More than words: Contending semiotic systems and the role of disciplinary knowledge in specialized text comprehension[1]

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Abstract

Comprehending multisemiotic texts has become a demanding task in all disciplinary domains, not only academic but also professional. Reading tables, pictures, graphs and words, as a whole or separately, is a challenge that most students must face. Nowadays there exists limited research available combining descriptive and experimental data on this field of study. In this paper, we help fill this gap by combining linguistic corpus descriptions and experimental designs in order to assess reading capacity of university students. The general objective of the paper was to determine if it was possible to comprehend a passage from a disciplinary genre (Monetary Policy Report, MPR) through a single predominant semiotic system. In order to achieve this objective, an experiment with three versions of a text was designed: (a) the original text (verbal and graphs), (b) the text with predominance of graphs, and (c) the text with predominance of the verbal system. The participants were 151 students of a university program in the field of Economics in Chile. They were divided into two groups: first and third year university students respectively. Overall results show no statistically significant differences between the three conditions of the experiment for each group. Nonetheless, there are significant differences between the reading scores of both groups, particularly, when the texts were composed predominantly of only one semiotic system (verbal or graphs). No differences were determined in the texts that required an integrated reading of verbal and graph systems. Results indicate that students with a higher level of disciplinary insertion (third-year students) were able to comprehend information coded solely through graphs or words and produced a summary that contained the core semantic meaning of the texts given. These findings show that reading

graphs is a skill that students acquire during instruction in specialized programs, by increasing their knowledge of disciplinary genres such as the MPR.

Keywords: multisemiotic written genres, reading comprehension, specialized disciplinary texts, economics discourse, Monetary Policy Report.

Resumen

Más que palabras: la tensión entre sistemas semióticos y el rol del conocimiento disciplinar en la comprensión de textos especializados

La comprensión de textos multisemióticos se ha convertido en una tarea exigente en todos los ámbitos disciplinarios, no sólo académicos sino también profesionales. La lectura de tablas, figuras, gráficos y palabras, juntos o por separado, es un reto al que la mayoría de los estudiantes deben enfrentarse. Hoy en día existe escasa investigación disponible que combine datos descriptivos y experimentales de este campo de estudio. Este estudio ayuda a llenar este vacío mediante la unión de descripciones lingüísticas de corpus y diseños experimentales, con el fin de evaluar las habilidades de lectura de estudiantes universitarios. Este artículo se enfoca en determinar si es posible comprender un pasaje de un género disciplinar (Informe de Política Monetaria, IPOM) por medio de un único sistema semiótico predominante. Para lograr este objetivo, se diseñó un experimento con tres versiones un texto: (A) el texto original (verbal y gráfico), (B) el texto con predominio del sistema gráfico, y (C) el texto con predominio del sistema verbal. La muestra de lectores se constituyó por 151 estudiantes en un programa universitario en el campo de la economía en Chile. Se dividieron en dos grupos: estudiantes de primer año y de tercer año. Entre los resultados generales no se identificaron diferencias estadísticamente significativas entre las tres condiciones de las pruebas de comprensión en cada grupo independiente de los estudiantes. Por otro lado, sí existen diferencias significativas entre las puntuaciones de lectura de los estudiantes universitarios de primer y el tercer año, sobre todo cuando los textos estaban compuestos predominantemente de un solo sistema semiótico (verbal o gráfico). No hubo diferencias significativas en las pruebas que requerían una lectura integrada de los sistemas verbal y gráfico. Los resultados indican que los estudiantes con un mayor nivel de inserción disciplinaria (tercer año) fueron capaces de comprender información codificada exclusivamente a través de gráficos o palabras y de producir un resumen que contenía el significado semántico nuclear del texto dado. Estos hallazgos muestran que la lectura de gráficos es una habilidad que los estudiantes adquieran durante la instrucción en programas especializados, mediante el aumento de su conocimiento sobre los géneros disciplinares como el IPOM.

Palabras clave: géneros escritos multisemióticos, comprension de lectura, textos disciplinares especializados, discurso de la economía, Informe de Política Monetaria.

1. Introduction

First and second language reading research has focused mainly on the comprehension of the verbal dimension of written discourse, considering textual and cognitive variables, which arise due to the complexity of the phenomenon (van Dijk & Kintsch, 1983; De Vega, Carreiras, Gutiérrez-Calvo & Alonso-Quecuty, 1990; Kintsch, 1998; De Vega & Cuetos, 1999; McNamara & Magliano, 2009; Alvermann, Unrau & Ruddell, 2013; Parodi, 2003, 2014; Parodi, Peronard & Ibáñez, 2010). From multidisciplinary backgrounds, this type of research has been carried out from mainly two venues: purely scientific and applied to both education and language teaching. The texts used belonged to genres that include everyday life topics, primarily narratives (Graesser, Singer & Trabasso, 1994; Arnoux, 2002; León, 2003), and highly specialized and disciplinary genres (Otero, León & Graesser, 2002; Parodi, 2007, 2015; Parodi, Julio & Vásquez-Rocca, 2015).

Comparatively, few studies have addressed the multisemiotic nature of written discourse, either by studying the comprehension of charts, tables, diagrams, and illustrations, or by exploring the interaction between those multisemiotic artifacts and their language cotext. In other words, there is a limited number of scientific studies on how meaning is constructed from the different kinds of information coded in a text, where the verbal and other semiotic systems, such as the pictorial, mathematical, typographical, color, and diagrams work synergistically together (Lemke, 1998; O'Halloram, 2006; van Leeuwen, 2005, 2006, 2011; Bateman, 2014). Although theoretical and empirical research on multisemiotic text comprehension has yet to advance in order to equal the developments attained by verbal text comprehension studies, research has focused on some multisemiotic domains, such as learning based on multiple representational systems (Paivio, 1971, 1986; Sadoski & Paivio, 2001; Holsanova, 2008; Holsanova & Nord, 2010; Aravena, 2011; Pereira & González, 2011; Gladic, 2012; Manghi, 2013; Sanchez & Wiley, 2014; Schüler, Arndt & Scheiter, 2015), multimedia learning (Mayer, 2005, 2009; Ainsworth, 2006; Segers, Verhoeven & Hulstijn, 2008; Rummer, Schweppe, Fürstenberg, Scheiter & Zindler, 2011; Rau, Michaelis & Fay, 2015) and, among others, the study of the cognitive load

from a variety of code types (Sweller, 1988; Chandler & Sweller, 1991; Brüken, Steinbacher, Plass & Leutner, 2002; Plass, Moreno & Brünken, 2010; Sweller, Ayres & Kalyuga, 2011).

The present experimental study is based on the aforementioned body of research, but it seeks to advance from a corpus-based approach on specialized genres, offering empirical data on the comprehension of written multisemiotic disciplinary discourse. The corpus was compiled from texts widely used by a specific college discourse community in the field of Economics (Corpus PUCV-UCSC-2013). The general objective was to determine if it was possible to comprehend a passage from a disciplinary genre through a single predominant semiotic system. In order to achieve this objective, three comprehension texts were designed, based on one original version of a rhetorical-functional section of a text taken from the Monetary Policy Report (MPR) genre: (1) predominantly graphs, (2) predominantly verbal, and (3) a combination of both, as in the original text. The three text versions were given to a random sample of 151 university students, grouped into two levels of disciplinary insertion (first and third year students of an Economics university undergraduate program).

This study aims at answering three research questions: (1) Is it possible to understand an excerpt from the MPR genre through a single predominant semiotic system? (2) Which of the three text versions shows the best results in discourse comprehension: (a) the version that uses the original text with both graph and verbal semiotic systems; (b) the version that uses predominantly the graph system; or (c) the version predominantly verbal? (3) In what way does the level of disciplinary insertion (the number of years a student has progressed in his/her undergraduate university program) affect the comprehension of these three versions of a specialized text?

This article is organized as follows: First, a brief description of the theoretical framework on multisemiotic text comprehension is presented, followed by the methodological procedures geared towards the examination of the three research questions. Then, the results of the analyses are presented, followed by conclusions and projections for this line of research.

2. Theoretical framework

2.1. Comprehension of multisemiotic discourse

Text comprehension research has developed theories and models focused fundamentally on static texts, predominantly verbal (Parodi, 2003, 2011, 2014). This means that the move towards the exploration of multisemiotic texts has just started to come forward. As Parodi (2014) points out, the prevalence of studies of static texts is due to the fact that there still are unanswered questions and unexplored areas regarding static, mainly verbal, text comprehension. There is yet a need of more empirical work to examine text comprehension considering just one semiotic system (De Vega, Graesser & Glenberg, 2008; Schüler et al., 2015). Nevertheless, text comprehension that includes semiotic systems other than the verbal has attracted the attention of some researchers who have provided the first insights in this area. In this section, we will briefly review four approaches regarding the comprehension of multisemiotic texts.

Without a doubt, the pioneering studies of Paivio (1971, 1986, 1991) and later on Sadoski's (1992, 2009) and Sadoski and Paivio's (2001, 2007) stand out for their early envisioning of a theory that brings together – in a scientific and systematic way – two old traditions: mental images and the linguistic or verbal system. Thus, the Dual Coding Theory (DCT) assumes that cognition operates on two types of mental representations: a code specialized on verbal language (logogens) and a non-verbal code, specialized in processing objects and non-linguistic events, in the form of mental images (*imagens*). While the DCT relies on the principle that both coding systems are frequently used together, the authors assert that, depending on the case, a system may take predominance over the others.

The DCT has originated and supported a variety of both theoretical (Sadoski, Paivio & Goetz, 1991; Schnotz, 2002; Mayer, 2005) and empirical research (Sadoski, Willson, Holcomb & Boulware-Gooden, 2005; Sadoski & Willson, 2006). Despite the impact and advances made by the DCT, one question regarding its tenets is whether there exist only two representational systems (*logogens* and *imagens*) with which the mind codes and represents information, or whether there could be just one format for information of different nature. Consensus has not been reached around these issues and, therefore, there are no definite answers for the moment (De Vega et al., 2008; Louwerse, 2010; Schüler et al., 2015).

In order to explain cognitive processing beyond the verbal code, a second approach is proposed by Mayer (2005, 2009, 2011): the Cognitive Theory of Multimedia Learning (CTML). This theory is based on three fundamental learning principles: the dual-channel (auditory and visual) assumption, the limited cognitive capacity assumption (each channel has a limited processing capacity), and the active-processing assumption (active learning requires the use of coordinated cognitive processes). Thus, the two processing channels initially code verbal and pictorial information independently. It is only after each representation is coded and organized that the integration stage is fulfilled. For the CTML, people learn more deeply when they process language and images together, rather than language alone. This idea gave rise to the Multimedia Principle, that is, two codes strengthen the construction of text meaning. At the same time, this theory identifies five cognitive processes of multimedia learning: word selection, image selection, word organization, image organization, and integration. These five cognitive processes result in the generation of five different levels of representations for words and images. The key level of representation is the one that establishes the connections between word-based representations and image-based representations. According to Mayer (2005, 2009), this connection involves a change from independent codes to an integrated model in which corresponding relations and elements are linked with one another from the input of parallel representations. In this way, it is possible to create a representation of an integrated model that includes connections of the reader's previous knowledge, which is drawn from both long-term memory and the working verbal and visual memory.

The CTML can be subjected to the same questionings as Paivio and Sadoski's DCT, regarding the levels of representations and coding formats. Besides, CTML could be a richer theory if it were connected to contemporary research on reading comprehension theories proposed, for example, by van Dijk and Kintsch (1983), Kintsch (1998), McNamara and Magliano (2009), to mention a few. Nevertheless, Mayer does connect his theory with other similar ones such as Paivio's (1986), Sweller's (1999, 2003), and Schnotz and Bannert's (2003).

The third approach is offered by Schnotz (2002, 2005), Schnotz, Bannert and Seufert (2002), and Schnotz and Bannert (2003). They proposed the Integrated Model of Text and Picture Comprehension (IMTPC), also based on the studies conducted by Sadoski and Paivio (2001, 2007). The model's cognitive architecture consists of sensory registers, working memory and

long-term memory. It also includes a cognitive level (comprising two channels: verbal and pictorial) and a perceptual level (comprising multiple sensory channels.) The central assumption of IMTPC is that the reader basically builds two levels of representations. One of them comes from the text (propositional representation) and the other one from the images (mental model). Schnotz and Bannert (2003) refer to them as descriptive representation and depictive representation, respectively.

According to Schnotz and Horz (2010), IMTPC differs from Dual Coding Theory (Paivio, 1986, 1971) and the Cognitive Theory of Multimedia Learning (Mayer, 2005, 2009) in both its structural terms and its predictions. These differences focus on the fact that the IMTPC assumes that it will not always be beneficial – in terms of learning – that the text provides both words and images: this is because it is supposed that two codes are not necessarily better than one. In other words, for the IMTPC, unlike other approaches, the interaction of various semiotic systems combined may produce detrimental effects (Sweller, 1999, 2003, 2005), under certain conditions and for certain learners. One of these detrimental effects is known as the General Redundancy Effect (Chandler & Sweller, 1991). The IMTPC predicts that learners, with a high level of expertise and a high level of prior topic knowledge do not often need to process texts containing both words and images, that is, single-format texts may be enough to achieve successful learning. One important feature of the IMTPC is its connection to seminal works in the field of text comprehension (e.g., van Dijk & Kintsch, 1983). It does not, however, consider more contemporary views nor does it adopt a critical stance regarding the debate about levels of representation and the format of such levels. As for Schontz and Horz (2010), they delve into multimedia learning and define it as the combination of different forms of representations. These authors highlight the new advances in multimedia and hypermedia and advocate for their use in the field of instructional design, as they would allow for a better adaptation of instructional materials according to the learners' needs and preferences.

In the fourth place, Communicability Theory (CT) and its assumptions regarding multisemiotic text comprehension are discussed. Parodi (2011, 2014) claims that text comprehension comprises a multidimensional macroprocess in which multiple psycho-socio-bio-linguistic factors intervene and various types of knowledge converge. Therefore, comprehension cannot be explained through just one dimension or factor. It is necessary to identify different levels of analysis and to distinguish the

dimensions that are inherently connected. In this perspective, Parodi (2011, 2014) advances the principle of Comprehension Accreditability and suggests three distinctive main assumptions: a) the Situated Cognition assumption, b) the Interactivity assumption, and c) the Socioconstructiveness assumption.

Concisely, Comprehension Accreditability is understood as a psycholinguistic mechanism by which expert readers should be able to give an account of what they have read and to communicate it in such a way that they could show that they understood the text, guided by their reading objectives. This principle entails a communication circuit, in which the reader must declare, through written or oral language, their understanding of the text meanings. In order to comply with this principle, Parodi (2011, 2014) explains that it is possible that comprehension is accredited through non-verbal semiotic systems, such as a sequence of drawings, a diagram or through a complex relationship between more than one semiotic system, for example, words and graphs. This act is thus constituted by revising the created representation and by an eventual re-representation or construction of a new representation, which may enrich comprehension. The CT also considers that text comprehension is a social act, contextualized and situated, which means that reading is not only reader driven, but also community driven.

Along with the aforementioned features, the CT considers the various semiotic systems found in static texts from a range of scientific disciplines. Numerous empirical studies examine the variations of multisemiotic devices used in specialized disciplinary genres (Lemke, 1998; Royce, 1999; Parodi, 2010; Hiippala, 2012; Taboada & Habel, 2013; Bateman, 2014; Parodi, Boudon & Julio, 2014; Parodi, Julio & Vásquez-Rocca, 2015). The static text features empirically observed involve different processing requirements, which must be taken into account if the purpose is to, for example, support readers in the development of efficient reading strategies to comprehend disciplinary texts. In this context, based on various empirical findings, Parodi (2010, 2014) argues that all static texts are constituted by a combination of semiotic systems. Among them, it is possible to identify the following: the verbal system, the graph system, the mathematical system, the typographic system, the color system, and the layout system (van Leeuwen, 2011; Parodi, 2014; Parodi, Boudon & Julio, 2014).

Regarding mental (de)coding systems, the CT argues for the existence of a range of representational systems. For text comprehension, the human brain

is capable of decoding information of varied nature and has several modules and specialized cells that allow the processing of the varied information conveyed in a text (van Essen & Dieker, 2007; Dehaene, 2010, 2011; Koch, 2012). In this sense, only two semiotic representational systems are not enough to describe and explain the rich nature of a text. It is evident, though, that research in biology, neuroscience, neurolinguistics, and cognitive sciences, among others, is still far from delivering a detailed account of all possible (de)coding modes and their features. One thing is certain: the brain does not have only one way to code our thoughts (Dehaene, 2011). In addition, information conveyed in texts does not necessarily have to be coded in different semiotic systems to make it more understandable.

The theory available regarding multisemiotic text comprehension is still scarce and preliminary. A close and critical review reveals that they do not manage to capture comprehensively the multidimensionality of the phenomenon that they intend to explain. As mentioned above, there are limitations and unanswered questions regarding the level and number of representational systems and the exact formats of these representations. Such limitations and questions apply not only to multisemiotic text comprehension, but also to the comprehension of purely verbal texts. At the same time, as Parodi (2010, 2011, 2014) points out, what seems to be under discussion is the very concept of written text (static in this case). In part of the specialized literature, it is common to find the expression "the text and the image". This distinction between two constitutive units seems to advance the idea that the text is basically composed of the verbal system, which is confusing because only one dimension of the textual conception is being emphasized. Texts potentially comprise many different semiotic systems (verbal, graphics, mathematical, color, typographic, among others). Therefore, the separation between "text and image" or between "text and illustrations" is not applicable according to the CT. If the aim is to emphasize the multisemiotic nature of a given text, we propose to use an expression such as "the text and its constitutive semiotic systems".

3. Methodology

3.1. The Monetary Policy Report genre

The Monetary Policy Report (MPR) genre is a specialized type of report, which is produced by the Chilean Central Bank. Its communicative

purpose is to inform about the projections of the country's monetary policy concerning short and long-term inflation at the moment in which it is issued. At the same time, its aim is to support decision-making regarding national monetary policies. Its audience is defined by law: it is intended for the Congress members, Government officials and the general community.

The MPR is one of the genres that were identified in the PUCV-UCSC-2013 corpus (Parodi, Julio & Vásquez-Rocca, 2015). This corpus was collected from required and supplementary readings of mandatory courses of two Economics university programs (Parodi, Julio & Vásquez-Rocca, 2015; Parodi, Boudon & Julio, 2014). The research team compiled all the texts that students were given as reading assignments, as part of the academic curriculum in Commercial Engineering and Accounting. The total number of texts in the PUCV-UCSC-2013 Corpus was 222.

Based on a subcorpus of 40 MPRs, Vásquez (2014) identified the complete rethorical organization of this genre. Five core macromoves in the MPRs rhetorical and functional organization were identified. The macromove number three, Assertion and Projection, plays a key role in achieving the communicative purpose of this genre, which is the presentation of information in relation to future projections of the economy and is repeated as many times as the writer deems necessary in order to elaborate on the addressed topics. Besides, this macromove presents the highest occurrence of figures and tables in this genre (Vásquez, 2014). Within this macromove, Vásquez (2014) identified a distinctive move, which was labeled as the Panoramic View of the Current and Future Situation.

Due to the presence of different semiotic systems and its status in disciplinary instruction, the MPR genre seems suitable to explore the following variables: (a) text comprehension of different semiotic system predominance, and (b) disciplinary insertion (number of years a student has progressed in a university program).

3.2. Experimental design: Comprehension test

3.2.1. Predominance of different semiotic systems

Based on previous corpus research that describes the rhetorical organization of the MPR (Vásquez, 2014; Parodi, Vásquez-Rocca & Julio, 2015), one issue of the MPR subcorpus was selected in which a passage containing the

Panoramic View of the Current and Future Situation (PVCFS) rhetorical move, part of the Assertion and Projection Macromove, was identified.

From this original rhetorical text segment, two new versions were developed. Thus, the three text versions were constituted as follows: Text A, the original text (with both verbal and graph semiotic systems); Text B, a predominantly graph text (the verbal system was mostly removed); and Text C, a predominantly verbal text (graphs were removed). Texts B and C are referred to as being with predominance of the graph or verbal system. This is because in neither case one semiotic system is absolutely independent from all other possible systems interacting in a text, such as, the typographic system, the color system, the layout system. Figure 1 shows the first page of each of the three experimental texts.
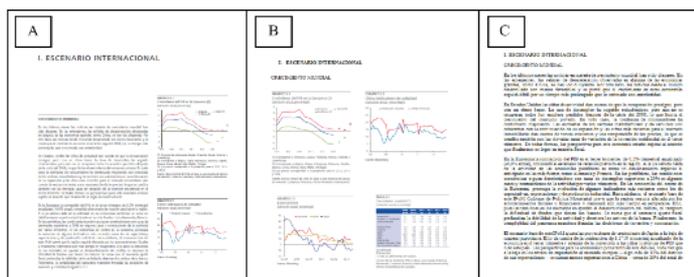

Figure 1. First page of Texts A, B and C.

As shown in Figure 1, in the original version (Text A), the text kept its original format, i.e. no changes were made. In Text B, all seven graphs and one table of the original text were kept. All verbal information was removed, except titles, subtitles, section numbering, figure titles, and explanatory notes. The rhetorical organization was maintained and the eight artifacts were arranged in two columns, from left to right, top to bottom. The aim was to maintain the original reading sequence, based on the flow of information of the original text. The graphs' colors were also maintained, as a key element in the construction of their meaning. In the predominantly verbal version (Text C), the eight artifacts were removed and the page layout was set with "normal configuration" margins. Original titles and subtitles were maintained, as well as the double spacing between paragraphs. Additionally, all explicit reference to the graphs and table were removed.

3.2.2. Multisemiotic comprehension of the MPR genre: The summary as an evaluation tool and its rubric

The three texts (A, B, and C in Figure 1) were the basis for the construction of a reading comprehension test to measure multisemiotic comprehension. In order to do this, a summarizing technique was used (Parodi, Ibáñez & Venegas, 2015) for all three text versions. Students were required to write a summary of what they had understood from the texts following these directions:

> Read the text given below and then write a summary containing its main ideas. This summary is intended to briefly inform a group of Economics professor about the information contained in the text.
>
> Please, do not use more than the space provided. If necessary, take notes and write on the test sheet.

Thus, the purpose of the summary writing task was that the readers focused on the main ideas of the text. In addition, there was a limited space (10 lines) in order for the readers to convey the core content of the given text. The students had a total of 90 minutes to complete the task.

The psycholinguistic process of writing a summary implies a series of linguistic and cognitive activities. According to Parodi, Ibáñez and Venegas (2015), the activity of concisely accounting for what has been understood can be materialized through various semiotic modes, such as a graph, a diagram, or words. From this perspective, the subject is seen as a reader/writer that must be capable of performing both psycholinguistic processes as part of the same macro-activity. It is this reading macro-activity, in this case, the reading task, what moves the reader to write the summary by indicating the reader/writer how to perform the task.

In order to assess the summaries written by the students, three experts in the field of Economics were asked to write a summary of the three texts already mentioned (see Figure 1). These experts' summaries were compared with the rhetorical steps described in Vásquez's (2014) MPR genre description. It was confirmed that the steps described by Vásquez (2014) matched those conveyed in the experts' summaries. Therefore, a scoring rubric was created based on the experts' summaries. Consequently, the students' summaries were scored following the rubric shown in Table 1:

Scoring			
Move	**Step**	**Score per step**	**Percentage**
Panoramic View of the Current and Future Situation (PVCFS).	Assertion 1	10	25%
	Evidence 1	5	
	Assertion 2	10	25%
	Evidence 2	5	
	Projection	30	50%
Totals		60	100%

Table 1. Summary assessment rubric.

As shown in Table 1, differentiating scores were given, based on the functional relevance that each rhetorical step serves in the rhetorical move, as well as the move within the macromove and, therefore, the macromove within the genre. In order to keep the reliability of the summary scoring process, two independent raters were trained in the rhetorical and functional aspects of MPR, its multisemiotic features and the use of the summary assessment rubric. The two independent raters scored each one of the summaries. Inter-rater agreement was established at 80%. In the case of disagreement, a third rater was consulted to settle the difference.

3.3. Participants: University students of an undergraduate program in the field of Economics

Considering the purpose of this study, 151 Chilean native-Spanish-speaking students from first and third years of an undergraduate program in the field of Economics were chosen (mean age = 22 years old). Participants were grouped according to their year in the university program:

Level of disciplinary insertion	Version of text/Nº of participants			Total
First-year students	Original (A) 22	Graph (B) 22	Verbal (C) 22	66
Third-year students	Original (A) 29	Graph (B) 28	Verbal (C) 28	85
Total				151

Table 2. Distribution of participants: Group and text versions.

The texts were distributed randomly among the participants, making sure all three texts were evenly distributed in each group. Table 2 shows the variables under study: text versions according to its predominant semiotic system

(three texts: A-B-C), and level of disciplinary insertion in a university program (two levels). These variables are consistent with the objective and questions of the study and they will be the basis for the statistical data analyses.

3.4. Hypotheses

This study aims at contrasting the following hypotheses:

Hypothesis 1: There are statistically significant differences in comprehension scores depending on the three versions of the text.

Hypothesis 2: There are statistically significant differences between the results of the different versions of the texts depending on the group of the students of the sample (first and third year).

4. Results and discussion

The general objective of this paper was to determine if it was possible to comprehend a passage from the disciplinary MPR genre through a single predominant semiotic system. In this section, the results are presented following the two hypotheses in order to answer the following research questions.

1. Is it possible to understand an excerpt from the MPR genre through a single predominant semiotic system?

2. Which of the three text versions shows the best results in discourse comprehension?

3. In what way does the level of disciplinary insertion affect the comprehension of these three versions of a specialized text?

4.1. Hypothesis 1

Non-parametric statistical analyses were conducted to test Hypothesis 1 (Kruskal-Wallis). The results of the analyses showed no statistically significant differences (p-value = 0.589; p-value = 0.076) in the comprehension results among the three versions of the text, taken independently first-year students (n= 66) and third-year students (n= 85). Thus, Hypothesis 1 is refuted. According to these results, participants in

each group comprehended the information regardless of the semiotic system used (graphs, verbal or mixed). Given that readers were able to produce similar summaries regardless of the semiotic system predominant in the texts, this indicates that they were able to construct similar representations from the texts, although the information was provided in different formats.

To answer the research question regarding whether it is possible to understand a text from one single predominant system, we can say that our data suggest that it is possible, since comprehension scores were similar across the three versions of the text. In the same line, Zwaan and Radvansky (1998) claim that situation models are needed to explain similarities in comprehension performance across modalities, which would explain that no differences among the three versions of the text were detected. Based on similar findings, Zwaan and Radvansky (1998) suggest that readers could use modality-independent cognitive procedures to construct situation models when, for example, reading, listening or viewing a text.

Now, these data provide presumably opposite evidence for the Multimedia Principle (Fletcher & Tobias, 2005; Mayer, 2005, 2009, 2011), which states that learners achieve a better level of understanding from texts that include both verbal and graph-visual systems, compared to texts that present information only through the verbal system. Fletcher and Tobias (2005) and Mayer (2009, 2011) emphasize that there is empirical evidence that support the Multimedia Principle, but they point out that in cases where subjects have a high previous knowledge, the graphs are not of much impact on learning. Regardless of that, this principle highlights that the combination of various semiotic systems generates better learning results, a claim that, in this case, our findings would not support.

4.2. Hypothesis 2

The results of the analysis to test the second hypothesis of this study (Mann-Whitney non-parametric test) indicate that there were no statistically significant differences (p-value = 0.6826) for the comparison between the two reader groups (first and third year students) in the complete original version of the text (Text A). However, there were significant differences between the two groups of students in both predominantly graphic (Text B) and verbal (Text C) representation systems (p-value = 0.0105 and p-value = 0.0057, respectively). In this context, evidence against the hypothesis is

presented only in the first case with the original version of the text (p-value = 0.6826).

The data showed no differences between first and third year students in the summaries they produced after reading the complete original version of the text (graphs and verbal). For the other two cases, the results support Hypothesis 2, which states that the difference between the scores of the respective texts is statistically significant. This means that third-year students, with more prior knowledge about the topic, the genre, the different semiotic systems, and the graph artifacts, did not differ from the first-year students when writing a summary of a text composed of verbal and graph systems (Text A). In spite of the fact that Text A is an excerpt of a text that is a required reading for students in an Economics university program (Corpus PUCV-UCSC-2013), and it plays an important role in the acquisition of specialized knowledge, the level of disciplinary insertion cannot explain the similar results obtained by the two groups in the reading comprehension of the complete original version.

Students with a higher level of disciplinary insertion performed better in the summary tasks, both when reading from the predominantly graphic and the predominantly verbal versions (Text B and Text C). This shows that readers with more disciplinary knowledge about Economics and the MPR genre managed to comprehend a single predominant semiotic system better (predominantly graph or a predominantly verbal).

Results indicate that students with a higher level of disciplinary insertion (third-year students) were able to comprehend information coded solely through graphs (Test B) and produce a summary that contained the core semantic meaning of the text assigned. These findings show that reading graphs is a skill that students acquire during instruction in specialized programs, by increasing their knowledge about specialized genres such as the MPR. Therefore, this data shows that the role of disciplinary knowledge is crucial to understand and comprehend a specialized text which contains specific multisemiotic artifacts, like the ones explored in this study. Furthermore, these findings support Schnotz's idea that the integration of information from diverse systems or codes does not necessarily contribute to deriving a deeper comprehension of a text. The General Redundancy Effect (Schnotz, 2005; Sweller, 2005; Schnotz & Horz, 2010; Leahy & Sweller, 2011; Sweller et al., 2011) states that students with high levels of prior knowledge perform better in reading

comprehension tasks in which only one single semiotic system is predominant.

From the comprehension perspective, however, processing redundant texts (that contain the same information in two or more semiotic systems) produces cognitive overload in the short-term memory and, consequently, hinders processing in the long-term memory. In fact, Schontz's (2005) integrated model predicts that readers with more background knowledge will obtain better results in texts with information from only one source (only picture or only written text). On the other hand, Sweller (2005) and Sweller et al. (2011) offer a body of empirical evidence to support that, in many cases, only picture texts produce better learning results, compared to traditional, less effective versions that require the integration of verbal and picture elements.

In the case of Text C (predominantly verbal), and according to the analyses conducted, the same results obtained in Text B were observed regarding the General Redundancy Effect. This means that learners with more background knowledge did not require texts with integrated information, but texts with only one format; in this case, verbal. This empirical finding in favour of the verbal-only format, and in detriment of the complete original format (Text A), is coherent with the following assertion:

> [...] adding a picture to a written text or adding written text to a picture means adding unneeded information. Although, only one of the two information sources is needed, the eye wonders between both of them resulting in a split of attention. Thus, the learner loses time and expends mental effort searching for redundant information. (Schnotz & Horz, 2010: 147)

This could imply that students reading the original version of the text segment from the MPR either: (a) do not use time efficiently to read the whole text and complete the summary within the time given for the task; (b) use their cognitive resources to integrate into the summary only what they have managed to read; or (c) if they have read the whole text, they cannot create a coherent mental representation, probably because they cannot integrate all the available information. These hypothetical scenarios contrast with the experience of students that read the graph and verbal versions. It would be possible then that, as stated in the research questions, participants were able to comprehend an Economics text from just one predominant semiotic system (whether it be verbal or graph), only if they had an advanced level of disciplinary insertion.

4.3. Comprehension of the rhetorical organization of the MPR

In order to study possible differences between the three versions of the text and the two groups of students, further analyses were conducted to disaggregate comprehension scores at the different rhetorical steps. Figure 2 below shows the percentage distribution of the level of comprehension attained by participants at the different rhetorical steps in the three text versions.
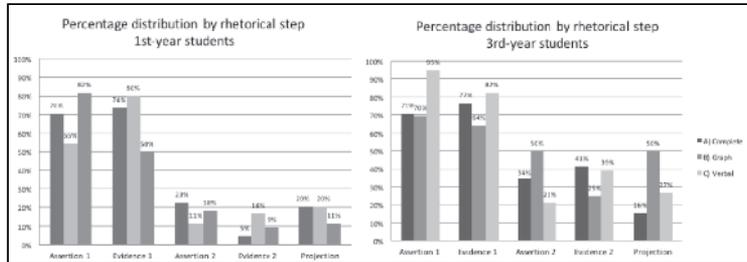

Figure 2. Comprehension of rhetorical steps for the three text versions.

Higher comprehension scores were observed in the rhetorical steps in the third-year student group. It is also worth noting that there is some regularity in the steps with a higher achievement since, in both student groups and in all text versions, the steps with the highest scores are Assertion 1 and Evidence 1. This suggests that, in general, readers focused on the first sections of the texts when producing the summaries, and that the quality of the comprehension progressively decreased in the following steps. In general, it is evident that students tended to first comprehend and then summarize, preferably, the first part of the texts.

As mentioned above, third-year students were significantly better in statistical terms at comprehending the texts than first-year students (51% and 36%, respectively). However, comprehension scores at the level of each rhetorical step do not indicate that they were proficient in terms of processes of text comprehension. Applied Mann-Whitney non-parametric test with a significance level of .05 here is enough sample evidence to say that first-year students test scores are smaller than the test scores of third-year students (p-value = 0.0006). This finding highlights again the relevance of the disciplinary insertion variable in effectively supporting the development of skills for the better comprehension of written texts using various formats, as those examined in this study.

Moreover, third-year students obtained higher comprehension scores (50%) on the Projection rhetorical step in Text B (graph version) than first-year students (20%). This pattern of results was observed across the three texts. The statistical analysis (Mann-Whitney non-parametric test with a significance level of .05) revealed there is enough sample evidence to say that scores of Projection in Text B by third-year students are larger than scores of Projection in Text B by first-year students (p-value = 0.0290).

The Projection, as indicated before, constitutes the fundamental rhetorical step within the rhetorical segment of the MPR genre chosen for this study, since it mainly contributes to determining the communicative purpose of the genre, hence the highest score in the summary assessment rubric. Third-year students were able to derive this information from the predominantly graphic text. In this text, the projective information was represented through a Cartesian plane. Thus, in order to create a cognitive representation of this information, students had to re-code the meaning that was represented by means of graphs and express it verbally in the summary. This process of communicating what has been read finds support in the circuit of communication posited by the Communicability Theory (Parodi, 2014), as well as in the process of verbally summarizing in writing, as is detailed in Parodi, Ibáñez and Venegas (2015).

5. Conclusions

The results of this study provide empirical evidence supporting the significant role of the predominance of a single semiotic system, such as the verbal or graph in the comprehension of texts in the disciplinary field of Economics; at the same time, the findings also reveal the relevance for reading comprehension of higher levels of disciplinary insertion. While we did not detect statistically significant differences in comprehension across the three texts in each student group, we did find that third-year students were able to derive deeper comprehension from texts in the verbal and graph versions. However, the complete original version that includes the two semiotic systems showed no differences between first and third year reader groups. Taking into account the Communicability Theory (CT), the findings indicate that it is possible to predict that a reader/writer with an adequate level of proficiency on a specialized topic is able to comprehend a predominantly graph text, construct a coherent cognitive representation of

those textual meanings in one or more types of mental codes, and then produce a summary through writing, which is verbal. Thus, the reader/writer is able to read and process one representational system and transform it in a different one. According to the guiding principles of the CT, third-year readers/writers that participated in this study established a communicational circuit. In this circuit, they first analyzed the graph version of the text and then produced a verbal summary. During this process, they created a mental representation, probably, in two codes: graph and verbal.

The study showed a core distinction between first and third year students of an undergraduate program in the field of Economics when reading the MPR genre. The third-year students showed that they had developed a body of disciplinary knowledge, coupled with knowledge about the conventions of written specialized discourse and its multisemiotic features and knowledge about the visual representation of information through graphs. They seemed to display these different types of knowledge especially when texts were presented in a single format (verbal or graph). However, these students did not differ from first-year students' comprehension level of the text that integrated both the verbal and graph codes. This could be due to a higher processing cognitive load and by higher requirements from working memory (General Redundancy Effect).

From a theoretical perspective, these empirical findings compel us to reexamine the multisemiotic nature of static written texts, as well as the multiple cognitive codes needed to process textual data. Recent studies (Rau et al., 2015; Schüler et al., 2015) highlight the relevance of further examining text theories of interaction between the different semiotic systems and their types and degrees of connection, considering textual and cognitive variables.

The answer to the first question presented in this study is that it is certainly possible to read a specialized text from a discipline such as Economics from a single, predominant semiotic system. This is achievable provided that the readers are advanced members of the discourse community (high level of disciplinarity), have attained an advanced knowledge of the MPR genre and know how the semiotic systems and their corresponding artifacts work in the texts they are required to read.

The results of this study show that third-year readers incorporated in their summaries the rhetorical-functional core elements of the rhetorical-functional move present in texts with a predominance of a single semiotic system, whether it be verbal or graph, but not in texts that integrated both

systems. Thus, the summaries show that readers significantly comprehended Assertion, Evidence, and Projection, and that, according to the CT, they were able to demonstrate such comprehension by keeping the rhetorical organization of the source text in the construction of the summary.

Regarding strengths, limitations, and projections, this study differs from others of the same sort in various aspects. For example, the experimental materials are based on a corpus study in the field of Economics and the selected genre is common in academic and professional circles in this field (Corpus PUCV-UCSC-2013). Also, the corpus texts have been carefully described and their rhetorical organization and multisemiotic features identified. This fact has allowed us to select well-defined rhetorical segments and artifacts, with naturalistic features, contextually situated. At the same time, writing a summary has proven to be an efficient task to measure the level of text comprehension, consistent with the Communicability Theory.

One limitation was that the readers' comprehension performance was not tested beforehand and therefore they were not grouped according to their reading comprehension level. That would have enabled us to further examine our results, especially for first-year students. In future studies, this procedure should entail a higher number of participants in order to have distinctive target groups. Besides, a deeper textual analysis of the relationship between the verbal and picture-visual system is needed in order to better understand how the text information is integrated and to know how much processing cognitive load is involved, especially in the complete original version of the text (Text A).

Despite these limitations, this study can be taken as a starting point to further examine, for instance, the theoretical implications of number and format of multisemiotic systems, and also to examine other more practical and instructional approaches, such as the compilation of corpora based on teaching-learning texts. As highlighted by Mayer (2009) and Schüler et al. (2015), we share the view that theories that deal with multisemiotic comprehension have to be based on cognitive research and that these studies should combine both theoretical and empirical research.

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