words uttered by children. The independent variables were parental input frequency, iconicity, difficulty of articulation, syntactic category, and imageability.

3.1. Dependent Variables

3.1.1. MCDI Words & Gestures American, 2016

The database consisted of a parental report checklist of whether their child understood and produced 396 words, organized in different words categories such as animal sounds and vehicles [22]. There were 1089 unique individual cases in which the words produced and the words understood were tabulated for each child at a given age [18] and [27]. The ages of the children in months ranged from 8 to 18 months. The final dataset included 386 words after combining the list's duplicate words that had multiple meanings (e.g., watch). The two dependent measures were the log 10 of the number of children who had the word in their comprehension vocabulary and their production vocabulary at a given age. The Spearman correlation between comprehension and production was .757, $p < .001$.

3.1.2. ChildFreq Database [31]

Another measure of vocabulary acquisition other than the MCDI is derived from child production data from part of the Childes database [28] and [29]. It consists of 5000 transcriptions of children's speech with 3,500,000 word tokens. The ages of the children in this database range from birth to 7 years.

I use the word frequency in ChildFreq database [30] and [31] as a measure of vocabulary acquisition. It seems reasonable to assume that the more often a word occurs in an age range, the more likely that word had been acquired by that age. The frequency of occurrence of words in the database can be considered as a metric of the age of acquisition of these words in the same manner that the MacArthur Bates parental questionnaire is used as a measure of acquisition age of words. The correlation between log 10 said words between 8 and 18 months in the MCDI database and the log 10 frequency in the age range of 6-17 months in the ChildFreq database was .397, $p < .001$. The analogous correlation for log 10 understood words was .318, $p < .001$.

Table 1. The number of transcriptions (# Tran), number of words (# Words), and the number of words per transcription (# Words Per Tran) across the eight age ranges (Age(m)).

Age(m)	# Tran	# Words	# Words Per Tran
6-17	375	66037	176.10
18-29	1612	936460	580.93
30-41	1333	1170055	877.76
42-53	839	566833	675.61
54-65	583	628317	1077.73
66-77	338	137179	405.86
78-89	226	110737	489.99
90-95	56	17274	308.46

The ChildFreq database [31] gives word occurrences at a given age range summed across transcripts and children. Ideally, we would like a measure of the number of children who uttered a given word at least once. However, this result is not available in this database. Viewing the number of transcripts and the total number of uttered words in Table 1, we see there is a fairly large number of words per transcript. Therefore, we expect that the frequency of each word's occurrences would be positively correlated with the number of children who uttered that word at least once.

3.2. Independent Variables

3.2.1. Parental Input Word Frequency

As a measure of this input, the parental vocabulary corpus, a subset of the Child Language Data Exchange System corpora [28] and [29] was used in the analyses. This CHILDES Parental Corpus database [32] consists of the contributions of 27 individual corpora provided by 27 different investigators. The total number of lexical items in this parental corpus is 2,579,966 word tokens, with 24,156 word types (counting all inflected forms of a word as separate types). It consists of spoken utterances from parents, caregivers, and experimenters in the presence of children (age: 0;7–7;5; mean age: 36 months). This corpus provides a huge sample of the speech that children are exposed to (e.g., dinner table talk, talk during free play, and storytelling), even though not all of the utterances are strictly child-directed.

3.2.2. Iconicity Ratings

To provide the present measure of iconicity, each of fifteen students was asked to rate the iconicity of the 644 words from the MacArthur-Bates Communicative Development Inventories (MCDI) Words and Sentences [22], a normed list given to parents to measure the early productive vocabulary of 16 to 30-month-old toddlers learning American English. Each of the words was presented in written form in a different random order for each student [33]. The instructions were identical to those used by Perry et al. [19], and are given in Massaro and Perlman [33]. The independent variable for iconicity is the average iconicity rating across the 15 students.

3.2.3. Difficulty of Articulation

Given that there were no established measures of difficulty of articulation (or difficulty of perception), Massaro and Rowe [18] created a metric based on several relevant studies referenced in their article. Difficulty of Articulation of the consonant segments was defined as a 1-7 value on a scale of easy to difficult, and a word's difficulty was defined as the sum of the difficulties of the consonants in the word. Other possible factors such as vowel identity and coarticulation were not included in the measure. The difficulty values for each of the consonant phonemes are given in [18].

3.2.4. Syntactic Category, Imageability, Concreteness

The words were partition into nouns, verbs, and other. Imageability and concreteness values were derived from [34]. Given that imagery and concreteness are highly correlated with a correlation value of .928, only imageability and not concreteness will be analyzed in the partial correlations.

4. Empirical Investigation: Results

4.1.1. MCDI Words & Gestures American, 2016

This database of the 386 words gives the number of children out of 1089 whose parents reported 1) that their child comprehended each word and 2) reported that their child produced each word. These totals were transformed into log 10 values, analogous to how word frequency is usually treated. For said words, the correlation with the concreteness of the words was .344. The analogous correlation for understood words was .180. The correlations with imagery were .311 and .168 for said and understood words, respectively.

To assess the influence of word class, the 386 words were partitioned into 3 categories: nouns, verbs, and other. Although there were statistically significant differences across the 3 categories, the differences were fairly small as shown in Table 2. Furthermore, partial correlations of said and understood words with noun versus verb categories were not significant when the other variables of interest were partialed out.

Table 2. *Log 10 of the number children who said and understood the three categories of words: nouns, verbs, and other.*

Category	Said	Understood	df
Nouns	1.43	2.44	374
Verbs	1.67	2.53	374
Other	1.51	.2.43	374

Partial correlations were carried out on log 10 Said words and log 10 Understood words for each of 4 independent variables with the other three independent variables partialled out. As can be seen in Table 3, all four variables had statistically significant influences on said words whereas only parental frequency and imageability were statistically significant on understood words. Even so, the all of the variables were influential in the expected manner.

Table 3. *Partial correlations and significance values carried out on log 10 Said words and log 10 Understood words for each of 4 independent variables with the other three independent variables partialled out. DA = Difficulty of Articulation; PF = Log10 Parental Input Frequency: IR = Mean Iconicity Rating; IM = Imageability Rating.*

Partial Correlation	Said	Understood	df
DA	-.223**	-.082	261
PF	.236**	.155*	261
IR	.146*	.090	261
IM	.439**	.255**	261

* = p < .05; ** = p < .001

4.1.2. ChildFreq Database [31]

The number of times each of the 386 words occurred across eight age ranges between 6 and 95 months in the ChildFreq database [30] and [31] was computed. Given the different sizes of the sample of total number of words at each age range, the frequencies were normalized to a count per one million occurrences, and transformed by a Log 10 function. More frequent occurrences of a word would be analogous to a highly likelihood of the word being in the child's vocabulary.

Partial correlations were carried out on the log 10 frequencies at the eight age ranges for each of 4 independent variables with the other three independent variables partialed out. Difficulty of articulation, iconicity ratings, and imagery ratings influenced word production in the appropriate direction, and this influence decreased more or less linearly with increasing age. A linear regression analysis with Fisher transformed correlations gave significant linear effects for all three variables ($p < .001$). Finally, parental input frequency had the largest influence at all age ranges and was only somewhat diminished at the youngest and oldest age ranges.

Table 4. Partial correlations and significance values carried out on the log 10 frequencies at the eight age ranges for each of 4 independent variables with the other 3 independent variables partialled out. DA = Difficulty of Articulation; PF = Log10 Parental Input Frequency: IR = Mean Iconicity Rating; IM = Imageability.

Age (m)	DA	IR	IM	PF
6-17	-.221**	.092	.247**	.477**
18-29	-.240**	.114	.157*	.737**
30-41	-.221**	.046	-.065	.803**
42-53	-.165*	-.076	-.162*	.808**
54-65	-.252**	-.056	-.150*	.836**
66-77	-.166*	-.012	-.142	.709**
78-89	-.147*	-.110	-.067	.733**
90-95	-.110	-.138	-.136	.488**

* = p < .05; = p < .001

When imagery is used in the partial correlations, there are fewer degrees of freedom because there are not imageability values for about a third of the items. Therefore, in the next analysis I eliminated imageability as an independent variable and carried out a multiple regression with iconicity ratings (IR), difficulty of articulation (DA), and log 10 parental input frequency (PF) as independent variables Table 5 gives the results for each age range with Standardized Beta values, t-test results, and significance levels. As can be seen in the table, iconicity accounted for very little of the variance, difficulty of articulation accounted significantly more, and log 10 parental frequency accounted for between 2 and 135 times that accounted for by iconicity or difficulty of articulation.

Table 5. Standardized Beta values, t-test results, and significance levels for multiple regressions at eight different age ranges with the 3 independent variables: iconicity ratings (IR), difficulty of articulation (DA), and log 10 parental input frequency (PF). The magnitude of the influence of PF relative to IR and DA are given in the column PF Mag.

Age (m)	IV	Beta	t-test	Sig	PF Mag
6-17	IR	.086	1.655	.099	4.93
18-29	IR	.063	1.725	.085	10.92
30-41	IR	.057	1.880	.061	13.84
42-53	IR	-.006	-.189	.850	134.83
54-65	IR	.024	.786	.432	33.46
66-77	IR	.030	.847	.397	25.07
78-89	IR	-.006	-.157	.875	123.17
90-95	IR	-.010	-.173	.863	58.90
6-17	DA	-.176	-3.324	.001	2.41
18-29	DA	-.151	-4.010	.000	4.56
30-41	DA	-.110	-3.467	.001	7.17
42-53	DA	-.070	-2.226	.027	11.56
54-65	DA	-.087	-2.760	.006	9.23
66-77	DA	-.100	-2.770	.006	7.52
78-89	DA	-.099	-2.664	.008	7.46
90-95	DA	-.107	-1.831	.069	5.50
6-17	PF	.424	8.060	.000	
18-29	PF	.688	18.186	.000	
30-41	PF	.789	24.876	.000	
42-53	PF	.809	26.155	.000	
54-65	PF	.803	25.377	.000	
66-77	PF	.752	20.702	.000	
78-89	PF	.739	19.824	.000	
90-95	PF	.589	10.250	.000	

It might be argued that parental input frequency has such a strong effect because it is positively correlated with overall frequency of words in the language. Not surprisingly, parental input frequency correlated .773 with one of the best overall word frequency measures for adults [35]. Parents' speech to their children will necessarily reflect to some degree their typical day-to-day word occurrences. However, the strong influence of parental input frequency in the present study is still highly significant at all eight ranges even after overall word frequency is partialed out. Thus the changes in the influence of parental frequency across the different ages are not solely accounted for by overall word frequency. We can conclude that the best measure of word frequency influences on a child's vocabulary acquisition is parental input frequency.

5. Discussion

The results demonstrate multiple influences in a child's word understanding and production. Most of these influences change dramatically with age. The influences of difficulty of articulation, iconicity, and imageability decrease dramatically with increasing age. Parental influence, on the other hand, has a strong and consistent influence with increasing age.

Children learn words that they experience. One of the benefits of reading aloud to young children is that it can expose children to words not normally heard in child directed speech. An analysis of a picture book database revealed that the vocabulary in picture books included many more rare words than that found in child directed speech [36]. Rare words tend to be more complex and cognitively challenging than common words. This difference exists because books tend to be a type of formal language whereas speech directed at children or even in the presence of children tends to be informal [36]. Future research might address how reading aloud books influences vocabulary development relative other influences such as child directed speech.

In addition to the variables studied in this paper, the benefits of the speech embellishments inherent to so-called motherese are well-documented [13]. The child also brings to bear statistical learning skills that allow mastery of new vocabulary [37]. Other relevant research documents a variety of processes and inputs that enable language acquisition [38], [39] [40], [41] and [42].

6. Conclusions

With perhaps an exponentially increasing family of databases and creative views of vocabulary learning, the future of the field is guaranteed to be informative and stimulating. The results have already shed light on the perennial question of the role of nature versus nurture in vocabulary learning.

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