Adapting the Portuguese Braille System to Formal Semantics

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Abstract

Since the seminal work of Richard Montague in the 1970s, mathematical and logic tools have successfully been used to model several aspects of the meaning of natural language. However, visually impaired people continue to face serious difficulties in getting full access to this important instrument. Our paper aims to present a work in progress whose main goal is to provide blind students and researchers with an adequate method to deal with the different resources that are used in formal semantics. In particular, we intend to adapt the Portuguese Braille system in order to accommodate the most common symbols and formulas used in this kind of approach and to develop pedagogical procedures to facilitate its learnability. By making this formalisation compatible with the Braille coding (either traditional and electronic), we hope to help blind people to learn and use this notation, essential to acquire a better understanding of a great number of semantic properties displayed by natural language.

1 Introduction

In their attempt to describe and understand the multiple aspects that underlie the construction of sentential meaning in natural languages, philosophers and semanticists explored different conceptions and methodologies, which gave rise to a large number of theoretical approaches.

A fruitful and promising way to tackle some of the most complex semantic problems, based on a formal notation, was initiated by Richard Montague in the decade of 1970 (see e.g., Montague, 1974). Formal approaches to semantics use logical and mathematical tools to account for various aspects of meaning in natural language. Although the initial task of formal semantics was to describe and resolve ambiguities regarding quantification in the nominal domain, it was rapidly expanded to cover other areas of interest to semanticists, from tense and aspect relations (e.g., Dowty, 1979; Bach, 1986; Moens, 1987; Parsons, 1990) to complex modal descriptions involving the interaction of time, situations, and possible worlds (cf. Portner, 2009 and the papers collected in Kratzer, 2012, for example).

The adoption of formal outlines in the context of the semantic descriptions for natural languages has the advantage of giving rise to unambiguous representations for the meaning of sentences, which facilitate the confirmation or rejection of the suggested hypotheses and postulates.

To illustrate this point, let us consider a simple example, classically discussed in the literature. A sentence like "Every student read a book" is clearly ambiguous between two interpretations: it may mean that every student read a (non-specific) book, whatever it is; or it may mean that there is a (specific) book that every student read. The formal representations in (1) and (2) unambiguously spell out these two readings:

1) $\forall$ x, student(x) $\rightarrow \exists$ y, book(y) & read(x, y)

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(For every x, if x is a student, then there is a y which is a book so that x read y)

2) $\exists$ y, book(y) & $\forall$ x, student(x) $\rightarrow$ read(x, y) (There is a y which is a book and for every x, if x is a student, then x read y)

book)

In other words, in the representation in (1), the universal quantifier has wide scope over the existential one, which leads to the multiple book reading. Conversely, in (2), it is the existential quantifier that has wide scope over the universal one, giving rise to the unique book reading.

On the other hand, formal representations have been able to transcend the domain of simple sentences. In fact, Kamp & Reyle's (1993) Discourse Representation Theory (DRT) extends the semantic formalisation to more complex discourses and Asher & Lascarides' (2003) Segmented Discourse Representation Theory (SDRT) even deals with pragmatic-based notions such as those underlying Rhetorical Relations.

Today, formal semantics supports a significant number of theories that describe meaning in natural language. In fact, formal approaches cover almost all areas that traditionally are ascribed to semantic studies, from simple word relations to the intricacies behind discourse structures.

Irrespective of the particularities that characterise the diverse frameworks departing from formal approaches to meaning, there are, nonetheless, some important principles that bring them together. In all cases, predicates are related to their argument(s), i.e., entities that fulfil the predicative relation. Different kinds of operators are introduced in order to model the interactions that arise between the participants in a sentence or even between independent sentences in a discourse.

The variables that may be introduced in a formula correspond to entities of distinct kinds: they can be individuals, intervals of time, situations or (possible) worlds. Besides the predicative relations, entities may interact with a range of operators that include quantifiers, relations between elements and sets of elements or between two sets of elements, or even precedence or overlapping relations in the temporal domain.

Despite its undeniable relevance regarding the semantic studies on recent years, no attempt has been done, at least to our knowledge, to provide visually impaired people with adequate tools that enable them to learn and manage this kind of formalisation.

The main goal of our project is, thus, to explore some ways that could make it possible to blind students and researchers to interact with the most common and widespread representations in formal semantics. To do so, we will make use of the immense potential that is offered to us by the Braille system.

2 The Braille system: some preliminary remarks

Braille is the most widespread and efficient means for blind people to read and write texts. It was created in France by Louis Braille in 1824 in order to provide a tactile representation for the French alphabet (cf. Mellor 2006). Based on the night writing encoding system developed by Charles Barbier, the Braille system consists of rectangular cells placed sequentially. Each cell corresponds to one character and it is traditionally constituted by two columns each of which presents three "slots" . The different combinations of salient or raised dots in each cell gives rise to the several Braille characters. The six dots that form a cell are numbered, so that each character can be identified by the raised dots that represent it. For instance, the character "b" , in Braille, is identified by dots 1 and 2, the character "t" by dots

2, 3, 4 and 5, and so on. There are 64 possible combinations, including no dots at all for spaces between words.

As we have pointed out, the original purpose of the development of the Braille system was to provide a tactile transcription of the printed alphabet, enabling blind people to read and write texts. Since the languages of the world differ considerably from each other, either concerning the alphabets that are employed, or regarding the number and type of graphic accents and punctuation marks they use, Braille encoding is language-specific, i.e., it varies according to the chosen language.

Braille has proven to be an immensely powerful and flexible system in various ways.

First, it was fruitfully adapted to include a large number of languages and alphabets around the world. Moreover, it was extended to cover other notations. Music, mathematics, physics, chemistry, phonetics, or informatics are some of the multiple areas in which Braille has been successfully employed to make knowledge more accessible to visually impaired people (cf. Herlein 1975; Thompson 2005; Schweikhardt *et al.* 2006; Englebretson 2009).

Second, Braille has adapted easily to the emergence of new technologies, following its continuous development. The ancient slate and stylus – a handwriting device – has been substituted by Braille writers, and, more recently, by refreshable Braille displays, notetakers and tablets (cf. Leonardis, Claudio & Frisoli 2017).

In order to cover a greater range of symbols, as well as to be used with Braille displays and notetakers, the six-dot Braille has been enhanced with two additional dots at the bottom of the cell, giving rise to the so-called 8-dot braille system or 8-dot Braille code.

Nowadays, Braille is used with computers, tablets, and smartphones, making information and knowledge easily accessible: it allows blind persons to access technology and to write and read emails, books, newspapers, and scientific articles on practically equal terms with respect to sighted people.

Although its use is declining in some parts of the world, due mainly to the growing influence of audio media, such as speech synthesizers, Braille remains essential for the learning process and for the general literacy of visually impaired people, facilitating their inclusion in the labour market and in other important social activities, especially when it is used in combination with new technologies (see, e.g., Wiazowski 2014).

Of course, it was not our intention here to provide an in-depth approach to the internal structure and functioning of the Braille system, having limited ourselves only to leave a few brief remarks on the aspects that seem most relevant and more useful to our purposes. For more details and information, see, among many others, Hampshire (1981), Croisdale, Kamp & Werner (2012), Wiazowski (2014), and, for specific aspects of the Portuguese Braille system, Lemos & Cerqueira (1996), Baptista (2000), Reino (2000) or Pereira (2002).

3 The project

Given that our project is still at an exceedingly early stage, it will not be possible to offer here any relevant results and conclusions. Nevertheless, I will expose our main goals and the methodology that was chosen to achieve them.

3.1 Main goals

As we said earlier, although the Braille system has been successfully used in different mathematical environments (cf. Annamalai *et al.* 2003; Alonso *et al.* 2006; Archambault *et al.* 2007; Asebriy, Raghay & Bencharef 2018), there is no attempt, to our knowledge, that has been done to adapt the Braille system to account for semantic formalisation in a comprehensive and systematic way. This is perfectly reasonable, given, on the one hand, the great complexity, as well as the inherent difficulties that such task involves, and, on the other, the reduced number of blind people that study or work with formal frameworks in the semantic field.

To fight against this state of affairs, we will take as our main goal the implementation of a first approach to the application of the Braille system to formal semantics.

Bearing in mind that the existing Braille displays are typically constituted by a single line of cells (cf. Leonardis, Claudio & Frisoli 2017), we decided to give primacy to linear formal systems, having therefore excluded proposals such as the Discourse Representation Theory developed by Kamp & Reyle (1993) or the Segmented Discourse Representation Theory of Asher & Lascarides (2001) that are based on more complicated two-dimensional graphic representations. However, if Braille tablets with multiple lines become standard, the inclusion of such approaches will be easily feasible.

Besides ascribing the correspondences between the symbols used in formal semantics and Braille characters, we will try to provide a simple description of the meaning and use of such tools, in order to facilitate the comprehension of the internal coherence and functioning of formal systems by blind students.

Moreover, we will attempt to explore the better way to provide visually impaired students and researchers with tools to interpret and produce texts that include semantic formulae.

The ultimate goal of our project is, therefore, to make semantic formalisation more friendly and accessible to blind people.

3.2 A note on challenges and decisions

Before describing the different stages that constitute our project, it seems important to address a few challenges underlying our task (I thank an anonymous reviewer of this paper for pointing them to me).

The choice for the one-to-one matching between symbols used in formal semantics and braille characters was preferred to the adoption of an audio output or to their simple substitution by the corresponding words in natural language. Regarding the use of a speech synthetiser to provide a translation of the formalisation, the difficulty of retrieving and retaining information must be taken into account (Braille is much more flexible and reliable in this respect). Concerning the translation into the corresponding words in natural language, it would create some difficulties when using automatic translation of printed texts in Braille displays or Braille printers: note that each "digital" character must be assigned to a well-defined combination of dots in the Braille system in order to be appropriately read by these devices. Moreover, the system we propose is closer to the original spirit of formalisation than the translation into natural language words proposal.

So, the use of Braille (in particular the 8-dot Braille system) seems the most appropriate way to provide blind students with valuable tools to learn and manage semantic formalisation. Bear in mind that a 6-dot Braille notation is also feasible, provided that we introduce compound characters, i.e., characters made of a prefix followed by the main symbol, a practice that is current in many other Braille notations.

3.3 Brief description

In this subsection, we will provide a brief description of the steps and tasks that we will undertake to achieve the goals sketched in 3.1.

1) Mapping the characters

   The first step to be performed in our project is the selection of the set of formal symbols that will constitute the base for mapping the Braille notation.

Given the quantity and the diversity of formal approaches to meaning, it will not be possible to cover the full range of existing symbols in this area. In that view, we will select only the most relevant and widespread symbols that appear in introductory textbooks dealing with formal semantics, that is, those that constitute the core subjects of the formalisation that students learn in the introductory courses of semantics. This does not mean, though, that our list will be regarded as a closed one; on the contrary, it will be considered as an open departure point that may be continuously enriched with new contributions.

Having elected the basic set of symbols, the next step will be to establish a mapping between each of them and the corresponding Braille character. Since many of these symbols come from frameworks related to mathematics and logic, we will try to attest the existence of their Braille correspondents in these systems.

If the correspondence already exists, we will incorporate it in our list; if not, we will try to propose a new Braille character, always obeying the rules that regulate the internal coherence of this system.

As we have already pointed out, the Braille rules vary considerably according to the chosen language. We will take as our working system the Portuguese notation since it is the most familiar to us. However, with the relevant adaptations, this matching procedure may be extended to cover other Braille codifications.

At the end of this stage, we hope to have a list of Braille characters (both the 6-dot characters and the 8-dot ones) that directly correspond to each of the preselected items, giving rise to a coherent "translation" of formal symbols into Braille.

2) Exemplification

Since textbooks on formal semantics do not account for Braille notation, we consider that it would be helpful to provide some explanation and exemplification of some particular aspects regarding the use of our formal system with special focus on the consequences of its adaptation to the Braille code.

Departing from some introductory texts in this area (cf., e.g., Gamut, 1991; Cann, 1992; Portner & Partee, 2002; Kearns, 2011; Winter, 2016), we will provide a simple explanation for the meaning and use of each of the symbols at hand. It is not our intention, of course, to offer a complete and detailed introduction to the semantic questions involved, as this is better done by the literature we have cited, but only to establish some bridges between the traditionally used symbology and the corresponding Braille characters, in order to facilitate the understanding of specific issues by blind people. In other words, we want to make clear some aspects of the formalisation that could pose problems to visually impaired students, due to the differences that exist between Braille and paper-printed representations.

To achieve this goal, we will construct a brief presentation of each Braille symbol, consisting of its Braille representation in 6 and 8-dot Braille, the explanation of its meaning and some examples of its use in semantic formulae. Such information may also be summarized in a table for easier and faster reference.

3) Braille tables

The last stage of our project deals with the construction of Braille tables.

To convert digital information associated with each character into Braille, screen readers and Braille displays make use of Braille tables. A Braille table is designed to make a one-to-one correspondence between ANSII (or Unicode) characters and their Braille correlates, enabling screen readers and Braille displays to represent the information through the correct combination of dots.

Screen readers, such as JAWS for Windows, Non-Visual Desktop Access (NVDA) or Windows Narrator, are a piece of software that turns the visual information that appears in the computer's screen into an audio or tactile output. The tactile output is typically conveyed by a Braille display or a Braille notetaker, electronic-mechanical devices that present a tactile surface in which the refreshable Braille text is gradually exhibited.

In the case of Braille displays, the text that is shown is controlled by an external device – a personal computer or a smartphone, for example. In the case of Braille notetakers, text can be stored in different formats in their internal memory, and, besides their usage as computer terminals, thanks to their own firmware, these devices can be operated autonomously.

In any case, the contribution of a Braille table that allows the translation of the original text into Braille is essential since it permits the correspondences between symbols and Braille characters to be correctly displayed.

Hence, our main task in this third stage of our project will be to build a Braille table that includes the symbols used in formal semantics so that blind students and researchers, employing specific electronic equipment, can produce and access texts in this field. Needless to say, the texts to be read have to be written in accordance with the standard symbology used in formal semantics. Unfortunately, texts that are based on images or graphic representations cannot be properly accounted for by these tools.

4 Conclusion

Our project aims to turn formal semantics more accessible to blind students and researchers who want to learn and investigate different aspects of this important area of linguistic knowledge. With this work, we want to contribute in some extent to a better inclusion of this part of the population into graduate and post-graduate programs, facilitating their participation in university advanced studies.

We believe that accessibility for all is the better way to spread knowledge and information, to improve social inclusion and to favour the empowerment of impaired people, contributing to a more equitable society. Our work hopes to constitute a small step to create better conditions of access and to open new horizons to blind people.

For future research, it would be interesting to provide Optical Character Recognition (OCR) software with the capacity of recognizing the symbols used in formal semantics; this would constitute an important step to turn printed texts fully accessible to screen readers. However, the complexities that this task involves are completely beyond the scope of our present work.

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