GIST MEMORIES VERSUS VERBATIM MEMORIES IN CHILDREN

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ABSTRACT

The present study experimentally investigates the way children store the representation of linguistic texts. The paper focuses on one of the most prominent models in current children's false-memory reports research: the fuzzy-trace theory. According to fuzzy-trace theory children store separate representations of targets' surface forms (verbatim memories) and of the semantic, relational, and elaborative properties in which targets participate (gist memories). Gist memories are better preserved over time, more widely accessible, more generalizable to different forms of reasoning, and easier to process during the course of generating solutions to problems. The results of our experiment showed that skilled comprehenders are more likely to elaborate constructive representations by integrating related statements into a unitary mental model compared to less skilled comprehenders. The fact that performance at these constructive representations is not improved by the performance on the memory tasks is confirming the fuzzy-trace theory. Thus, the independence of the linguistic form from the gist of the statements is actually the independence of recalling from reasoning.

KEYWORDS: fuzzy-trace theory, text comprehension, working memory.

A great deal of research on text memory has demonstrated that some elements of a text (such as the semantic relations among entities, or situational aspects) are better remembered (with more accuracy and over greater periods of time) than other elements (such as the exact wording of a particular sentence) (Ledoux, Camblin, Swaab, & Gordon, 2006). This suggests that different types of information from a text are represented and organized differently in memory. Several researchers have

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described the processes through which text representations are created and maintained in memory (Graesser, Singer, & Trabasso, 1994; Jarvela, 1979; Zwaan & Madden, 2004).

Most of the research about the reading process is almost exclusively focused on the analysis of elements the subjects recall from the text they read. Text comprehension is explored in the same manner and is based on the remembered (or recognised) contents within a certain text (reading). Based on these contents, the researchers conjecture about the nature of inferences made on-line during reading and the processes involved in subsequent logical inferences production. There is a possibility to reproduce a text by heart without being able to transfer the informational content on similar tasks, thus the information provided by the text cannot be used or processed. There are frequent situations in the learning process in schools, where an assessor does not differentiate between a student who has a proper understanding of the text he is reading and another student who reproduces the text superficially without a proper understanding of what he memorised. A fundamental aspect of text understanding is represented by the necessity to transform the learned information into an integrative part of the subject’s knowledge.

The present study intends to investigate the difference between learned and memorised contents by using an alternative method apart from that implying only giving an answer to questions. We intend to analyse two of the fundamental theories regarding the recalling of information from a text: the fuzzy-trace theory and the constructivist theory.

The fuzzy-trace theory postulates a relative independence between verbatim memories and gist memories inferred from the same input (Reyna & Brainerd, 1992; Reyna & Brainerd, 1998; Swanson, Cooney, & Brook, 1993). Thus, children store separate representations of the target’s surface forms accompanied by other item-specific information (verbatim traces), and the semantic, relational, and elaborative properties in which the target is presented (gist traces) (Reyna & Brainerd, 1995). These dissociated contents cannot be considered as idiosyncrasies of cognitive immaturity because they occur in adult subjects as well (Ackerman, 1994; Brainerd & Reyna, 1993). However, according to the fuzzy-trace theory, as people acquire more knowledge and experience in solving a task, their information processing becomes more gist-based. That is, they tend to increasingly process information in a simple, qualitative, and categorical manner, given the constraints of the task (Brainerd, Reyna, Ceci, & Holliday, 2008).

At a more general level the fuzzy-trace theory claims that mature thinking is much more intuitive (consequently less logical) than considered by traditional theories. However, this intuitiveness is level-specific. Fuzzy-trace theory postulates that the sheer memorising of some linguistic content does not lead to a
proportionally better performance on the reasoning processes. Accordingly, the reasoning process affects both (a) the memorised patterns, and (b) the relationships formed between the memorised inputs (on the essential contents of the inputs). The reasoning process is indirectly dependent on the system of memorised inputs (Reyna, Adam, Poirier, LeCroy, & Brainerd, 2005; Reyna & Brainerd, 1995). In the domain of reasoning, there are three assumptions: (a) people encode both verbatim memories and gist representations for any meaningful stimulus (e.g., pictures, words, numbers, sentences, narratives, and events, all of which have been processed); (b) these processes are preferential, meaning that they rely on the least precise gist representation that can be used to accomplish a task (for both memorizing and reasoning tasks); (c) this tendency to operate on fuzzy memory representations increases with experience (e.g., with age - from childhood to adulthood, and in adulthood - with increases in expertise; Reyna & Adam, 2003). Hence, fuzzy-trace theory is the only developmental theory that predicts that gist mechanisms develop until adulthood and represent an advanced form of mature reasoning (Jacobs & Klaczynski, 2002; Reyna, 2004; Reyna, Lloyd, and Brainerd, 2003). The improvement of the ability to extract the gist of a linguistic input and transfer it to reasoning tasks improves the process of memorizing such contents. Nevertheless, the contents of gist memories are less precise than the contents of verbatim memories. As presented in Table 1, gist memories are better preserved over time, more widely accessible, more generalizable to different forms of reasoning, and easier to process during the course of generating solutions to problems.

Table 1

<table>
<thead>
<tr>
<th>Advantage</th>
<th>Explanation</th>
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<tr>
<td>Memory availability</td>
<td>Gist memories are more persistent over time than verbatim memories in terms of precise details, because reasoning is engineered around the type of information that is highly available.</td>
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<td>/ accessibility</td>
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<td>Generalizability</td>
<td>Gist memories are applicable to a broader range of problem-solving contexts than memories of specific problem-related facts.</td>
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<td>Processing</td>
<td>The reasoning operations that process gist memories are less complicated, less effortful, less time-consuming, and less error-prone than the reasoning operations that process verbatim memories of precise details.</td>
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<td>simplicity</td>
<td></td>
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<tr>
<td>Parallelism</td>
<td>Gist memories are easier to store in parallel with verbatim memories, by simply using retrieval cues to access well-learned concepts and patterns from long-term memory.</td>
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processes can occur in one subsystem without reference to the other (Chalfonte & Johnson, 1996). A gist memory trace is a fuzzy representation of an event’s underlying meaning and structure. A verbatim memory trace is an exact representation of an event’s surface level features. Thus, the independence of text reproduction processes from reasoning processes is similar to the independence of the essential content and the linguistic form of a statement. According to Kintsch (1998) a similar differentiation exists between the situation model and the textbase level of the text. The distinction between these two levels is useful when explaining differences between text memory and learning from a text (Kintsch, 1998). The textbase level is closer to text memory. The situation model level is closely related to learning from a text (e.g., making inferences), which requires the integration of text information with the reader's prior knowledge. This sort of independence requires that the representations of the essence and of the linguistic forms remain accessible (Reyna, 1992).

Psycholinguistic research-based evidence demonstrates that the representation of the linguistic form deteriorates much faster than the representation of essential contents (Clark & Clark, 1977; Kintsch, Welsch, Schmalhofer, & Zimny, 1990). Fuzzy-trace theory states that the memorising of linguistic forms and essential contents of the same linguistic input are stored separately. Furthermore, the semantic content could be accessed without previous access to linguistic form and vice versa.

Based on the paradigm of ”false recognition” Loftus, Levidow, and Duensing, (1992) have elaborated the principle of the „discrepancy detection”. According to this principle, a higher level of accuracy in the recognition of initial linguistic elements and related inferences from a text will result in a more efficient rejection of incongruent elements and inferences. Similarly to the fuzzy-trace theory, this paradigm postulates the existence of a relative independence between verbatim memories and reasoning (Reyna & Kiernan, 1994). This paradigm claims that high memory performances for a learned content should allow the subject to better recognize the elements presented in a text and recognize those elements that were not presented in the same text (Loftus, 2005).

False recognition of text propositions has also been interpreted as a by-product of memory processes used to construct coherent, meaningful representations, including inferences that relate ideas in the text to background knowledge (Reyna & Kiernan, 1995).

Research based on the constructivist paradigm sustains the idea of simultaneous recall of the verbatim form of the text and of the inferential structures. Thus, performances achieved on the memorising test versus comprehension tests should be co-dependent on the same semantic content (gist). This assumption implies that it is difficult to know exactly the specific mechanisms involved in text processing. Bransford, Barclay, and Franks (1972) were the first to show that
although verbatim wording of short texts is rapidly forgotten, readers later confuse sentences that are compatible with the gist of the situation described by the text, resulting in false recall of information not present in the text. In the same vein, Bransford and Franks (1971) have reported that subjects presented with a non-sequential order of interrelating sentences automatically integrate the partial ideas into holistic units. The authors base their conclusion on two facts: (a) subjects were unable to identify the exact forms that were presented and (b) subjects showed a bias in choosing more complex sentences as having been part of the acquisition corpus. Constructivist approaches consider that an important component of our memory system is the ability to combine related facts into higher units of knowledge. However, in order to combine these, a new fact must act as a cue in the retrieval of information already in the system; in this manner related ideas can be stored as a single unit. Consequently, there are often occasions when individuals do not integrate related facts but store them as independent units of knowledge.

When a written text is processed, readers are introducing additional relations/connexions, which are not explicit within the text. Thus they build an integrated semantic representation of the whole. This representation is more abstract than the representations of isolated statements.

Children who possess medium reading abilities, expressed through an understanding of the meaning of words separately read, have difficulties in the global/exhaustive understanding of a certain text. These discrepancies are determined by an inadequate representation of the text.

We predict that the process of comprehension can be operationalized through the mechanism of representation-construction.

Consequently, in the present study, based on the constructivist theories and on the fuzzy-trace theory we intend to test the ecological validity of some components of these theories by choosing to analyse the relationship between the textual memory and the process of inference generation. This relationship should be co-dependent, thus an adequate process of comprehension should require accurate memorising of a text. However, some of the recent studies undermine this hypothesis stating that these two processes are independent.

Based on these considerations our main objective could be formulated as it follows: the representations of the textual content of skilled comprehenders (SC) are more elaborated than those of the less skilled comprehenders (LSC).

The two specific hypotheses are:
(1) LSC will „make” more errors than SC when they have to recognise congruent semantic items.
(2) The number of the recognition errors for statements incongruent with the original text will be similar for both groups of subjects.

We are interested to study another two variables: (a) the type of the relationships within the scenarios: spatial relationships versus linear relationships.
and (b) time. Thus, the first test was completed immediately after the reading was finished, and the second test was completed 4 days later. Research conducted this far regarding this problem, which included children and adults, did not take into account the type of material (statements) used during testing (which can contain linear / spatial relationships). The types of relationships expressed in sentences material are spatial (e.g., “The greeting card is in the envelope. The envelope is on the book”) or linear (e.g., “The water is cooler than the milk. The milk is cooler than the juice.”). As Binet mentioned in 1903, the representations of spatial relationships have specific proprieties which differentiate them from linear relationships, because spatial relationships imply double coding: a semantic one and an imagistic one. Binet (1903) investigated his subjects by tests which were focused on measuring short term memory. However, our study investigates the mechanisms through which knowledge and information are assimilated, and can be recognised few days after the coding (Reyna et al., 2005). It is also important to observe and understand how test results change and how corresponding learning processes modify in time.

**METHOD**

**Participants**

Thirty-five participants, seventeen good comprehenders (aged 8.9 to 9.7 years, mean age 9.3 years; 9 females and 8 males) and seventeen poor comprehenders (aged 8.7 to 10.1 years, mean age 9.5 years; 6 females and 11 males) took part in the study. They were selected from a sample of 193 third-grade children from three elementary schools in Cluj-Napoca and other three elementary schools in Târgu-Mureş. Participants in the two groups were matched for age, scores on a vocabulary task, and differed significantly in comprehension skills. Vocabulary knowledge was measured with the Gates-MacGinitie Vocabulary Test (an adapted form, MacGinitie & MacGinitie, 1989), in which children select from five words the word that means the same or nearly the same as the target word. Less-skilled text comprehenders did not differ from skilled comprehenders in vocabulary knowledge $t(33) = 1.8$, $p = .08$. Level of comprehension is measured with the Test of Reading Comprehension (TRC) (Mih, 2004). The score for reading comprehension was based on the number of comprehension questions that the child answered correctly from the stories. Poor comprehenders were selected from the second, third and fourth deciles and good comprehenders were selected from the seventh, eighth and ninth deciles of TRC. According to their teachers, none of these children were dyslexic, or had cognitive impairments or severe learning difficulties.
Experimental Design

The experimental design is 2x2x2x3 factorial, with variables defined as follows: the classificatory variable, represented by the subjects category (LSC-SC), which is a between-subjects variable. The other three variables are within-subjects: (a) the moment of testing, every subject being tested twice, first time immediately after the presentation of the text and again after four days; (b) type of relationships, the subjects are given two categories of texts: one containing spatial relations and the other involving linear relations; (c) the recognition test, regarding the type of statement from the recognition task: the premise, the congruent inference and the incongruent inference.

Materials

The materials used were six stories, each of them containing three statements: two premises and a filler sentence. In order to test the comprehensibility of the six stories, we first tested ten subjects of similar ages with our subjects in order to check the level of their understanding of the words. Each word which was not recognised by all participants was eliminated from the study and replaced with another word which was also previously tested. All stories contained two event-statements about the same theme. The package of test items contained four statements. One of the statements was semantically congruent with the story; the second statement was semantically incongruent with the same scenario. The recognition items were similar with those included in the original scenario.

Example:

Premise item: The greeting card is in the envelope.
Congruent item: The greeting card is on the book.
Incongruent item: The book is on the greeting card.

Procedure

Each student was tested individually. After an initial period of familiarisation with the task, the experimenter told subjects that he is interested to find out „how well children remember what they read”. The testing was completed based on the instruction: „I will read some short stories to you. You have to try to memorise the stories in the exact way I read them. Then, I will read several statements (sentences) and you have to answer Yes, if I say the same words that I previously read to you. If
anything is different from the story, answer No”. Before testing we ensured that the subject understood the instructions and we repeated the instructions when they were not understood. In order to ensure an adequate and accurate understanding of the task participants were initially given two examples. After the first story was read, students were presented with the recognition items. These items contained 3 distinct statements: an identical statement with the one from the original text (the premises) and two new statements. One of the statements was an inference congruent with the text content and the second statement was incongruent with the content. All items were based on the original text, through the combination of words in new linguistic structures. After students gave the answers to the familiarisation task, the experimenter indicated the correct answers and also explained how children could select the correct answer. In order to actively involve the subjects in the reading task, they were told that they have to understand what they read.

This was assessed by analysing the answers given to certain questions related to the text content. The answers to these questions were not taken into account. Students read aloud all six stories. Each story was given separately on a card. In order to prevent effects related to the order of stimulus presentation, which could distort test results, we had to re-balance the presentation of the stories. First we introduced a distracter task of sorting some cards containing images. Then participants were given a list of twenty-four statements which they had to read and answer Yes when the statement was contained in one of the texts previously read or No when the statement was new. We only recorded the errors participants made on this task.

RESULTS

The number of recognition errors was recorded for each modality of the four factors involved in the experiment: type of statement, category of subjects, type of relations contained in the story, and results obtained at re-testing. The means and standard deviations of the percentage of errors made by SC and LSC were counted for the following independent variables: (a) the type of the statements: the premise items, the congruent inference and incongruent inference; (b) the type of the relations: spatial / linear and (c) the moment of recalling: immediately after testing / after five days. Results are presented in Table 2.
We will now analyse recognition based on spatial relations:

(a) **Reasoning-remembering relations.** The differences between congruent item means and premises item means at the first testing confirm the hypothesis that SC misrecognise a significantly higher percentage of inferences which are semantically congruent compared to LSC, $F_{(2,32)}=3.76, p < .01$. The configuration of error patterns for the original statements and for the incongruent statements is similar for the two groups of participants except the magnitude. There were no significant differences between the two groups, although the percentage of errors for SC group recognition was inferior in comparison with LSC. The analysis of variance for recognition errors of false statements indicates that more errors were made in the congruent semantic items in comparison to incongruent ones $F_{(1,33)}=8.97, p < .01$. The interaction between the comprehension level and the type of recognition was also significant, $F_{(1,32)}= 47.34, p < .00$. SC presented a higher rate of recognition errors for congruent items in comparison to LSC, but the rate of recognition errors made by SC was lower for incongruent items (Fig. 1).

(b) **The type of relations.** The SC evolution followed approximately the same pattern in the case of linear relations and spatial relations. For LSC we observed that the magnitude of the error rates for incongruent item recognition changed when the relations were linear, in comparison with the spatial ones; the rate errors increased significantly, $F_{(1,33)}= 5.43, p<.01$.

(c) **Long-term retention.** For LSC participants, in the context of linear relations, we observed at the second testing that results even out in all three types of statements.
The results of our experiment confirm that during the reading task SC are much more likely to elaborate representations by integrating the related statements into a unitary mental model than the LSC (Fig. 1). The fact that performances on these constructive representations are not improved by performances on the memory tasks is confirming again the fuzzy-trace theory. Thus, the independence of linguistic configuration from the gist of statements suggests the independence of memorizing from reasoning.

The mean of recognition errors for items which were semantically congruent was 50% higher in both groups tested. We observed that SC and LSC have “made” more errors in respect to items which were semantically congruent in comparison to items which were semantically incongruent. This result may be caused by the fact that participants mismatched the information contained in the premises and the information semantically congruent with the text (inference). In comparing error means for the recognition of semantically congruent items with text content, we can conclude that SC are contributing more to providing meaning for the message being processed. This mechanism of meaning construction is a result of an in-depth implicit processing of the material. At the surface structure-level there are no significant differences in the recognition process between the two groups of subjects.

**Figure 1**
Interaction of recognition errors for SC versus LSC as a function of type of statements (in the case of spatial relations).
An alternative explanation to the obtained results could be formulated as follows: the factor which determines the direct relation between the comprehension process and the rate of recognition errors for semantic statements is the manner in which the subject uses the basic general knowledge he possess. As a result, the volume of SC’s knowledge should be significantly higher and more consistent compared to LSC. This factor would facilitate an easier access to a variety of cognitive schemas related to the processed contents. If this presumption is true, then the rate of recognition errors for items semantically congruent in SC should be much lower than the rate of the recognition errors on premises items. The results obtained through the test do not confirm this hypothesis.

In sum, the pattern of results is congruent with the first interpretation, which sustains that comprehension abilities of skilled readers are related to the construction process of the cognitive system. This relationship is not necessarily dependent on the basic general knowledge of participants.

The experiment described does not directly address the problem of the locus of integrative processing. This integrative processing could take place during reading or later as well, during items recognition. The moment when the integration occurs could be reflected in the differences among error patterns observed for the two groups of students. Thus the less skilled readers could experience some level of difficulty during the recognition process of the original item, in comparison with the more skilled readers because they are insufficiently related to the premises items. This hypothesis is becoming plausible because there were no significant differences between the two groups in respect to recognition errors. It was also observed that the two groups of students made similar errors in original statements. These results suggest that the ability of the SC in the preferential recognition of congruent items, compared to the original statements, could be attributed to the process of partial dissociation between memorizing and the process of inference induction which is related to recognition items in a post-factum manner.

Considering the results obtained, we can conclude that LSC are „using” to a lower extent construction processes. We can also conclude that LSC show a certain minimal capacity to integrate information.

Thus, we can assume that these subjects will get more involved in the activity of better integrating elements of a text when they have sufficient awareness on the importance of these elements. Consequently, readers with difficulties in understanding written material could be trained through appropriate instructions targeting metacognitive abilities. The training will consist in the summarization of a given material in various coherent versions. Also, through group training sessions participants will learn how to elaborate certain situational models according to the text being processed.

Regarding the type of relations variable, a more noticeable difference between the two groups of subjects was observed. Thus, the differences between the inferential performances of subjects are higher in the condition when stimuli are...
based on linear relations than when they are based on spatial relations. In the case of less skilled readers, there were no statistically significant difference between the numbers of incongruent items recognized compared to congruent items. This pattern could be explained by the increase in the level of task difficulty. In order to produce a coherent representation of the text, subjects needed to process more complex linguistic elements, which led to a decrease in their performance. This phenomenon did not happen in the case of skilled readers.

When looking at the effects of the time variable, we noticed a homogenizing process for the recognition performances on all types of items, which means that the initial pattern is not maintained, thus there is no significant difference between the rate of recognizing original, congruent and incongruent items. This is the case for both accounts containing linear relations and those containing spatial relations. However, in the case of items containing spatial relations, we noted a better recognition of congruent items compared to incongruent ones. The more able readers presented a specific pattern during the recognition tasks three days after the initial experiment.

There are significantly more errors in the recognition task after three days compared to the immediate recognition exercise, but the ability to remember the congruent items was maintained at approximately the same rate. This pattern could be explained by Gernsbacher’s (1990) theory of integration, suggesting that linguistic elements are encoded in bigger units. The words are encoded in simple phrases, while sentences and phrases are encoded in bigger units of discourse or in a mental model. This encoding process leads to more efficient processes on the basis of long term memory; the smaller parts of the text will be forgotten. This theory shows how subjects remember the situation described by phrases and not the phrases themselves. In summary, this theory states that the process of consolidating memories of small units into bigger units of discourse leads to smaller elements to be forgotten.

An alternative explanation for the increase in error rates for the task of recognizing superficial structures could be found in the theory of processing commutation. Roediger and McDermott (1995) underline that the retention of a specific item depends on the attentional resources allocated to the processing of that particular item. The structures processed in chronological order will be temporarily maintained by being incorporated in working memory. When a new structure (phrase) intervenes in the text, structures of the previous text become under-activated. The accuracy of surface structure retention and retrieval will then decrease due to successive deactivation of cognitive units which existed up to that moment in working memory and following the allocation of attentional resources to new created structures. This could mean that the majority of surface structures could be lost, but Gernsbacher, Robertson, Palladino, and Werner, (2004) showed that the textual form is the type of information that changes most rapidly in all circumstances. The subject then commutes the allocation of attentional resources.
Because this process happens simultaneously at different levels (word, sentence, phrase, event), a hierarchy of processing types takes place, influencing the content of the memory. Because surface structures form the inferior level of this hierarchy, the retention specific to this level is weaker.

We found that even at a young age, children’s skills that foster meaning construction make an important contribution to the determination of comprehension level more than the contribution made by word-level and verbal skills. These findings lead us to conclude that working memory should be regarded as one of several factors that can influence comprehension ability and comprehension development. Clearly, neither good verbal skills nor good working memory resources are in themselves sufficient for the application of processes such as inference making and comprehension monitoring used in the construction of text representations. Instead, further research is needed to establish which particular aspects of the comprehension-fostering skills need to be taught and included in future curricula (Cain, Oakhill, and Lemmon, 2004).

The fuzzy-trace theory offers good explanation to the processes through which the surface structure gets deactivated immediately after structural connexions are formed between sentences and the development of a semantic structure for the text. This leads to the conclusion that for subjects with high comprehension ability a mental model is formed, which is stronger than that of surface structure (Kintsch, 1998). This process does not occur in the case of subjects with lower reading abilities.

Based on our results, we conclude that the simultaneous use of the three information processing codes: verbal, semantic and spatial would be beneficial for less skilled readers. These readers are more influenced by insufficient processing of spatial aspects during the encoding stage.

REFERENCES


