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SENTENTIAL PRIMING OF SEMANTIC INFORMATION IN GOOD AND POOR YOUNG READERS AND IN ADULTS[1]

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Summary.—Using Tabossi and Johnson-Laird's technique to test whether 8- to 10-yr.-old children with good and poor reading comprehension differ in use of context while they read, those with good reading comprehension in one study and adults in another showed an inhibitory effect for incongruent context, unaccompanied by a facilitative effect of congruent context. The poor comprehenders in Grade 2 showed a facilitative effect of congruent, context-dependent context.

Recent research has shown that the way in which unambiguous words are processed depends upon the information conveyed by the sentence context in which the word occurs (Barsalou, 1982; Tabossi, 1982; Tabossi & Johnson-Laird, 1980). In Tabossi and Johnson-Laird's study adult subjects were presented a series of sentences, each followed by a yes/no question to be answered by the subject. The question was always about one particular aspect of the meaning of a word that occurred in the preceding sentence (the test word). There were three experimental conditions (the example sentences are taken from Tabossi and Johnson-Laird): (1) In the *congruent condition* the sentence stressed the meaning aspect of the word that the question was about, e.g., S: "The goldsmith cut the glass with the diamond." Q: "Is a diamond hard?" (2) In the *incongruent condition* the sentence stressed some other meaning aspect of the test word, e.g., S: "The goldsmith cut the glass with the diamond." Q: "Is a diamond brilliant?" (3) In the *neutral condition* the sentence did not stress any meaning aspect of the test word in particular, e.g., S: "The film showed the person with the diamond." Q: "Is a diamond hard?" The reaction times of the answers (verification RT) were registered and subsequently analyzed. The results showed that verification RT is influenced by the prior sentence: Verification RTs turned out to be shorter in the congruent condition than in the neutral condition. Furthermore, verification RT was longer in the incongruent condition than in the neutral condition.

In Exp. 1 below we used Tabossi and Johnson-Laird's technique to see whether children with good and poor reading comprehension differ in their use of contextual information while reading. There is some evidence that

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poor reading-comprehension is not exclusively caused by a lower-level impairment in decoding abilities (Paris & Myers, 1981; Stanovich, 1982). A passive attitude towards text may constitute a further cause of poor reading comprehension (McFarland & Rhodes, 1978; Paris & Lindauer, 1976). If that is indeed the case and assuming that the pattern of results obtained by Tabossi and Johnson-Laird (1980) reflects an active approach to text, their results may be expected to replicate for children with good reading comprehension, whereas for children with poor reading comprehension but with sufficient decoding skills, the three experimental conditions, namely, congruent, incongruent and neutral, should produce equal RTs.

The above hypothesis was tested in Exp. 1 below, in which second and fourth graders participated as subjects. Exp. 2 constitutes a close replication of Tabossi and Johnson-Laird's study with adult subjects.

Experiment 1

Method

In general, the procedure of this experiment was the same as that of Tabossi and Johnson-Laird (1980). However, their method and ours differed in two respects. Whereas the presentation time of the sentence in Tabossi and Johnson-Laird's study was always 5 sec., our subjects controlled the exposure time of the sentence themselves. This was done under the assumption that in this way the normal reading process is better imitated. Furthermore, while in their study the interstimulus-interval between sentence and verification question was 1000 msec., it was only 500 msec. in our experiment.

Materials.—The experimental materials consisted of two lists, List 1 and List 2. Any single subject was presented either List 1 or List 2. Each list contained 40 test stimuli (the 'critical' stimuli), 40 filler stimuli, and 10 practice stimuli. Each stimulus consisted of a sentence followed by a verification question. The sentences were all shorter and had a simpler grammatical structure than those used by Tabossi and Johnson-Laird. All words contained by the sentences were derived from calibrated materials on the vocabulary of children, such that we could be reasonably sure that all of the subjects knew all the words in the sentences. All questions asked for information that may be expected to be present as declarative knowledge among the knowledge store of 8- to 10-yr.-old children. Indeed, as will be seen below, the subjects in this experiment make very few errors when responding to the verification questions. Ten of the 40 test stimuli within a list constituted the congruent condition, and 10 others formed the materials of the incongruent condition. The remaining 20 test stimuli within a list were all neutral stimuli. Ten of them served as controls for the 10 congruent test stimuli and the other 10 were the control stimuli for the 10 incongruent

test stimuli. A neutral stimulus always contained the same question, but a different sentence, as the corresponding congruent or the corresponding incongruent stimulus. For any pair of a neutral test stimulus and a corresponding congruent test stimulus in List 1, a pair of neutral test stimulus and incongruent test stimulus occurred in List 2, with the same sentences, but a different question. The consequence of this was that between lists not only the *questions* of the congruent and incongruent conditions but also those of the neutral conditions consisted of different materials. The *context sentences* were the same across lists. The way the materials were constructed is illustrated in the following example. List 1, congruent condition: The orange rolls off the table. Is an orange round? List 1, neutral condition: The orange lies on the table. Is an orange round? List 2, incongruent condition: The orange rolls off the table. Is an orange juicy? List 2, neutral condition: The orange lies on the table. Is an orange juicy? For all questions in the test stimuli 'yes' was the correct answer. The 40 filler stimuli within the lists required a 'no' answer. The same 40 sentence-question pairs served as filler stimuli in both List 1 and List 2. The 80 experimental stimuli were preceded by 10 practice stimuli that were the same for both lists.

Procedure.—The experiment was run on an Olivetti-PC. The subjects were tested individually. In front of the subject was a response panel with two response keys and a bar. A trial started with the presentation of a sentence on the PC screen. The subject was asked to read each sentence silently and to press the bar with pinky, ringfinger and middle finger of the left hand as soon as he had finished reading it. The sentence immediately disappeared and 500 msec. later the associated verification question appeared on the screen. The subject was asked to answer this question, as quickly as possible, by pushing one of the two response keys. The right-hand key was for 'yes' responses, the left-hand key for 'no' responses. Subjects were asked to keep the right-hand forefinger on the right-hand key and the left-hand forefinger on the left-hand key all through the experiment. One second after pushing either key, a new sentence appeared on the screen and remained there until the bar was pressed. The experimental stimuli were presented in blocks of 20 each. Every question occurred only once in each block. Within blocks the presentation of the stimuli was fixed, but the presentation order of the blocks was varied systematically. A session lasted 15 min. at the most.

Subjects.—In the experiment 137 children participated as subjects. All children attended regular classrooms. The data from 18 were removed from the analyses either because these subjects did not follow the instructions (16) or because they had more than 10% errors (2). The final experimental sample consisted of 119 children, 50 boys and 69 girls. Fifty-seven of these

children were from Grade 2 (mean age: 99 mo.; range: 90—113) and 62 of them were from Grade 4 (mean age: 124 mo.; range: 108—142). For all of them a score on a reading-comprehension test (Brus & van Bergen, 1971), one on a reading-decoding test (Brus & Voeten, 1973), and one on a test of nonverbal intelligence (Raven, 1958) were collected prior to the actual experiment. The IQ test showed the following results: Grade 2, mean score: 25, *SD*: 9.4, range: 9—42; Grade 4, mean score: 36, *SD*: 7.4, range: 11—51. The relevance of collecting reading-decoding scores in addition to the reading-comprehension scores will become clear later. For Grade 2 the Pearson correlation between the subjects' scores on the reading-comprehension and on the reading-decoding tests was .41; for Grade 4 it was .43 ($p < .01$ in both cases).

Results

In responding to the verification questions, subjects in each of the six grade by reading comprehension conditions (see below) made only very few errors (4.2% over-all). Therefore, the errors were not subjected to further analysis. A 2 (grade: 2 vs 4) by 3 (reading comprehension: poor vs medium vs good) by 2 (congruence: congruent vs neutral) analysis of variance was performed on the data of the congruent and neutral conditions combined, collapsed across Lists 1 and 2. The assignment of subjects to the three levels of the reading comprehension variable was based on a rank-ordering of the subjects' scores on the reading-comprehension test, with exactly one-third of the subjects being assigned to each of the three levels of the reading comprehension variable. The main effect of grade was significant ($F_{1,116} = 41.91$, $p < .001$): the over-all mean verification RT for second graders was 2931 msec., whereas it was 2348 msec. for fourth graders. The main effect of reading comprehension was also significant ($F_{2,116} = 7.44$, $p < .001$): the mean verification RTs for poor, medium, and good comprehenders were 2750 msec., .2750 msec., and 2420 msec., respectively. The main effect of congruence was not statistically reliable ($F_{1,119} = 2.14$, $p > .10$): the over-all mean verification RTs in the congruent and neutral conditions were 2603 msec. and 2659 msec., respectively. Finally, none of the interactions between the three variables was statistically reliable.

The same 2 (grade) by 3 (reading comprehension) by 2 (congruence) analysis of variance was performed on the data of the incongruent and neutral conditions. Again, the main effect of grade was significant ($F_{1,116} = 25.23$, $p < .001$): the over-all mean verification RT for second graders was 3160 msec., whereas it was only 2593 msec. for fourth graders. The main effect of reading comprehension was also again significant ($F_{2,116} = 3.11$, $p < .005$): the mean verification RTs for poor, medium, and good comprehenders were 2955 msec., 2964 msec., and 2688 msec., respectively. As on the above analysis, the main effect of congruence was not statistically re-

liable ($F_{1,119} = 1.83$, $p > .10$): the over-all mean verification RTs in the incongruent and neutral conditions were 2889 msec. and 2836 msec., respectively. None of the interactions between the three variables was statistically reliable. The above (nonsignificant; $p > .10$) difference of 177 msec. between the two neutral conditions is presumably due to the fact that different questions were presented in the two neutral conditions (see the Materials section).

In view of Tabossi and Johnson-Laird's results, the most striking outcome of the analysis is that no statistically reliable effect of congruence was observed. With respect to the specific predictions of this experiment (see the introduction), it is particularly noteworthy that in neither of the two analyses congruence and reading comprehension interact.

To obtain a more detailed picture of the data, the difference scores of the congruent vs neutral and the incongruent vs neutral conditions were calculated for all subjects in each of the six grade by reading comprehension conditions, and these difference scores were subjected to further analysis. Of these 12 difference scores only one was statistically reliable: the fourth graders with good reading comprehension responded significantly slower to the verification questions in the incongruent condition (2432 msec.) than in the neutral condition (2253 msec.; $F_{1,28} = 3.98$, $p < .05$).

To summarize the results of the above analyses: verification RT is shorter for fourth graders than for second graders, and it is shorter for good comprehenders than for poor comprehenders. The above analyses do not generally support the hypothesis formulated in the introduction that, as adults, young readers with good reading comprehension might respond both faster to a verification question in the congruent condition and slower in the incongruent condition than in the neutral condition, whereas children who are poor at reading comprehension should not show these effects. Consistent with the hypothesis, poor comprehenders neither show a facilitatory effect of congruent context nor an inhibitory effect of incongruent context, but, contrary to the prediction, that is also the case for good comprehenders of Grade 2. Consistent with the hypothesis, good comprehenders of Grade 4 show an inhibitory effect of incongruent context, but they do not show the predicted facilitatory effect of a congruent context.

Before concluding that our predictions were partly wrong and need to be accommodated, there is one question that has to be settled first, namely, whether *adult* subjects presented with our materials would produce the same pattern of results as the adult subjects in Tabossi and Johnson-Laird's (1980) study. If not, the difference between the predicted pattern of results and the one obtained may not be due to the predictions being wrong, but to other matters such as the sample of experimental materials or to differences between the procedures of our Exp. 1 and of the study by Tabossi and

Johnson-Laird. One procedural difference between these two studies was that in our experiment the sentence preceding the verification question remained on the screen until the subject pressed the bar (see the Procedure section of Exp. 1), whereas in their study this sentence was always presented for a fixed duration of time. To see whether this procedural difference was partly responsible for the results, in Exp. 2 for half of the subjects, all adults now, the presentation duration of the prior sentence was fixed, whereas for the other half it varied, as it did in Exp. 1, that is, the sentence remained on the screen until the subject pressed the bar.

Experiment 2

Method

Materials and procedure.—The stimulus materials of this experiment were identical to those of Exp. 1. For half of the subjects the procedure was the same as in Exp. 1; for the remaining half the presentation duration of the prior sentence was always 4 sec., which is 1 sec. shorter than the presentation duration of this sentence in Tabossi and Johnson-Laird's study. The reason for presenting the sentence for a shorter time duration than they did was that their sentences were generally longer and grammatically more complex than ours (see also above). Five hundred msec. after the sentence had disappeared the verification question appeared on the screen.

Subjects.—In contrast to Exp. 1, now adults participated as subjects. These adults all were students or staff members of the Psychology Department of the University of Nijmegen, 64 in all, who volunteered as unpaid subjects. Half of them participated in the 'fixed sentence-duration' condition, and the remaining half participated in the 'variable sentence-duration' condition (see above). Henceforth, these conditions are referred to as the 'fixed' and 'variable' conditions, respectively.

Results

A 2 (congruence: congruent vs neutral) by 2 (sentence presentation: fixed vs variable) analysis of variance was performed on the data of the congruent and neutral conditions, collapsed across Lists 1 and 2. The over-all mean verification RT in the congruent condition was 31 msec. shorter (1158 msec.) than that in the corresponding neutral condition (1189 msec.), but this main effect of congruence was not significant ($F_{1,62} = 2.16$, $p > .10$). In contrast, the main effect of sentence presentation was significant ($F_{1,62} = 6.93$, $p < .05$). The mean verification RT in the fixed and variable conditions were 1090 msec. and 1257 msec., respectively. The interaction between these two variables was not significant ($F_{1,61} < 1.00$, $p > .10$).

The same 2 (congruence) by 2 (sentence presentation) analysis of variance was performed on the data of the incongruent and neutral conditions. Now both main effects were statistically reliable ($F_{1,62} = 15.40$, $p < .001$, and

$F_{1,62} = 5.63$, $p < .05$, respectively). The over-all mean verification RT in the incongruent condition was 1296 msec., whereas that in the corresponding neutral condition was 71 msec. shorter, namely, 1225 msec. The over-all mean RTs for the fixed and variable conditions were 1175 msec. and 1346 msec., respectively. The interaction between the congruence and sentence presentation variables was not significant ($F_{1,61} < 1.00$, $p > .10$).

The results of Tabossi and Johnson-Laird's (1980) study are only partially replicated. Whereas, as they did, we observed an inhibitory effect of incongruent context, unlike them we did not obtain a facilitatory effect of congruent context. In fact, the present results are the same as those obtained for the good comprehending fourth graders in Exp. 1. The fact that this same pattern of results was obtained both with a fixed and a variable presentation duration of the prior sentence indicates that this procedural difference between our Exp. 1 (variable duration) and the study of Tabossi and Johnson-Laird (fixed duration) has not caused the differences in results between these two studies.

An alternative cause for the differential results of their study and the present one may be that the experimental materials that were used in the two studies were different. When we ran our experiments we were not familiar with the complete set of materials used by Tabossi and Johnson-Laird. Later we obtained this set, and it turned out that in one, presumably critical, respect it differed from ours.

Barsalou (1982) distinguished context-dependent (henceforth: CD-) and context-independent (henceforth: CI-) properties of objects. A CI-property is one that is activated each time the object is referred to, irrespective of the context in which the object's name occurs. In contrast, a CD-property is only activated in an 'appropriate' context, that is, a context that stresses this particular aspect of the concept referred to. For instance, the (CD-) property 'has lungs' of the concept /bear/ will be activated when encountering the sentence 'the bear caught pneumonia,' but not when encountering the sentence 'the bear is hairy.' In contrast, the (CI-) property 'has fur' will be activated in both cases. Barsalou showed that a congruent context only speeds up the verification RT of the subsequent question when it stresses a CD-property of the test word. He then suggests that in Tabossi and Johnson-Laird's study relatively many stimuli in the congruent condition may have stressed a CD-property of the test word, producing the facilitatory effect of a congruent context. However, their materials not being available to him, he was unable to verify this suggestion.

Having received Tabossi and Johnson-Laird's materials, we categorized theirs as well as our own congruent-condition materials in a set of stimuli in which the context stressed a CD-property of the test word and in one in which the context stressed a CI-property of the test word. It turned out

that in 63% of their congruent materials the stressed property could be categorized as context-dependent, whereas that was only the case in 35% of our congruent materials. We then reanalyzed the data of the congruent condition and the corresponding neutral condition of our Exps. 1 and 2 for the congruent CD-stimuli and the congruent CI-stimuli separately. The analyses of the data of Exp. 1 (with children as subjects) included three variables, namely, grade, reading comprehension, and congruence (congruent vs neutral), whereas those of the data of Exp. 2 (with adult subjects) included the variables congruence and sentence presentation.

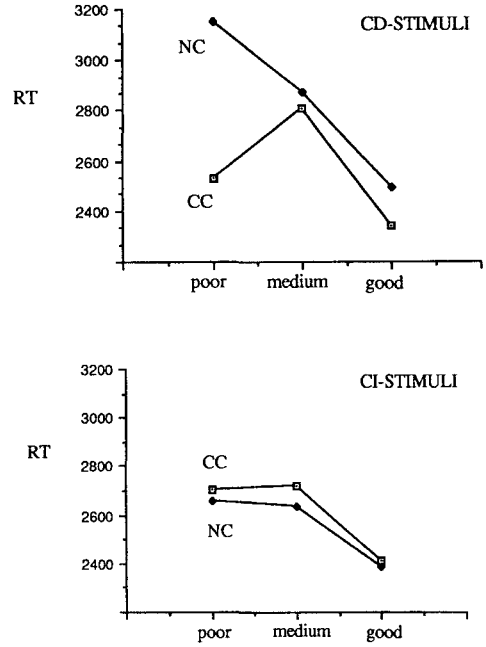

FIG. 1. RTs (in msec.) on the context-dependent (CD) and context-independent (CI) stimuli for the congruent (CC) and neutral (NC) conditions for children with poor, medium, and good reading comprehension

With adults as subjects, (Exp. 2), no differentiation between CD- and CI-materials occurred: not only the congruent CI-materials but also the congruent CD-materials failed to produce a statistically reliable facilitatory effect as assessed from their respective neutral conditions. However, in the experiment with children as subjects (Exp. 1) a differentiation between congruent CD- and CI-stimuli *did* emerge: the main effect of congruence was statistically reliable ($F_{1,113} = 15.50$, $p < .001$) for CD-stimuli, whereas it was not statistically reliable ($F_{1,113} = 3.10$, $p > .10$) for CI-stimuli. Collapsed

across reading comprehension and grades, the verification RT for congruent CD-stimuli was 2566 msec., whereas that for the corresponding neutral stimuli was 242 msec. longer (2808) msec.). In contrast, the over-all mean verification RT for congruent CI-stimuli and that for the corresponding neutral stimuli were about the same, namely, 2601 msec. and 2551 msec., respectively. In both the analysis with congruent CD-stimuli as in that with congruent CI-stimuli the main effects of grade and reading comprehension were statistically reliable. Since these effects were already reported above for the *complete* set of congruent materials, collapsed across CI- and CD-stimuli (see Results section of Exp. 1), no further details about them are reported here.

In the analysis on congruent CI-stimuli and their controls, none of the interactions between reading comprehension, grade and congruence was significant or approached significance, but in the analysis of congruent CD-stimuli and their controls two statistically reliable interactions were obtained, namely, that between reading comprehension and congruence ($F_{2,113} = 6.17$, $p < .001$) and that between grade and congruence ($F_{1,113} = 4.16$, $p < .05$). The first of these interactions is depicted in Fig. 1, together with the corresponding (nonsignificant) interaction for the CI-materials. It indicates that the effect of congruence is attributable to poor comprehenders mainly. For poor, medium, and good comprehenders the difference scores between the congruent and neutral conditions were 618 msec., 63 msec., and 156 msec., respectively. Only the 618-msec. congruence effect of poor comprehenders was statistically reliable ($F_{1,116} = 18.22$, $p < .01$). The second interaction indicates that the effect of congruence is particularly large for the younger children. For second and fourth graders the difference scores between the congruent and neutral conditions were 321 msec. and 144 msec., respectively. Only the former of these two difference scores was significant ($F_{1,116} = 9.87$, $p < .01$). Even though congruence interacts both with reading comprehension and with grade, the second-order interaction for congruence, grade, and reading comprehension did not approach significance ($F_{2,113} = 1.38$, $p > .10$).

As indicated earlier (see the Subjects section of Exp. 1), the subjects' scores on the reading-comprehension and decoding tests correlated. To see whether the above interaction between congruence and reading comprehension is not due to a confounding of reading comprehension by decoding skill, one final analysis was performed on the data of the congruent CD-stimuli and their controls. For this analysis each subject was assigned to either a group of good decoders or to a group of poor decoders. Subsequently, a 2 (grade) by 2 (decoding skill: good vs poor) by 2 (congruence: congruent vs neutral) was performed on the data. Of course, the main effects of grade and congruence were again statistically reliable. Since they were already dis-

cussed above, no further details about them are provided here. The main effect of the new variable, decoding skill, was also significant ($F_{1,116} = 46.10$, $p < .01$). The over-all mean verification RTs for poor and good decoders were 3078 msec. and 2349 msec., respectively. None of the interactions was statistically reliable. The fact that congruence and decoding skill do not interact ($F_{1,116} = .80$, $p > .10$) suggests that in the analysis above it is indeed reading comprehension, uncontaminated by decoding skill, that interacts with congruence. In short, it appears that poor reading comprehenders (and especially those of Grade 2), but not medium and good comprehenders, independent of their decoding ability, are facilitated by a congruent CD-context in answering the associated verification questions.

Discussion

The above Exp. 2, with adult subjects, only partially replicates the results of Tabossi and Johnson-Laird's (1980) investigation. Only an inhibitory effect of incongruent context, unaccompanied by a facilitatory effect of congruent context, was obtained. This same pattern of results was obtained for the good comprehenders of Grade 4, but not for the remaining groups of children-subjects.

In exploring the cause of the differential results between Tabossi and Johnson-Laird's study and ours we ruled out the possibility that a particular procedural difference between the two studies was responsible (Exp. 2). In an attempt to point to differences in the materials used by Tabossi and Johnson-Laird and by us as the source of the null-effect obtained for congruent stimuli, we categorized our congruent materials in a class of CD-stimuli and a class of CI-stimuli, a distinction introduced by Barsalou (1982), suggesting that a facilitatory effect might occur for CD-stimuli. However, in the adult study, as for CI-stimuli, no such effect emerged. It would be presumptuous to regard this result as counter-evidence for Barsalou's suggestion that CD- and CI-properties of words are differentially available during reading comprehension, since the materials used in the experiment with adults, originally being developed to be tested on 8- to 10-yr.-old children (Exp. 1), presumably were very easy for them to process. Processing may thus already have been at its maximally possible speed in the neutral condition, so that no facilitatory contextual process could be effective in the congruent condition. Suggestive of this interpretation is the finding that a reanalysis of the congruent and neutral data of Exp. 1 showed a facilitatory effect of congruent CD-context in the *slowest* readers, namely, the second graders who are poor comprehenders. At the same time, the latter finding supports Barsalou's classification of concept properties in CI- and CD-contexts.

It is, however, unclear how the fact that the children with the poorest reading comprehension are the ones to be facilitated by (a particular type of) congruent context, should be reconciled with the predictions formulated in

the introduction. There, a facilitatory effect of congruent context, as well as an inhibitory effect of incongruent context, was associated with active text processing that, in turn, was regarded as an essential characteristic of *good* reading comprehension. The finding that neither adults nor the better younger readers show the above facilitatory effect may presumably best be interpreted as an indication that the facilitatory effect observed for the poor younger readers does not reflect active text processing, but some other, as yet unidentified, process.

Finally, the most interesting result is that the older children with good reading comprehension show the same pattern of results as adults. This finding is consistent with the predictions that were formulated for this study (see Introduction).

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