To answer questions from text, one has to understand what the question is asking: Differential effects of question aids as a function of comprehension skill

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Abstract

The present study investigates the effectiveness of question paraphrases in supporting students' understanding of a specific task. Secondary school students (i.e., eighth grade) read two texts and answered several questions while texts were available. A paraphrase including core information about each question was included before students provided their answer. Individual differences in reading comprehension explained the beneficial effect of paraphrases. Concretely, the presentation of paraphrases improved the performance of less-skilled but not skilled comprehenders. These findings are discussed in terms of the processes involved in task model formation and individual differences underlying these processes.

Keywords: Task model formation, question-answering, reading, comprehension

Introduction

Teachers routinely ask students to answer questions from an available text with the purpose of comprehending and learning from the text (e.g., Armbruster & Armstrong, 1993; Ness, 2011; Pressley, Wharton-McDonald, Mistretta-Hampston & Echevarria, 1998). These activities have been labelled *task-oriented reading scenarios* (Vidal-Abarca, Mañá & Gil, 2010), and are defined as situations in which readers read texts or documents knowing in advance they are a crucial and available source of information for a specific task. Research on the effects of questions inserted as part of text comprehension and of other learning activities is extensive (e.g., Anderson & Biddle, 1975; Rickards & Di Vesta, 1974). This evidence has shown that asking students to answer questions as they read can facilitate their comprehension of the materials (Mayer, 1984). However, this effect vary as a function of the position and type of questions, among other factors (Andre & Thieman, 1988; Rickards, 1979). Furthermore, when questions are presented after a text has been read, students' answers depend on their ability and willingness to engage in strategic processing (e.g., Ozuru, Best, Bell, Witherspoon, & McNamara, 2007; Vidal-Abarca, et al., 2010).

The present study focuses on students' cognitive processes as they read and interpret the questions before engaging into text search. Accordingly, we will first review current theories emphasizing the role of goals and tasks in reading comprehension. Subsequently, we will examine past research into individual factors that may affect students' comprehension of task demands and their construction of adequate strategies. Based on the extant research, we articulate a set of new questions and hypotheses regarding the role of task elaboration on students' search strategies. Finally, we will explain how our experiment addressed these questions.

Metacognitive processes in question-answering tasks: The role of task encoding

Research on question-answering (e.g., Cerdán, Gilabert & Vidal-Abarca, 2011; Cerdán, Vidal-Abarca, Martínez, Gilabert & Gil, 2009; Goldman & Durán, 1988; Rouet, Vidal-Abarca, Erboul & Millogo, 2001) has put little emphasis on how students construct a task representation from a given question that guide a set of iterative processes between the task and the text. However, early research on reading comprehension demonstrated the encoding of the task and instructions has an impact on reading strategies and outcomes. Moreover, other research has evidenced that the perspective taken by the reader (e.g., thief vs. home buyer) influenced readers' memory for text contents (Pichert & Anderson, 1977).

More recently, van den Broek et al. proposed that readers set up "standards of coherence" to adjust their strategies to the demands of pre-reading tasks and instructions (e.g., van den Broek, Bohn-Gettler, Kendeou, Carlson, & White, 2011; van den Broek, Risden, & Husbye-Hartmann, 1995). For example, college students produce different types of inferences when they are asked to read for leisure purposes compared to when they do it to prepare an exam (van den Broek, Lorch, Linderholm, & Gustafson, 2001). In relation to this, McCrudden and Schraw (2007) proposed a general descriptive model of goal-focusing processes in reading. According to this model, instructions prompt readers to set up goals that modulate the allocation of cognitive resources to specific segments of the text. When answering questions students display critical processes to focus on relevant pieces of text information to achieve the goal of giving the right answer. In these situations, students activate question-answering strategies and engage in information search processes, either from memory or from the text.

Similarly, the Task-based Relevance and Content Extraction (TRACE) model (Rouet, 2006), offers an approach for purposeful reading. However, this model considers the comprehension of task instructions as a processing step itself. Once a reader understands the task demands (Step 1), he/she builds a task model (Step 2) which is a mental representation of the actions that are necessary to perform the task and to reach the expected outcomes. The task

model will determine whether the reader needs to search for an external resource (Step 3) and, if this is the case, he/she will probably inspect the text and select the relevant content (Step 4). The selected content will be processed in a way that will help the reader to answer the specific questions (Step 5). At this point, the reader develops an internal response model that is updated with respect the previous one (Step 6), and subsequently he/she will check if this model fits the specifications of the task model (Step 7) reinstating the whole process again in case it does not fit. Therefore, according to this model the task model has a critical impact on the selection and processing of relevant pieces of information from the text.

In sum, the TRACE model suggests that the link between task instructions and reader goals is mediated by the reader' understanding of the task demands. In other words, readers construct a task model, which is a mental representation of the task and a set of strategies that readers will execute to get it accomplished (Rouet, 2006; Rouet & Britt, 2011). The RESOLV model recently put forward by Britt, Rouet, & Durik (2018; see also Rouet, Britt & Durik, 2017) further expands the definition of a task model. They in fact propose that prior to their engagement with texts, readers construct two types of representations: a *context model* and a *task model*. The *context model* is a representation of a reading situation. Context models are based on schemata that readers construct about familiar reading situations based on repeated exposure (see also Lorch, Lorch, & Klusevitz, 1993). Context models are based on the selection and prioritization of selected cues from the context, and readers can then turn these into a *task model*, or an initial set of goals and actions (Rouet & Britt, 2011). Thus, the *task model* specifies concrete goals and plans to solve a specific reading assignment, is updated throughout the reading task and guides the strategic reading behaviors.

Individual differences in task model formation

Differences in how students represent task demands have consequences in which information is selected and given as sufficient. Research has demonstrated that less-skilled comprehenders represent task goals superficially, which may then affect the selection of information and subsequent performance. Vidal-Abarca et al. (2010) investigated high school students' individual differences in task-oriented reading. Specifically, they focused on three main components that capture the interaction between a reader and a text when answering questions: a) monitoring the comprehension of the question, b) self-regulating the search process, and c) monitoring the decision to search. Using an error detection paradigm applied to measure the ability to monitor inconsistencies within questions, they found that less-skilled comprehenders were less able than skilled comprehenders to detect these inconsistencies.

According to the *partial semantic processing* hypothesis (Hannon & Daneman, 2004), these results were interpreted as showing less-skilled comprehenders' tendency to process information in a shallow way. Moreover, the same results were related to less-skilled comprehenders' propensity to apply a *low standard of coherence* (van den Broek et al., 1995), as these readers might have considered as sufficient a partial or even mistaken representation of the question. Overall, less-skilled comprehenders produce less accurate representations of a question, which in turn impacts on subsequent task-oriented behaviors causing difficulties for a question-answering situation.

Additional research has found that less-skilled comprehenders process task demands more poorly bringing consequences on their search process. For instance, Cerdán et al., (2011) asked secondary school students to read two texts and answer several questions. Half of the questions induced a misleading matching between the wording of the question and distracting pieces of information in the text. The authors assessed whether skilled and less-skilled comprehenders paid attention to distracting pieces of information affecting their reading patterns and task outcomes. They found that compared to skilled comprehenders, less-skilled

comprehenders were not able to discard the distracting information, having a detrimental impact on their task outcomes. These findings suggest that skilled comprehenders are probably able to build a task model based on a deep representation of relevant text information, whereas less-skilled comprehenders tend to consider superficial cues in their task model as valid, selecting more distracting pieces of information and consequently less relevant .

A significant number of studies have investigated differences between skilled and less-skilled comprehenders when processing textual information. For instance, less-skilled comprehenders have difficulties in integrating several propositions (e.g., Rubman & Waters, 2000) and therefore, they experience difficulties generating inferences while reading (e.g., Magliano & Millis, 2003; Oakhill, Yuill, & Donaldson, 1990). Finally, less-skilled comprehenders have poorer knowledge of the structural characteristics of a text, which might negatively affect the understanding of the temporal sequence of events, sentence integration and search for information (i.e., Cataldo & Oakhill, 2000; Meyer, Blandt & Bluth, 1980; Wijekumar, Meyer & Lei, 2017).

In summary, less-skilled comprehenders might have difficulties when answering questions from a text due to failures in comprehension processes, such as forming and integrating propositions within a sentence, making inferences and building the text meaning based on its structural characteristics. These problems might negatively affect their task model formation and their searching for relevant information in the text when answering questions. Therefore, a reliable way to improve answering-question success could be by enhancing task model formation. This possibility is addressed in the following section.

Enhancing task model formation to improve question-answering success

A possible strategy to enhance task model formation is self-explanation (i.e., Chi, Leeuw, Chiu & Lavancher, 1994). Self-explanation has been a key component of different instructional

interventions to improve text comprehension (McNamara, O'Reilly, Best, & Ozuru, 2006; Jackson, Boonthum, & McNamara, 2009). A study conducted to enhance task model formation through self-explanation was carried out by Cerdán, et al. (2013). Secondary school students (eighth grade) were asked to explain with their own words what a specific question was asking for. Contrary to their expectations, Cerdán et al. found that self-explanations did not benefit less-skilled comprehenders' performance in the questions, but it even hindered it. In fact, self-explanations inhibited less-skilled comprehenders' active engagement in search for textual units of information. Moreover, a deeper analysis of the self-explanation protocols revealed that less-skilled comprehenders presented more inaccuracies, with a negative impact on their search process.

Less-skilled comprehenders seem to require specific assistance in understanding task demands, especially when these include long sentences and unclear statements of what information to search and what type of answer to provide. Accordingly, another important strategy to enhance task-model formation would be by means of providing students with paraphrases of the original wordings of the questions. Paraphrasing consists in reinstating a sentence (e.g., a question) in such a way that it is lexically and syntactically different from the original but remains semantically equal (McCarthy, Guess & McNamara, 2009). Interestingly, paraphrasing strategy has proven to improve reading comprehension especially for less-skilled readers, by transforming text information into a more familiar construct or by activating relevant prior knowledge (i.e., McNamara, 2004; McNamara, Ozuru, Best & O'Reilly, 2007).

We predicted that question aids, elaborated as simplified paraphrases of the original wording of the questions, would likely favor less-skilled comprehenders' question-answering performance. The same question aid might be redundant for skilled comprehenders, given their level of command of key comprehension processes such as building propositions, syntactic parsing and inferencial processes, as well as their better capability to use text structure to link

adjacent sentences (i.e., Cataldo & Oakhill, 2000; Meyer, Blandt & Bluth, 1980; Wijekumar, Meyer & Lei, 2017)

The present study: Goals and predictions

Our study had two main goals. First, we investigated whether the administration of paraphrases to the questions would facilitate task model formation, improving performance in question-answering. Second, we explored whether individual differences in reading comprehension would explain the beneficial effects of paraphrasing. To achieve these goals, we designed the following learning situation. Students of varying comprehension levels, as determined by a standardized comprehension test, were asked to read two texts and answer several open-ended questions per text. Before answering the questions, students could search the text to find the relevant information for the answers. Importantly, one of the texts included a simple paraphrase (i.e., question aid) after the presentation of each question, which clarified task demands. This question aid was presented just after the question and before students' response. According to previous literature, we expect that question aids presented as simplified paraphrases of the original wording of questions would improve less-skilled comprehenders' task model formation, given their difficulties in constructing meaning from text (i.e., McNamara, 2004; McNamara, Ozuru, Best & O'Reilly, 2007)

Method

Participants

A total of 198 secondary school students (Age, *M*= 15.77, *SD*= 0.78) participated in the experiment. They came from state urban schools from a southern European country. They belonged to different school classes of around 25 participants each. Despite belonging to different schools, data was treated collectively. They were all assessed using the same materials

and procedure, and similar instructions were provided by experimenters. Teachers did not participate in the experimental phase. Despite this, permission was obtained from principals, parents and teachers. As a compensation for participating in the study, schools were provided with individual reports about students' comprehension level.

Materials

Reading comprehension test. The standardized comprehension strategies test (TPC, Martínez et al., 2008) was measured to assess reading comprehension skills. In the TPC test, students were presented with two texts and 10 multiple-choice questions per text scored one point each (maximum score of 20). The test was designed to cover basic comprehension processes such as the formation of text ideas, anaphoric inferences, knowledge-based inferences and macro-idea formation. Students' reading comprehension score (M= 14.79, SD= 3.07) was analyzed as a continuous variable to predict individual differences in the question aids comprehension task.

Question aids comprehension task. Two texts (i.e., *Flu* and *Runners*) with five questions each were presented in their Spanish version. They were adapted from the Program for International Students Assessment's (PISA) reading materials. The *Flu* text was 439 words long and explained the details of a voluntary flu immunization program in the fictitious company ACOL. The *Runners* text was 406 words long and described the features that good runners should have to avoid foot injuries.

Questions. According to PISA reading assessment (OECD, 2009), we selected a pool of the original a) *retrieve questions*, where the location of simple units of information is required, and b) *interpret question*s, where more than one piece of information should be combined from the texts to produce an elaborated answer. For instance, a specific example of retrieve question from the Runners text was "A *common injury runners suffer is the formation of blisters. According to the text, identify a specific recommendation to avoid this problem"*.

Consider that the location of a specific recommendation provided in the text was enough to provide a good answer. On the other hand, an example of interpret question from the Flu text was "*Miguel works in the ACOL Company and in the 17th of May week will be on a business trip. Justify if Miguel should contact Raquel*". In order to answer the question students were required: (a) to retrieve who Raquel was (i.e., the responsible for the vaccine program), (b) to consider that on the period of the workers' absence the vaccine against Flu would be administered and (c) to understand and justify why Miguel should contact Raquel since the vaccine program was recommendable for all workers. A total amount of six (three per text) retrieve questions and four (two per text) interpret questions were assessed. For the specific purposes of the present study, these questions were adapted to have open-ended format. The question aid comprehension task was scored using a rubric, where each correct question obtained 1 point (out of 10 questions). Scoring was done by two experimenters, with an interrater agreement higher than 90%.

Question aids. Paraphrases were created for all questions with the aim to highlight two main aspects of the questions: a) the *cognitive processes* required to correctly answer the question, including searching for, relating and interpreting information by explanations use, inspired by the PISA typology of questions, and b) *key information to search in the text,* by emphasizing keywords which would facilitate the information search process and question-answering (Llorens & Cerdán, 2012), while trying to avoid wording overlap with the original question wording. Thus, the paraphrased question aids aimed to restate in a simplified manner the original wording of the question and highlight the key information relevant to answer the questions. This reinstatement implied very frequently avoiding overlapping of words, but not necessarily. Our main goal was to simplify the message by reducing the number of ideas to be processed and by making specific emphasis in what to get from the text (i.e., key information

to search in the text) and what to do with the information (i.e. cognitive processes required by the question), so that strategic directions would be also provided.

For example, the question aid to the "interpret question" shown above (i.e., *Miguel works in the ACOL Company and in the 17th of May week will be on a business trip. Justify if Miguel should contact Raquel*) was elaborated as follows: "*Explain if Miguel should get in touch with Raquel to get the vaccine and why*". A similar pattern was followed in the elaboration of aids to retrieval questions aids. For instance, for the "retrieve question" shown above (*A common injury runners suffer is the formation of blisters. According to the text, identify a specific recommendation to avoid this problem)*, was elaborated the following aid: "*Locate a recommendation to prevent blister formation in runners*".

Note that we emphasized the process required by the question (i.e., explain and locate) and we synthesized core information to be included in the answer in the form of a paraphrase. Critically, in order to facilitate less-skilled comprehenders processing of the information, the amount of information to be processed, in comparison to the original question, was reduced in the question aid.

Procedure

The experiment lasted two sessions of approximately fifty minutes each. In session one, students completed the reading comprehension test, whereas in session two, they performed the question aids comprehension task. Both the order of texts presentation (Flu and Runner) and the presence/absence of question aids (Aid and No aid), were counterbalanced across participants.

Students were told to read the first text and answer their corresponding five questions. Then they read the second text and answered the other five questions. When they encountered question aids, they were told to first read the question and its corresponding aid, and only

afterwards inspect the text and answer the question. Texts were always available, so students had the possibility to return to the texts as many times as they needed.

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Data analysis

The following variables were considered for the analyses. On the one hand, the dependent variable was the success in questions, that is, the percentage of correct responses to the question aids comprehension task. On the other hand, we used two types of independent variables: a) the presence/absence of question aid (aid vs. no aid) of the question aids comprehension task, and b) the continuous scores obtained in the reading comprehension (i.e., TPC) test, to explain the existence of individual differences.

A linear mixed effect (LME) model is a powerful statistical analysis that accounts for both random and fixed effects. Taking this into account, we carried out a LME model on success in questions, using the *lmer* function of the lme4 R package. This model included Participants as a random factor, and Question aid (aid and no aid) and Reading comprehension as the fixed factors. In this way, the fixed structure was composed by a two-way interaction (i.e., question aid x reading comprehension). All trials were included in the analyses. Moreover, the

continuous variable (i.e., reading comprehension) was centred to improve the interpretability of the results (e.g., Schielzeth, 2010). The LME was performed by following the procedure described by Pérez, Joseph, Bajo, & Nation (2016)

Results

To understand whether the aid condition helped students to provide a greater percentage of correct responses in questions than the no aid condition, and whether this was explained by individual differences in reading comprehension, we ran a LME with question aid and reading comprehension, on the dependent variable of success in questions (see means and standard errors in Table 1).

<Insert Table 1 about here>

Our model showed the significant main effect of reading comprehension, F (1) = 70.24, p < .001, dv = 9.87, where lower reading comprehension was associated with less correct responses. The main effect of question aid, F (1) = 2.72, p = .10, was not significant. More importantly, the two-way interaction between question aid and reading comprehension skills was significant, F(1) = 6.63, p = .01, dv = 0.93, demonstrating that although lower reading comprehension predicted less correct responses in both the aid, χ^2 (1) = 27.81, p < .001, and no aid, χ^2 (1) = 68.82, p < .001 conditions, this effect was significantly reduced in the aid condition, χ^2 (1) = 6.63, p = .01 (see Figure 1).

<Insert Figure 1 about here>

These findings indicated that the pervasive effect of less-skilled comprehenders in comprehension performance was relatively reduced by helping students in specific strategic processes, such as building a task model from the demands of a specific question. Thus, we observed the expected significant interaction between aids and comprehension skill, so that a low level of comprehension benefited from the inclusion of question aids, and this beneficial

effect tended to disappear as the level of comprehension increased. The relevance and implications of these results are discussed in the next section.

Discussion

The present study had two main goals. The first goal was to investigate whether the presentation of paraphrases in questions would enhance students' task model formation and performance when answering these questions. The second goal was to explore whether individual differences in reading comprehension would explain the beneficial effect of questions aids, with less-skilled comprehenders benefiting more than skilled comprehenders. The role of reading comprehension was crucial in question-answering because the use of paraphrases depends on students' ability to form and integrate the propositions required by the question and transform this information into a task-goal to be achieved (see Introduction). In addition, students' comprehension skill also plays an important role in their ability to ask and answer questions from an available text (i.e., Miyake & Norman, 1979). Accordingly, we predicted that paraphrases would only benefit less-skilled comprehenders, since they have been demonstrated to have difficulties in these processes (McNamara et al., 2009; Vidal-Abarca et al. 2015), whereas skilled comprehenders have not. To accomplish both goals, we provided simplified paraphrases to the questions presented in the question aids comprehension task.

Our results supported previous predictions. We found a general main effect of reading comprehension indicating that comprehension skill positively correlated with success independently of the question aid condition (aid vs. no-aid). More importantly, we also found an interaction between question aid and reading comprehension skill, showing that the presence of paraphrases significantly improved success in less-skilled (but not in skilled) comprehenders. The question aids provided in our paradigm signaled the key information to be searched in the text and included specific directions regarding how to answer the question (i.e., what to do with

the information), with an overall strategy to avoid wording overlap. Taking this into account, our findings are consistent with the idea that providing students with paraphrases of the questions helps them to form an appropriate task model. The task model formation in turn may allow them to make further decisions such as whether or not they need to search for text information to provide the answer and, in case they make a search decision, where in the text they need to look for relevant information (Vidal-Abarca et al., 2010). However, paraphrases were not helpful for skilled comprehenders as they had already formed an appropriate task model when reading the question. We will now explain the comprehension processes underlying these results in more detail.

Task model formation mainly involves text-base formation (i.e., forming and integrating propositions within a question), that is, it involves using linguistic information (e.g., lexicon and syntax) to construct the meaning of the text (van Dijk & Kintsch, 1978). This view is now accepted by most theories and models of reading comprehension (see McNamara & Magliano, 2009, for a review). Interestingly, skilled comprehenders seem to form a text-base quite automatically (McNamara et al, 2009). For instance, using a large sample of secondary school students and five different texts, Gil et al. (2015) reported that the time spent reading a question (in milliseconds) negatively predicted question-answering success. In other words, the less time students spent reading the questions the better they scored on the questions. This is in line with the idea that skilled readers form an appropriate task model quite quickly and automatically, and that these processes involve mainly a text-base level representation (Kintsch, 1998).

In contrast, our findings suggest that less-skilled comprehenders have problems not only with processes related to text-base formation, but also with key processes to construct meaning based on the structural characteristics of the texts (i.e., Cataldo & Oakhill, 2000; Meyer, et al. 1980; Wijekumar, et al., 2017).These difficulties might negatively affect their task model formation and their searching for relevant text information to answer the questions. The

presentation of question-aids, constructed as simplified paraphrases that included both the key ideas to search for in the text, as well as strategic directions on how to answer (i.e., what to do with the information), seems to be especially effective for students with comprehension difficulties in the task formation and searching for information processes.

Overall, less-skilled comprehenders seem to need support in order to adequately represent the demands of a specific task. According to our results, the facilitation of task encoding has a positive impact on question-answering specifically for less-skilled comprehenders. This effect reinforces the prediction that task model formation has an important impact when comprehending documents to solve a task, as defended in frameworks of purposeful reading such as TRACE and RESOLV models (i.e., Rouet, 2006; Rouet et al. 2017). A possible strategy to enhance task model formation proposed in this paper has been the clarification of task demands by elaborating simple paraphrases of the original task wording. This strategy seems to work for less-skilled comprehenders, but we should try to find consistency in more systematic intervention studies. Evidence-based principles for the elaboration of easy-to-comprehend task demands could also be extracted from this and similar studies.

An important limitation of our study is the fact that it was conducted by using a paper and pencil task, and therefore online measures such as the dynamic processes of task model creation and updating described by the TRACE and RESOLV models (i.e. Rouet, 2006; Britt, et al., 2018), were not precisely analyzed. In addition, we did not register additional evidence of how students were processing the question aids, for example, by using think-aloud methodology. Future research should try to investigate the role of task encoding in question-answering tasks by designing parallel measures that capture the online processes of task encoding.

To conclude, providing different types of instructions is a routine activity that teachers constantly employ. Knowing how to facilitate students' understanding of those instructions is, therefore, essential for teachers at different educational levels. In line with our results, elaborating and providing a second simplified version of the original instructions might be particularly helpful for some learners, especially those with comprehension difficulties. Although similar findings have been found in recent computerized intervention studies on task-oriented strategies in primary school students (Serrano, Vidal-Abarca & Ferrer, 2018; Vidal_Abarca, Gilabert, Ferrer, et al., 2014), this effect would require further systematic investigation in different learning contexts and different learners' populations.

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Table 1. Means and standard errors of success in questions, in both aid and no aid conditions with high and low comprehension score[1].

	Aid		**No aid**	
	M	*SE*	*M*	*SE*
High	54.59	1.41	42.59	1.46
Low	42.97	1.40	51.58	1.37

[1] It is important to note that the distinction between high and low comprehension (mean split) was done for illustrative purpose only. The comprehension score was treated as a continuous variable in the analyses, and therefore, it should not be understood as different groups.

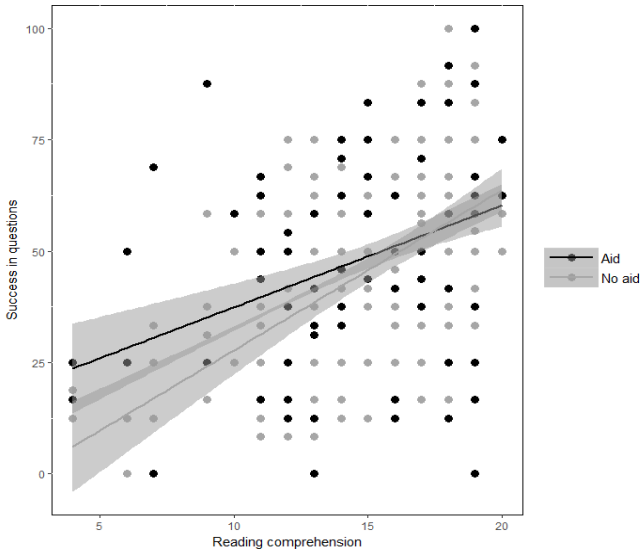

Figure 1. Relationship between success obtained in the question aids comprehension task, taking into account the division of aid and no aid conditions and individual differences in reading comprehension.