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On the Comprehension of Lexical Ambiguity by Young Children: Investigations into the Development of Mental Modularity

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The fundamental questions concerning the human language faculty have traditionally been cast as involving at least: (1) the determination of the general nature of that faculty, (2) an understanding of how that faculty develops, and (3) the determination of innate and learned characteristics of that faculty (see, e.g., Chomsky, 1986). These questions, in fact, represent fundamental issues in the study of all domains of cognitive performance, language or otherwise.

Fodor's (1983) recent delineation of cognitive processes into domain-specific modular routines and domain-general systems offers an important framework within which to consider these general questions about cognitive processes. Briefly, in Fodor's proposed architecture of cognitive processes, basic perceptual systems (e.g., language) are argued to be modular, while more integrative, problem-solving types of processes act across modules. Criterially, "modularity" involves information encapsulation and cognitive impenetrability for processes activated within a perceptual module. Thus, for example, language perception is argued to be a form-driven process, one relying for its initiation only on information of acoustic/phonetic/graphemic form received by the listener/reader, and not on world knowledge or other contextual influences. Descriptively, perceptual processes in modular systems are held to be automatic, very rapid, and autonomous. Much support for the existence of perceptual modules has been developed over the past few years, with a large amount of the work focusing on modularity of smaller and smaller processing units within perceptual systems-submodules, if you will (e.g., Forster, 1979).

One such putative submodule within the language domain, lexical access, has been the focus of work by a large number of researchers (see others chapters in this volume), many of whom have used resolution of lexical ambiguity during language comprehension as a testing ground for claims of modularity. Briefly, such research has focused on examination of whether or not prior contextual information constrains access to the various meanings of the ambiguity when it is heard or read. The overwhelming bulk (but certainly not all) of the evidence from sentence processing studies has supported the modularity position; even in the face of strongly biasing contextual information, multiple interpretations of a clearly polysemous word are accessed automatically by normal adult listeners when they first hear it in a sentence.[1]

Assuming for the moment, then, that lexical access during sentence comprehension for normal adult listeners is best characterized as a modular process, the second and third questions raised above come into play: Is this modularity an innate property of the lexical recognition system, one which is in place in the neonate as part of the functional wiring of the neurological substrate underlying language processing? (The issue of whether it is expressed immediately or developmentally as a part of prescribed maturation of the system represents a separate question.) Or, rather, is modularity an acquired characteristic of the lexicon, the result of practice and developing automaticity? (After all, the descriptive characteristics of a modular system could be obtained through development of a system which becomes so practiced and automatic that its most efficient functioning is maintained purely through extremely rapid bottom-up, contextual-free processing-in short, modular, autonomous, rapid processing.)

Clearly, the answers to these questions will have considerable impact on the answer to the basic question first raised above: namely--the general nature of the process. A formal characterization of language processing may differ considerably depending on whether or not a modular system in the adult is innate, or alternatively, has a developmental history tied to purely practice and/or learning considerations. Similarly, the characterizations of *child* language will differ greatly depending on the answers to these questions. For example, even if there is an innate propensity for a modular system that is not realized in the immature individual (the maturational hypothesis). the lack of a modular system in a child will require descriptions of the child-to-adult transition in language to encompass the discontinuity of these systems with regard to modular perceptual systems.

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[1]Some recent work by Tabbossi (1988; see also Chapter 3 this volume) has presented a particularly interesting challenge to what has come to be orthodoxy here. However, it does appear that the effects achieved by Tabossi may be reflecting issues dealing with *how much* information related to each meaning is accessed when all meanings are accessed for a word. Schema theory (e.g., Kintsch. 1988) suggests that even if many independent meanings are accessed for each word, the depth of features related to these meanings may be very shallow. Although it may not turn out to be the case upon further investigation, it appears that Tabossi's interesting and exciting effects may be caused because only a few, strongly related features are ever activated upon access for a word, whereas features such as she examined, being a function of schema, are a result of nonmodular post-access processing. See also footnote 3.

Finally, it is important to note that while this paper is focused on language and ambiguity processing, the issues are arguably generalizable to other cognitive systems. Thus, the issues concerning development of modularity for a processing subsystem apply equally to processes as far removed from language (or as closely aligned, depending on your point of view) as object recognition, number perception, attentional processes, and memory. While developmental research has not directly examined the question of whether or not modularity in any domain is acquired, there is some indirect evidence that modularity may be innate in certain instances. Hasher and Zacks (1975), for example, argue that there are two types of automatic (modular) process, those that are innate or prewired and those that are acquired through (over)learning. In their scheme, as in Fodor's, language is considered a privileged domain, that is, one in which automaticity is determined structurally. Similarly, certain .automatic properties of attention are deemed innate in this system, while nonmodular, intentional properties of attention are claimed to develop between the ages of 6 and 10 (see Treisman & Gelade, 1980; Treisman & Schmidt, 1982, for examples of a variety of attentional properties). Further, there is a population of children in whom controlled attention (as opposed to automatic properties of attention) develops more slowly than for their peers, children with the formal diagnostic label of *attention deficit hyperactivity disorder* (ADHD). These children show no delays in acquisition of motor, language, and other developmental milestones and no apparent deviance or delay in acquisition of basic skills until entering school. At that time, however, these children show problems in "getting organized" and in "processing language" (e.g., difficulty with complex constructions). Since their inattentiveness (deficits in controlled attention) affects complex linguistic processing but not acquisition of basic lexical and syntactic skills, then it seems reasonable to assume that these latter skills do not require conscious, attentive learning and therefore that their modularity or automaticity may be innate rather than acquired.

Overall, however, there is little empirical data to draw on in discussing merits of the acquired versus innate positions concerning mental modules. The work which we present below focuses on language (and, in particular, on lexical ambiguity) processing in young children, and is aimed at shedding light on the issue of whether or not the modularity of processing displayed by adults in lexical access has a developmental history

General Methodological Issues

The process under discussion here-lexical access of the meanings of ambiguous words-is first and foremost an unconscious perceptual process. Thus, tasks which are intended to be used to measure such processes should be known to be sensitive to this level of processing. If a task requires conscious introspection/analysis about the lexical-access process, or about the role of the lexical target in the sentence, it will, at best, be a distant and impoverished reflection of this targeted process. Similarly, if the task used to reflect the targeted process "taps" processing at a point temporally removed from the occurrence of the process, it too will only vaguely and indirectly, and perhaps incorrectly, reflect the nature of that process (see Neely, 1977; Prather & Swinney, 1988, for further discussion). Thus, it is critical that tasks be as temporally close to the target as possible (such tasks are typically referred to as *on-line* tasks), and they must require as little conscious introspection as possible about the target and its role in the sentence. In short, we want accurate tasks that add as little to the process under study as possible and tasks that are in a position to reveal temporally evanescent effects. There is no ideal task; all bring their own complications. However, there are clearly distinctions among usefulness of various tasks that do exist. Our review of the literature below and our own choice of tasks reflect these points.

Comprehension and Detection of Ambiguity by Young Children

There exist some studies of children's comprehension of ambiguity in the literature, but they tend to be studies involving the metalinguistic- and hence conscious-ability of children to detect linguistic ambiguity. Kessel (1970), in what may be the first modem research on children's comprehension of ambiguity, used a picture selection task to examine children's ability to detect ambiguities. In this, children were asked to pick the correct one that represented the meaning(s) of the word from a set of four pictures. Kessel argued that his data demonstrated that most children in kindergarten and first grade (the youngest age was approximate 6.3 years) could perceive lexically ambiguous sentences. Using a similar task, Shultz and Pilon (1973) found that their first-grade students only detected about 10% of the lexical ambiguities they were presented with. However, as has been pointed out (see, e.g., Evans, 1976; Wankoff & Cairns, 1987), there were a large number of methodological difficulties that prevent definitive establishment of precisely when lexical ambiguities are available to conscious introspection, at least from these experiments. In studies which closely link the ability to detect ambiguity to the development of Piagetian conservation skills in children, Wankoff and Cairns (1987), using a picture-choice task, discovered that their youngest children (kindergarteners, mean age 5.6) only detect a low percentage of lexical ambiguities in language, while third graders perform quite well on this task. Thus, by age 5 or so, children do not demonstrate behavior that would support a strong belief that they access multiple word meanings upon encountering a lexical ambiguity.

As noted above, however, the question of whether or not children can become consciously aware of polysemy is not at issue here. Rather, the essential question focuses on the nature of their (unconscious) perceptual processing of lexical ambiguities. There are two studies examining this issue with slightly more "on-line" tasks of ambiguity processing in young children that deserve comment. Evans (1976), using a word-monitoring task, asked children to monitor for a target word in a sentence and measured reaction time to detect the target word. These target words immediately followed an ambiguous word in the sentence. (Foss, 1970, and Foss, Starkey, & Bias, 1975, have demonstrated that reaction time to detect such a target word is a function of the complexity of the immediately preceding sentential material, in both children and adults.) In her study, Evans examined kindergarten and first-grade children (divided on the basis of having attained Piagetian-type conservation skills or not) and discovered that, overall, there was a main effect for the ambiguity variable (reaction times to monitor for words following an ambiguity were longer than for those following a nonambiguous control word). The increased reaction times following ambiguities were taken to indicate that the child's processing device was being forced to deal with more than one meaning, and hence performing the monitoring task was slower following ambiguities than controls. At first blush, this evidence appears to lend support to the innate (or, at least, "very early") modularity hypothesis. Since the time that this research was performed, however, it has been demonstrated that monitoring tasks are subject to a number of potential confounds that were not controlled for in this study (see, e.g., Mehler, Segui, & Carey, 1978; Newman & Dell, 1978), and, consequently, the interpretation of these results is not secure.

In another study of lexical access of ambiguity in children, Bowman (1979) used a picture verification task. In this work, a picture was presented during comprehension of the sentence and subjects (children age 6-7) had to make a decision about whether or not the picture was related to the sentence). Unfortunately, although Bowman's results were interpreted as supporting multiple access of meanings for the ambiguity, the data were merely suggestive rather than significant, and this, combined with the fact that her task required an attempt at conscious reflection/integration on the target of inquiry, suggests that these data, also, cannot help us in any absolute determinations of an answer to our basic question concerning innateness of modularity.

The Current Study

BACKGROUND

Thus, we are still left with the question of whether all (or only one) meanings of an ambiguity are accessed by very young children. The set of studies detailed below is aimed at providing more revealing, fine-grained evidence concerning what information is actually accessed by very young children when they encounter lexical ambiguities during sentence comprehension. Such work required development of a task that children could perform that was sensitive to both the automaticity and short time course of lexical access.

In research with adults, a cross-modal priming task that required either lexical decision or naming of a visual word in order to examine lexical-access processes on-line has proved to be quite useful in this regard (e.g., Swinney, 1979; Tanenhaus, Leiman, & Seidenberg, 1979). Since young children cannot read, it was decided to modify that task to include a picture priming rather than a word priming task. A number of experimenters (e.g., Carr, McCauley, & Sperber, 1982; Kroll & Potter, 1984; Vanderwart, 1984) have demonstrated that words reliably prime pictures, and thus the task is a promising one for subjects who cannot read. The essential characteristics of the task used with children were the same as that used with adults. The task, an on-line, cross-modal, sentence comprehension -picture priming (CMPP) task, was designed to allow evaluation of which meanings of an ambiguous word are available to children as they hear the word in a sentence context. Children were asked to make sentence-unrelated (this is important!) decisions about pictures which were visually presented at a point simultaneous with the offset of an ambiguity in a sentence they were listening to. Their task was twofold: (1) they were to listen to and understand the sentence. They were told that they would be tested often for sentence comprehension. And (2) they were told that a picture would be presented at some point while they were listening to the sentence, and that they were to decide as quickly as they could whether or not the pictured object was something they could eat. An important advantage of this task is that it does not require the child to try to link the picture to the sentence in any conscious way (and, indeed, due to the ratio of related to unrelated pictures throughout the experiment, such a strategy would hurt task performance). The relevant data using this task were the differences between reaction times on pictures that were and that were not preceded by a related word (in our case, an ambiguity) in the auditorily presented sentence. If the child accesses a particular meaning of the ambiguity, then reaction time on the "eat/no eat" task should be faster for a picture related to that meaning of the ambiguity than to the same picture when it is preceded by an unrelated word (e.g., replacing the ambiguous word with a different word in the same sentence). If the child accesses both meanings, then reaction times for pictures related to each meaning should, by the same argument, be faster than their respective controls. Thus, this picture priming task constitutes an on-line measure that can directly reflect activation of meanings for a word in a sentence, much like lexical-decision or naming tasks in the adult literature (see Swinney, 1984, for a review of assumptions in this type of work).[2] It might best be noted here that a great

[2]There is a small literature on a putative phenomenon known as "backward priming" (Kiger & Glass. 1983) which has been claimed by Glucksberg, Kreuz, and Rho (1986) to put in jeopardy the interpretation given for the cross-modal results

deal of pretesting concerning the type of decision to be used with children took place. "Something you can eat or not" was chosen as the task because children demonstrated quite definite ideas on the topic in pilot work, and because they could be trained to make this classification; in short, it worked.

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with adults. This deserves some brief comment here, although several more recent pieces of work demonstrate that the claims for backward priming are not supportable as presented (see, e.g.. Burgess, Tanenhaus, & Seidenberg, 1988; Prather & Swinney, 1988). In short, the claim is that the effect obtained by (for example) Onifer and Swinney (1981) is caused by the following: The appearance of the lexical-decision target item related to the contextually irrelevant interpretation of the ambiguity causes reanalysis of the ambiguity which has just been heard in the sentence (and for which only the contextually relevant interpretation was originally accessed, in this view) such that the "other" meaning of the ambiguity then gets activated, which then, in turn, helps the ongoing lexical decision (which started this effect) for that target. This claim hinges on results reported by Kiger and Glass (1983), who obtained an effect in the visual domain (only) of a lexical decision to a word presented initially for 50 ms by a semantically related word that followed such presentation 30 ms later. It is critically important to note that this effect was obtained only with these timing constraints (others were tried, but the effect was not maintained), only for visual-visual presentation (where modality interference effects are notorious), *and* that the effects obtained are far better described as a lessening-of-inhibition effect rather than any sort of priming effect. (To be convinced of that fact, look at the absolute RTs obtained by Kiger and Glass compared with normal lexical-decision RT. Additionally, look at the fact that in their Experiment 1, which contained a "neutral" control, no effect was obtained.) Importantly, many attempts to replicate this effect cross-modally have failed to find *any* evidence of such an effect, and the effect itself in the visual domain has also been remarkably resistant to replication (see, e.g., Prather & Swinney, 1988; Forster, personal communication). Now, Glucksberg et al. performed their experiment *assuming* that there was such a thing as backward priming. They did not, in any sense, provide a test of backward priming. Their results with nonwords are most easily interpretable as effects driven by prior material in the sentence which have nothing to do with the presence of any ambiguity. Further, a careful analysis of the post hoc control conditions run by Glucksberg et al. reveals that their effect seems to obtain clearly in only one of their experimental conditions. Finally, Burgess et al. (1988) have recently demonstrated that the Glucksberg results were a function of the particular conditions they chose. There is simply not sufficient space to give adequate argument about all of these, and other related, issues here. However, it is the case that the general interpretation of the overall results in the literature provided above (in the text of this paper) are secure, and are not susceptible to interpretation by a "backward priming" argument, at least given everything that is currently known about the issue.

Finally, note that the backward priming argument, even if it could have been mounted, would be much more difficult to argue for pictures and words (since we don't know how pictures are coded, and they would have to be coded the same manner as words to "interact in memory," as held by the backward priming argument). In short, this is not an argument that has any current empirical or logical support in terms of the work presented here.

PRETESTING AMBIGUITIES AND PICTURES

Preparation of the materials for the present research involved a good deal of pilot work to assure that both meanings of ambiguous words were familiar to our young subjects and to be certain that the pictures and sentences were easily understood by preschoolers. It was important to establish the children's level of conscious awareness of ambiguities in order to examine the question of whether or not they automatically access those multiple meanings during on-line processing. The procedures used to select materials are described briefly here.

In the first stage of materials preparation, 56 ambiguous words were pretested in three successive stages with 33 children between the ages of 4,0 and 5,6 (all enrolled at the Eliot-Pearson Children's School at Tufts University). Stage 1 involved asking children to give definitions for orally presented ambiguous words. This was done under the guise of a game. Once one definition was given, the child was asked if the word could mean anything else. The second stage of testing, done on a separate day, involved presenting each child with a description of an item for those meanings of ambiguous words that they had not produced spontaneously during stage 1 testing. So, for example, if a child did not spontaneously produce a definition of baseball bat for the word *bat* in stage 1, then in stage 2, the child would be asked, "What do you hit a baseball with?" Finally, in stage 3, for any meanings of ambiguous words that were not demonstrated to be familiar to the child in stages I and 2, a third session was scheduled in which the child was shown a picture of the item and asked to name it. From this initial work, 20 lexical ambiguities identified by all children at stage 1, plus 4 additional ambiguities know to all but one child at stage I and demonstrated to be familiar to that child under stage 2 testing, were chosen for use in the on-line studies described below.

In the next step of materials preparation, line-drawn pictures representing each meaning of each of the 24 ambiguous words, plus those of a number of other items (to be used for filler sentences), were created. The items and drawings were chosen so that approximately 50% represented edible objects. Each picture was tested for easy and quick recognition on a group of 10 children in the same age range as those participating in the major study described below. This step was done to validate that the pictures were easily identifiable representations of the word meanings. Subsequently, two sentential contexts were created for each of the 24 lexical ambiguities (as well as appropriate filler sentences), and this same group of 10 subjects was used to verify that these sentences were easily understood. Each child was asked to explain what each sentence meant, and sentences were rewritten according to a criterion of ease of understanding based on these children's responses.

Finally, the 56 sentences and accompanying pictures (see detailed materials description in the next section) were presented to 23 college-aged students as an initial pilot test of the cross-modal picture priming (CMPP) sentence comprehension methodology, and in an attempt to replicate effects found for adults with other on-line techniques. In this initial experiment, no effects of any type were discovered: mean reaction time was 489 ms to classify the pictures as edible or not, with no RT difference for either edible versus nonedible classifications or for ambiguity versus control materials. It was apparent from our analyses that floor effects were obtained with adults, and so the pictures were "degraded" by the simple procedure of presenting them with the experimental room lights on. Using this degraded condition, priming was obtained for classifying pictures related to each' meaning of the ambiguity for both of the contextual bias conditions, thus replicating results obtained for normal adults with cross-modal lexical-decision and naming studies. At this point it was decided that this methodology could be used to investigate children's access of meanings for ambiguous words in sentential context.

STUDY OF LEXICAL ACCESS FOR AMBIGUOUS WORDS IN YOUNG CHILDREN

The basic experiment with young children involved use of the CMPP technique briefly described above. We elaborate on the experimental design here in slightly more detail. In this study, subjects (the same group of thirty-three 4- and 5-year-olds used in the pilot work, but tested 2 to 11 months later) heard 56 sentences presented over headphones. Twenty-four of the sentences contained a lexical ambiguity placed in a semantically biasing context. Two different sentence contexts were written for each ambiguity: one biased toward the most frequent interpretation (version 1, experimental) and the other biased toward the least frequent interpretation (version 2, experimental). (Frequency of meanings was determined on the basis of the first definition given during stage 1 testing, described in the preceding section.) A second set of "control" sentences was written in which an unambiguous control word was substituted for the ambiguity in the same sentence frame (version 1 and version 2, control). This word was of the same frequency and length as the ambiguity (age 5 children's frequency norms were used; Carroll, Davies, & Richman, 1971), and was chosen so as to roughly maintain the meaning of the sentences. However, the word itself was not semantically identical to the meaning of the ambiguity. (See the Appendix for an example of the two sets of materials.) Thus, there was a total of four sentence conditions. To prevent repetition of the same ambiguity in different context conditions, four different scripts were prepared, each recorded on one channel of a reel-to-reel tape. The four sentence conditions were counterbalanced across scripts, so that each script included equal numbers of sentences for version 1, experimental; version 2, experimental; version 1, control; and version 2, control. Each ambiguous word was presented in just one sentence context in each script. Finally, a tone marker was placed on the unused (and unheard) channel of the tape for each of the 56 sentences; for experimental sentences, tone placement was always coincident with the end of the ambiguous or corresponding control word.

Each subject heard one of the four scripts at one session, and a second script at a second session 1 week later. The task presented to the subjects was to listen to and understand the sentences they were hearing because they would be asked questions about the sentences; in fact, after every third sentence, they were asked "yes-no" questions about the sentence they had just heard. The purpose of this,testing was to keep the subject's attention on the sentences. In addition, the children were told that they had a second task: At some point in the sentence, a picture would be displayed in front of them (via a tachistoscopic shutter attached to a slide projector, triggered by the tone on the audio tape) and the children were asked to decide as quickly as they could whether or not the presented picture was something they commonly ate. They indicated their decision by a choice button press. The same picture was always presented for each ambiguity-containing sentence and its control, and that picture was always something nonedible, i.e., always a negative decision for experimental sentences. (Recall that two sets of pictures were created, one for each of the two interpretations of the ambiguity.) For the nonexperimental filler sentences, pictures were presented that were not related to the sentence, and the pictures were selected for those sentences in a way that maintained roughly a 50/50 balance of edible-nonedible items.

Each of the four scripts was presented in conjunction with each of the two sets of pictures, thus creating eight experimental conditions. Each subject participated in two of these conditions: once with a sentence version containing the ambiguous word and with a picture related to one meaning of that ambiguity and once with a sentential version containing the control word along with the picture related to the "other" meaning of the (nonpresent) ambiguity. (Thus, in the latter case, the picture was not related to anything in the sentence.) These two test conditions were presented at least I week apart.

As mentioned earlier, reaction time to decide that a depicted object was edible was assumed to be a function of time to process the picture as well as a function of any possible priming that might occur from the ambiguity in the sentence. Priming could only occur if the relevant meaning of the ambiguous word in the sentence was activated so as to then provide some "prime" for processing of the picture. As mentioned earlier, both pictures and words have been demonstrated to provide similarity and semantic priming, both within-mode (picture-picture) and cross-modally (word-picture) (Vanderwart, 1984; Walls & Siple, 1987). Thus, any priming for decisions to pictures in the presence of the ambiguity compared with decision time for the same picture in the neutral control sentence is

TABLE 12.1. Priming scores (control - experimental) for all 33 children, in ms.

	Picture of:	
	Most freq.	Least freq.
Sentential bias:		
Most frequent	56**	27*
Least frequent	49**	23*

*p < .06.
**p < .02.

considered evidence of activation of that meaning of the ambiguity in the sentence.

RESULTS

The results are presented in Table 12.1 in terms of priming scores (RT for control minus RT for experimental conditions). As can be seen, there is significant priming for the most frequent interpretation of the ambiguity regardless of the biasing contextual material. There is also marginally significant priming for the least frequent interpretation of the ambiguity under all conditions of contextual bias.[3]

In examining evidence from studies with children, support or rejection of any hypothesis that encompasses a developmental argument typically requires careful scrutiny of data for important trends. Thus, rather than just concluding that these data somewhat weakly support an innate (or very early) modularity claim (i.e., exhaustive, context-independent access appears to be weakly defensible in these data), we decided to examine the data more closely from a developmental perspective.

The children were divided into two roughly equal-sized classes-a

[3]1t is important to note that the issues addressed in this paper all concern existence proofs-that is, proof of whether there is or is not any priming for "edibility" decisions for pictures related to each of the meanings of the ambiguity. For a large number of reasons, the magnitude of the priming effect is not interpretable. While the mean differences in reaction times which constitute priming do differ in magnitude, it is inappropriate to attempt to interpret these differences with respect to the issues at hand. One of the many reasons for this stems from the fact that the degree of relationship holding between each of the "related" pictures used to probe for activation of meanings of the ambiguity and the ambiguity itself were not equated (a difficult, if not impossible, task given the other constraints on materials in the design of this experiment). So, there may exist a priori differences between the degree of this relationship for these two conditions (primary and secondary). This and other sources of confound preclude any possible interpretation of the magnitude effects of the priming found here. Thus, the only appropriate interpretation of these data centers on the existence-proof aspect of these data-whether there is or is not priming- indicating activation of the various meanings of the ambiguity. For this reason, only priming scores are provided in this chapter.

TABLE 12.2. Priming scores (control - experimental) by age groups:

	Picture of	
	Most freq.	Least freq.
a. Younger 16 Ss (age 4.0 - 4.7), RT in ms		
Sentential bias:		
Most frequent	59**	8
Least frequent	54**	0
b. Older 17 Ss (ages 4.8 - 5.6), RT		
Most frequent	54**	47*
Least frequent	44**	46*

*$p < .05$.
**$p < .03$.

"younger" group of 16 children (ages 4.0-4.7 years) and an "older" group of 17 children (ages 4.8-5.6 years). Data for each of these groups were then analyzed separately, and the results can be seen in Table . 12.2. As is evident, these two groups perform quite differently.

The older group provides data that look remarkably similar to data for adults; picture decisions for pictures related to both interpretations of the ambiguity are primed, regardless of the contextual bias of the sentence. Certainly, a simple, straightforward interpretation of these data might be that these older subjects are experiencing context-free, exhaustive access of all meanings of an ambiguous word immediately upon hearing it in a sentence. Thus, it looks as though modularity for lexical access is in place at least by age 4.8 years.

The younger children's performance, however, is a different matter. It looks as though there is activation of *only* the most frequent meaning of an ambiguous word for these children at the point tested (immediately after hearing the ambiguity). Notice that this effect is independent of the contextual bias of the sentence; that is, context does not cause the less frequent interpretation of the ambiguity to be activated. Thus it might be claimed that modularity is evident in these youngest children insofar as modularity is defined as contextual impenetrability. However, it also appears that exhaustivity of access might not be a characteristic of young children's lexical-access routines!

There is, however, a plausible alternative interpretation. Research with both older children (10 year olds; Prather, Schmidt, & Marakovitz, 1988) and elderly subjects (e.g., Swinney, Zurif, & Nicol, 1989) has demonstrated that while both of those populations exhibit exhaustive lexical access, access to both primary and (when examined with the elderly) secondary meanings of words is more protracted than access times found for the more typically examined college student population. Similarly, work by Simpson & Lorbach and Simpson & Foster (1983) (1986) argues strongly for a change from automatic to attended processing as children get older, and for the existence of changes in the apparent speed of initial activation with increases in age. It is not clear why access is slowed in these groups. Slowing may be secondary to familiarity (10-year-olds have less familiarity with words and particularly with reading than college students) or to processing speed (older individuals have slower reaction times and slower basic word-finding skills than young normals). In any case, however, lexical access is slowed for young and old individuals relative to college age individuals.

Given this perspective, it seems plausible that the lack of priming for the secondary (less frequent) meaning of ambiguous words for 4-year-olds represents a slow "rise time" of availability to the secondary meaning relative to their older counterparts. By the use of "rise time" we are suggesting that all information stored with a lexical item may be made available for further processing by a sentence comprehension device, but all such information may not become available simultaneously. Thus, while the information related to the more frequent meaning of the ambiguity may be made immediately available upon access for further processing, it may be that, for younger children, it takes time for information related to secondary or tertiary meanings simply to become available. Note that this is not a state of affairs that would argue against modularity: The issue of modularity revolves around demonstrations of information encapsulation and contextual impenetrability. All of our subjects, younger and older, demonstrated information encapsulation. Thus this is simply an issue about the nature of information availability from the lexicon for other processes.

Interestingly, connectionist accounts of access have rise time built naturally into their models, as the frequency of the meanings should control the order of information availability. It may be, in fact, that even for college students there are different rise times for different information sources in the lexicon, but that their processing is simply so rapid and automatic that our on-line techniques have not been sufficiently sensitive to pick up the slightly different rise times that do exist (see Simpson, 1984, for experimental work which did find evidence for this position).

The pattern of activation found here for young children has also been found both in dyslexic readers and in Broca's aphasics. It is well known that "disordered" populations often mimic developmental effects, and these may both be examples of that fact. In the case of dyslexics, Swinney (1982) found slow rise times for phonetic priming (see Seidenberg & Tanenhaus, 1979, for more about phonetic priming) as compared with semantic priming. In the case of Broca's aphasics, the exact same pattern of results (from a very similar study) as found for these younger children has been found for agrammatic subjects (Swinney, Zurif, & Nicol, 1989). Clearly, whether or not appeal to the concept of "slow rise time" is the proper explanation for these data is an empirical matter to be determined by further investigation. Obviously, proof of this issue of rise time (but not that of modularity) will hinge on finding priming for these secondary meanings slightly "downstream" from those for the primary meanings. This work is under way at the present time.

Overall, the results of the present research with preschoolers are most consistent with a modular view of the lexical-access system, where exhaustive, context-free access is the rule rather than the exception, even for relatively young children. Certainly, these data can support the notion that for children at least as young as age 4.0 one finds evidence for the modularity of lexical access, and these data strongly suggest that there is a frequency effect governing the time course of activation of information from the lexicon.

Summary

In these studies with young children, we have found no evidence suggesting that, at any point at least as young as age 4.0 years, lexical access is anything but a modular, informationally encapsulated, contextually impenetrable process. However, we have evidence suggesting that under about 5 years of age, access is not mature in children, leading to more frequent entries being made available before less frequent ones. It is argued, therefore, that different sources of information may be available at different times from the lexicon, but that there is not any evidence supporting a developmental growth of "modularity," even as young as age 4.0 years. Thus, it is reasonable at this point to assume that modularity in lexical processing may be an innate characteristic of human language performance.

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Appendix

SENTENCE VERSIONS (BIAS) FOR TWO OF THE TWENTY-FOUR AMBIGUITIES USED IN THE STUDY. THE AMBIGUITY AND ITS CONTROL ARE GIVEN IN EACH SENTENCE (/).

A. Bias toward most frequent interpretation:
  1. "The nearsighted girl put her glasses/bundles on the table."
  2. "The baseball player picked up the bat/cap lying in the park."

B. Bias toward least frequent interpretation:
  1. "The thirsty girl put her glasses/bundles on the table."
  2. "The birdwatcher picked up the bat/cap lying in the park."