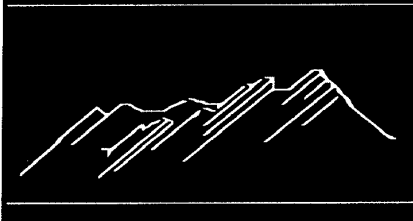


INSTITUTE OF COGNITIVE SCIENCE



*Technical Report*

University of Colorado, Boulder

## **Developmental Differences in a Summary Task: The Role of Active Knowledge**

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Technical Report #93-08

"Developmental differences in a summary task: the role of active knowledge"

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### Abstract

The aim of this paper is to study the role of active knowledge in explaining developmental differences found in the application of macrorules. Two experiments were designed manipulating four independent variables: school level, aid, familiarity and macrorule. Three conclusions can be drawn: a) developmental differences could be understood in terms of retrieval operations needed to construct macrostructure; b) there exists a decreasing trend in the correct use of the different macrorules, greater at lower school-levels; and, c) the lack of previous knowledge blocks the application of proper macrorule.

\*Some people have helped us. The first author spent three months visiting University of Colorado, at Boulder. We want to thank to Eileen and Walter Kintsch for their comments and inestimable help. Likewise, Malcolm Bauer improved a previous version of this paper. Second author is visiting Princeton University supported by a Quincentenary Postdoctoral Fellowship from the USA-Spanish Joint Committee for Cultural and Educational Cooperation. Part of our research was also supported by a grant from the Spanish *Centro de Investigación y Documentación Educativa (CIDE)*.

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### Abstract

The aim of this paper is to study the role of active knowledge in explaining developmental differences found in the application of macrorules. Two experiments were designed manipulating four independent variables: school level, aid, familiarity and macrorule. Three conclusions can be drawn: a) developmental differences could be understood in terms of retrieval operations needed to construct macrostructure; b) there exists a decreasing trend in the correct use of the different macrorules, greater at lower school-levels; and, c) the lack of previous knowledge blocks the application of proper macrorule.

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### Précis of the presentation.

Introduction. Our general aim was to study the role of active knowledge in text comprehension and memory, specifically, in the implementation of macrorules and in the explaining of developmental differences. A particularly important issue for this work is the existence of developmental differences in subjects' ability to use macrorules (Brown & Day, 1983) and the tendency shown by younger readers to use a passive and partially efficient strategy called "copy-delete" (Brown, Day & Jones, 1983). Scardamalia and Bereiter (1984) have also pointed out that younger and novice subjects do not carry out operations directed to building macropropositions by linking the text with their knowledge schemata. In addition, Oakhill (1983) has shown that skilled and less-skilled comprehenders appear to differ in the extent to which they make use of context and specific knowledge in the interpretation of a text. Hence, the role that active knowledge plays in text processing is especially important, particularly in the construction of macrostructure.

First Experiment. We have developed a summarization task consisting of brief paragraphs with a very familiar content for subjects from two different school levels. The experimental manipulation consisted in providing one of the groups with a key concept or idea needed to write the summary. This key concept is the final result of the operations that should be carried out by the subjects based on their prior knowledge to write a proper summary. Our general hypothesis is that, since the content schemata with their respective procedures are familiar to subjects, the mere presentation of the key concept would activate the macrorule of correct operation. Thereby, the differences in difficulty of the macrorules and those existing between the school or developmental levels would be diminished.

A mixed 2 x 2 x 4 factorial design was used: school level factor (5th & 8th grades); aid factor (aid and no-aid condition); and macrorule factor (selection, 1st-order generalization, 2nd-order generalization and construction). Most interesting results were the following. First, a analysis of variance (MANOVA) of the total accuracy score on the test revealed the predicted main effects of the three factors: school level ( $F= 9.96, p<0.002$ ); aid factor ( $F= 31.76, p<0.0001$ ); and macrorule ( $F= 33.95, p<0.0001$ ). Second, a chi-square was used to test for the existence of a pattern in the correct choice of the macrorules, since the four macrorules form a nominal scale. The only significant difference between the fifth and eighth grade students was in their use of the construction macrorule (Chi-square=6.89,  $p<0.032$ ). Finally, the interaction between aid and macrorule factors produced significant results ( $F= 13.34, p<0.0001$ ), showing that experimental treatment influenced macrorule performance.

Second Experiment.- Because we found no strong effect of age, the second experiment incorporated a larger age range, adding high-school

and adult groups. Likewise, a new experimental factor was added that distinguishes between very familiar items and extremely non-familiar items. If younger readers use their previous knowledge in a less efficient manner, then significant differences should be found among the different school levels even on familiar items. On the other hand, if specific-domain knowledge is considered the source from which subjects retrieve and recognize the information required to build the text macrostructure, then the lack of previous knowledge should limit the subjects' performance, included adult groups.

A mixed 4 x 2 x 2 x 4 factorial design was used: school level (5th, 8th, 11th & 2nd of technical college); aid factor; familiarity factor; and the four macrorules. Most important results were the following. First, an ANOVA of the total accuracy revealed the predicted main effects of the four factors (school level,  $F= 9.52$ ,  $p<0.0001$ ; aid factor,  $F= 220.49$ ,  $p<0.0001$ ; familiarity factor,  $F= 669.48$ ,  $p<0.0001$ ; macrorule factor,  $F= 222.79$ ,  $p<0.0001$ ). Second, regarding the interactions, both aid by macrorule and familiarity by macrorule interaction were significant ( $F= 39.29$ ,  $p<0.0001$  &  $F= 108.77$ ,  $p<0.0001$ , respectively). The interactions between school-level and the other three factors reached significant results (aid:  $F= 2.85$ ,  $p=0.04$ ; familiarity:  $F= 2.87$ ,  $p=0.039$ ; macrorule:  $F= 2.21$ ,  $p=0.021$ ). Of special interest was to find second order interactions between school-level, aid, and familiarity factors ( $F= 4.60$ ,  $p=0.004$ ). Finally, the performance of subjects by familiar/non-familiar condition were compared. Significant differences were found in: 1st-order generalization ( $\text{Chi}= 216.84$ ,  $p<0.00001$ ); 2nd-order generalization ( $\text{Chi}= 171.90$ ,  $p<0.00001$ ); and, construction macrorule ( $\text{Chi}= 83.62$ ,  $p<0.00001$ ).

Conclusions. The following conclusions can be drawn from the analysis of our two experiments. First, experimental results show that developmental differences between young and adult readers could be understood in terms of the retrieval operations necessary to construct the macrostructure, at least in simple and brief paragraphs where the situational model and the macrostructure coincide largely, and rhetorical knowledge is not playing an important role. Both in the first and in the second experiments, all of the school levels reached equivalent scores in the familiar and aid conditions, i.e., when the subjects only had to recognize explicit relations. However, although young readers had the prior knowledge to write a good summary in familiar and no-aid conditions, their performances were significantly worse than those from superior school levels. Secondly, experimental results show a decreasing trend in the correct use of the four macrorules, clearer at the lower school levels. Thirdly, when good readers lack previous knowledge about the topic of the paragraph their performances are very similar to that of younger readers. It can be said that either lack or inefficient use of previous knowledge blocks the application of proper macrorules.

## 1.- Introduction.

Text comprehension implies building up a mental representation that gives account of the meaning of the text. This mental representation includes different levels and eventually leads to the construction of a mental or situational model containing both what appears in the text as well as different kinds of previous knowledge that the subjects must retrieve when processing text (Just and Carpenter, 1987; Johnson-Laird, 1983; van Dijk and Kintsch, 1983). According to Kintsch and van Dijk (1978; van Dijk and Kintsch, 1983), readers must also build up two other levels of representation: a microstructure, or text base, that represents directly the information that appears in the text and which involves coherence at the local level; and a macrostructure that gives account of the global meaning of the text, providing it coherence as a whole. Every macrostructural proposition (macroproposition) in a text is constructed strategically by applying a set of "macrorules", deletion, generalization and construction, to a particular set of propositions of microstructure (micropropositions), under the control of a schema representing the reader's knowledge and aims.

These macrorules can be regarded as inference processes and allow the reduction and organization of information (Kintsch, in press). Deletion allows us to eliminate secondary or redundant information and therefore enables the selection of the gist. Generalization allows us to substitute some concepts, propositions or sentences in the text with other superordinate ones. In the construction macrorule a set of propositions is substituted by a new global proposition that maintains the following relationship as with the others: every substituted proposition is an element, a part or a consequence of the new one. These macrorules increase in difficulty that is related both to the increase in the complexity of cognitive operations involved and to the organization of the knowledge base. For example, to make a generalization subjects need to recognize that a proposition "X IS an instance of ..." denotes a relationship between different concepts or ideas. If this superordinate concept does not appear explicitly in the text, subjects will have to carry out a retrieval process based on their previous knowledge, while if the superordinate concept is explicit

only a recognition process is needed to properly apply the procedure (Guindon and Kintsch, 1984).

A particularly important issue for this work is the existence of developmental differences in subjects' ability to use these macrorules. Based on the summarization model proposed by van Dijk and Kintsch (1977; Kintsch and van Dijk, 1978) and an informal consideration of summarization protocols obtained from children and adults, Brown and Day (1983) identified the basic rules of summarization that included the deletion or verbatim copy, generalization and construction (integration) macrorules such as were described before. They compared subjects from four developmental levels, fifth graders, seventh graders, tenth graders and college students. Their results showed that both of the deletion rules (delete trivia or delete redundancy) that permitted subjects to select the gist were used effectively by all age groups. Subjects as young as fifth grade were able to delete both trivial information and redundant material. Second, the other more complex macrorules were more difficult for younger subjects showing an increase of appropriate use with age. According to Brown and Day, the macrorules differ in how easily they are applied because they demand different degrees of manipulation of the text contents. Furthermore, younger readers appeared to use a superficial summarization strategy called "copy-delete" strategy (Brown, Day and Jones, 1983). This passive, although partially correct, strategy basically consists in copying verbatim part of the text.

In a similar way, Scardamalia and Bereiter (1984; Bereiter and Scardamalia, 1987) have pointed out that younger and novice subjects do not carry out operations directed to building macropropositions by linking the text with their knowledge schemata. They have referred to this type of processing as "topic-plus-details", in which the subject takes one element after another following a superficial coherence criterion.

If it is necessary to establish connections between the text and prior knowledge in order to understand it, this brings us to consider the crucial role of inference processes in text comprehension and memory. Several studies show that skilled comprehenders devote more effort to the active construction of meaning than younger or less-skilled readers (Oakhill, 1982; 1984;



Oakhill, Yuill and Parkin, 1986). Oakhill (1983) has shown that when the readers have to make a type of inference, called *instantiation*, in which the interpretation of a word depends on the specific context in which it appears, skilled and less-skilled comprehenders differ in the extent to which they spontaneously infer the particular interpretations of the word; that is to say, the diverse abilities shown by skilled and less-skilled readers could be explained not in terms of their differences in knowledge, but only in the extent to which they make use of context and specific knowledge. Therefore, we would like to underline the importance of active and self-controlled processing in text comprehension and particularly in the explaining of developmental and novice-experts differences.

As we can see, text comprehension involves both previous knowledge and text content, and therefore a theory about how these two kinds of information interact is needed. The construction-integration model of Kintsch (1988) proposes a most complete and suitable explanation. According to Kintsch (1992; in press), there are two possible explanations for the context sensitivity of knowledge. The traditional explanation is that provided by schema theory: there exist cognitive control structures such as schemata, frames, or scripts, which filter out inappropriate knowledge. While knowledge about the world and domain-specific knowledge are indeed needed to build up situational models, Kintsch (1992) claims that situation models are not merely knowledge structures. They are the product of information provided by the text with the already existing world and domain-specific knowledge. We need a more psychologically plausible and computationally flexible account of how knowledge is used in comprehending discourse. As an alternative to schematic structures, the construction-integration model explains how knowledge becomes integrated with text as an unselective activation process that occurs in an uncontrolled, bottom-up manner, determined only by the strength of the associations between items in long-term memory and in the text.

## **2.- EXPERIMENT 1.**

### **2.1.- Objectives and hypothesis.**

We have developed a summarization task consisting of brief paragraphs and very familiar content for subjects from two

different school levels. The experimental manipulation consisted in providing one of the groups with a key concept or idea needed to write the summary. This key concept is the final result of the operations that should be carried out by the subjects based on their previous knowledge to write a proper summary. Our general hypothesis is that significant differences in overall performance on the summarization test will be found as function of: presence or absence of the facilitating aid; the difference in age or school levels, (5th grade vs. 8th grade); and finally, differences in the difficulty of the four macrorules (selection, 1st. generalization, 2nd. generalization, and construction). In addition, because the content schemata with their respective procedures are familiar to the subjects, the mere presentation of the key concept would activate the macrorule or correct operation. Therefore, the differences in difficulty of the macrorules and those existing between the school or developmental levels would be diminished.

## 2.2.- Method.

### 2.2.1.- Subjects and Design.

The subjects (N = 119), came from two public schools in Madrid, and from two different grades: fifth grade, (n = 67, average age: 10 years and six months), and eighth grade (average age: 13 years and eight months). A mixed 2 x 2 x 4 factorial design was used: school level factor (5th & 8th grades); aid factor (aid and no-aid condition); and macrorule factor (selection, 1st-order generalization, 2nd-order generalization and construction).

### 2.2.2.- Materials.

The no-aid condition test consisted of 12 paragraphs no longer than five sentences. The contents used were very familiar to the subjects. The topics referred to their daily life, games, school activities, etc. The test was prepared as to induce the subjects to use four different macrorules, three items per macrorule.

In the aid condition the test version contained the same 12 paragraphs, however each item was preceded by a heading that, under the title of aid, contained a key concept or main idea. We established four kinds of operations or macrorules: selection<sup>1</sup>, 1st. generalization, 2nd. generalization, and construction. (See **Appendix 1**)

### 2.2.3.- Procedure and Scoring..

The tests were administered in a collective way at each to school level. The experimental conditions were randomly assigned. In the instructions, the importance of a thorough and careful reading was emphasized. Subjects were asked to write a single sentence summary for each of the paragraphs given.

Two different types of measurement were used. The first one assessed the accuracy of the summaries produced by subjects to those set by the researchers. Each item received "1 point" if the response coincided exactly with the researchers criteria,

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<sup>1</sup> Our Selection macrorule corresponds to the deletion one in the terminology used by Kintsch and van Dijk. We decided to use this term since the final outcome of deletion rule is the selection of the gist as is stated in the text. In addition to this, from an strategic standpoint it seems to us that in a summary task people are going to select main ideas, farther than delete redundant or trivial ones.

and "0.75 point" if it was very close the concept or idea. The second measurement dealt with the operators or macrorules actually used by the subjects. The responses were classified according to the macrorules used. Thus, there were four categories each corresponding to each of the four operators or macrorules.

### 1.3.- Results.

A multivariate analysis of variance (MANOVA) of the total accuracy score on the test revealed main effects of the three factors: school level ( $F=9.96$ ,  $p<0.002$ ); aid factor ( $F=31.76$ ;  $p<0.0001$ ); and macrorule ( $F=33.95$ ,  $p<0.0001$ ). The Scheffè tests showed significant differences in 5th grade between no-aid and aid conditions, 8th grade between no-aid and aid conditions, and, finally between 5th no-aid and 8th aid ( $p=0.05$ ) (see figure 1.1.). A chi-square was used test for the existence of a pattern in the correct choice of the macrorules, since the four macrorules form a nominal scale. Thus, we compared the subjects of the two grade levels in their use of the four macrorules. The only significant difference between the fifth and eight grade students was in their use of the construction macrorule. The older students made greater use of this macrorule than the younger ones ( $\text{Chi-square}=6.89$ ;  $p<0.032$ ). Figure 1.2. shows a clear decreasing trend in the use of macrorules, clearer at the lower school level. We also found a significant interaction between aid and macrorule factors ( $F=13.34$ ,  $p<0.0001$ ), showing that experimental treatment influences macrorule performance (see figure 1.3). In addition to this, we found significant differences in the actual use of macrorules by subjects, between the no-aid and the aid conditions in the macrorules of first order generalization ( $\text{Chi}=8.24$ ;  $p<0.04139$ ), second order generalization ( $\text{Chi}=19.58$ ;  $p<0.00021$ ) and construction ( $\text{Chi}=55.03$ ;  $p<0.000001$ ) (see figure 1.4.) Finally, we compared the two age groups with and without aid according to their correct use of each macrorule, i.e., 5th no-aid, 8th no-aid, 5th aid, and 8th aid. The global differences between groups both in the second-order generalization macrorule and the construction macrorule were significant (in that order:  $\text{Chi}=27.29$ ,  $p<0.00125$ ;  $\text{Chi}=61.01$ ,  $p<0.000001$ )(see figure 1.5.).

### 2.4.- Discussion.

As it is showed in figure 1.1., the most outstanding differences were due to experimental manipulation, those associated with the school level factor being less important. This

result was expected given the familiarity of the text contents and school levels used.

As it was predicted, results in figure 1.2 show a clear decreasing trend in the correct use of the macrorules. The results coincide completely with those obtained by Brown and Day (1983), and can be explained in a similar way<sup>2</sup>. The subjects generated those items closer to the "copy-delete" strategy better, i.e., those items that required the selection macrorule. The performance of subjects worsened as the macrorules moved away from the passive and partially successful strategy. This decreasing trend turned out to be clearer at the lower school levels: significant differences appeared within the school levels in the macrorule demanding more complex operations to generate knowledge, i. e., the construction rule. As mentioned before, this passivity of younger readers in the use of knowledge has been pointed out as a main reason for differences between subjects of different ages in summary tasks (Scardamalia and Bereiter, 1984).

The results presented in figures 1.4 and 1.5. clearly show that the key concept provided in the aid condition eliminated the differences between the several macrorules and almost completely eliminated the developmental differences including that of the construction macrorule. Moreover, both figures reinforce the idea that the aid condition clearly changes the decreasing trend in the correct performance of the different macrorules.

Results that show the effectiveness of the experimental treatment can be explained in the following way. One could assume that the subjects possess "expert" knowledge consisting in the schemata triggered by the concepts and ideas appearing in every day activities. Despite this, the subjects in the control group did not always carry out the necessary retrieval operations to obtain the gist or macroproposition, which demanded linking the text with their knowledge schemata. Our experimental manipulation consisted

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<sup>2</sup> The only difference between our results and Brown and Day's ones appears in the selection macrorule. However, the facility with which our subjects used this macrorule is undoubtedly due to the kind of materials used. Brown and Day (1983) used long texts, where "selecting" means "disrupting the sequentiality", whereas our subjects dealt with paragraphs not longer than five sentences. Here it was much easier to keep all the operations in working memory, as they concentrated on one paragraph only.

in providing the key concepts to trigger this last operation, thereby changing a retrieval process into a recognition process. As Eileen Kintsch (1990) has pointed out, younger students are more successful at generating macropropositions when answering the questions than in summarizing. She explains her results in terms of the different retrieval demands of the two tasks because the questions themselves function as recall cues. Given that the subjects possess a knowledge schema, and given that the key concept is connected to other similar ones from the input text, the subjects' access to the key concept automatically activates the procedure that allows the application of the correct macrorule. Thus, the decreasing trend in the correct use of the four macrorules is eliminated, distinguishing only subjects who have received aid from those who received the no-aid condition.

### **3.- EXPERIMENT 2.**

#### **3.1.- Objectives and hypothesis.**

After the results of the first experiment, a second experiment was designed to improve our understanding of two variables. First, school level was extended across four groups, including school-age and adult groups. Secondly, a new experimental factor was added that distinguishes between very familiar items and extremely non-familiar items. Our general goal was to face subjects with extreme conditions, so that main relationships between knowledge and macrostructure building would be as explicit as possible.

We may consider both school age and adult groups to be experts on familiar items. As we pointed out in the introduction, developmental differences seem not to be caused by limitations in the general capacity to make inferences or by the lack of previous knowledge. If younger readers use their previous knowledge in a less efficient manner, then significant differences should be found among the different school levels, even on familiar items. On the other hand, if specific-domain knowledge is considered the source from which subjects retrieve and recognize the information required to build the text macrostructure, then the lack of previous knowledge should limit the subjects' performance. Moreover, the aid and familiarity factors should exert different influences on the macrorules. Likewise, aid, familiarity and macrorule factors should

exert different influences on the school levels. Finally, if young readers tend to use a copy-delete strategy as a consequence of problems in linking text with previous knowledge, then the performance of adult readers with non-familiar items should be similar. In such cases, adult performances should be very similar to those of school-age groups. Therefore, our hypotheses were the following:

1. Significant differences will be found within the four experimental conditions: the presence or absence of aid; the familiarity of the topic; the school levels; and, finally, the diverse macrorules.
2. We predict five interactions: between aid and familiarity by macrorule; and between aid, familiarity and macrorule by school-level.
3. Subjects will show a tendency to use the macrorules as a function of both the unfamiliarity of items and complexity of cognitive operations involved.

### 3.2.- Method.

#### 3.2.1.- Subjects and Design.

The subjects (N = 145) belonged to four different school levels: fifth grade (n = 35, average age: 10 years and 7 months); eighth grade (n = 52, average age: 13 years and 8 months); eleventh grade or high school (n = 29, average age: 18 years and 3 months); and finally, second year in a technical college (n = 29, average age: 21 years and 7 months).

A mixed 4 X 2 X 2 X 4 factorial design was used. The first factor, of fixed effects, was the school level. The other three factors were within-subject factors. The second factor was the aid factor. The third factor consisted of a familiar versus no-familiar content. Finally, the four types of macrorules were the fourth factor: selection, first-order generalization, second-order generalization and construction.

#### 3.2.2.- Materials.

Materials used were similar to those used in the first experiment. We used 16 paragraphs in two booklets. The booklet for the no-aid condition contained four no-familiar items on the first page and four familiar items on the second page. No-familiar items were topics about Clinical or Cognitive Psychology, while familiar items referred to students' daily life, games, school activities, etc. As before, the test was prepared to induce the subjects to use four different macrorules. The second booklet, the aid condition version, included a heading containing a key concept or main idea, under the title of aid. There were four no-familiar items on the first page and four familiar items on the second page (see **Appendix 2**)

#### 2.2.3.- Procedure.

The tests were administered in a collective manner at each school level. First, subjects received a booklet with the no-aid condition by familiar/non-familiar items. They had 10 minutes to answer four no-aid and non-familiar items. Later, they had the same time to answer the four no-aid and familiar items. The researcher checked that subjects strictly followed these steps without going back to any page. After a small break, they received the second booklet following an identical procedure. They had 10 minutes to answer four aid and non-familiar items and the same time to answer the four

aid and familiar items. The importance of a reading thoroughly and carefully was emphasized in the instructions. Subjects were asked to summarize in a single sentence each of the paragraphs given. In the first no-aid condition booklet, half of the subjects received eight items that the others received in the second booklet for the aid condition.

#### 2.2.4.- Scoring.

As in study 1, two measurements were used. The first one was applied in a strict way: each item received "1 point" if the response coincided exactly with the researchers criteria. The second measure was as in the first experiment, but a new category (including "Others", "Selection", "Generalization-1st", "Generalization-2nd", and "Construction") was added to cover in the difficult answers.

### 3.3.- Results.

An ANOVA of the total accuracy score in the test was performed to test the first hypothesis. It revealed main effects of the four factors. First, the school level factor was significant ( $F=9.52$ ,  $p<0.0001$ ), and Scheffè tests showed significant differences between 5th and 11th grades, 5th and 2nd technical college grades, 8th and 11th grades, and, finally between 8th and 2nd technical college grades ( $p<0.05$ ). Second, the aid factor was equally significant ( $F=220.49$ ,  $p<0.0001$ ). Scheffè tests showed significant differences in no-aid condition between 5th and 11th grades, 5th and 2nd technical college grades, 8th and 11th grades, and, again between 8th and 2nd technical college grades ( $p<0.05$ ), but there were no differences in aid condition. Third, the familiarity factor was significant ( $F=669.48$ ,  $p<0.0001$ ). Scheffè tests showed significant differences in non-familiar condition between 5th and 2nd technical college grades, and in familiar condition between 5th and 11th grades, 5th and 2nd technical college grades, 8th and 11th grades, and, finally between 8th and 2nd technical college grades, ( $p<0.05$ ).

Finally, the macrorule factor showed significant differences, ( $F=222.79$ ,  $p<0.0001$ ). Scheffè tests showed significant differences in selection macrorule between 5th and 11th grades, 5th and 2nd technical college grades, 8th and 11th grades, and 8th and 2nd technical college grades ( $p<0.05$ ); no differences in generalization-1st; significant differences in generalization-2nd between 5th and 11th grades, 5th and 2nd technical college grades, 8th and 11th grades, and 8th and 2nd technical college grades ( $p<0.05$ ); and, no differences in construction macrorule.

The interactions predicted in our second hypothesis were fully supported by the results. Both aid by macrorule interaction and

familiarity by macrorule interaction were significant ( $F=39.29$ ,  $p<0.0001$  and  $F=108.77$ ,  $p<0.0001$  in that order). The interactions between school-level and the other three factors reached significant results: the aid and school-level interaction was significant, ( $F=2.85$ ,  $p=0.040$ ); the familiarity and school-level interaction was significant ( $F=2.87$ ,  $p=0.039$ ); and, finally, interaction between school-level and macrorule factors was significant ( $F=2.21$ ,  $p=0.021$ ).

Of special interest was to find second order interactions between school-level, aid, and familiarity factors (MANOVA:  $F=4.60$ ,  $p=0.004$ ). Scheffè tests show significant differences in: non-familiar by no-aid items between 5th and 11th grades, and 8th and 11th grades; familiar by no-aid items between 5th and 11th grades, 5th and 2nd technical college grades, 8th and 11th grades, and, finally between 8th and 2nd technical college grades ( $p<0.05$ ); there were no differences in non-familiar by aid, and in familiar by aid conditions. Figures 2.1., 2.2. and 2.3. offer different perspectives of this interaction.

In order to test the third hypothesis we used a Chi-Square tests to compare the performance of subjects in the familiar/no-familiar conditions. We did not find any significant differences in the selection macrorule. In contrast, significant differences were found in the 1st-order generalization ( $\text{Chi}=216.84$ ,  $p<0.00001$ ), 2nd-order generalization ( $\text{Chi}=171.90$ ,  $p<0.00001$ ), and construction macrorules ( $\text{Chi}=83.62$ ,  $p<0.00001$ ).

We also made some comparisons of aid/no-aid by familiar/non-familiar conditions. The selection macrorule did not reach significance either. However, 1st.-order generalization macrorule showed significant differences both in no-familiar items ( $\text{Chi}=45.77$ ,  $p<0.00001$ ) and in familiar items ( $\text{Chi}=8.32$ ,  $p=0.03993$ ). The 2nd.-order generalization macrorule reached similarly significant results in non-familiar items ( $\text{Chi}=49.87$ ,  $p<0.00001$ ) and in familiar items ( $\text{Chi}=41.07$ ,  $p<0.0001$ ). Finally, in the construction macrorule the differences were also significant in no-familiar items ( $\text{Chi}=61.33$ ,  $p<0.00001$ ) and in familiar ones ( $\text{Chi}=48.18$ ,  $p<0.00001$ ). Figure 2.4. shows how the different macrorules are used by subjects through the different experimental conditions.



### 3.4.- Discussion.

As it can be observed in figure 2.1., 2.2. and 2.3. the performance of subjects at different school levels is determined by familiarity and aid factors and their interaction. The mean scores of no-aid and no-familiar condition were expected, both being almost never greater than 1, i.e., if the subjects lack the knowledge base about the specific domain they cannot make the necessary retrieval operations involved in generalization and construction items. It seems that the absence of previous knowledge blocks the application of proper macrorule. If this is true for the no-aid and no-familiar condition, then it should be also true for the aid and no-familiar condition, since recognition processes must also be based on previous knowledge. However, all the groups, especially adult ones, were able to profit from the aid in some way, clearly increasing their performance. Subjects may have found some useful analogy and got the expected response. For instance, in a construction no-familiar item the process described was how a researcher makes a propositional analysis of a text, which was quite similar to syntactic analysis taught in school. This was sufficient to alter the experimental condition and to produce an item at least analogically familiar, which added to the aid condition unexpectedly improved the performance of subjects.

The no-aid and familiar condition results are perhaps the most interesting, because they show how the main difference between young and adult readers is focused on the active use of knowledge during text processing, without any type of aid or key concept. Adult subjects are more efficient at performing the retrieval operations needed to reach good summaries, and they seem to use knowledge in a better and deeper way. Figure 2.3. reinforces the idea that adult subjects obtained a considerably smaller increase from the aid condition than younger ones on the familiar items. It would appear that although items were extremely familiar, younger readers make the worst use of their previous knowledge in the familiar and no-aid condition, i.e., when they need to make inferences by retrieval operations. On the other hand, in terms of the aid and familiar condition, when subjects only have to recognize the explicit relations presented in the material, all different school levels had similar performances. Finally, no-familiar by aid/no-aid

conditions revealed a similar pattern of increase according to school levels.

The third hypothesis predicted that subjects would show a tendency to use macrorules as a function of both unfamiliarity of items and the complexity of cognitive operations involved. The experimental results appearing in figure 2.4. show how familiarity and aid factors interact. First, subjects tend to use the selection macrorule when they cannot access any type of previous conceptual knowledge. Secondly, subjects use more frequently the selection macrorule in the no-aid condition than in the aid condition. This interaction is characterized by a reduction of selection across experimental conditions and an increment of the proper macrorule use.

#### **4.- Conclusions.**

From the analysis of our results of the two experiments we may reach the following conclusions. First, experimental results show that developmental differences between young and adult readers could be focused on the retrieving operations necessary to construct macrostructure, at least in simple and brief paragraphs where the situational model and the macrostructure coincide largely, and rhetorical knowledge is not playing an important role. Both in the first and second experiments, all of the school levels reached equivalent scores in the familiar and aid conditions, i.e., when the subjects only had to recognize explicit relations. However, although young readers had the prior knowledge to write a good summary in familiar and no-aid conditions, their performance was significantly worse than those from higher school levels. These results fully agree with those described in our introduction as to the importance of the active use of knowledge in the explaining of developmental and novice-expert differences. In this same line, we have shown the efficacy of an intervention program focused in the enhancement of active processing strategies of summarization and the construction of structural outlines (García Madruga, Martín Cordero, Luque and Santamaría, 1992) .

Secondly, we assumed that the different macrorules demanded different degrees of difficulty related to both integration and retrieving processes. Experimental results show a decreasing trend

in the correct use of the four macrorules, greater at the lower school levels.

Thirdly, the trend to use the selection macrorules, in other terms the "copy-delete" strategy, is a consequence of a less-efficient and pasive use of previous knowledge. We can say that the "copy-delete" strategy works as a "backup strategy" to which people, even adult subjects, could "regress" when facing problems especially difficult an no-familiar (Siegler, 1983, 1988). When good readers lack previous knowledge about the topic of the paragraph their performances are very similar to that of younger readers. It can be said that either lack or inefficient use of previous knowledge blocks the application of proper macrorules.

We would like to conclude by mentioning one of the limitations of our work. We are just begin to use for a new experimental paradigm. It is clear that it needs further exploration and improvement.

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**Appendix 1: Examples of materials, macrorules and aids (1st. Exp.):**

a) **Selection:** the first sentence of the paragraph can integrate or account for the three or four following sentences. The operation consists in copying verbatim a sentence, recognizing an explicit relationship in the text.

*Buses and cars are different. For example, buses are bigger than cars and have more tires. Another difference is that buses can carry many more people than cars. Lastly, buses are much slower than cars, and they are noisier.*

Summary sentence: Buses and cars are different.

Aid: To be different.

b) **First-order generalization:** a set of concepts, each of them corresponding to a word, is replaced by a superordinate concept that the subjects must retrieve from their previous knowledge. The relationship between the substituted concepts and the superordinate one is that the first ones are instances of the new superordinate concept.

*Johnny would like to have a German Shepherd more than to have a cat. He would rather have a Cocker Spaniel than a cat. Johnny told his father that he would even prefer having a French Poodle than any breed of cat.*

Summary sentence: Johnny prefers dogs over cats.

Aid: Dogs

c) **Second-order generalization:** a set of ideas, each corresponding to a sentence or proposition, is replaced by another sentence or proposition containing a superordinate idea that the subjects must retrieve from their previous knowledge.

*Andrew's mother constantly suffers from severe headaches. To help her, Andrew's father asked him and his brother to refrain from shouting and raising their voices. He also requested that they lower the volume of the television set and of the music system.*

Summary sentence: Since Andrew's mother suffers from headaches, his father requested them not to make noise.

Aid: Not to make noise.

d) **Construction:** a set of ideas, expressed by several sentences or propositions, must be replaced by a new sentence accounting for them globally that has also to be retrieved from their previous knowledge. The relationship between the new idea and the ones expressed in the paragraph is that the latter are elements, consequences or causes of the new idea.

*Tom got in line to get his ticket. Once he got it, he then gave it to the doorman and then bought a large bag of popcorn and a soda. He then went into the room, sat near the aisle and waited until the lights went out before paying attention to the screen.*

Summary sentence: Tom went to the movies.

Aid: Going to the movies.

**Appendix 2:**

Examples of unfamiliar materials (From Psychology contents), macrorules, summaries and aids used in the 2nd. experiment.

**SELECTION**

*There are several hypotheses on the nature of mental representations. For example, several experts support the propositional character of mental representations. Nevertheless, others have proposed images as one of the basic types of representations used by the human cognitive system. Lastly, some researchers created mixed models that combine both types of representations.*

Summary sentence: There are several hypotheses on the nature of mental representations.

Aid: Several hypotheses.

**1st order GENERALIZATION**

*Psychologists working on improving readers' text comprehension think that it is more adequate to teach people to identify main ideas than to instruct them in domain-specific knowledge. In the same fashion, they would rather teach people to make summaries than to instruct them in domain-specific knowledge. Finally, psychologists consider it is most useful to instruct people in building outlines than only to instruct them in domain-specific knowledge.*

Summary sentence: Psychologists prefer to teach strategies than to instruct in domain-specific knowledge.

Aid: Strategies.

**2nd order GENERALIZATION**

*Reading is an extremely difficult and complex activity. A reader must identify letters and syllables, and recognize words in order to understand what it is read. He/she must process the words making semantic and syntactic analyses. Lastly, he/she must be able at the same time to reach a global interpretation of the information.*

Summary sentence: Since reading is an extremely difficult and complex activity, the reader must integrate different levels of processing in order to understand.

Aid: To integrate different levels of processing.

**CONSTRUCTION**

*The researcher carefully read the text several times. Firstly, he divided the text in several sentences, and inside each he identified the clauses. Secondly, he checked for the main verb of the first sentence and its arguments, and represented it. He/she then represented in this order the predicate modifiers and the arguments. He repeated this process in each sentence and each clause until he covered all the text.*

Summary sentence: The researcher made a propositional analysis.

Aid: To make a propositional analysis.

FIGURE 1.1. TOTAL SCORE OF SCHOOL LEVELS BY AID FACTOR.

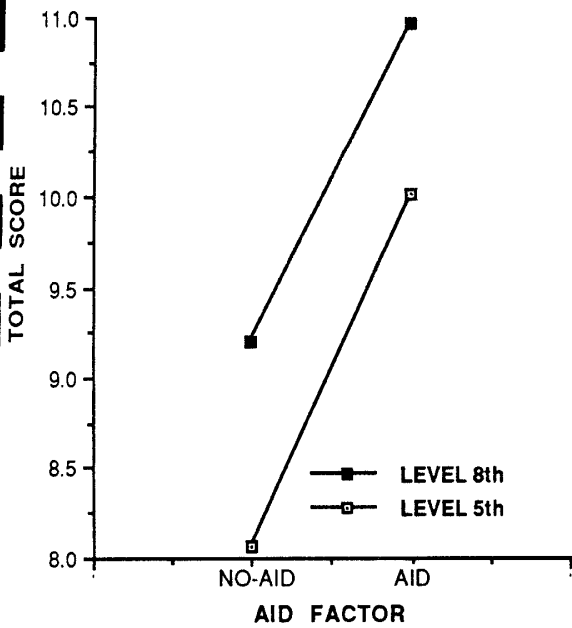


FIGURE 1.2. PERCENTAGES OF CORRECTLY USED MACRO-RULES BY SCHOOL LEVEL.

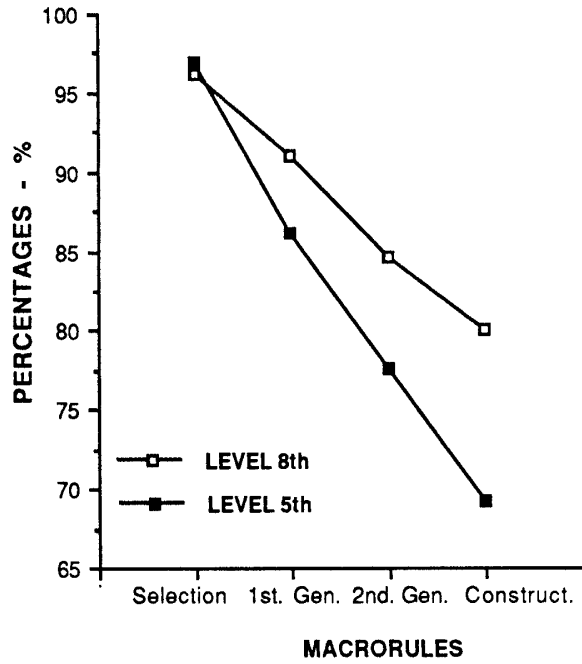


FIGURE 1.3. INTERACTION BETWEEN AID & MACRORULE FACTORS.

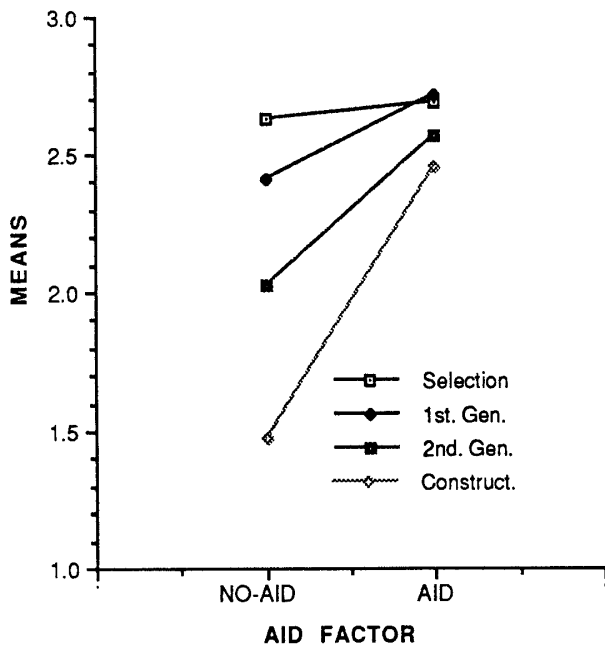
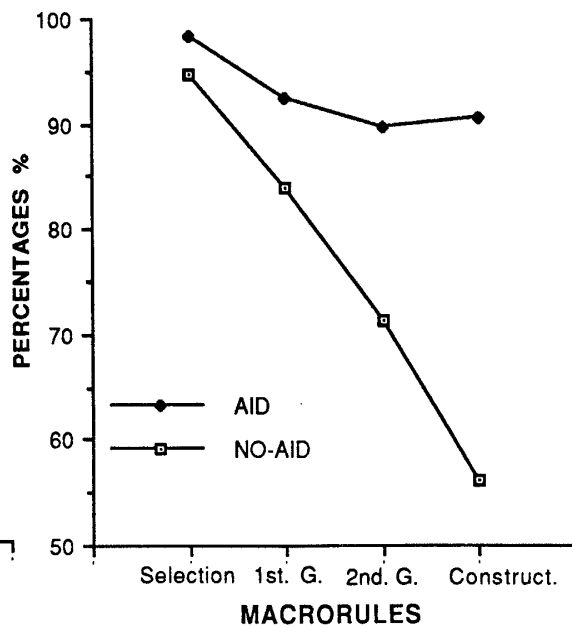
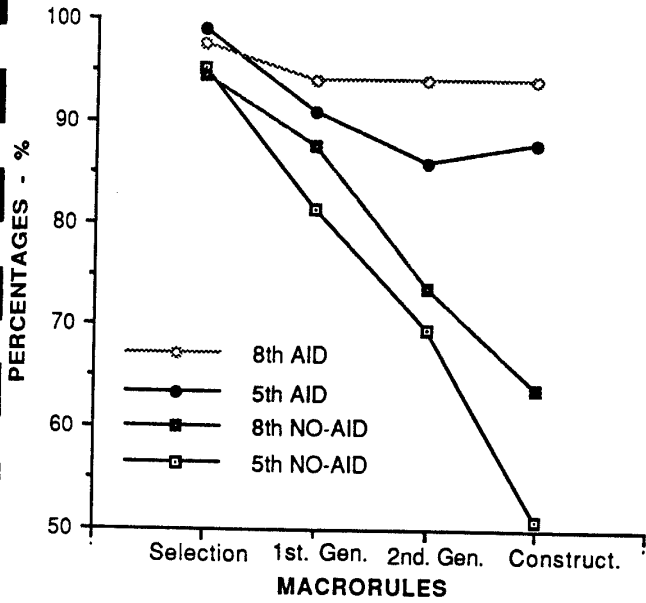


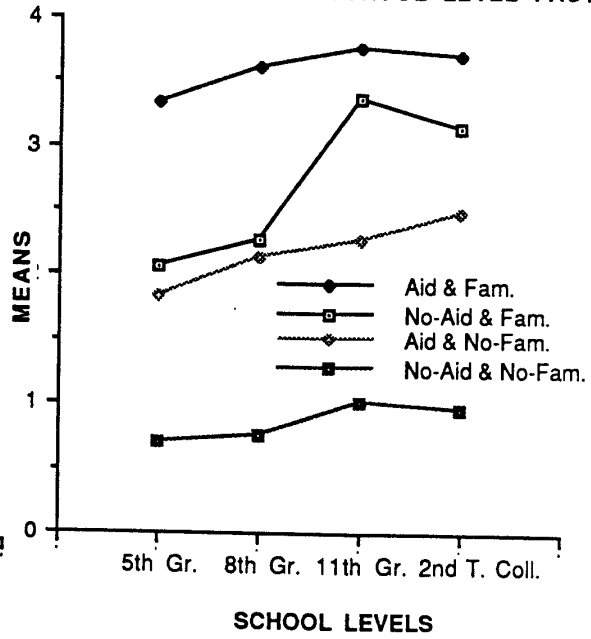
FIGURE 1.4. PERCENTAGES OF CORRECTLY USED MACRORULES BY AID FACTOR.



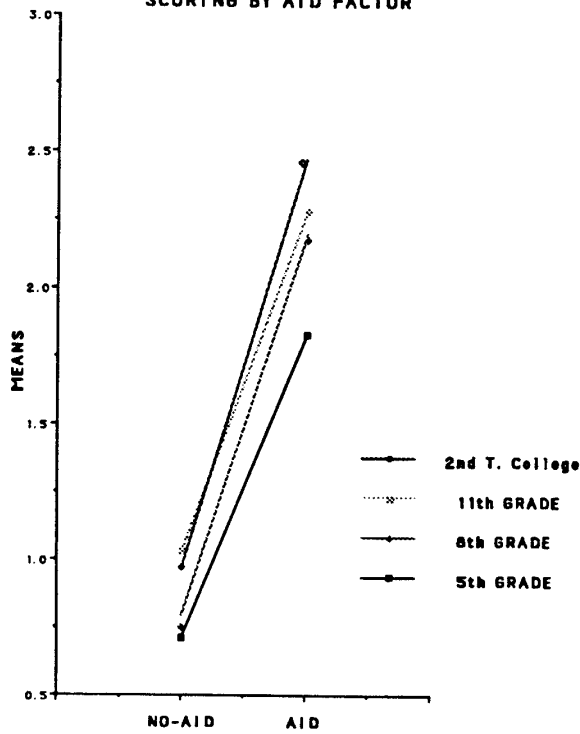
**FIGURE 1.5. PERCENTAGES OF CORRECTLY USED MACRORULES BY SCHOOL LEVEL AND AID FACTOR.**



**FIGURE 2.1. MEANS OF AID BY FAMILIARITY AND SCHOOL LEVEL FACTORS.**



**FIGURE 2.2. NO-FAMILIAR ITEMS SCORING BY AID FACTOR**



**FIGURE 2.3. FAMILIAR ITEMS SCORING BY AID FACTOR**

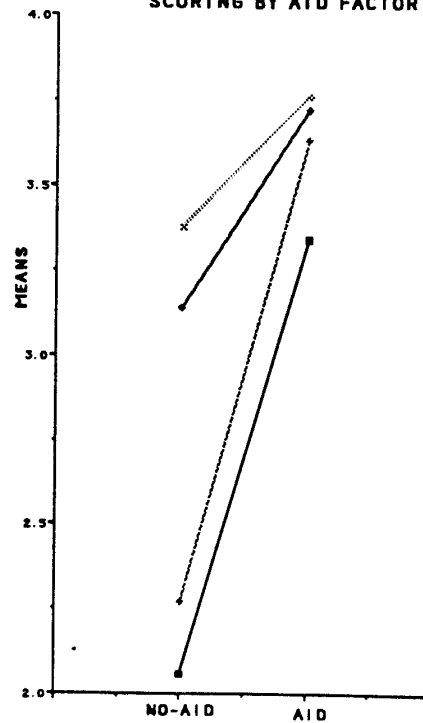
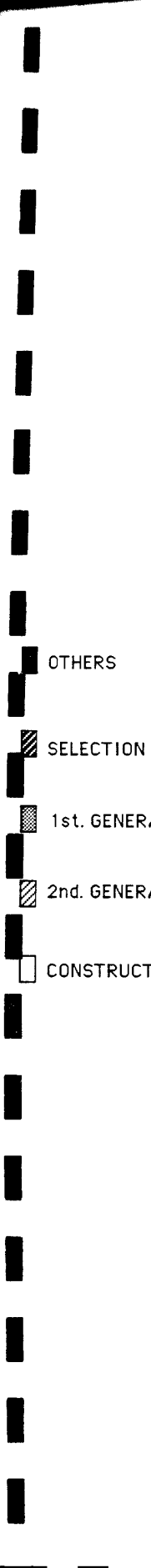




FIGURE 2.4. MACRORULES USED IN AID BY FAMILIAR ITEMS



- OTHERS
- SELECTION
- 1st. GENERAL.
- 2nd. GENERAL.
- CONSTRUCTION

