Using NLP for Enhancing Second Language Acquisition
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Abstract

This study presents SMILLE, a system that draws on the Noticing Hypothesis and on input enhancements, addressing the lack of salience of grammatical information in online documents chosen by a given user. By means of input enhancements, the system can draw the user’s attention to grammar, which could possibly lead to a higher intake per input ratio for metalinguistic information. The system receives as input an online document and submits it to a combined processing of parser and hand-written rules for detecting its grammatical structures. The input text can be freely chosen by the user, providing a more engaging experience and reflecting the user’s interests. The system can enhance a total of 107 fine-grained types of grammatical structures that are based on the CEFR. An evaluation of some of those structures resulted in an overall precision of 87%.

1 Introduction

Research on the field of second language acquisition (SLA) has already shown that the mere presentation of input to a language learner is not enough for ensuring that some linguistic information will be retained (Meurers et al., 2010). This means that the language learner may process the input for its meaning alone, without noticing its linguistic structures, because there is no salient grammatical information. Input is, therefore, understood as “potentially processible language data which are made available, by chance or by design, to the language learner” (Smith, 1993). On the other hand, the intake is the part of the input which can potentially be connected to the long-term memory (Reinders, 2012).

As such, an input in its raw form has lower chances of being converted into intake by the learner, and may thus not provide any new linguistic information. In the early 90’s, Schmidt (1990) developed the hypothesis that, in order to convert input into intake, a language learner needs to notice the relevant information in the input. More recently, Schmidt (2012) stated, in a less controversial way, that “people learn about the things that they attend to and do not learn much about the things they do not attend to”. There is much discussion regarding the assumptions of the Noticing Hypothesis, and it has some fierce contesters, such as Truscott (1998). Nevertheless, it seems to be of general agreement that noticing is at least a facilitator of the language learning process, even though there is differences in the way that authors view the process of noticing, either as a purely conscious process or as a possibly unconscious process (Cross, 2002).

To solve the lack of salience in raw input, Smith and Truscott (2014) suggested the use of “input enhancements”, so as to give prominence to the relevant linguistic information. This focus-on-form strategy (Doughty, 1991) provides a way to assist language learners, and recent studies on SLA have shown that input enhancements represent a positive step in transforming input into intake (Plonsky and Ziegler, 2016; Simard, 2009).

CALL systems that are able to deal with authentic texts and uses NLP for rendering a better presentation of linguistic information are called Authentic Texts Intelligent Computer-Assisted Language Learning (ATICALL) Meurers (2012). In this paper, we present the Smart and Intelligent Language Learning Environment (SMILLE), an ATICALL system that enhances authentic Web pages by using available NLP tools. It extracts the
text content of a Web page chosen by the user (i.e.,
the language learner) and processes it, retrieving
linguistic information that can be enhanced ac-
cording to the user’s specific language learning
needs. To ensure that the highlighted information
is relevant, SMILLE is linked to the users’
language level, as described by the Common Eu-
ropean Framework of Reference for Languages
(CEFR) (Council of Europe, 2011).

SMILLE was developed based on a scenario in
which the users are already pursuing a foreign lan-
guage course and wish to continue the language
learning activity by means of reading Web-based
material that corresponds to their interests. In this
case, SMILLE can help not only with the text-
understanding process, for it has built-in access
to dictionaries and meaning-related information,
but also with improving the users’ awareness of
the grammatical structures that correspond to their
language learning level. As such, the system can
be seen as a complementary application to a lan-
guage course, where the grammatical structures
of the user’s level will be in focus (by means of text
highlighting), with the bonus of having a plethora
of new vocabulary available, since it is designed to
process any user-chosen, Web-based text.

Some of the grammatical structures that should
be highlighted are complex linguistic structures
that are not always recognized by parsers and need
hand-written rules to cover this lack of parser in-
formation. Since these rules are not trivial to im-
plement and require specialized knowledge, in this
paper we evaluate the performance of the special-
ized rules against a gold standard. In specific, we
focus on rules precision, because it is a key point
of the pedagogical purpose of our system. In ad-
dition, we compare our specialized rules perfor-
ance against parser dependency tagging perfor-
ance.

This paper is organized as follows: we present
information on systems that automatically en-
range grammatical structures in Section 2, spe-
cially focusing on what type of information and
what resources they use for text enhancements; in
Section 3, we describe SMILLE, some of its fea-
tures, and briefly discuss the CEFR and its lan-
guage learning levels; we then describe the eval-
uation process of some of SMILLE’s features in
Section 4; lastly, in Section 5 we present our final
remarks.

2 Related Work

CALL systems have recently started to use NLP
applications for aiding in reading activities (Azab
et al., 2013b), so, in this section, we describe a
selection of ATICALL systems that use text en-
hancements for SLA: SmartReader (Azab et al.,
2013a,b), WERTi (Meurers et al., 2010), and
FLAIR (Chinkina and Meurers, 2016; Chinkina
et al., 2016).

The SmartReader provides a reading assistant
tool that uses a parser to process texts and high-
lights information for the user based on the parser
analysis. The system presents definitions for con-
tent words, grammatical information for function
words, and encyclopedic information for named
entities. It also displays the syntactic function
(such as subject, object) of selected words in the
given sentence and generates simple questions
about named entities, provided the answers are in
the near context.

The WERTi system allows for text enhance-
ments of selected linguistic elements of English,
Spanish and German. It also presents exercises
corresponding to the selected structure, such as
clicking on relevant words, filling the gaps with
multiple choice questions or writing the correct
word in a gap. The user can choose any URL as in-
put, and WERTi will highlight (by means of color
coding) the linguistic structure that was selected
by the user or modify the text for testing the user’s
skills based on the selected activity. It uses pars-
ing combined with rules and regular expressions to
retrieve text information for seven linguistic struc-
tures.

The FLAIR system is described as an online in-
formation retrieval system “that uses efficient al-
gorithms to retrieve, annotate and rerank Web doc-
uments based on the grammatical constructions
they contain” (Chinkina et al., 2016). FLAIR
searches online documents based on keywords se-
lected by the user, parses the first twenty docu-
ments retrieved by the search engine and ranks
them according to the settings the user selected as
most important. It can also recognize 87 differ-
ent types of grammatical structures described in
the official curriculum for German schools. These
structures are annotated in the texts and high-
lighted for the user.

In addition to these systems, there are also oth-
CALL systems that present information from texts
to the user, but do not focus on grammatical high-
lighting. This is the case, for instance, of the REAP system (Brown and Eskenazi, 2004), which is more focused on text retrieval based on user profile and on vocabulary information, and the COBRA system (Deville et al., 2013), which has a database of aligned multilingual texts and relies on the teacher to select the relevant information for the language learner. There are also systems that were developed within the field of text simplification or readability, but they usually focus on the text properties themselves and on L1 instead of L2.

3 System Description

SMILLE is being developed for English, but there will be an effort to port it to other languages as well. Following the idea of WERTi (Meurers et al., 2010) and the SmartReader (Azab et al., 2013a,b), SMILLE was designed in a way that the users have independence for choosing online reading materials in the foreign language, so that the freedom of choice should serve as an incentive for further developing the learning process. Using the selected, Web-based text, SMILLE provides a reading assistant module that helps the user to notice linguistic content of the target language by highlighting (i.e., enhancing) language structures in context, while also offering the possibility of looking up meaning and word class.

In the way it presents the text enhancements and the features of the reading assistant module, SMILLE bears some similarities with the systems presented in Section 2. However, it distinguishes itself in how the enhancements are selected. For instance, in WERTi, only a few grammatical structures are highlighted for the user, and, in SmartReader, only information more relevant to the meaning of the lexical units is presented, and only parser information is shown as part of the grammatical training. And, while FLAIR and SMILLE share a bigger scope in terms of enhancements, the types and granularity of grammatical structures are different (for instance, FLAIR does not distinguish between gerund and present participle, but SMILLE does). In addition, SMILLE links the displayed information to the guidelines of the CEFR and to other language learning resources, so that the enhancements are not limited to isolated linguistic structures, but covers the needs for the different language levels. As such, users can read texts that are interesting according to their own preference, while keeping an eye on important information in terms of linguistic structures that are relevant for their process of acquiring a second language.

For retrieving the relevant content in the chosen Web page, SMILLE crawls over the HTML structure and extracts its text content. This text content is then parsed for part-of-speech (PoS) and syntactic dependencies with the Stanford parser (Manning et al., 2014). The parsed text content is then analyzed with hand-written rules for creating new tags for each relevant grammatical structure. After this process, a new Web page is constructed, showing the same information extracted from the original one, but with new HTML code and different JavaScript and CSS scripts that allow for real-time modifications of the text.

Some of the grammatical information that is detected by SMILLE requires only that the parser correctly analyzes the word or structure in question. Such is the case, for instance, of adverbs, adjectives and simple verb tenses. Other structures require some rules for retrieving more complex word formations, such as compound verb tenses, phrasal verbs and passive voice, but the information is mostly retrieved from the dependency and PoS tags. Still other structures though, such as WH-questions and question tags, are retrieved based on rules specifically written for them. As such, SMILLE combines the analysis done by the parser with hand-written rules to extract text information that would not be easily identified, and would not be salient, in a raw input.

3.1 CEFR Levels

The Common European Framework of Reference (CEFR) for Languages (Council of Europe, 2011) presents a guide in terms of language levels and content. It provides a description for the communication goals of a language learner.

As a general guide, it leaves various gray areas in which the content of the learning process is not so clear. The information at each level also does not cover the different needs for language learners with different native languages. As such, the specific curricula of different language courses do not need to be necessarily the same regarding the six language mastery levels (Alderson, 2007; Little, 2007). SMILLE is being developed in the framework of a partnership between the Univer-
sité catholique de Louvain and Altissia, so, our information regarding the grammatical structures and CEFR levels are linked to the language course structure of our enterprise partner.

While developing the system, we had to make a decision regarding the granularity of grammatical structures and the escalation of knowledge associated to each language levels. The CEFR was designed for language learning, but Web-based documents normally don’t have this instructive approach by design. In a language course, different grammatical structures can be learned in progressive steps, so, for instance, today a language learner may study the modal verb “can” and later, during another session, it is possible to learn the modal verb “must”. In an online text, the chances are that different modal verbs will appear at the same time, interwoven in the text. To address this fine-grained differentiation, SMILLE would have to encompass specific rules for each case, sometimes for each word in a grammatical category. This would require more processing and an undesired increase in the number of rules. So, although the system respects the escalation related to different language levels (e.g., different grammatical structures in levels B1 and B2 were separated in specific rules), the progression in the same level was overruled and generalized.

3.2 System Resources

SMILLE is responsible for analyzing a text that was chosen by the user and for outputting an enhanced text. For example, if the user is currently studying phrasal verbs, the system can highlight phrasal verbs in the chosen text, so that the user’s attention is more easily drawn to the in-context occurrence of this kind of syntactical construct of the English language. The output of SMILLE is a new Web page that can highlight relevant grammatical structures based on the user’s language level, but it can also help the user to understand the meaning of different vocabulary that is present on the text.

For the grammatical content of the text, there is a sidebar menu showing all the grammatical information available on the text that corresponds to a given language level. The highlighting is done in real-time, so that the user can change the highlighted structures on the fly. The highlighted text is modified in terms of color coding (font and background colors) and by changing the format to bold. The option for these three modifications are based on the results of Simard (2009), which have shown that the use of three modifications was among the best ways of enhancing a text structure without saturation.

Our system is designed to be able to show grammatical information corresponding to levels A1 to C1 of the CEFR. Depending on the chosen level, a number of grammatical structures will be displayed on the sidebar menu. These structures can vary from simple part-of-speech information, such as adjectives, adverbs, nouns, proper nouns, etc. in level A1 to more complex structures such as the use of gerund as object in B1 or the use of passive voice and phrasal verbs in B2. Figure 1 exemplifies structures that can be highlighted by SMILLE’s reading assistant module.

If the user wants to look up the meaning of a word, SMILLE offers two possibilities: if it is not a content word, there is the possibility to look it up online on the Merriam-Webster; on the other hand, if it is a content word, then both the Merriam-Webster’s definitions and the WordNet’s glosses can be looked up online. The access to both online resources was implemented by CTRL-clicking on the desired word and selecting the desired resource from a context menu. In addition, by hovering the mouse over a word, the system displays PoS and lemma information. In Figure 2, the word speculative was selected and the information from two online resources (Merriam-Webster and WordNet) is displayed; lemma speculative and PoS adjective of the word are also shown in the form of a tooltip.

The CTRL-click menu has yet another function, and it is related to the grammar information. Any word that is part of a grammatical structure that can be highlighted also has a link to a database of grammatical rules. Since the clicked-on word also belongs to a relative clause, by hovering over the relative clause menu, the gerund sub-menu would collapse and a new sub-menu would be displayed with links to information on relative clauses. This provides for further grammatical training when needed by the user.

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1Site: http://altissia.com/
2Level C2 is focused on reviewing the grammatical knowledge acquired in previous levels.
3Site: www.merriam-webster.com/
4The WordNet was included as a lexical resource because it presents semantic relations between words, such as hypernyms, meronyms, that are usually not present in a regular dictionary.
4 System Evaluation

The system was evaluated to verify its performance in retrieving grammatical information with rules. Since SMILLE has language learners as target users, and has a pedagogical function as goal, it is important that the information highlighted on the text really corresponds to the grammatical categories selected by the user. If the system has too low precision, than it may impair the user’s capacity of understanding the correct use of the different grammatical structures.

For the evaluation process, a gold standard was manually annotated with the required information. The necessity to create a gold standard is due to the fact that, to our knowledge, there exists no corpus annotated with more complex grammatical structures. There do exist many corpora annotated with PoS and dependency information, but those do not present information such as the ones we are working with here. So, in this section, we first describe our gold standard and the annotation process, and later present and discuss the results of the evaluation.

4.1 Gold Standard

The gold standard comprises online newspaper articles and excerpts from literary texts. The newspaper articles were extracted from the sites of The New York Times\(^5\) (20 articles; 31k tokens), The Guardian\(^6\) (20 articles; 18k tokens), The Washington Post\(^7\) (10 articles; 23k tokens), and the USA Today\(^8\) (5 articles; 9k tokens). These were selected for being dedicated to nation wide and international news, and the articles were collected in a time period that starts at the beginning of March 2017 and ends at the beginning of April 2017. Since newspaper articles generally do not present much dialogue and interaction, and some of the grammatical structures (e.g., short answers, WH-questions, question tags) appear more often in dialogues, we further selected seven literary texts from the Project Gutenberg\(^9\) which contained longer dialogues: The Yellow Sign (9k tokens), Varney, the Vampyre (chapters II to V; 20k tokens), The Great God Pan (chapter V; 11k tokens), and An Ideal Husband (First Act; 2k tokens).

The corpus was annotated with the following grammatical structures: (1) phrasal verbs, (2) relative clauses, (3) WH-questions, (4) question tags, (5) short answers, (6) gerunds, (7) present participles, (8) infinitives with “to”, and (9) infinitives without the particle “to”. Most of these structures were selected because they are not retrievable based only on PoS or dependency information, and, although phrasal verbs are indeed recognized based on dependency information, we decided to include this structure for its importance in the learning of English as second language. Each type of grammatical structure was annotated following specific criteria, which were laid out in an annotation manual. Since some grammatical structures are rarer than others, the annotation was not done equally in all texts. Structures that are not abundant in most texts (i.e., wh-questions, question tags, short answers, and phrasal verbs) were annotated in all documents of the corpus, whenever they appeared. The other ones (i.e., gerunds, present participles, infinitives with and without “to”, and relative clauses) were annotated in only a part of the corpus. Since there is this different distribution along the corpus, Table 1 presents the number of documents (newspaper articles and literary texts) that contains the structure and the token and sentence count in the gold standard.

Table 1 shows how many structures were annotated in the gold standard. As can be seen, even though the whole corpus was scrutinized in the search for certain structures, we couldn’t find many instances of question tags and short answers.

4.2 Evaluation

The evaluation was made on a sentence basis. Table 2 shows precision, recall and F-measure for each of the nine tested grammatical structures.

The overall precision, recall and f-measure of the rule-based annotation\(^10\) was, respectively, 85.20%, 82.40% and 83.78%. Since the system

\(^5\)Site: www.nytimes.com.
\(^6\)Site: www.theguardian.com.
\(^7\)Site: www.washingtonpost.com.
\(^8\)Site: www.usatoday.com.
\(^9\)Site: www.gutenberg.org.
\(^10\)This excludes the evaluation of phrasal verbs, which was just based on parser information.
Figure 2: SMILLE can show dictionary information for a given word.

Table 1: Gold standard description

| Grammatical Structure   | # Texts | # Sentences | # Tokens | # Structures Annotated |
|-------------------------|---------|-------------|----------|------------------------|
| Phrasal Verb            | 58      | 6,052       | 121.1 k  | 534                    |
| Infinitive with “to”    | 14      | 1,478       | 31.9 k   | 444                    |
| Infinitive without “to”| 13      | 1,477       | 31.8 k   | 564                    |
| Gerund                  | 26      | 3,920       | 66.8 k   | 282                    |
| Present Participle      | 13      | 2,443       | 35.0 k   | 453                    |
| Relative Clause         | 34      | 2,217       | 56.7 k   | 425                    |
| WH-Question             | 20      | 4,044       | 66.9 k   | 176                    |
| Question Tag            | 3       | 1,992       | 22.6 k   | 25                     |
| Short Answer            | 7       | 3,024       | 42.3 k   | 42                     |

Table 2: The SMILLE’s Evaluation: Precision, Recall and F-measure

| Grammatical Structure     | P    | R     | F    |
|---------------------------|------|-------|------|
| Phrasal Verbs             | .951 | .673  | .878 |
| Gerunds                   | .879 | .697  | .778 |
| Present Participles       | .891 | .799  | .843 |
| Infinitives with “to”     | .983 | .859  | .917 |
| Infinitives without “to”  | .840 | .979  | .904 |
| Relative Clauses          | .870 | .780  | .823 |
| WH-Questions              | .957 | .779  | .859 |
| Question Tags             | .905 | .760  | .826 |
| Short Answers             | .215 | .676  | .327 |

is focused on the learning process, the higher precision score is positive, because showing correct structures is more important than showing a lot of structures that may be incorrect. So, as Meurers et al. (2010) point out, in CALL, the balance tends to be more inclined to the precision side, and less to recall.

The results showed an f-measure that is above the mean ($\alpha = 0.05$) for generating labeled dependency parsing (Cer et al., 2010). We also compared the performance of our rules for relative clauses with the performance of an annotation solely based on the relative clause annotation that the Stanford parser provides, and the annotation based only on the parser had 59.32% of precision, 94.04% of recall and 72.75% of f-measure, which ranks below the annotation with our rules.

In terms of comparison to state-of-the-art systems, the only other work we know of that presents a similar evaluation is FLAIR (Chinkina and Meurers, 2016), which used 9 newspaper articles as corpus to evaluate 87 different rules used in the FLAIR system for retrieving grammatical information from web-based texts. Unfortunately, the rules and the evaluation process were different than the ones presented here. For instance, Chinkina and Meurers (2016) did not separate gerunds and present participles, considering both as “-ing verb forms”; thus, they use a rule that is more broad in scope than ours and do not have the problem of distinguishing between the structures. So, although some of the patterns are probably similar, such as the ones for WH-questions and question tags, the different corpora that were used represent a hindrance for a more detailed comparison.

To better understand the results we got from the
evaluation, we conducted an error analysis. The errors (false positives and false negatives) of the evaluated structures were classified into four categories: parser (parsing error), rule coverage (the rules do not address the specific structure or are too permissive in scope), no rule (there is no rule designed for the structure), GS error (gold standard annotation error), as can be seen in Figure 3. While errors made by the parser annotation (in which some of the rules are based) are responsible for a great part (48%) of the errors, the coverage of our rules (responsible for 38% of the errors) was the main reason for the lack of recall of the system and, especially, for the low precision we got for short answers (in this case, because of a single, too permissive rule). The errors in the gold standard annotation, while not very frequent, prevented, for instance, that our question tag precision reached 100% (which would be the correct precision for this type of structure). This error analysis was a very important step for the future developments of the system, since it allowed us to better pinpoint where there is room for improvement in the rules.

5 Conclusion

This paper presented a system that combines available NLP resources for enhancing language learning. SMILLE extracts raw text from a Web page chosen by the user and enhances its contents by providing the user with tools for a more independent language learning that can take place anywhere with available Internet access. The text is parsed, and a set of rules specific for the different grammatical structures is then applied. By processing texts with NLP tools and rules, the system presents a series of linguistic information, aiding the user to notice in-context grammatical structures and providing access to glosses and definitions for words, while also offering grammatical explanations for specific types of structures.

SMILLE performed above 85% in terms of precision in most of the evaluated grammatical structures, but lacked a bit in terms of recall. The case of short answers can be considered an outlier, since it presented a very low precision, and so will require special attention. Future improvements will take into account the full error analysis that was carried out and that pinpointed how the flaws in the rules can be addressed.

In terms of the system as a whole, further developments have to be implemented to cover other languages, and to create a database for keeping track of user information and user activity concerning language learning (e.g., words that are looked up in dictionaries, grammatical rules consulted, etc.). With these features in place, SMILLE will be able to provide a more customizable user experience.

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