Accessing Meaning vs. Form at Different Levels of Comprehension Skill

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Abstract

We examined adult and 10-13 year old skilled and average comprehenders' representation of spoken sentences. In immediate probe tasks, skilled adults were better than average adults at accessing word order information, but they were *poorer* at accessing sentence meaning. After hearing a text, skilled adults were more accurate than average adults in recognizing meaning, but they were *less* accurate in recognizing the wording of test sentences. Speeded speech increased the differences between skill groups *more* for memory for wording than for memory for meaning. The results suggest that comprehenders compute representations of surface form and meaning independently and simultaneously. These representations compete for attention.

Introduction

Formal models of language comprehension must specify the nature of the hypotheses that comprehenders form about utterances and the mechanisms they use to form them. One of the most striking facts about comprehension is the speed at which comprehenders form these hypotheses. For example, subjects can shadow speech at delays as short as 250 ms and still be sensitive to semantic context (Marslen-Wilson 1975).

The nearly immediate effect of semantic information seems to rule out models in which comprehenders compute successively more abstract representations serially. Highly skilled comprehenders, however, may be able to perform these computations rapidly enough for some aspects of meaning to have immediate effects. If *serial models* are correct, reducing the time that is available for language processing should decrease comprehenders' sensitivity to semantic properties (French 1981; Stine, Wingfield, & Poon 1986), particularly for less skilled comprehenders who may not perform lower level computations as efficiently as skilled comprehenders (cf., Daneman & Carpenter 1980; Lesgold & Perfetti 1978).

A second interpretation of the speed of comprehension is that comprehenders map acoustic information directly onto a relevant discourse representation without any independent representation of sentence information. One *direct model* asserts that comprehenders use expectations based on prior knowledge to by-pass the computation of sentence structure (Bower, Black, & Turner 1979; Schank & Birnbaum 1984). Thus, understanding a sentence is more a matter of confirming expectations than forming syntactic hypotheses. On this view, less skilled comprehenders understand text less well because they fail to recognize the schemata that underlie texts (Schank 1982). If "schema perception theory" is correct, sentence structure should have a smaller role as comprehension skill increases.

Another direct model acknowledges the use of syntactic information during comprehension, but does not distinguish its role from that of discourse-level information. For example, a decrease in either syntactic or semantic constraints may cause comprehenders to build a new structure for subsequent words. Such a "processing shift" might cause comprehenders to forget the surface form and meaning of previous material. According to this model, less skilled comprehenders use sentence- and discourse- constraints less effectively than more skilled comprehenders (Gernsbacher, Varner, & Faust 1990). This model predicts that surface properties of sentences will have a larger role as comprehension skill increases.

A third interpretation of the immediate effects of semantic information emphasizes the on-going interactions between representations at different levels. According to the *representational model*, comprehenders compute form and meaning simultaneously and independently. Access to semantic vs. syntactic constraints depends on how comprehenders shift attentional resources between representations at different levels. Using a dual discourse-judgment and speaker-monitoring task, Townsend & Bever (1991) found that increased sentence-level constraints reduced the time to detect a change of speaker, but increased discourse-level constraints increased it. Thus, making a discourse-level task easier decreases accessibility to acoustic information. Other studies have shown a

functional distinction between representations at different levels (Townsend 1983; Townsend, Ottaviano, & Bever 1979; Townsend & Ravelo 1980; Townsend & Saltz 1972). For example, Townsend & Bever (1978) found that the position of *up* in fragments like *Pete called up his aunt each...* versus *Pete called his aunt up each...* influences probe recognition for UP more in some clauses than in others, depending on the discourse-level role of the clause. In those cases in which the position of the target word had a large effect, subjects were slower to judge that USING THE TELEPHONE is synonymous with the clause. These results suggest that representations of word order and meaning compete for attention. Some aspects of comprehension skill may depend on how comprehenders focus attentional resources on already computed representations.

Hypotheses

We tested serial, direct, and representational models by comparing skilled and average comprehenders at two age levels. We assessed their access to the meaning and form of sentences in immediate and delayed tests.

Two tasks assessed comprehenders' immediate representation of isolated sentences. In a "meaning probe" task subjects heard a sentence fragment that ended just before the end of a clause, and then a short verb-object phrase (Townsend & Bever 1978). The subjects' task was to say as quickly as possible whether the phrase was similar in meaning to the sentence fragment. In a "word probe" task subjects also heard a sentence fragment, but then a single probe word. Now the task was to say whether the probe word had occurred in the sentence fragment. By varying the location of the target word, we assessed subjects' sensitivity to word order.

If average comprehenders' inefficient lower-level computations prevent them from computing meaning, their deficits will be greater on the meaning probe task. Since there is no linguistic context to activate a schema, a schema perception model predicts that skilled and average comprehenders will perform similarly. If average comprehenders engage in more processing shifts than skilled comprehenders, they should access meaning and word order less effectively than skilled comprehenders. If representations of form and meaning compete for attention, comprehenders who show increased access to word order will show decreased access to meaning, and vice versa.

Two tasks assessed memory for the form and meaning of sentences in text. Subjects heard texts at two different speeds. After each text, subjects took two tests that assessed their recognition of the wording and meaning of sentences.

If average comprehenders inefficient lower-level processes normally disrupt their computation of meaning, a faster rate of speech will increase these deficits. If the presence of a linguistic context allows skilled comprehenders to by-pass syntactic processes, skilled comprehenders will make more errors than average comprehenders on recognizing details about word order. If average comprehenders are less sensitive to constraints of any type, they will make more errors than skilled comprehenders on recognizing the form and meaning of sentences from text. If comprehenders can compute meaning independently of form, a faster rate of speech will not impair their recognition of meaning.

Method

Subjects

The "skilled adults" were twelve college students with Verbal Scholastic Aptitude Test scores of at least 610. The "average adults" were twelve college students with VSAT scores of 400-560. The "skilled children" were twelve 10-13 year old school children who were reading at least one grade level above their current grade, based on the Verbal Standardized Achievement Test. The "average children" were twelve 10-13 year old children who were reading within one grade of their current grade. Skilled and average subjects within age groups were matched on quantitative achievement test scores. All subjects spoke English as their first language, and all were right-handed. Half the subjects in each group were male and half had no left-handed relative.

Procedure

The subjects were tested individually. All subjects received the text memory task before the immediate probe tasks. The order of presentation of the immediate probe tasks was counter-balanced. Matched subjects received identical experimental materials and presentation orders.

Immediate Representation. For the meaning probe task subjects said as quickly as possible whether a phrase probe was consistent or inconsistent with the meaning of the sentence fragment. For the word probe task subjects said as quickly as possible whether a word probe had appeared in the sentence fragment. Two sets

Table 1
Mean Response Times (ms) on Meaning Probe Task

	Skilled	Average	Difference
Adults	2230	2124	-106
Children	2267	2808	541

Table 2
Mean Response Times (ms) on Word Probe Task

	Adults			Children		
	Skilled	Average	Mean	Skilled	Average	Mean
Early Target	1561	1446	1504	1551	1837	1694
Late Target	1800	1411	1606	1451	1951	1701
Early Target Advantage	239	-35	102	-100	114	7
Group Mean	1681	1429		1501	1894	

of six lists of materials were prepared. Subjects received a list from one set for the meaning probe task and a list from the other set for the word probe task. Each list appeared as both meaning probe and word probe across subjects. Each list had six critical positive trials in which the fragment ended before the last word of an initial clause. There were 18 trials that either interrupted the final clause or required a "no" response.

The critical fragments were 9-11 words long. These fragments contained a word that could occupy two different positions without changing the fragment's meaning. At least two words separated the "early" and "late" positions of the target word and the average separation was 2.9 words. An independent group of college students (N=31) rated how similar the meanings of the phrase probes and the fragments were. On a five point scale, the average ratings were 3.65 for positive trials and 1.23 for negative trials.

A male speaker recorded the fragments, and a female speaker recorded the probes. Each fragment ended with a 50 ms, 500 Hz tone. The tone signalled the end of the fragment and triggered a Hunter ms timer that stopped with the subject's vocal response. The probe began 333 ms after the tone. Half the subjects heard the fragments and probes in the right ear, and half heard them in the left ear.

Memory Representation. Each subject heard one narrative and one expository text. The texts for adults were selected from a Scholastic Aptitude Study Guide, and those for children from the McCall-Crabbs Standard Test Lessons in Reading. The texts were 550 words long for adults and 200 words long for children. Half the subjects in each group heard the texts in the right ear, and half in the left. Each subject heard one text at a "normal" rate and then one at a "fast" rate. The presentation rates were 3.1 versus 6.2 words per sec for adults and 2.2 versus 4.4 words per sec for children. The tapes for the speeded conditions were prepared by a speech compression system that does not change pitch. Following each text, subjects received two tests. The first test consisted of two-choice meaning recognition questions such as *The writer says that the fog was (a) rising and falling, or (b) like a wall.* The second test consisted of sentences to be classified as having appeared or not appeared in the text. Half of these involved changes in the wording of a text sentence without changing its meaning (Sachs 1967), as in *The carrier's deck...* vs. *The deck of the carrier...* Distractor items were semantically plausible for the text. Each test had 12 items for adults, and 6 items for children. Test items were presented at the "normal" rate of speech.

Results

Immediate Representation. Tables 1 and 2 present the average response times for positive initial clause trials on the immediate probe tasks. Errors occurred on 1.7% of the trials for both tasks. Response times for these trials were replaced by the cell means for correct responses. Tables 1 and 2 show that average adults respond faster than skilled adults on both tasks, but that these skill differences are reversed for children. The skill by age interaction was significant, F (1, 44) = 10.4, $p < .01$. These results disprove the claim that linguistic contexts cause skill differences. They also disprove the claim that average adult comprehenders access words, meaning, or both, more slowly than skilled adults.

The size of the response time advantage for early targets over late targets assesses sensitivity to the left-to-right order of words in the immediate representation of sentences (Townsend & Bever 1978). The Early Target Advantage in the third row of Table 2 suggests that adults overall are more sensitive than children to the left-to-right order of words, that skilled adults are more sensitive than average adults, and that average children are more sensitive than skilled children. The interaction between age, skill, and target position was significant, F (1, 44) = 4.83, $p < .05$. Assuming that children as a whole are less skilled comprehenders than adults, it is clear that there is no direct relationship

Figure 1A
Adults' Errors on Memory for Text

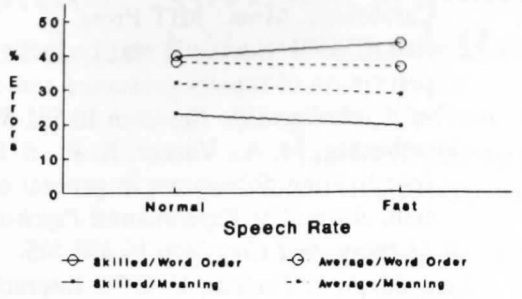
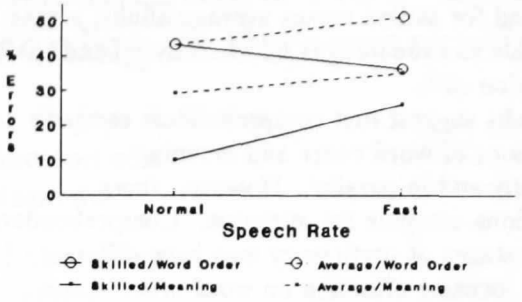


Figure 1B
Children's Errors on Memory for Text



between comprehension skill and immediate access to surface form. However, access to meaning (Table 1) and the Early Target Advantage (Table 2) are related inversely: When a group quickly accesses meaning, it has poorer access to word order, and vice versa.

Memory Representation. Figures 1A and 1B show the percentage of errors on memory for word order, shown with circles, and memory for meaning, shown with dots. Errors were more frequent for word order recognition (44%) than for meaning recognition (27%), F (1, 44) = 55.7, $p < .001$. Skilled comprehenders, shown with solid lines, made fewer errors overall than average comprehenders, shown with dashed lines, (30% vs. 37%), F (1, 44) = 5.86, $p < .05$. However, Figure 1A shows that skilled adults actually made more errors than average adults in recognizing word order changes.

Figure 1A shows that the fast rate decreases meaning recognition errors equally for skilled and average adults. Figures 1A and 1B show that the fast rate impairs performance more for meaning recognition than for word order recognition only for skilled children. The interaction between age, skill, task, and rate was significant, F (1, 44) = 4.57, $p < .05$. The results for skilled adults suggest that reducing the time that is available for comprehension can improve access to more abstract levels of representation.

Discussion

As expected, skilled comprehenders' memory for meaning was better than that of average comprehenders. However, there were several cases in which average comprehenders did better than skilled comprehenders. These results present difficulties for popular views about the organization of language comprehension processes.

Serial models claim that comprehension involves the use of shared processing resources to construct representations at successively higher levels of structure. Less skilled comprehenders understand less well because they have fewer of these resources. Serial models predicted that the fast speech rate would increase the size of skilled comprehenders' advantage over average comprehenders more for recognition of meaning than for recognition of word order. This prediction followed from the serial assumption that computations of meaning depend on first computing a syntactic representation that is sensitive to word order. The serial prediction was not confirmed: the only case in which the fast rate increased skilled comprehenders' advantage was in children's recognition of word order. The fast rate actually reduced the size of skill differences for children's recognition of meaning. Thus, skill differences do not depend on limitations in the resources that are available for serially-ordered computations.

A schema perception model (Schank 1982) claims that as comprehenders learn more about the world, they map linguistic information directly onto memory schemata without determining sentence structure. According to this model, skilled comprehenders should have done more poorly than average comprehenders on remembering the syntactic details of sentences in text. Our text memory results confirmed this prediction only for adults, not for children. In addition, skilled and average comprehenders should have performed similarly on the immediate probe tasks, which provided no linguistic context to activate a schema. We found several differences between skilled and average comprehenders in immediate probe tasks.

The view that skilled comprehenders use sentence and discourse constraints more effectively than average comprehenders predicted that skilled comprehenders would access word order and meaning faster and more accurately (Gernsbacher, Varner, & Faust 1990). We found that skilled children recognized the wording of sentences from text better than average children did, and they responded faster overall on immediate tests of meaning. However, skilled children were less sensitive

than average children to the order of words on the immediate word probe task. Since all of these results were reversed for skilled versus average adults, access to word order and meaning is not directly related to comprehension skill.

Our results suggest that comprehenders compute representations of word order and meaning independently and in parallel. However, those representations compete for attention. Comprehenders at different stages of proficiency may have different "habits" for focusing attention on word order versus meaning. The most salient results that support this model are:

Independent Computations. The fast rate reduced skilled adults' errors on recognition of meaning and increased their errors on recognition of word order. This result suggests that their computations of meaning do not rely on computations of word order.

Competition. On immediate tests skilled adults showed greater sensitivity to word order than did average adults, but they were slower than average adults in accessing meaning. This result suggests that focusing on word order draws attention away from sentence meaning, and vice versa.

Proficiency. Children also showed an inverse relation between access to word order versus meaning, but the direction of these skill differences was opposite that for adults. Skill in childhood involves an immediate focus on sentence meaning, but skill in adulthood involves an immediate focus on word order.

This model differs from previous models by distinguishing different kinds of representations and different kinds of processing resources. It also differs from the modular view that distinct physiological processes prevent syntactic and semantic processes from sharing both information and processing resources (cf., Fodor 1983).

Acknowledgement

This research was supported by NIE G-79-0040, NSF BNS-8120463, and the Separately Budgeted Research Program, the Sabbatical Leave Committee, and the Institute for Critical Thinking at Montclair State College. We are grateful to Marcia Johnson and Princeton University for providing office space during the preparation of this report.

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