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# Identification of written discourse topics by structure coherence and analogy strategies: General aspects and individual differences

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## Abstract

Categorically structured informative texts exhibit their discourse-topic in the beginning. When asked what the text is about, the skilled reader would deeply process the first proposition and skim through the rest for disconfirmation. S/he will, therefore, perform poorly on incoherent texts whose discourse-topic is displaced. Gifted and normal high-school students from a high socioeconomic neighborhood correctly identified more topics in coherent than in incoherent texts (Experiment 1). Low socioeconomic status subjects performed more poorly than the high socioeconomic status subjects on coherent texts, but better on incoherent texts (Experiment 2). Analogy improved performance on coherent texts among low socioeconomic status subjects, who came from academic classes, but did not affect performance on incoherent texts. Experiment 3 studied discourse-topic identification of schematically organized texts by low socioeconomic status subjects, and found that analogies impaired it. The results are discussed in terms of the distinction between general comprehension and text-specific strategies.

## 1. Introduction

An essential aspect of text comprehension is the identification of the topic of the discourse. The present study tackles questions concerning strategies of informative text comprehension. The major function of an informative text is to convey information in the most economical way. In this respect it differs, for example, from the literary text, whose distinctive function is aesthetic. One type of informative text, called categorical, is organized like a taxonomy. Its principle of organization is similarity (Giora, 1985b). Such a text is highly redundant: Each of its propositions repeats information shared by the rest, while at the same time adding new informa-

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tion. The text's shared information is its discourse-topic, on which the whole text is a comment (see detailed description later). The other type, called schematic, is organized in terms of spatial and temporal contiguity. Unlike the categorical text, which requires abstraction in processing, the schematic organization relies on previous experience with spatial-temporal relations (see, e.g., Mandler and Johnson, 1977). Our major interest here concerns processing strategies of categorically organized informative texts.

What does a reader do while reading an informative text? Two possible types of processing strategies come to mind: One that is text specific, and another that relies on general cognitive procedures. The distinction between task- (text-) specific and general cognitive processes is a crucial distinction in cognitive psychology. Several researchers suggest that exposure and practice lead subjects to form task-specific strategies. Consequently, skilled and less skilled processing are qualitatively different. Less skilled processing is slow, error-prone, and effort consuming, while skilled processing is fast, relatively error free and requires only minimal effort (Ackerman, 1988; Anderson, 1983; Navon and Gopher, 1979; Shiffrin and Schneider, 1977; Schneider and Shiffrin, 1977). Task-specific strategies usually rely on the probabilistic structure of the domain: They are best at dealing with typical cases but become less appropriate as the case deviates from typicality. For example, connectionist theories of skill acquisition show that the practiced strategies have properties similar to regression equations in the sense of being tuned to the most likely or average situation (e.g., Stone, 1986).

From the considerations above we suggest that a major candidate for text-specific strategy relies on *coherence-structure*. Structurally, a coherent informative text is one that begins with its generalization, which is its *discourse-topic*. The first proposition of the text is thus a summary of what the text is about (e.g., Giora, 1985b; Giora and Shen, 1994). The discourse-topic, thus, serves as the text title, and it best represents the whole text. Cognitively, it functions as the text's point of reference relative to which all oncoming propositions are assessed and stored. The oncoming propositions which are related to the first, discourse-topic proposition are ordered along the informativeness axis. Thus, the text begins with its least informative message. The oncoming propositions gradually increase the informativity of the text, while repeating information in the initial position (Giora, 1985b, 1988). Consider the following paragraph:

"It has often occurred in the history of SCIENCE that an IMPORTANT DISCOVERY was come upon by CHANCE. A scientist looking into one matter unexpectedly came upon another which was far more important than the one he was looking into. Penicillin is a result of such a discovery."

The text above begins with a generalization which presents the set of properties shared by all the propositions in the text: Scientific (1), chance (2), discovery (3), of some importance (4): The second proposition shares this set but adds another property: the relative importance of the scientific chance discovery. The third proposition repeats all the aforementioned properties while adding another one, the discovery of

penicillin. The mention of the discovery of penicillin is a specific instance of the discovery of important scientific chance discoveries. Its mention eliminates other alternatives that can be included in the category.

A coherent text is best adapted to our cognitive system. It is structured like a Roschian category, beginning with the proposition that reflects the redundancy structure of the text and ending with the most marginal one (Giora, 1985b, 1988). Readers probably make use of coherence-structure by forming appropriate strategies. Previous work (Gernsbacher, 1990; Gernsbacher et al., 1990; Giora 1985a,b) has shown that readers comprehend coherent texts more easily or rapidly than less coherent ones. The present study focuses on a single, global measure of text comprehension which should be most sensitive to strategies based on coherent structure: the identification of the text's discourse-topic.

What strategies will be adopted by skilled and less skilled readers when required to extract the discourse-topic of a paragraph? Given that a skilled reader is familiar with coherence structure, even unknowingly, an extremely economical processing for her would be to treat the first proposition as the discourse-topic and superficially skim throughout the rest of the text for disconfirmation. Such a strategy allows for only the first proposition to be deeply processed (as attested by Haberlandt, 1980). The rest of the passage may be read only to make sure that it is semantically related to the first proposition. A less skilled reader, on the other hand, is probably less familiar with coherence-structure. S/he is therefore expected to use general comprehension strategies. Gernsbacher and her associates (Gernsbacher, 1990; Gernsbacher et al., 1990) have described such strategies. They suggested that subjects form a representation structure during comprehension. The first proposition is used to lay the foundation for the structure while additional information is mapped into that structure. This general comprehension strategy is common to the comprehension of audiotively presented material, cartoon-stories and texts. When applied to texts, it makes readers carefully read all of the text when asked to state its discourse-topic.

Another obvious candidate for a general cognitive strategy in text comprehension is analogy. Analogy constitutes an exemplification from a distant domain. It involves mapping of relations from the source to the target domain (Gentner, 1983). The major thrust of cognitive research into analogies shows that analogies are functional in problem-solving (Sternberg, 1977), explanation (Gentner, 1983), theory formation (Gentner, 1982; Rumelhart and Norman, 1980) and constitute the best measure for general intelligence (Carpenter et al., 1990; Spearman, 1927; Sternberg, 1985). However, despite its contribution to problem solving, we suggest that in text comprehension the introduction of analogy might be harmful, since it constitutes a digression from the general discourse-topic under discussion. Though the relation conveyed by the analogy is relevant to that topic, the domain by which this relation is exemplified is irrelevant. In order to benefit from analogy, the reader must abstract the relation while disregarding the other features of the domain. Giora (1993) compared texts with and without analogies, and showed that analogies interfered with understanding.

Since skill is expected to affect subjects' use of coherence-structure strategies, we also expect skill differences in analogy effects. Skilled readers, who skim through

most of the text, are not expected to be greatly influenced by analogies. Support for this hypothesis comes from recent research on metaphor reception. Steen (1994) showed that readers pay less attention to metaphors in a journalistic (informative) text than in a literary (non-informative) text. Glucksberg and McGlone (1992) demonstrated that when readers do not have time, they do not access all that is available. However, we predict that readers who use general comprehension strategies and read the text carefully will be influenced by analogies. As digressions, analogies may cause such readers to shift from the current text representation to a new one. Such shifts interfere with the original representation of the text and result in forgetting, and consequently in poor comprehension (Gernsbacher, 1990). Less skilled readers, who are likely to use general comprehension strategies, may or may not be good comprehenders. When the less skilled reader is a good comprehender, s/he may profit from analogies. When s/he is not, analogy would probably result in poorer discourse-topic identification.

We selected subjects that differ in their text comprehension skills on the basis of their socioeconomic status (SES). Our choice was partly based on the (definitional) association between parent educational level and SES.<sup>1</sup> Subjects' comprehension ability was operationalized as their class academic level. The justification for this choice was that in Israel, high-school students are assigned to classes mainly on the basis of their past junior high school academic achievements and group IQ tests. Both of these entrance criteria are highly correlated with reading comprehension. For example, Meiran et al. (1990), Meiran and Fischman (1989) and Meiran et al. (1995) administered a group intelligence test to junior and high-school subjects. They found that the reading-comprehension subset had the highest loading on the general-intelligence factor of their battery.

Our selection of neighborhood was based on the SES statistics provided by the General Bureau of Statistics (State of Israel, General Bureau of Statistics, 1987). The Bureau divides the country into 'statistical regions' such that in each, SES is more or less homogeneous. Our high SES subjects came from a Tel-Aviv neighborhood which is divided into eleven statistical regions, very similar to one another. The low SES subjects, on the other hand, came from a working-class satellite town of another city. This town is divided into seven statistical regions, also similar to one another.

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<sup>1</sup> According to Smootha (1993), the population in Israel is divided between the poor (about 15%), the working class (about 25%), the middle class (about 45%), the upper middle class (about 15%) and the elite (less than 1%). This means that Israel is basically a middle class society.

This stratification is highly related to ethnicity. The population making up the poor and the working class are mostly of oriental origin-mizrahim (people whose parents immigrated to Israel from the Middle East and Africa). Middle class population is of both western origin-ashkenazim (people whose parents immigrated to Israel from Europe and America) and oriental with a slight advantage to ashkenazim. The upper middle class and the elite are basically ashkenazim.

Though ashkenazim and mizrahim share the same western oriented culture, they differ in their original subcultures and education. Among academic high school graduates, about two thirds are ashkenazim. In contrast, among nonacademic high school graduates, about two thirds are mizrahim.

In our research we associate socioeconomic status (SES) and skill rather than ethnicity and skill, because it is SES that determines the amount of exposure to texts. Despite the close relationship between SES and ethnicity, it is exposure to texts rather than ethnicity that affects skill.

In order to compare the two neighborhoods we averaged the statistics across their regions. In every case, there were no overlaps in region statistics between the two neighborhoods. The two differ in many respects, such as percent of white-collar workers (40.3% versus 23.5%), people holding academic degrees (16.4 versus 4.7%), median schooling years (12.5 versus 11.7) and the bureau general SES index (1.14 versus 0.19).

We predict that high SES subjects, who are skilled informative texts readers, will rely more heavily on the coherence structure/skimming strategy compared to low SES subjects. High SES subjects are, therefore, expected to perform better on coherent texts. However, when texts are made incoherent by displacing their first propositions, high SES subjects are expected to perform more poorly compared to low SES subjects. This prediction stems from our assumption that using the skimming strategy described above is likely to result in erroneous discourse-topic identifications in incoherent texts. Furthermore, we predict that subjects' academic ability will affect their gain from analogies in the case of low SES subjects but not in the case of high SES subjects. As detailed earlier, high SES subjects, who usually employ the skimming strategy, are less prone to be influenced by analogy, compared to low SES subjects, who are unlikely to skim. Specifically, when subjects use the general comprehension strategy described by Gernsbacher (1990), they use the first proposition to lay the foundation for the mental representation. If the first proposition is the discourse-topic (when texts are coherent), and the subjects are skilled comprehenders, they are unlikely to be distracted by analogies. However, if the text is incoherent and/or the subject is a less skilled comprehender, analogies are expected to interfere with topic identification.

## **2. Experiment 1**

Experiment 1 tested subjects from the high SES neighborhood. Two groups of subjects were tested, who differed in their academic ability. One group included subjects from classes for gifted students. The other group included subjects from normal classes that prepare students for the national matriculation examinations. In that respect, our normal academic ability subjects probably belong in the upper middle portion of the population. The subjects were presented with four different texts. Each text was produced in four versions, formed by the crossing of two independent factors: Text coherence (discourse-topic in the beginning/end) and exemplification (analogical/relevant example). Each subject read the four texts so that s/he was exposed to all version types. Note that different subjects received different combinations of versions and texts. For example, the text on scientific discoveries, presented earlier, was given to some subjects with an analogy and a coherent structure, to other subjects with analogy but incoherent structure, yet others were presented with this text coherently structured but with a relevant example, and the rest read an incoherent version of the text that contained a relevant example. Furthermore, the order of exposure to texts and versions was counterbalanced. In this way, each condition (version) was evenly represented by all the four texts, which ensured control over text and order of exposure.

## 2.1. Method

*Design:* A three way factorial mixed design with academic level (normal vs. gifted) as a between-subject factor and structure coherence (coherent/incoherent) and exemplification (analogical/relevant example) as within-subject factors.

*Subjects:* The subjects were 169 senior high school students. 126 of the subjects (68 females) were students of ordinary biology and mathematics classes. The remaining 43 subjects (9 females) came from special classes for the gifted. Overall, six classes participated in the experiment, three (one gifted) of the 10th grade and three (one gifted) of the 11th grade.

*Texts:* Four texts were used, each of which appeared in four versions. Two versions were coherent and two were incoherent. Coherent texts contained the discourse-topic as their first proposition. Incoherent texts contained the same discourse-topic but it did not appear in initial position. The coherent versions differed in that one included an analogy while the other contained a relevant example instead. The same was true for the incoherent versions. Slight stylistic changes were made to ensure the smoothness of the passages. Consider the following example (and see also Appendix):

### **Coherent conditions:**

“It has often occurred in the history of science that an important discovery was come upon by chance. A scientist looking into one matter unexpectedly came upon another which was far more important than the one he was looking into.”

*Relevant example condition:*

“Penicillin is a result of such a discovery.”

*Analogy condition:*

“Such scientists resemble Saul who, while looking for donkeys, found a kingdom.”

### **Incoherent conditions:**

“A scientist looking into one matter, unexpectedly comes upon another which was far more important than the one he has been looking into.”

*Analogy:*

“Such scientists resemble Saul who, while looking for donkeys, found a kingdom.”

*Relevant example:*

“Penicillin is a result of such a discovery.”

*Both continued with:*

“It has often occurred in the history of science that an important discovery was come upon by chance.”

*Materials:* The materials contained four booklets of eight pages each, consisting of four informative texts. Each booklet contained the two coherent texts followed by the two incoherent texts. Within the two coherent texts in half of the booklets, the texts containing analogies came first while those containing examples came later. The same was done for the two incoherent texts. The four possible orders were combined with four possible arrangements of the four texts used, formed by a Latin

square. The four booklets thus contained the following combinations of texts and arrangements (A, B, C, and D stand for texts):

1. coherent: analogy (A), example (B) / incoherent: analogy (C), example (D).
2. coherent: analogy(D), example (A) / incoherent: example (B), analogy (C)
3. coherent: example(C), analogy(D) / incoherent: analogy (A), example (B).
4. coherent: example(B), analogy (C) / incoherent: example (D), analogy (A).

Each text was immediately followed by a single multiple choice question placed on a separate page. The distractors in the question were systematically formed such that one was an overgeneralized description of the discourse-topic, one was too specific (subordinate), one was the correct answer and one was at the same level of generalization as the correct answer but was incorrect. This last distractor, referred to as ‘basic-level distractor’ was different for texts containing analogies as opposed to those containing relevant examples. In the former, this distractor was a paraphrase of the analogy. In the latter, it was a paraphrase of the example. The location of the ‘correct’ distractor was randomly chosen, but was kept the same for the same text. The following is an example of a multiple choice question regarding the relevant example versions of the text that appeared above:

“What is the topic of the passage you have read? What is it about?”

1. “Chance discovery”. (over-generalization)
2. “An example of chance discovery”. (subordinate level)
3. “Scientific chance discovery”. (correct)
4. “A scientist came upon an important discovery by chance, while he was looking for another”. (basic level)

*Procedure:* Subjects were tested in groups. The four booklets were distributed in a serial order, such that the first subject received booklet 1, the second booklet 2, etc. and the fifth received booklet 1 again and so on. We explained the assignment to the subjects. We also told them that the test measured text comprehension. Attempts were made to ensure the cooperation of the subjects. We instructed the subjects to read the passage once and then to respond to the multiple choice question. They were not allowed to go back to the texts. A session took approximately 15 minutes.

## 2.2. Results

The gifted and the normal readers performed similarly and relied heavily on coherence structure. On the face of it, they also gained from analogy, but only in the incoherent texts. The proportions of subjects correctly responding according to group and manipulation condition are presented in Table 1.

Our response measures were dichotomous (correct/incorrect). Therefore, the data were submitted to a logistic-regression analysis (Nelson and Aldrich, 1983) with group, structure coherence, and exemplification as independent factors. The analysis yields an analysis of variance table similar to the standard table. The group main

Table 1

Percents of subjects correctly responding according to group and manipulation condition, Experiment 1.

Group	Coherent text		Incoherent text	
	Analogy	Example	Analogy	Example
Normal ( $N=126$ )	59.5	63.5	27.0	5.6
Gifted ( $N=43$ )	67.4	62.8	23.3	7.0

effect was insignificant and did not interact with the remaining factors. As predicted for skilled readers, the main effect of structure coherence was significant ( $\chi^2=80.04$ ,  $df=1$ ,  $p<0.0001$ ). The proportion of correct responses was higher on structurally coherent texts than on incoherent ones. There was also a main effect of analogy ( $\chi^2=13.61$ ,  $df=1$ ,  $p<0.005$ ). However, this effect was qualified by the significant interaction between structure-coherence and analogy factors ( $\chi^2=8.63$ ,  $df=1$ ,  $p<0.01$ ). This interaction was clarified by two analyses that tested the effect of analogy separately within coherent and incoherent texts. Analogy was not significant for coherent texts ( $\chi^2=0.14$ ). However, the proportion of correct responses was larger for incoherent texts containing an analogy than for incoherent texts with a relevant example ( $\chi^2=21.04$ ,  $df=1$ ,  $p<0.0001$ ).

### 2.3. Discussion

As predicted for high socioeconomic background readers, academic ability did not affect the degree of usage of the two strategies, as indicated by the insignificant group by condition interactions. We take this as evidence of little (if any) reliance on general comprehension strategies. These two groups are entirely skill-dependent and use the skimming strategy. As expected, when the text was coherent there was no difference between analogy and relevant example conditions. This, we believe, indicates that the skilled readers simply disregarded digressive material.

On the face of it, though, it seems as if the subjects do gain from analogy under the incoherent conditions. Nevertheless, we would like to claim that even under incoherent conditions, these subjects do not use analogical reasoning. When we analyzed the error patterns under these conditions, we found that for texts with analogies, the least preferred response was the analogy distractor (11.8%). Indeed, when a subject employs the structure coherence strategy, s/he is unlikely to choose the analogy as a discourse-topic, because it digresses from the topic of the majority of the propositions. It turned out that in three out of the four texts used in this condition, the analogy occupied the initial position, which is usually preserved for the discourse-topic proposition. As a result, there was no obvious candidate for topic-hood for this type of subjects. It is no wonder, then, that the response distribution between the other three alternatives was nearly even: 26.0% for the correct, 30.1% for the over-generalization, and 31.9% for the subordinate alternative. Such distribution suggests no preference for any alternative over the others. In other words, the analogy was merely identified as deviating from the discourse-topic but was not otherwise put into use.



When we consider the error pattern under the incoherent texts with examples condition, the distribution of responses was different. As expected, the correct response, which occupied final position in the text (14.8%), and the subordinate alternative (11.2%) were the least preferred. The most preferred were the over-generalization (39%), and the basic-level distractors (34.9%). The latter was placed in the initial position in two of the four texts. These two are more probable candidates for topic-hood. The selection of over-generalization seems a 'to be on the safe side' response strategy in this kind of test. Indeed, this was found to be the most common error for all the conditions in all the experiments. When the basic-level distractor selection was preferred, it was probably because of its discourse-topic position.

### 3. Experiment 2

Experiment 2 studied subjects who came from a low SES neighborhood. Such subjects are not expected to depend largely on text-specific strategies. On the other hand, general-comprehension differences should be reflected in analogy-effect differences between high and low academic ability subjects. High academic ability subjects, who are also good comprehenders, are expected to profit more than poor comprehenders from general strategies. This experiment was an exact replication of Experiment 1. In order to reject the possibility that our findings are test dependent, we added another measure of discourse-topic identification: Before turning to the multiple choice question, subjects were required to write down what they believed was the discourse-topic of the text.

#### 3.1. Method

*Subjects:* 182 senior high school students of the same age group as in Experiment 1. Ten school-classes participated in the experiment, five in the 10th grade and five in the 11th grade. Three of the 11th grade classes were academic and two were nonacademic. In the 10th grade, two classes were academic and three were nonacademic. In the academic classes there were 97 subjects (62 females), while in the nonacademic classes there were 85 subjects (34 females). The assignment to academic versus nonacademic classes is based in both cases on previous academic achievements. The group differences in this experiment are between normal and below-average students.

*Materials:* As in Experiment 1.

*Procedure:* As in Experiment 1. Only this time an open-ended question was added before the multiple choice test of each text. The subjects could not see the multiple choice alternatives before completing response to the open-ended question; neither could they return to the open-ended question while answering the multiple choice question.

### 3.2. Results

The data of the multiple choice and the open-ended questions were analyzed separately. The percents correct for each condition on the multiple choice test are given in Table 2, and the data for the open-ended questions are in Table 3.

#### 3.2.1. Multiple choice questions

As expected, subjects from academic classes performed better than subjects from nonacademic classes. Furthermore, performance was better with coherent than with incoherent texts.

Table 2

Percents of subjects correctly responding to the multiple choice question, Experiment 2.

Academic level	Coherent text		Incoherent text	
	Analogy	Example	Analogy	Example
Normal ( $N=97$ )	45.4	53.6	33.0	27.8
Low ( $N=85$ )	36.5	29.4	28.2	27.1

The data of Table 2 were analyzed as before. There was a main effect of group ( $\chi^2=5.47$ ,  $df=1$ ,  $p<0.05$ ), indicating that students from academic classes outperformed students from nonacademic classes. The effect of structure coherence was also significant ( $\chi^2=10.85$ ,  $df=1$ ,  $p<0.001$ ), indicating better performance on coherent texts. The main effect of analogy was insignificant and so were all the interactions between analogy and the remaining factors. Of all the interactions only the interaction between structure coherence and group approached significance ( $\chi^2=3.08$ ,  $df=1$ ,  $p=0.079$ ).

#### 3.2.2. Open-ended questions

The main effects of group and structure coherence were significant. Furthermore, analogy interfered with understanding of incoherent texts, but, as expected, improved the performance of the subjects from academic classes in the coherent text conditions.

Each written discourse-topic was evaluated by two independent raters. Inter-rater reliabilities were computed as percent of agreement between them. When reaching disagreement, the raters consulted and agreed on a common rating. The reliabilities were: 0.90, 0.79, 0.85, and 0.85 for the analogy-coherent, example-coherent, analogy-incoherent and example-incoherent conditions respectively.

The data for the open-ended question were analyzed as before. There was a significant main effect of group ( $\chi^2=3.97$ ,  $df=1$ ,  $p<0.05$ ) and a main effect of structure-coherence ( $\chi^2=25.26$ ,  $df=1$ ,  $p<0.0001$ ). However, the main effect of analogy was insignificant. The interactions between structure coherence and analogy ( $\chi^2=7.98$ ,  $p<0.005$ ), those between analogy and group ( $\chi^2=4.42$ ,  $df=1$ ,  $p<0.05$ ), and the third order interaction ( $\chi^2=6.68$ ,  $df=1$ ,  $p<0.01$ ) were clarified by two separate analyses,

Table 3

Percents of subjects correctly responding to the open ended question, Experiment 2.

Academic level	Coherent text		Incoherent text	
	Analogy	Example	Analogy	Example
Normal ( $N=97$ )	73.2	45.4	32.0	47.4
Low ( $N=43$ )	45.9	52.3	30.6	38.8

one for coherent texts and the other for incoherent texts. When coherent texts were analyzed, there was a significant effect of group ( $\chi^2=4.35$ ,  $df=1$ ,  $p<0.05$ ), for analogy ( $\chi^2=4.01$ ,  $df=1$ ,  $p<0.05$ ), and for the interaction between group and analogy ( $\chi^2=10.57$ ,  $df=1$ ,  $p<0.005$ ). When incoherent texts were analyzed, there was a main effect for analogy ( $\chi^2=5.56$ ,  $df=1$ ,  $p<0.05$ ), indicating worse performance on analogies as compared to relevant example conditions. There was no effect for group nor for group by analogy interaction.

#### 4. Comparisons between Experiments 1 and 2

The fact that we used the same texts and the same multiple choice questions in Experiment 1 and 2 enabled us to compare their data formally. The populations in the two experiments differed in SES and academic level. Consequently, two contrasts were formed: The differences in academic level divided the subjects into three groups: gifted (Experiment 1), normal-academic (Experiments 1 and 2), and nonacademic subjects (Experiment 2). The effect of SES could be best estimated when comparing the two normal-academic groups (Experiments 1 and 2). These two groups belong to classes of similar training and entrance requirements but differ in SES.

##### 4.1. Academic level comparisons

The differences were estimated as before, with the group factor having three levels. The repeated measure effects were the same as before. The effects of interest were the interactions between the group factor and the repeated measures factors and the main effect of group. The group main effect was insignificant. The only interaction with group reaching significance was the group-by-structure-coherence for the parameter comparing gifted and nonacademic subjects ( $\chi^2=11.28$ ,  $df=1$ ,  $p<0.001$ ). Gifted subjects showed greater effect of structure coherence than nonacademic subjects. However, the two groups differ also in terms of SES, which leaves the academic level effect difficult to interpret.

Recall that the interactions between structure coherence and group, computed separately for each experiment, estimate academic ability differences in the use of the coherent structure strategy. In Experiment 2 this interaction was not significant, and in Experiment 1 it only approached significance. Taken together, the data suggest

that the use of coherent structure strategy is not related to general comprehension as indicated by academic ability.

#### 4.2. *SES comparisons*

The differences were estimated as before, but only the data of the normal-academic subjects from the two experiments were used. Only the group effect and the interactions were considered. The group main effect was only marginal ( $\chi^2=3.31$ ,  $df=1$ ,  $p=0.069$ ). However, all the interactions with the group factor were significant. The group by structure coherence interaction ( $\chi^2=14.78$ ,  $df=1$ ,  $p<0.0001$ ) indicates that high SES subjects were more likely to employ the coherence-structure strategy than lower SES subjects. The analogy by group interaction ( $\chi^2=8.92$ ,  $df=1$ ,  $p<0.005$ ) showed a better use of analogy for high SES subjects compared to that of lower SES subjects. This interaction was further qualified by the third order interaction ( $\chi^2=4.55$ ,  $df=1$ ,  $p<0.05$ ). It indicated that the better performance under analogy found for the high SES subjects is limited to incoherent texts only. However, our interpretation of the error patterns questions this finding.

#### 4.3. *Benefits and costs*

To estimate the benefits and costs of structure coherence skill, we compared group differences separately for coherent and incoherent texts. In coherent texts, normal academic subjects of high SES background perform better than similar subjects of lower SES background ( $\chi^2=5.79$ ,  $df=1$ ,  $p<0.05$ ).

However, it is much more interesting to consider the costs of the skill. Better performance for less skilled subjects as compared to more skilled ones would provide a strong support for our hypotheses regarding the strategies employed by skilled readers.

Indeed, normal academic subjects of lower SES outperformed similar subjects of higher SES in incoherent texts ( $\chi^2=14.90$ ,  $df=1$ ,  $p<0.0001$ ). There was also a significant group by analogy interaction ( $\chi^2=9.63$ ,  $df=1$ ,  $p<0.005$ ). According to this interaction, there was no group difference in incoherent texts containing analogy ( $\chi^2=0.949$ ,  $df=1$ ), but a highly significant difference in incoherent texts containing a relevant example ( $\chi^2=21.05$ ,  $df=1$ ,  $p<0.0001$ ).

An even more striking difference was found when we compared the gifted and the nonacademic subjects. The results show that gifted subjects performed worse than nonacademic subjects on incoherent texts ( $\chi^2=6.12$ ,  $df=1$ ,  $p<0.05$ ). Despite the insignificant group by analogy interaction, there were no group differences when the texts contained an analogy ( $\chi^2=0.363$ ,  $df=1$ ), but large differences when the texts contained a relevant example ( $\chi^2p=7.11$ ,  $df=1$ ,  $p<0.01$ ).

#### 4.4. *Discussion*

As predicted, the comparisons between the two experiments showed that the use of the coherent structure strategy distinguishes between subjects of high and low

SES. Both groups benefit from coherent structure, but high SES subjects rely more heavily on this strategy. On the one hand, while the high SES subjects benefit more from coherent structure, they also suffer larger costs once coherence is made less accessible.

Complementarily, as predicted, lower SES subjects relied less heavily on coherent structure. Therefore, they read the text throughout, trying to process deeply every proposition. Less skilled readers thus apply general comprehension strategies in which subsequent information is interpreted in terms of initial information (e.g., Gernsbacher, 1990). Such reading strategies allow for the identification of the analogy as a digression and require special processing for its integration. Text coherence makes the integration easier and allows the higher academic ability subjects to gain from the analogy.

### 5. Experiment 3

In contrast to our results, Vosniadou and Ortony (1983), who used schematically organized texts, found that analogy facilitated understanding. Therefore, the purpose of Experiment 3 was to replicate their experiment, using our measure of text comprehension.

#### 5.1. Method

*Subjects:* The same subjects as in Experiment 2.

*Materials:* The materials were the two schematic texts from Vosniadou and Ortony (1983), which were translated into Hebrew. Each text appeared in two equally long (about 300 words) versions, one with an analogy, and the other containing relevant material instead. One text concerned blood circulation, and the other text described how the body fights an infection. Unlike Vosniadou and Ortony, we presented the texts without their titles. The texts appeared in the end of the booklet mentioned in Experiment 2. The text about blood circulation always preceded that about infection. An open-ended question appeared at the bottom of the page containing the text. A multiple choice question, which contained four distractors, appeared on a separate page immediately after the text. In the multiple choice question, the distractors were designed as before. Half the booklets contained the analogy version of the text about blood circulation, followed by the relevant material version of the text about infection. This order was reversed for the other half.

*Procedure:* The experiment was performed immediately after Experiment 2. Otherwise the procedure was the same in the two experiments.

#### 5.2. Results

As in Experiment 2, the data of the open-ended and the multiple choice questions were analyzed separately.

### 5.2.1. Multiple choice questions

Normal academic subjects performed better than nonacademic ones. The data of the multiple choice questions regarding schematic texts are presented in Table 4.

Table 4

Percents of subjects correctly responding according to the multiple choice question, Experiment 3 (Schematic texts).

Academic level	Coherent text	
	Analogy	Example
Normal ( $N=97$ )	76.3	81.4
Low ( $N=85$ )	51.8	61.2

These data were analyzed as before, using only two independent factors: Exemplification (analogy versus relevant material) and subjects' academic level (academic versus nonacademic classes).

Only the effect of academic level was significant, with academic classes performing better than nonacademic ones ( $\chi^2=17.71$ ,  $df=1$ ,  $p<0.0001$ ). Though there was no significant effect for analogy, there was poorer performance on analogy conditions as compared to relevant material conditions.

### 5.2.2. Open-ended questions

Subjects of normal academic classes performed better than those of nonacademic classes. The performance under analogy was poorer than the performance under a relevant example. This analogy effect was larger for normal academic subjects.

Inter-rater reliabilities were estimated as before and were 0.82 for both the analogy and example conditions. The data of the open ended questions regarding schematic texts are presented in Table 5.

Table 5

Percents of subjects correctly responding according to the open ended question, Experiment 3 (Schematic texts).

Group	Coherent text	
	Analogy	Example
Normal ( $N=97$ )	50.5	88.9
Low level ( $N=85$ )	42.4	54.1

In the logistic-regression analysis all the effects were found significant. There was a main effect of academic ability ( $\chi^2=17.96$ ,  $df=1$ ,  $p<0.0001$ ) and of analogy ( $\chi^2=30.83$ ,  $df=1$ ,  $p<0.0001$ ). The interaction between the two factors ( $\chi^2=11.96$ ,  $df=1$ ,  $p<0.0005$ ) was clarified by two separate analyses, one for each subject acade-

mic ability. The effect of analogy was significant for both academic ( $\chi^2=28.09$ ,  $df=1$ ,  $p<0.0001$ ) and nonacademic subjects ( $\chi^2=3.95$ ,  $df=1$ ,  $p<0.05$ ).

### 5.3. Discussion

Contrary to Vosniadou and Ortony (1983), our results show worse performance under analogy conditions. This finding eliminates the possibility that the results of Experiments 1 and 2 are a function of the specific analogies that we chose. The same materials that produced improvement in text understanding in Vosniadou and Ortony's study yielded a decrement in performance in our experiment. However, there are several differences between the two studies. First, the task employed by Vosniadou and Ortony tested local aspects of comprehension, while our task required global understanding. Second, though the two studies used the same materials, in our study the texts had no titles (i.e. no discourse-topic mention). Finally, the subjects in our study were older (10th and 11th graders) than Vosniadou and Ortony's 1st and 3rd graders.

The task employed by Vosniadou and Ortony required close attention to all the components of the test. Since the low SES subjects that participated in our experiment would pay full attention to all the text's components anyhow, this difference cannot explain the discrepant findings. However, the absence of titles in our experiment seems crucial. As we hypothesized, the presence of the discourse-topic in the beginning of the text provides a good preliminary hypothesis as to its nature. Such a hypothesis excludes the potential distraction caused by analogies. In this experiment the discourse-topic was not supplied, which, we believe, explains the worse performance under the analogy condition. Finally, the subject age differences between the studies should, if at all, have worked in the opposite direction. Older subjects are more likely to be familiar with the analogies used, and hence not to be distracted by them; but this was not the case. We conclude, then, that in order to benefit from an analogy, the text should be read to the end and it should have a discourse-topic mention in the beginning.

## 6. General discussion

Taken together, our results show that when the discourse-topic is placed in the beginning of the text, it is more likely to be identified. Note, however, that this effect is smaller for low SES subjects, who are supposedly less skilled as compared to the more skilled high SES readers. Our findings show that group differences related to the benefit from discourse-topic mention are a function of the socioeconomic background rather than of academic ability.

Second, there was no overall benefit from analogy. Analogy facilitated understanding in coherent texts when readers were less skilled. However, when the texts did not contain a mention of the discourse-topic in the beginning, analogy interfered with understanding. This was observed for both incoherent categorically structured texts and coherent schematic texts. (For further research on possible interference of

analogy with understanding see Simons, 1984, and references there). It is unlikely that the type of analogies used is the reason for our findings. The materials used by Vosniadou and Ortony (1983) have proven to yield benefits from analogy. When the same materials were used in our study, analogy interfered with understanding. Furthermore, the negative influence of analogies is not limited to incoherent texts. This influence is observed also when coherently structured schematic texts are used.

These findings are explained by the two kinds of reading strategies we proposed: general-comprehension versus text-specific. In accordance, we predicted that less skilled readers will employ general-comprehension strategies under circumstances in which skilled readers will employ text-specific strategies. The text-specific strategy we studied relies on coherence structure. When trying to identify the discourse-topic, the skilled reader processes deeply only the first proposition of the passage, and then skims through the rest of it for disconfirmation. This implies little or no effect of the contents of the remainder of the passage on her/his comprehension, as our results show. The less skilled reader, on the other hand, employs the general comprehension strategy. As a result s/he forms a representation of the whole text that is based on all of its propositions. The first proposition is still the most important one since it lays the foundations for the mental representation (Gernsbacher, 1990). However, unlike the skilled reader, a less skilled reader does not skim through the remaining propositions but reads them carefully. This strategy enables her/him to be affected by analogies that appear later in the text because s/he makes an attempt to integrate them into the representation structure. Especially striking was the finding that spelled out the costs of a skill: Our most skilled and academically advanced subjects performed worse even than our least skilled and academically advanced ones, when their strategy was no longer functional. This finding echoes other findings concerning the costs paid by experts.

We manipulated text coherence by displacing the first proposition. This manipulation is conceptually similar to that used by Gernsbacher et al. (1990, Experiment 3), who compared subjects' memory of scrambled and unscrambled materials. Gernsbacher et al. found that high comprehension-ability subjects outperformed low ability ones on unscrambled texts. However, the two groups performed similarly on the scrambled texts. According to Gernsbacher's (1990) structure-building framework, comprehenders use the first proposition to lay the foundation for the representation structure. Oncoming propositions are mapped onto that structure. However, when mapping is impossible, subjects shift and build a new structure. Their shifts impair memory for the old structure and result in poor comprehension. According to Gernsbacher and her associates, high and low comprehension ability subjects differ in their shifting likelihoods. However, when these likelihoods are similar, differences between the subjects vanish. Discourse scrambling increases the likelihood of shifting and therefore eliminates the good comprehenders' superiority. However, Gernsbacher's structure-building framework does not predict low comprehenders' superiority under scrambling, as we have found. In contrast, the use of structure-coherence strategy predicts such superiority. Furthermore, the use of structure-coherence strategy predicts skill but not general comprehension ability differences, as found. These and other aspects of the data, such as analogy effects,



suggest that skilled readers do not identify discourse-topics by using general structure building.

As for analogy, our findings show that it can be both beneficial and harmful, depending on the extent to which it distracts the reader from the discourse-topic under discussion. When the identification of the discourse-topic is enabled, analogy is conducive to understanding only when the reader is a good comprehender and bothers to read it. However, when the discourse-topic is less accessible (as when the discourse-topic is either missing or does not appear in the beginning), reading the analogy distracts the reader and deteriorates her/his performance.

One may argue that our findings are limited to a test measuring the identification of the discourse-topic, and do not reflect comprehension under normal conditions. We argue that this claim is unjustified on the following grounds: Previous work (Giora 1985a,b, 1988) has shown that text understanding is discourse-topic dependent. Each proposition in the text is evaluated and stored relative to the discourse-topic. In this study we have shown that the understanding of the analogy as such is conditioned upon the explicit mention of the discourse-topic in the beginning. This is further confirmed by the findings of Vosniadou and Ortony (1983) which favor the use of analogy. Indeed, in their study, the texts were presented with their titles. That such a test has a psychological reality is also made obvious by our findings concerning skill differences. An artificial test would have been equally novel for skilled and less skilled readers. However, the presence of skill differences attests to the fact that understanding a text implies identification of its discourse-topic.

We, thus, conclude that to gain from analogy, the text must explicitly mention its discourse-topic in the beginning, and its reader must attempt a full integration of all its propositions. If the reader is a good comprehender, s/he will probably make the most of analogy, otherwise not.

## **Appendix: The remaining texts used in the experiment**

### *Text 2*

When we want to classify the living organisms in terms of the amount of similarity and difference which they share, the question that arises immediately is which features constitute the basis for establishing similarity and difference between animals: Their external shape, their habitat, their internal structure, or their activities?

[Now came one of the following:]

#### *Relevant example condition:*

For instance, will we categorize them by their habitat in water, or in the air, or by the structure of their wings or fins?

#### *Analogy condition:*

A stamp collector, for example, faces a similar problem when he wants to catalogue his stamp collection independently. Will he categorize his stamps by topics, or according to their countries of origin?

*Both of the texts ended with*

It is important which features are selected as a basis for classification, and what is their importance? Suppose we decide on a classification according to the organism's habitat either in water, in the air or on earth. Following this principle, we will include in the class of flying creatures, birds, bats and butterflies. If we examine their habitat in water, we will include whales and fish in the class of swimming creatures.

*Text 3*

According to traditional psychological schools, the connection between a word and its meaning is associative. The association is a result of co-occurrence of sound and object. The word evokes its meaning in memory.

*Relevant example:*

For instance, the sound of the word 'ball' is associated in our memory with the object we play with.

*Analogy:*

as a friend's coat reminds us of its owner and a house of its tenants.

*Both of the texts continued with*

The development of meaning was attributed to the changes of association between single words and single objects. A word can refer to one object in the beginning and be associated with another at a later stage

*Relevant example:*

For instance, the word 'ball' [in Hebrew] was first associated with the object we play with, and then denoted a pill.

*Analogy:*

as a coat, changing its owner, reminds us first of its first and then of its second owner.

*Text 4*

Some old people are oppressed by the fear of death. The best way to overcome it is to make our interests grow gradually wider and more impersonal, until bit by bit the interests in the self decrease, and our life becomes increasingly merged in the universal life.

*Relevant example:*

For example, when young, a person is concerned only with his own needs. But when he grows up, he gets more interested in the problems of the people about him, thus widening his horizons.

*Analogy:*

An individual human existence should be like a river – small at first, narrowly contained within its banks. Gradually the river grows wider, and in the end, without any visible break, it becomes merged in the sea.

*Both of the texts ended with*

The man who in old age, can see his life in this way, will not suffer from the fear of death, since the things he cares for will continue. And if, with the decay of vitality, weariness increases, the thought of rest will be not unwelcome.

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