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# Assessing the Structure of Verbal Protocols

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## Abstract

One approach that has been used to study processes that give rise to comprehension is to have readers verbally report their understanding during reading. The thoughts that readers produce usually contain multiple clauses that convey different kinds of processing strategies, such as paraphrasing, bridging, or elaborations. The goal of this study was to examine the structure of verbal protocols and to identify whether there was a sequence to the information sources that comprised a given verbal report. Participants produced think-aloud protocols while reading scientific texts. With respect to whether there was an identifiable sequence to the information contained in a verbal protocol, the results indicated that participants tended to begin their protocols with information from the current sentence before adding information from world knowledge and the prior text. As additional clauses were produced, there was a shift in focus from the current sentence to elaborative information.

## Introduction

It has been well established that to comprehend text, readers must go well beyond the information explicit in it (e.g., Graesser, Millis, & Zwaan, 1997). This requires readers to actively participate in the comprehension process by engaging in inferential and strategic processes that serve to connect text events to one another and to the reader's general knowledge about the world (Graesser & Kruez, 1993). These types of processes presumably aid in the construction of coherent mental representation of what the text is about, a fundamental aspect of most theories of text comprehension (Gernsbacher, 1990; Graesser, Singer, & Trabasso, 1994; Kintsch, 1988; van den Broek, Young, Tzeng, & Linderholm, 1999; van Dijk & Kintsch, 1983).

One methodological approach that has been used to study inferential and strategic processes that give rise to comprehension is to have readers verbally report (i.e., think-aloud, self-explain) their understanding as they proceed through text (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Coté & Goldman, 1999; Ericsson & Simon, 1993; Magliano & Millis, 2003; Magliano, Trabasso, & Graesser, 1999;

Olson, Duffy, & Mack, 1984; Pressley & Afflerbach, 1995; Trabasso & Magliano, 1996; Wolf & Goldman, 2005). Procedurally, this requires readers to either verbally report, or type whatever thoughts come to mind after reading sentence (s) of a text. Thus, one commonly held assumption regarding verbal protocols is they reveal what information from the prior text of the passage and the reader's world knowledge is consciously available in working memory and 'codeable' in language (Ericsson & Simon, 1993). Therefore, if a reader is making a causal connection between the current sentence and a prior one, evidence of it could be found in his or her verbal protocol.

Because verbal protocols do not reflect a veridical description of the processes per se, researchers must develop qualitative coding schemes that can be used to classify the inferential and strategic processes presumed to be present. More frequently than not, this requires parsing a reader's utterance into clauses and then classifying each clause as belonging to one of the categories specified by a particular coding scheme without considering the overall structure of the verbal protocol. By structure, we mean the preceding and proceeding clauses.

Proponents of verbal protocol methodologies (Ericsson & Simon, 1993; Pressley & Afflerbach, 1995) contend that the structure of verbal protocols per se may be systematic and meaningful of the covert mental processes involved in the phenomena of interest. Unfortunately, in the context of reading comprehension research, the structure of verbal protocols is rarely considered. Consequently, much less is known about the structure of verbal protocols and how that structure might be reflective of the conscious processes involved in comprehension. Thus, the goal of this study was to examine the structure of verbal protocols and in particular to determine whether there was an identifiable sequence to the inferential and strategic processes readers engage in when constructing meaning from text.

## Information Sources and Verbal Protocols

It has been well established that in order for inferential and strategic processes to occur during reading, readers must be

able to access and have available in working memory different information sources (e.g., Corbett & Chang, 1983; McKoon & Ratcliff, 1980; O'Brien, Duffy, & Myers, 1986; Trabasso & Magliano, 1996). Once made available to working memory, these different information sources can subsequently be used to support the use of specific inferential and strategic processes (Trabasso & Magliano, 1996). For example, information from the current sentence can be used to compute a paraphrase, in which the reader restates the ideas contained in the current, focal sentence (i.e., the sentence currently being thought about) using their own words. Information from the prior text can be used to establish causal coherence between the current, focal sentence and the prior discourse, both locally and globally. Finally, information from world knowledge can be used to generate knowledge-based elaborations in which the reader incorporates his/her general world knowledge to establish explanatory coherence or to flesh-out the details of a situation model.

There is considerable evidence to suggest that the extent to which these inferential and strategic processes occur during reading depends in part on the type of text that is read. For example, Magliano and his colleagues have demonstrated that knowledge-based elaborations tend to predominate in the context of narrative comprehension (Trabasso & Magliano, 1996; Magliano et al., 1999), whereas paraphrasing tends to predominate when comprehending difficult scientific text (McNamara, 2004). Moreover, there is some evidence to suggest that the presence of these inferential and strategic processes tends to co-occur within a given verbal report. For instance, McNamara (2004) reported that 84% of the verbal protocols that contained a text-based explanation also contained a paraphrase. This would be in contrast to when the verbal protocols contained a knowledge-based elaboration, in which case the co-occurrence of paraphrasing was less likely. Thus, there is some evidence to suggest that readers may coordinate their use of inferential and strategic processes when verbally reporting their understanding.

### The Current Study

The primary objective of this study was to examine the structure of verbal protocols and in particular to determine whether there was an identifiable sequencing among the inferential and strategic processes readers use to construct meaning from text. It was hypothesized that readers may adopt a discourse strategy that would have implications on when readers engage in these processes as a verbal protocol is produced. For example, some researchers suggest that integration and elaboration occurs only when the reader has established an understanding of the current sentence (McNamara, 2004). As such, readers might begin their protocol with a paraphrase of the current sentence because engaging in this type of processing strategy aids in sentence understanding, thereby enabling the reader to integrate that information into the larger discourse context.

Additional support for this expectation comes from Gernsbacher's (1990) Structure Building Framework. According to the framework, comprehension proceeds by

laying down a foundation and then attaching incoming information to the foundation, provided they are related. In the context of a discourse strategy, the current sentence might be thought as a foundation that the reader adds to by attaching prior text, or elaborating upon it with world knowledge.

A third reason for this expectation comes from the given-new principle that is followed in the context of conversational discourse (Clark & Haviland, 1997). Accordingly, speakers first establish common ground (i.e., the given information) before introducing new information into the discourse. With respect to a discourse strategy during verbal reporting, we conceptualize the given as the information most immediate in working memory, namely the current sentence. The new would consist of information from the prior text or world knowledge that establishes how the current sentence is related to the larger discourse context. We conceptualize this information as "new" because it often involves inferences that are not explicitly stated in the text. Although verbally reporting one's thoughts has been conceptualized as a conversational discourse (Trabasso & Oezyuerek, 1997), we make no claims that readers imagine themselves in a conversation with an imaged participant. However, we do believe that it is reasonable to assume that pragmatic principles that guide conversational discourse may also guide verbal reporting in the form of a discourse strategy.

With respect to readers adopting a discourse strategy, we posit an *Ordering* hypothesis. According to this hypothesis, readers will initiate their verbal protocols with content from the current sentence before including information from the prior text and world knowledge. Therefore, there should be a shift in focus as readers describe their understanding with the first clause of their verbal protocol primarily containing information from the current sentence and later clauses containing information from the prior text and world knowledge.

## Method

### Participants

Sixty-four students who were enrolled in a critical thinking course taught at Northern Illinois University volunteered to participate in exchange for extra course credit.

### Materials

Four scientific texts were used in the current study. The topics of the text were heart disease, the origin of coal, the development of thunderstorms, and the food chain. These texts were adopted from popular textbooks and popular science books. Flesch-Kincaid Grade Level scores were obtained to assess the appropriateness of each text using Coh-Metrix (McNamara, Louwerse, Cai, & Graesser, 2005). The scores can range from 0-12 and are equivalent to a U.S. grade-level. The Flesch-Kincaid Grade Level scores for heart disease, the origin of coal, the development of thunderstorms, and the food chain were 6.059, 9.184, 8.567, and 8.85, respectively. Each text ranged between 20 and 34 sentences in length (total  $N = 97$ ). Because of time constraints, each

participant read only two of the four texts. Participants read either origin of coal and heart disease, or development of thunderstorms and food chain. Each participant was randomly assigned to one of these two sets of texts and the order of the two texts in each set was counterbalanced across participants.

### Procedure

Participants were run individually in small rooms, each of which was equipped with a workspace and a computer. The procedure consisted of two phases. During the first phase, participants read a short text about mitosis ( $N = 5$ ). The text was presented on a computer screen one sentence at a time. After reading each sentence, the participants were instructed to “report your understanding of the text in the context of what you have read thus far.” The participants typed their understanding into the computer. The purpose of phase one was to familiarize participants with the task of producing verbal protocols concurrently while reading. Phase two was identical to that of phase one, except that participants read two of the four experimental texts, as opposed to a short practice text. In both phases of the experiment, Microsoft Excel was used to display the texts and to collect the verbal protocol data (which was recorded into an Excel spreadsheet). Access to the Excel toolbars was removed so that participants could only proceed by pressing the “next” button, which appeared at the bottom of the screen. This button was appeared after the participants typed their understanding into a box that appeared near the bottom of the screen. Paragraph formatting was maintained in the presentation of the texts so that the texts looked natural to the participants. Participants could use the scroll bar to re-read any portion of the text that was not visible on the screen.

### Protocol Analysis

The verbal protocols that readers produced were first parsed into clauses. A clause contained a main verb that expressed an event, activity, or state and one or more arguments (e.g., nouns, adjectives, adverbs). Each verbal protocol was then classified according to the number of clauses that were present. There were three levels to this classification: one, two, and three or more clauses. For each clause, two independent raters (the first and second authors) identified the source of information for the verb and argument (s). There were three sources of information for which the verbs and arguments could be derived: the current sentence, the prior text, and the reader’s knowledge about the world. Table 1 provides example verbal protocols that were produced after reading the sentence “*Most babies are born with perfect hearts*” and how each of the verbs and arguments were coded.

Consider for example, verbal protocol statement 1. The words *ductus arteriosus* and *foramen oval*, and *close* were coded as world knowledge because they were not mentioned in the discourse. The words *babies* and *born* were coded as current sentence because both are mentioned in the current sentence. Finally, the word *work* was coded as prior text because this verb was present in earlier text sentences. Percent agreement

among raters was acceptable (86%). Disagreements were resolved through discussion.

Table 1. Example Verbal Protocols.

Verbal Protocol	Statement	Sources of Information
1	There aren’t many babies that are born with hearts that don’t work. However, they may have ductus arteriosus or a foramen ovale that doesn’t close properly after birth.	babies, born, hearts, <i>work</i> , <b>ductus arteriosus</b> , <b>foramen ovale</b> , <b>close</b>
2	Most babies do not have a congenital disease when they are born.	babies, born, <i>congenital disease</i> , <i>have</i>
3	Babies tend to be born with perfect hearts.	babies, perfect hearts, born

Note: plain text = current sentence, italics = prior text, and bold = world knowledge

### Results

In order to test whether readers adopt a discourse strategy when verbally reporting their understanding during reading, we first distinguished between those verbal protocols that were one, two, and three or more clauses in length. For each participant, we calculated the mean number of words that were derived from the current sentence, prior text, and world knowledge for each of the different clause lengths. One participant failed to produce verbal protocols that were three or more clauses in length and was excluded from the analysis. The means were submitted to a 3 (source of information: current sentence, prior text, world knowledge) X 3 (clause length: one clause, two clauses, three or more clauses) mixed Analysis of Variance (ANOVA) with source of information and clause length as the within-participant factors. The results from the analysis revealed a main effect for source of information,  $F(2, 124) = 78.21$ ,  $MSE = .08$ ,  $p < .01$ . Post-hoc analyses using Least Square Difference (LSD) revealed that information from the current sentence ( $M = .54$ ,  $SD = .17$ ) was produced more frequently than information from the prior text ( $M = .18$ ,  $SD = .07$ ) and world knowledge ( $M = .28$ ,  $SD = .14$ ). In addition, information from world knowledge was produced more frequently than information from the prior text. This main effect was qualified by a significant source of information by clause length interaction,  $F(2, 124) = 7.06$ ,  $MSE = .01$ ,  $p < .01$ . The nature of this interaction is depicted in Figure 1.

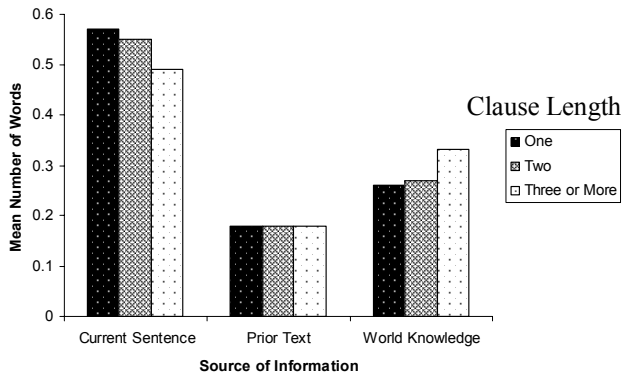


Figure 1: Mean number of words from the current sentence, prior text, and world knowledge as function of clause length.

Post-hoc (LSD) analyses revealed differences in the production of these information sources both across and within clause position. First, with respect to the pattern of differences across clause length, there were no differences in the production of information from the current sentence for protocols that were one clause ( $M = .57, SD = .23$ ) or two clauses in length ( $M = .55, SD = .17$ ). Three clause protocols, however, contained a significantly less information from the current sentence ( $M = .49, SD = .17$ ) than both the one clause and two clause protocols. Similarly, the production of information from world knowledge did not differ for protocols that were one ( $M = .26, SD = .19$ ) and two clauses in length ( $M = .27, SD = .15$ ). Three or more clause protocols did, however, contain significantly more information from world knowledge ( $M = .33, SD = .15$ ) than both the one clause and two clause protocols. There were no differences in the production of information from the prior text as a function of clause length (all  $p$ 's  $> .05$ ).

With respect to differences within clause length, one clause protocols contained more information from the current sentence ( $M = .57, SD = .23$ ) than information from the prior text ( $M = .18, SD = .11$ ) and world knowledge ( $M = .26, SD = .19$ ). World knowledge, however, was produced more than information from the prior text. Similarly, two clause protocols contained more information from the current sentence ( $M = .55, SD = .17$ ) than information from the prior text ( $M = .18, SD = .08$ ) and world knowledge ( $M = .27, SD = .14$ ). World knowledge, however, was produced more than information from the prior text. Finally, for protocols that contained three or more clauses, current sentence information ( $M = .49, SD = .17$ ) was produced more than information from the prior text ( $M = .18, SD = .13$ ). Information from world knowledge ( $M = .33, SD = .15$ ) was produced more than information from the prior text. There was, however, no difference in the production of information from the current sentence and world knowledge when the protocols were three or more clauses in length. In sum, these data suggest that as protocols get longer, readers shift their discourse focus away from the current sentence and use world knowledge to elaborate upon it.

A more direct test of this hypothesis, however, would be to assess the inclusion of information from the current sentence, prior text, and world knowledge for only those protocols that were three or more clauses in length. For each participant, we calculated the proportion of constituents that were derived from the current sentence, prior text, and world knowledge for each of the different clause positions. The means were then submitted to a 3 (source of information: current sentence, prior text, world knowledge) X 3 (clause position: first clause, second clause, third clause) mixed ANOVA with clause position and source of information as the within-participant factors. The results from the analysis revealed a significant main effect for source of information,  $F(2, 124) = 43.66, MSE = .10, p < .01$ . Post-hoc analyses (LSD) revealed that information from the current sentence ( $M = .49, SD = .17$ ) was produced more than information from the prior text ( $M = .18, SD = .13$ ) and world knowledge ( $M = .33, SD = .15$ ). World knowledge, however, was produced more than information from the prior text. This main effect was qualified by a significant clause position by source of information interaction,  $F(2, 124) = 38.16, MSE = .02, p < .01$ . The nature of this interaction is depicted in Figure 2.

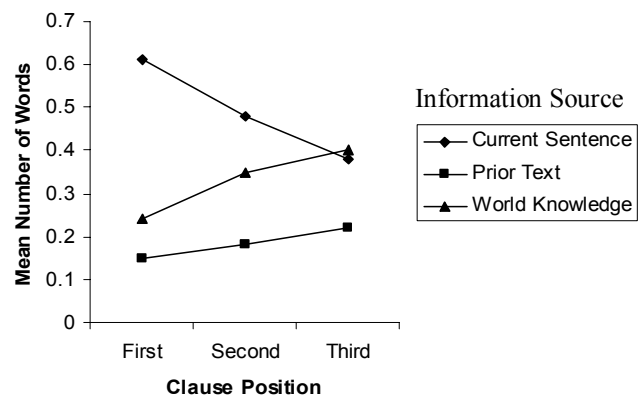


Figure 2: Mean number of words produced from the current sentence, prior text, and world knowledge as function of clause position.

Post-hoc analyses (LSD) revealed that there were differences in the use of information from the current sentence, prior text, and world knowledge both across and within clause position. With respect to the pattern of differences across clause position, information from the current sentence was produced more frequently in the first clause ( $M = .61, SD = .19$ ) than in both the second ( $M = .48, SD = .22$ ) and third clause ( $M = .38, SD = .19$ ). Moreover, information from the current sentence was produced more frequently in the second clause position than in the third clause position. This would be in contrast to the pattern of difference observed for the production of information from world knowledge across clause position. More specifically, information from world knowledge was produced more frequently when the clause was in the third position ( $M = .40, SD = .19$ ) than when the clause was in either the second ( $M =$

.35,  $SD = .17$ ) or first position ( $M = .24$ ,  $SD = .16$ ). Moreover, information from world knowledge was produced more frequently in the third clause position than in the first clause position. It is important to note that although there were no significant differences in the production of information from the prior text for the first ( $M = .15$ ,  $SD = .14$ ), second ( $M = .18$ ,  $SD = .15$ ) and third ( $M = .22$ ,  $SD = .14$ ) clauses, the proportion of information from the text does increase slightly as a function of clause position.

With respect to the pattern of differences within clause position, clauses in the first position contained more information from the current sentence ( $M = .61$ ,  $SD = .19$ ) than information from the prior text ( $M = .15$ ,  $SD = .14$ ) and world knowledge ( $M = .24$ ,  $SD = .16$ ). In addition, information from world knowledge was produced more frequently than information from the prior text. Similarly, clauses that were in the second position contained more information from the current sentence ( $M = .48$ ,  $SD = .22$ ) than information from the prior text ( $M = .18$ ,  $SD = .15$ ) and world knowledge ( $M = .35$ ,  $SD = .17$ ). In addition, information from world knowledge was produced more than information from the prior text. Finally, clauses that were in the third position contained more information from the current sentence ( $M = .38$ ,  $SD = .19$ ) than information from the prior text ( $M = .22$ ,  $SD = .14$ ). In addition, information from world knowledge ( $M = .40$ ,  $SD = .19$ ) occurred more frequently than information from the prior text. There was, however, no difference in the production of information from the current sentence and world knowledge when the clauses were in the third position ( $p > .05$ ). In sum, these results suggest that readers adopt a discourse strategy when verbally reporting their thoughts. Accordingly, readers tended to initiate their verbal protocols with information from the current sentence and then add information from the prior text and world knowledge in subsequent clauses.

## Summary and Conclusions

Provided that verbal protocols can be used to reveal higher-order cognitive processes that give rise to comprehension, it is important that researchers understand the constraints that influence the production of verbal protocols during reading. In the present study, we examined how readers use different information sources, namely, the current sentence, prior text, and world knowledge when constructing meaning from text.

With respect to the question regarding whether readers adopt a discourse strategy when verbally reporting their understanding during reading, we found strong evidence for the *Ordering* hypothesis. This is an important and novel contribution of this study, as it is the first study that we know of to address the structural form of verbal protocols. As predicted by the *Ordering* hypothesis, participants tended to begin their protocols with information from the current sentence before adding information from world knowledge and the prior text. As additional clauses were produced, there was a shift in focus from the current sentence to elaborative information. These findings are consistent with the claim that students self-explaining during reading can be promoted by

first asking readers to paraphrase the sentence that was just read (McNamara, 2004). A more speculative reason for the ordering is that students follow a given-new strategy as they supply verbal protocols.

Some researchers have claimed that thinking-aloud could be conceptualized as a conversational discourse (Trabasso & Oezyurek, 1997). Consequently, one pragmatic principle that would apply to the present study is the given-new strategy (Clark & Haviland, 1997). According to this strategy, speakers first establish common ground - the given information - before introducing new information into the discourse. In the context of reading, the reader would implicitly encode the current sentence as constituting the common ground (i.e., given) between him or herself and the author. Consequently, the reader begins his or her contribution with that information before adding new information. The new information would be how information from the current sentence can be integrated with prior text and the reader's general world knowledge. Obviously, future research is needed to directly test whether the given-new strategy or aspects of it operate when readers produce verbal protocols.

Although the results of the present study suggest that there may be an identifiable sequence as to when information from the current sentence, prior text, and world knowledge is produced over the course of a verbal protocol, it is important to note that this ordering is independent of both text-based and reader-based factors that could potentially influence this sequencing. For example, Todaro, Magliano, Millis, Kurby, & McNamara (2007) found that the inclusion of information from the prior text depended on whether a given text sentence afforded either a local or distal causal connection, whereas the inclusion of information from world knowledge depended on whether a text sentence contained information that overlapped with a reader's prior knowledge. As such, future research is needed to examine how features of the text and characteristics of the reader influence how readers coordinate their use of inferential and strategic processes.

Nevertheless, the results of the present study may have implications for computer-based reading intervention tools that rely on the use of verbal protocols to teach and to identify the use of specific reading strategies during reading (Gilliam, Magliano, Millis, Levinstein, & Boonthum, 2007; McNamara, Levinstein, & Boonthum, 2004; Millis, Magliano, & Todaro, 2006). For example, McNamara and her colleagues have developed iSTART (Interactive Strategy Training for Active Reading and Thinking; McNamara et al., 2004), which is a web-based computer tutor that uses animated agents to teach student how to self-explain difficult scientific texts to themselves. In the context of this tool, students learn how to use a specific set of reading strategies such as paraphrasing, comprehension monitoring, predicting, elaborating, forming bridging inferences, and logic. The hope is that students will use all of these strategies in concert so as to improve comprehension. The results of the present study suggest that this expectation might be more easily attained if readers were instructed to first paraphrase the sentence they

are currently reading before engaging in more strategic types of processes such as forming bridging inferences and elaborating. In other words, paraphrasing may provide a basis for phrasing the complex language of a scientific text in terms more familiar to a reader (McNamara, 2004), which should facilitate the activation of relevant background knowledge necessary for forming bridging inferences and elaborating.

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