Across Languages and Cultures 25 (2024) 2, 288–309
DOI: 10.1556/084.2024.00903

AKADÉMIAI KIADÓ

Capturing variation of discourse relations in English parallel data through automatic annotation and alignment

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ORIGINAL RESEARCH PAPER

Received: December 15, 2023 • Revised manuscript received: March 22, 2024 • Accepted: July 1, 2024

ABSTRACT

We present a study of discourse connectives and discourse relations in English parallel texts, i.e. in written and spoken originals, as well as translation and interpreting from German. For this, we apply automatic procedures to annotate discourse connectives and relations they trigger in a parallel corpus. We look at distributions of various connectives and discourse relations, comparing spoken and written mode, as well as original and translated or interpreted language production. Furthermore, we analyse the translation patterns in terms of translation entropy. We link our observations to the phenomena of explicitation and implicitation. We find that in both interpreting and translation, explicitation and implicitation patters are affected by the cognitive complexity of the discourse relation signalled by the connective. Moreover, we also show that the difference in the specificity of the same connectives in interpreting and translation also depends on the type of relation they trigger.

KEYWORDS

discourse connectives, discourse relations, explicitation, implicitation, interpreting, translation

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1. INTRODUCTION

In this paper, we present a study of discourse connectives (DCs) in English political texts that were either originally produced (written or spoken) in English by the delegates of the European parliament or translated and interpreted from the speeches originally produced by the German-speaking delegates. We explore the distributions of discourse connectives triggering various relations in translated and non-translated language linking our observations to the phenomena of explicitation and implicitation – a tendency to transfer the content of the source into the target in a more explicit or more implicit way (Blum-Kulka, 1986; Klaudy & Károly, 2005). These phenomena are counted to the specific properties of translated language generally referred to as translationese (Gellerstam, 1986) and can be traced back to general human cognitive capacities or to the functional uses of language (Mauranen, 2007, p. 35).

From the existing studies (see e.g., Ferraresi & Miličević, 2017; Kajzer-Wietrzny, 2012; Kunilovskaya, Przybyl, Lapshinova-Koltunski, & Teich, 2023; Lapshinova-Koltunski, Bizzoni, Przybyl, & Teich, 2021; Shlesinger & Ordan, 2012, amongst others), we know that simultaneous interpreting shows properties different from written translation and can be described as more spoken than translated. Similarly to translationese, these interpreting-specific properties, also called interpretese, are linked to the particular cognitive effort and time constraints of the interpreting process. As stated in the existing theoretical interpreting models (Gile, 2009; Seeber, 2013; Seeber & Kerzel, 2012), simultaneous interpreters have to balance their cognitive resources in the overlapping comprehension and production processes so that their cognitive capacities are not exceeded. While written translations tend to be more explicit than their written source texts, there exist diverging observations for interpreting (see section 2.1), which may originate from a diverging set of connectives explored by different authors. In addition, we know that in spoken contexts, language users tend to employ a more restricted repository of connectives than in written ones (Crible & Cuenca, 2017).

Besides that, it is known that cognitively more complex relations (e.g., comparison and condition) cannot be easily left out (Hoek, Zufferey, Evers-Vermeul, & Sanders, 2017). At the same time, Lapshinova-Koltunski, Przybyl, and Bizzoni (2021) showed that this is true for translation only and does not apply for the interpreting data they analysed. However, their observations were made for a restricted set of connectives only. Generally, most existing studies of explicitation effects of connectives in parallel texts (e.g., Defrancq, Plevoets, & Magnifico, 2015; Dupont & Zufferey, 2017; Hoek, Evers-Vermeul, & Sanders, 2015, 2017; Lapshinova-Koltunski, Przybyl, & Bizzoni, 2021, 2022; Marco, 2018; Zufferey & Cartoni, 2014), focused on a limited subset of connectives only.

Consequently, we want to utilise the automatic approach proposed by Yung, Scholman, Lapshinova-Koltunski, Pollkläsener, and Demberg (2023) and analyse explicitation phenomena through all connectives that can be automatically detected in spoken and written translation in the data at hand. Yung et al. (2023) examined over 300 instances of connectives in parallel data. In this way, automatic annotation allows for the analysis of discourse relations on a large scale. The authors showed that this approach provided more fine-grained insights into translation patterns and also the specificity of connectives for written translation. In our work, we would like to use this approach and apply it on both written (original and translation) and spoken (original and interpreting) data.

Using this approach, we will compare explicitation phenomena in interpreting and written translation, as well as in original (spoken and written) language production. Apart from general observations about distributions of connectives and discourse relations triggered, we will also look into translation patterns extracted from parallel data. We expect to observe different tendencies in translation patterns between translation and interpreting in general, and also in terms of specific connectives. With the approach at hand, we can comprehensively analyse discourse connectives without costly manual annotation effort that is commonly required for this task.

This approach will allow us to gain more insights into the general translation patterns of connectives in translation and interpreting. For instance, Yung et al. (2023) observed that explicitation and implicitation effects in their translated data could be explained by the mode difference between the source and target texts: the translated texts under analysis seemed to be more written than their originals, as they were official published translations of the scripts containing political speeches which were prepared to be spoken. For this reason, the discourse relations in the translated texts seem to be more specified than in the original texts.

Following this statement, we will look at the degree of specification of connectives quantified by translation entropy. Previous works use translation entropy as a static measure of the diversity of a word's translation, which in turn estimates the cognitive load of the task that could be imposed on the translators (Carl & Schaeffer, 2017; Schaeffer & Carl, 2013), see more details in section 2.2 below. In this work, we propose to use the resulting observed translation entropy as a measure of the cognitive load experienced by the translators or interpreters. Translation entropy of connectives specifically extracted from translation and interpretations are compared (see more details in section 3.4).

On the one hand, translation entropy will indicate the degree of specificity of connectives: the more translation equivalents a connective has, the less specific it is. On the other hand, the difference in the translation entropy of the same connective, but calculated based on translation and interpreting data, could reflect the cognitive load experienced by the translator or interpreter. We expect that connectives with higher entropy in translation data should also have higher entropy in interpretation data, compared with other connectives, while the entropy of the same connective should be higher in translation than interpretation due to the higher cognitive load in interpretation.

Overall, the method used in this study will enable a more comprehensive comparison of written and spoken translation, both from the formal descriptive and the cognitive perspective. Moreover, we will also see if the automatic procedures adapt well to spoken data. For our analyses, we formulate the following hypotheses. We expect that, based on the Asymmetry Hypothesis, there will be more explicitation than implicitation in our data (H1a). Furthermore, we expect that interpreters add and omit more discourse relations than translators (H1b). We also expect that there is a difference in distribution of discourse connectives that trigger different relation types for translations. As cognitively more complex relations, such as condition or comparison, cannot be easily left out, they will be more often expressed with discourse connectives in translated data (H1c). Since this tendency has not been corroborated for interpreting, we expect no effect of discourse relation on explicitation and implicitation patterns in interpreted data (H1d). Besides that, we expect that due to the diverging production conditions, connectives in interpreting will be translated into a smaller range of connectives than in translation, i.e. the translation entropy of the same connectives will be lower in interpreting (H2).

The remainder of the paper is organised as follows. In section 2, we provide an overview of related works and main concepts for our study. section 3 gives details on the data, procedures and annotation scheme used in our analysis. We proceed with a presentation and discussion of the results in section 4 and draw conclusions in section 5.

2. RELATED WORK

2.1. Phenomenon of explicitation and implicitation

For a better operationalisation of explicitation and implicitation in terms of linguistic items occurring in texts, we adopt the definition of explicitation introduced by Klaudy and Károly (2005, p. 15). According to this definition, explicitation takes place when a translation contains more specific linguistic units instead of more general units in the source, or new linguistic units not present in the source. Implicitation is the opposite, when a translation contains a more general unit than the source or omits an item that is present in the source. Different authors have put forward different types of reasons and types of explicitation. The most well-known account of the phenomena under analysis is probably the Explicitation Hypothesis suggested by Blum-Kulka (1986), who claimed that the process of translating made translations more explicit than their underlying sources, coining the term "translation-inherent explicitation". Klaudy (2008) identified four types of explicitation: obligatory, optional, pragmatic and translation-inherent. Obligatory explicitation is dictated by differences in the syntactic and semantic structure of languages, optional explicitation is related to the differences in textbuilding strategies and stylistic preferences, and pragmatic explicitation is driven by cultural differences. Becher (2011) criticised Blum-Kulka (1986)'s notion of a translation-inherent type of explicitation for being too vague and studies that confirm it for lacking a consistent definition of explicitation and failing to control for interfering factors such as source language interference. He suggests the Asymmetry Hypothesis by Klaudy and Károly (2005, p. 14) as a better alternative. The Asymmetry Hypothesis states that optional explicitation shifts in one translation direction may not always be matched by optional implicitation shifts in the other direction. With the data and method at hand, we are able to check for the Asymmetry Hypothesis but are not able to tease apart the different types of explicitation. Furthermore, we will look into the effect of discourse relations based on Hoek et al. (2015, 2017)'s framework that is motivated by cognitive principles.

Hoek et al. (2015, 2017) investigate explicitation and implicitation patterns based on the assumption that connectives that signal cognitively simple and expected discourse relations can be inferred more easily and therefore, be left implicit more often compared to cognitively complex and less expected relations. Hoek et al. (2015) define the expectedness of discourse relations on the basis of the continuity hypothesis (recipients are supposed to expect by default that discourse segments are causally and temporally continuous with the preceding context, Murray, 1997) and the causality-by-default hypothesis (recipients are supposed to expect two discourse segments to be causally related by default, Sanders, 2005). Hoek et al. (2017) take the further-reaching Cognitive approach to Coherence Relations (CCR, Sanders, Spooren, & Noordman, 1992), which makes predictions about relations not covered by the causality-by-default and continuity hypotheses. More specifically, Hoek et al. (2015) hypothesise and provide evidence that connectives signalling cognitively simple relations are more often added and omitted in translation because there are many instances in the source where a simple discourse relation is

implicit and a connective can be added or where a connective signalling a simple relation can be omitted. Conversely, there are fewer instances where cognitive complex relations are implicit in the source and a connective could be added or where a connective signalling a complex relation can be omitted in the target. This means that cognitively more complex relations are added and omitted to a smaller extent.

Explicitation effects related to discourse connectives were observed not only in written translation, but also in interpreting for various language pairs (see Defrancq et al., 2015; Götz, 2023; Gumul & Bartłomiejczyk, 2022; Morselli, 2018). However, the observations on the occurrence of explicitation and implicitation in interpreting are diverging. While Shlesinger (1995) observed a reduction of cohesive ties (implicitation) in interpreting if compared to the source language input, Gumul (2006, p. 6) reported that interpreters tend to add discourse markers and other means of cohesive explicitness.

Lapshinova-Koltunski, Przybyl, and Bizzoni (2021) could not confirm the effect of discourse relations on interpreted data on a set of selected connectives. This means that the type of relation may have a different role in interpreting than translation, as expectedness on the reader/listener side plays a minor role in the process of interpreting. As stated by Defrancq et al. (2015), interpreters add and omit connectives as a strategy to lighten or deal with cognitive load. This means that the interpreter is more focused on reducing her or his own cognitive processing effort during language production than on audience design, as also observed by Lapshinova-Koltunski, Pollkläsener, and Przybyl (2022) who showed that interpreters perform less audience design than translators.

Studies comparing translation and interpreting (e.g., Defrancq et al., 2015; Kajzer-Wietrzny, 2012; Lapshinova-Koltunski, Przybyl, & Bizzoni, 2021, 2022) showed that translation and interpreting show differences in terms of usage of discourse connectives. Kajzer-Wietrzny (2012) stated that translation seemed to use more linking adverbials which made it look more explicit. Interpreters seem to both add and omit more connective items compared to translators (Defrancq et al., 2015). Besides that, interpreted speech is even more spoken than comparable spoken language production (Lapshinova-Koltunski, Bizzoni, et al., 2021; Shlesinger & Ordan, 2012).

It is known from previous studies (Lapshinova-Koltunski et al., 2022; Przybyl, Karakanta, Menzel, & Teich, 2022) that in marking logical relations, interpreters tend to prefer more general items over more specific ones, which is also typical for spoken production in general (Crible & Cuenca, 2017). Moreover, previous studies found that the explicitation pattern of a given connective in a target language is related to the alternative options available in that language (Becher, 2011; Zufferey & Cartoni, 2014). However, the repository of the connectives analysed by the authors is restricted to a small subset. In general, most existing empirical studies on specificity of discourse connectives, i.e. the second part of Klaudy and Károly (2005)'s definition, provide a rather qualitative account of explicitation (Crible, 2020; Lapshinova-Koltunski et al., 2022) without providing comprehensive quantitative evidence. Yung et al. (2023) developed a method which allows to quantitatively describe specification and under-specification of discourse connectives in relation to explicitation and implicitation effects. The authors reported interesting observations for written translations from English into German and from German into English. We apply their approach to analyse both written and spoken data which will allow us to quantify the specificity gap between a connective and its translation, identify all cases where a more specified connective verbalises the relation to a greater degree, as well as compare

if the same connectives get specified similarly in translated and interpreted texts. Similarly to Yung et al. (2023), we investigate all connectives occurring in the data under analysis that can be automatically extracted.

2.2. Translation entropy as a measure of cognitive load

For our analysis, we will use not only distributional information on connectives in the sources and targets, but also translation entropy, which is a probabilistic measure related to predictability of words. Language processing rests on predictability of words in context, as it was shown in experimental settings for surprisal (Delogu, Crocker, & Drenhaus, 2017). Surprisal is another word-based probabilistic measure derived from Information Theory (Shannon, 1948). The main idea is that highly predictable words, i.e. words with low surprisal require low cognitive processing effort (Hale, 2001). In the context of translation, such probabilistic measures were used for the analysis of translated and non-translated language (Rubino, Lapshinova-Koltunski, & van Genabith, 2016; Teich, Martînez Martînez, & Karakanta, 2020). For instance, Lapshinova-Koltunski et al. (2022) used surprisal analysis to explain differences in the use of discourse connectives in translation and interpreting.

Word translation entropy is based on the number of translation alternatives available for a single word in a given context (e.g., in a given corpus or a subcorpus). The more alternatives there are, the higher translation entropy is observed. In translation production, translation alternatives available for the source words compete for selection (Hantsch, Jescheniak, & Schriefers, 2005), if there is no strong default equivalent best fitting the source item meaning. The higher translation entropy (many target alternatives), the more cognitive effort is required for selection. Word translation entropy was used by Martínez and Teich (2017) who studied differences in the lexical choices by professional and student translators relating them to either source-dependent and target- dependent translationese. Schaeffer, Dragsted, Hvelplund, Balling, and Carl (2016) showed that the number of translation alternatives for a single word indexed by translation entropy has an effect on very early and late eye movement measures. This means that translation entropy correlates with both automatic processes (indicated by early eye movement) and conscious processing (indicated by late eye movement). Carl and Schaeffer (2017) use word translation entropy along with further measures to describe different early and late hidden translation processes in a translator's mind and also point to the correlation of this measure with eye-tracking and key-stroke-logging process data.

In our analyses, we compare translation entropy of the same connectives in translation and interpreting. Translation entropy indicates how many and how equally likely translations may be produced for a source word in a given context. In our case we have contexts of either translation or interpreting process. Thus, with translation entropy we model the process of either interpreting or translation. Higher translation entropy means more choices and thus higher cognitive effort on the translator's or interpreter's side. We assume that interpreters reduce translation entropy to also reduce their cognitive effort. This means that translation entropy of the same connectives would be lower in interpreting than in translation, as interpreters restrict their resources to a smaller range of translation alternatives.

2.3. Identification and alignment of discourse connectives

As already mentioned above, we base our work on the approach suggested by Yung et al. (2023). The authors extracted 300 types and 18,000 instances of aligned connectives from the corpus of

European Parliament speeches. Other existing works were mostly based on a restricted selection of connectives, mainly due to the fact that connective identification on a large scale is a difficult task: many discourse connectives have to be disambiguated from their non-connective use. As a consequence, most existing corpus studies have mostly focused on a handful of connectives and senses. Zufferey and Cartoni (2014) analysed 200 occurrences each of the English causal connectives *since, because* and *given that* in Europarl. The frequent causal connective *as* was excluded because of its frequent use as a preposition. Lapshinova-Koltunski et al. (2022) investigated occurrences of ten connectives. A more comprehensive analysis that takes into account a larger range of connectives and discourse relations senses in the same text is critical to be able to gain more insights into the general translation patterns of connectives. For this, automatic word alignment is essential. This type of alignment is used in machine translation (Och & Ney, 2000). In the era of neural machine translation, word alignment is often used for annotation projection, including the projection of English discourse annotations (Laali, 2017; Sluyter-Gäthje, Bourgonje, & Stede, 2020; Versley, 2010). The studies focused on assigning a discourse sense label annotated for a connective in one language to the discourse connective aligned on the other side, in the other language. In contrast, we use word alignments to examine where the discourse connective marking differs between source and target languages, when connectives are omitted or their specificity is changed, following (Yung et al., 2023).

Other works use automatic word alignments to generate cross-lingual lexicons of connectives: Bourgonje, Grishina, and Stede (2017) extracted alignments between German and Italian adversative connectives that were identified on the basis of connective lexicons of both languages. Similarly, Özer, Kurfalı, Zeyrek, Mendes, and Valunaite Oleškevičiene (2022) linked the multilingual annotation of the TED-MDB corpus (Zeyrek et al., 2019) to induce multilingual connective lexicons. Robledo and Nazar (2023) examined the mapping of English and Spanish connectives in order to identify possible new categories of relation senses. In our work, a similar technique will help to investigate whether connectives are inserted, i.e. if we observe explicitation. We use a neural word aligner, which has reported lower error rates compared with statistical aligners.

3. METHODOLOGY

3.1. Data

The written and spoken data used in the current analysis are the English originals and translations or interpretations taken from the Europarl-UdS corpus (Karakanta, Vela, & Teich, 2018) for the written and the EPIC-UdS corpus (Przybyl, Lapshinova-Koltunski, Menzel, Fischer, & Teich, 2022) for the spoken texts respectively. The corpora contain political speeches from the European Parliament and have German source texts for English translations or interpretations and German translations or interpretations for English originals. To improve the accuracy of the parser, we manually inserted punctuation in the spoken EPIC-UdS corpus. However, spoken features such as corrections and repetitions are not included in the version of the spoken data we used. For example, repeated utterance of a connective is only transcribed once. It is because the automatic parsers and aligner are trained to annotate cleaned texts and our focus is the translation of the connectives.

We parsed the raw texts of the whole EPIC-UdS corpus. However, due to the limited time for data preparation, we only included a random subset of the Europarl-UdS that matches the size of the spoken data for the analyses described in this study. This means that the written and spoken data are connected; the written originals are not the verbatim reports of the spoken originals. Table 1 summarises the statistics of English texts in the data at hand.

3.2. Procedures

We used the Discopy parser (Knaebel, 2021) to identify and classify the connectives in the English side of the parallel data. The parser considers the semantic representation of a connective token and its contexts in order to distinguish discourse and non-discourse usage of the connective tokens. If a candidate is classified as a discourse connective, it is further labelled with a sense label based on the PDTB 2.0 framework (Prasad et al., 2008). The reported accuracies on Europarl data were 85% for connective/non-connective classification and 92% for 4-way coarse-grained relation sense classification (Yung et al., 2023). Although the parallel data from the corpora are originally sentence-aligned, we refined the alignments using the Vecalign aligner (Thompson & Koehn, 2019), using sentence embeddings from LASER (Artetxe & Schwenk, 2019). Following Yung et al. (2023), the tokens of each cross-lingual sentence paired are aligned with Awesome Align (Dou & Neubig, 2021). This aligner extracts many-to-many mappings as well as "null" alignments and the error rate (on all words, not just connectives) is reported to be 15%.

Yung et al. (2023) reported that the precision of connective identification and 4-way sense classification were 85% and 92% for English and 83% and 90% for German, based on a manual analysis of 400 randomly extracted connective pairs, and the alignment accuracy was 90%. We expect a similar level of accuracy to be achieved by our automatic annotation since the texts belong to the same domain.

3.3. Classification of discourse connectives

PDTB classifies discourse relations under four main categories: temporal, contingency, comparison and expansion. Under these main categories there are two levels of subcategories. Even expert human annotators show low agreement rates on some of these distinctions, which is why the annotation by an automatic parser should be taken with a grain of salt. For the purpose of this study, we decided to mainly go with the main categories, with the exception of dividing *contingency* between the subcategories of *condition* and *cause*. The reason for this is that

Table 1. Statistics of the English data at hand

Original/translation	Mode	Docs	Tokens	Connectives
Original	written	20	92,128	2,254
Translated	written	20	87,098	2,253
Original	spoken	137	69,747	2,013
Translated	spoken	165	61,159	2,015
Total		353	310,132	8,535

according to some studies and frameworks, most notably Hoek et al. (2017), *condition* and *cause* show differences in how difficult they are to process cognitively. Since they are usually signalled by different connectives, the parser did not have difficulty in distinguishing between these two subcategories.

3.4. Translation of connectives

Based on Klaudy and Károly (2005)'s definition, explicitation can either take the form of additions or of specifications and implicitation can take the form of omissions or underspecifications. In our study, we extract the statistics of the translation of the connectives based on the word alignments of the English connectives identified by the parser. If an English connective in the original text is aligned to "null" in the German target text, it is a case of implicitation because the connective is omitted in the translation or interpretation process. On the other hand, if an English connective in the target text is aligned to "null" in the German source text, it is a case of explicitation because the connective is added in the translation.

The correspondence between the English and German connectives in both translation directions can be extracted from the alignments of the English connectives to the German source or target texts respectively. We use translation entropy to quantify the variability of the translation of a connective. A high translation entropy value means the connective has a large number of translation options, or the translation options are evenly distributed, or both.

4. RESULTS AND DISCUSSION

First, we look at the overall distribution of discourse connectives (H1a and b) and the relations they trigger (H1c and H1d). Then, we focus on the percentage of additions and omissions in the written and spoken modes, comparing it with the expectations raised by Hoek et al. (2017)'s frameworks (H1c and H1d). Next, we look into the translation alignments between the English and German connectives and the entropy of the English connectives (H2).

4.1. Distribution of discourse connectives and relations

As seen in Fig. 1, the parser identified more discourse connectives in the spoken data compared to the written data. This is in line with previous findings that show that connectives are more frequent in spoken compared to written language (e.g., Defrancq et al., 2015).

Comparing explicitation and implicitation patterns in spoken and written texts, we see that interpreters both add significantly more ($\chi 2(1) \approx 134.31$, $p < 0.05$) and omit significantly more ($\chi 2(1) \approx 176.76$, $p < 0.05$) connectives than translators do. This corroborates previous findings (e.g., Defrancq et al., 2015) and is in line with H1b. When comparing the amount added and omitted connectives, it can be observed that the number of additions exceeds the number of omissions in both written and spoken data. This confirms the Asymmetry Hypothesis and H1a.

Furthermore, more discourse connectives were identified in translation and interpreting compared to the original corpora. This is a tendency that has been observed for translations in this language-pair (e.g., Hoek et al., 2015; Volansky, Ordan, & Wintner, 2015) It is notable that the gap between translation and non-translation in DC use is greater in spoken than in written. As can be seen in the figure, more connectives are added in interpreting whereas the

Fig. 1. Overall distribution of DCs in spoken (spoken org = spoken originals, spoken si = simultaneous interpreting on the left) and written (written org = written originals, written tra = written translations on the right) English data normalised as frequency per 100,000 tokens

amount of connectives that have an equivalent in the source text is about the same in spoken and written.

Figure 2 zooms in on the distribution of discourse relations that were signalled by the connectives the parser identified. Comparing additions and omissions, H1a is also confirmed

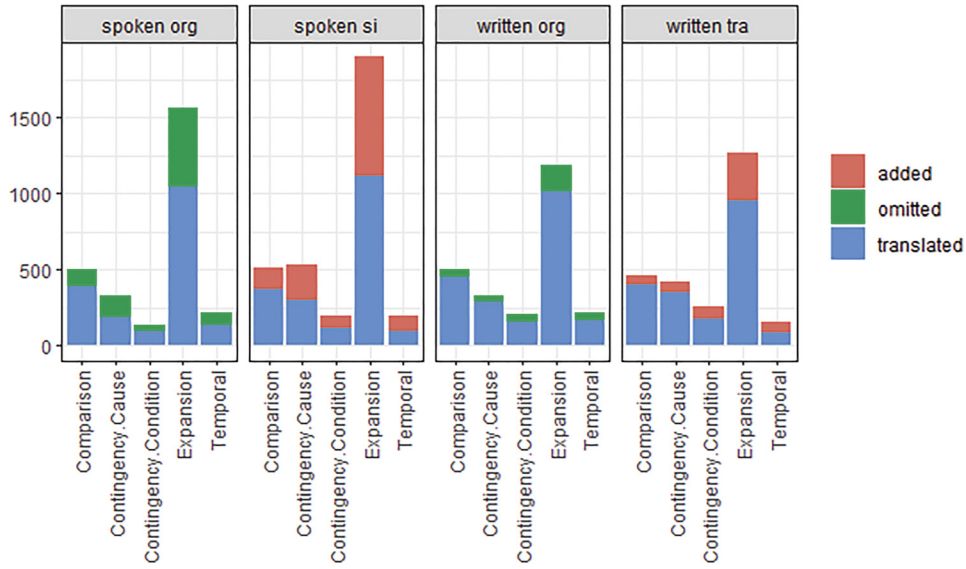

Fig. 2. Distribution of explicit discourse relations in spoken (spoken org = spoken originals, spoken si = simultaneous interpreting on the left) and written (written org = written originals, written tra = written translations on the right) English data, normalised as frequency per 100, 000 tokens

for each individual relation. The amount of additions is always greater than that of omissions in the other translation or interpreting direction. Furthermore, it is striking that overall the ranking from most to least frequent relation is approximately the same across all four corpora. The most frequent relation is that of *expansion*, usually followed by *comparison* and *cause*, whereas *condition* and *temporal* are the least frequent relations. Comparing original and interpreted language in the spoken data, there is a significant difference regarding *cause* ($\chi2(1) \approx 13.607$, $p < 0.05$), *comparison* ($\chi2(1) \approx 4.7089$, $p < 0.05$) and *temporal* ($\chi2(1) \approx 6.9231$, $p < 0.05$). An interesting observation is that interpreters use even more causal connectives than they use comparison connectives, which is the other way around in all other corpora. Furthermore, considering that interpreters use more discourse connectives overall, the figure reveals that this is mostly due to a higher frequency of causal and expansive connectives in interpreting. In fact, the most frequent causal connective in the spoken data is *so* and the most frequent expansive connective is *and*. Both of them are very ambiguous and polysemous (e.g., Bendazzoli, 2019; Crible, 2020; Dupont & Zufferey, 2017), which makes them good candidates for adding and omitting (Crible et al., 2019; Cuenca, 2022).

Comparing written originals and translations, again, causal connectives ($\chi2(1) \approx 7.0598$, $p < 0.05$), comparison connectives ($\chi2(1) \approx 4.2734$, $p < 0.05$) and temporal connectives ($\chi2(1) \approx 11.764$, $p < 0.05$) are significantly more frequent in translations compared to originals. It is interesting to observe that these are the same relations as in the spoken mode. The figure also gives a hint about source language interference regarding causal connectives in written translations. The number of translated causal connectives triggered by German connectives in the source (blue bar) is already higher than the total number of causal connectives in written originals (blue and green bar together). This means that even without explicitation, the translations already overuse causal connectives compared to original texts. This is not the case in interpreting where more causal connectives are added and less were aligned to German connectives by the parser. Another indication of source language interference in the translated data is that the connective *therefore* is the most frequent causal connective overall and the most frequent causal connective that was translated from German. In written originals, *because* and *so* are more frequent, which indicates that *therefore* is overrepresented in the translations.

Comparing spoken and written language, it can be observed that the difference between normalised frequencies for expansion connectives seems to be the greatest. That is where most of the difference in overall frequency between the spoken and written language seems to stem from. An interesting commonality between interpreting and translation in comparison to their sources is that in both the amount of causal connectives is higher. However, the reasons behind this seem to differ. In interpreting, more causal connectives are added whereas in written translations, the amount of connectives that were triggered by a source connective already outnumber the causal connectives in written originals.

Figure 3 shows the percentages of how often a relation was omitted in the German translations from English originals and added in the English translations of German originals. As we have seen in the numbers above, the absolute frequencies of connectives are affected by the frequencies of connectives in the source language. In order to disentangle the influence of the source language and the influence of cognitive processing, Hoek et al. (2015) look at relative frequencies of additions and omissions. Applying their framework, *cause* and *expansion* should be the easiest to process relations, followed by *comparison*, and *condition* should be the hardest to process and therefore least added and omitted relation. Note that Hoek et al. (2017)'s

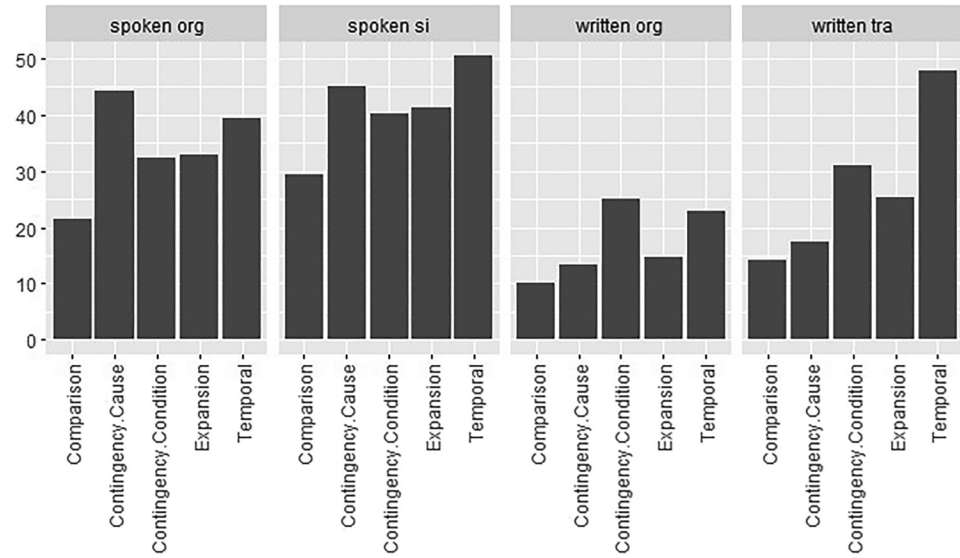

Fig. 3. A Percentage of omissions in written and spoken originals (org) and additions in written translations (tra) and simultaneous interpreting (si) per type of relation, per mode

framework differs in some ways from the PDTB annotation used in this study. We still believe that there are enough parallels between the annotation schemes showing an effect. Generally, it can again be noted that there are fewer omissions than additions across all relations in both modes, even when looking at relative frequencies. This is again in favour of the Asymmetry Hypothesis and confirming H1a.

Another general trend across translators and interpreters is that they tend to add the same types of connectives they omit. The distribution between added and omitted relations is very similar. Keeping temporal relations aside, the least and most added relations in translation and interpreting are also the least and most omitted relations respectively. This corroborates, H1a and Hoek et al. (2015)'s findings and arguments that if a connective can often be omitted, it can also often be added.

Turning to analysing the individual relations according to Hoek et al. (2017)'s hierarchy of cognitive processing ease, within the expectations of the framework, connectives signalling cause and expansion are more often omitted and added compared to connectives signalling comparison. This is true for both the written and spoken mode, which is remarkable since Lapshinova-Koltunski, Przybyl, and Bizzoni (2021)'s data showed that this does not apply to interpreting. Since their study only looked at a restricted set of connectives, this shows the advantage of our automatic approach where we can have a more comprehensive look at a greater range of connectives.

Furthermore, it is as expected that there does not seem to be a clear difference in additions and omissions between expansion and cause. In interpreting and written originals, percentages are on a comparable level, whereas in spoken originals, causal connectives are more often omitted and in written translation expansion connectives are more often added. This lack of

a systematic pattern can be interpreted as a sign that there are other factors at play than the relation itself that affect the omission and addition of these types of connectives.

What is contrary to Hoek et al. (2017)'s model is that condition connectives, classified as the hardest relation to process implicitly, are added and omitted to a higher extent than expected. For spoken data, the percentage of additions and omissions is on the same level as expansion connectives, classified as the easiest to implicitly process relation. In the written data, putting temporal relations aside, it is even the most added and omitted relation in the four relations classified in Hoek et al. (2017)'s framework. A qualitative look at the data revealed a potential reason for this. In the data, there were many cases like that in example (1), where the German original or translation used syntax to mark the conditional sentences and the English source or translation used a connector.

(1) But that means **if** you want to gather a million signatures, you must first of all get a group of from seven Member States for a proposal.
Das heißt, **wer** eine Million Unterschriften sammeln will, **der** muss es vorher schaffen, mindestens sieben aus sieben Ländern zusammenzubringen unter seinem Vorschlag.

In these cases, the conditionality of the segment is maintained. In Hoek et al. (2017)'s annotation scheme, they would be classified as paraphrases and count toward explicit translations. That means that they would not constitute additions or omissions in their data as the marking of the conditional relation stays intact in translation. This could explain the difference in the results.

Figure 3 shows that there are interesting differences in regard to temporal relations, which are not mentioned in Hoek et al. (2017)'s framework. Temporal relations seem to be added substantially more than they are omitted in both the spoken and written modes. A qualitative look into the data reveals that for the written mode, both additions and omissions encompass mostly the connector *then*. In example (2), a translation from English, *then* has a function of signalling emphasis rather than signalling temporal asynchrony. Addition or omission of this connective does not change the propositional value of the segment, which the omission or addition of other connectives sometimes would. As there are more additions than omissions of this type of *then* in the data, this can again be interpreted as support for the Asymmetry Hypothesis.

(2) Both sides must **then** work to create conditions that do not allow radicalism, paramilitary activity and religious extremism to operate.
Beide Seiten müssen daran arbeiten, dass Rahmenbedingungen entstehen, durch die Radikalismus, Paramilitarismus und religiöser Extremismus verhindert werden.

In the spoken data, the difference between additions and omissions is not as strong as in the written data and a qualitative look at the data shows that the variety of added and omitted temporal connectives is greater in interpreting, *when* being another frequent candidate. The following two examples in (3) from interpreting show that interpreters can use *when* to reformulate the source. In example (3-a), the German source is lexically very dense. The interpreter seems to use the *when*-clause to buy time and to think about the continuation of the segment. In example (3-b), the interpreter is not buying time but directly reformulating a cumbersome nominal structure in a prepositional clause from the German source into an easier to process subclause using *when*.

(3) a. Obviously **when you are talking about human rights** human rights mean no discrimination.
Die uneingeschränkte gesellschaftliche Teilhabe ist ein Menschenrecht.
b. We had major difficulties with this in the **past when we looked at other legislation**.
Wir haben hier bereits in der Vergangenheit erhebliche Schwierigkeiten bei anderen gesellschaftsrechtlichen Rechtsakten gehabt.

Finally, we compare spoken and written data. The percentages of omissions and additions are generally higher in the spoken than they are in the written data. Not only in absolute numbers but also in terms of proportions do interpreters add and omit more connective items compared to translators. Comparing the distribution of the relations, causal connectives are more often omitted than conditional and expansive connectives in spoken originals and interpreting, whereas the percentage of additions and omissions of causal connectives is lower compared to conditional and expansive ones in the written originals and translations. This can be explained by the frequent addition and omission of *so* in the spoken data as the connective *so* is more common in spoken than in written language. Furthermore, conditional connectives seem to be added and omitted relatively more often compared to the other relations in the written data than they are in the spoken data. A reason could be of a stylistic nature. Formulations where the conditional relation is marked by syntax rather than by a connector are quite common in formal, written German, but not in English. As we have seen in the spoken data, interpreters are known to add and omit polysemous and ambiguous causal (*so*) and expansive (*and*) connectives. These two effects taken together could then explain why in the written data we find a higher percentage of conditional connectives added and omitted compared to causal and expansive connectives, whereas in the spoken data this is not the case.

4.2. Translation entropy

Next, we look into the correspondence between English and German connectives, assuming that connectives are translated into a smaller range of items in the spoken data compared to the written data. Figure 4 shows the normalised distribution of the alignment between the 20 most frequent English connectives (y-axis) and their translation or source connective (x-axis). Higher numbers and darker colors represent more frequent translation alignments, showing that an English connective has been translated frequently into the corresponding German connective (for English as source language) or that the English connective has often been triggered by the corresponding German source connective (for English as translated language). *Implicit* means the English connector has been omitted (originals) or added (translation and interpreting). *Others* is an umbrella category for the proportions of alignments to German connectives that are not displayed on the x-axes.

Focusing on the originals on top, it can be observed that the picture is not as clear as expected. Some spoken connectives are aligned to fewer tokens than their written counterparts, but overall it seems to be mixed. This impression is also confirmed by Fig. 5. This figure shows the distribution of connectives grouped by the entropy of their translation alignments for written vs. spoken data. Connective pairs that were only once aligned with each other were excluded from the analysis so as to reduce the possibility of alignment errors. The left-hand figure compares translation entropy of spoken and written originals. High entropy means that a source connective is translated into a wider range of target connectives than a low entropy connective. Entropy also takes into account how even the distribution across the translation options is.

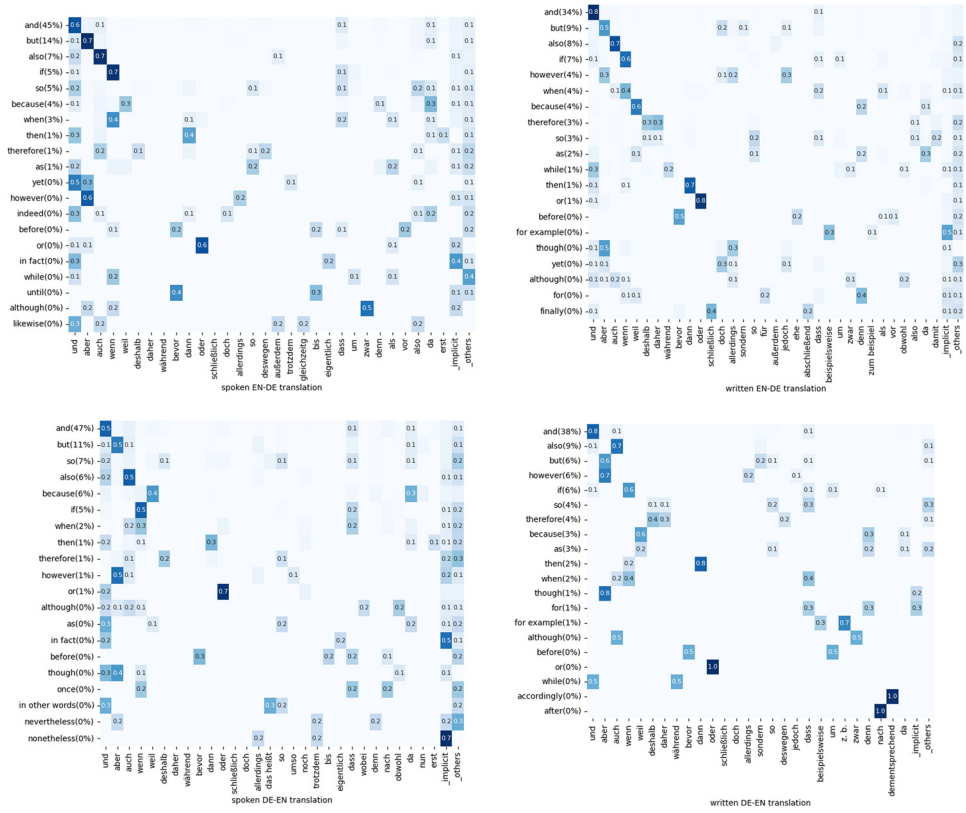

Fig. 4. Alignment between individual connectives in spoken originals (top left) written originals (top right), simultaneous interpreting (bottom left) and written translation (bottom right)

This means that connectives that have a preferred translation option have lower entropy compared to connectives where the choice between the translation options are more evenly distributed. It can be observed that written originals have connectives with higher translation entropy than spoken originals, but the spoken originals do have a peak on the right side of the graph. Just like in Fig. 4, this gives a mixed picture about the assumption that interpreters have less variation in their translation compared to translators. The entropy of the written originals resembles a normal distribution with a slight skew to the left whereas spoken originals have a more balanced distribution.

Table 2 provides a deeper look into the entropy values calculated from the proportions of alignments of some individual connectives. An interesting pattern is that connectives that mainly signal comparison (*however, but, yet*) or condition (*if*) are in line with H2, whereas connectives that mainly signal cause (*so, therefore, because*) or expansion (*and, also*) sometimes confirm (*so, also*) and sometimes contradict H2 (*because, therefore, and*). So, for cognitively harder relations interpreters seem to use a smaller range of translation options compared to translators whereas for cognitive easier relations interpreters sometimes even have a higher

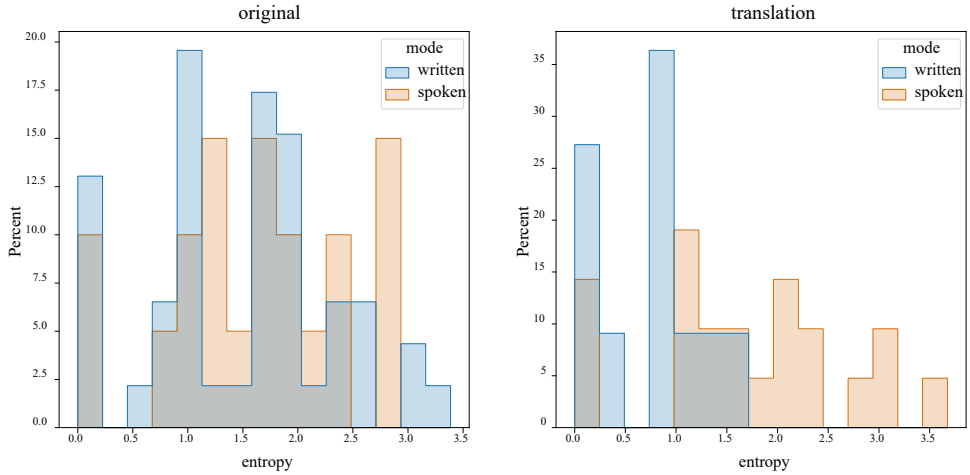

Fig. 5. Distribution of connectives grouped by the entropy of their translation alignment for written vs. spoken corpora

Table 2. Entropy for a selection of connectives for spoken and written originals

Connective	Entropy spoken original	Entropy written original
and	2.74	1.49
so	2.82	3.39
therefore	2.47	2.37
however	1.30	2.24
but	1.77	2.32
because	2.92	1.61
also	1.58	1.86
if	1.79	1.99
as	1.28	2.64
yet	1.88	2.61

range of translation alignments. This could be an indication that interpreters try to decrease their cognitive load when faced with hard to process relations by sticking to only a few translation options compared to translators, who have more time and cognitive resources to think about alternatives. For easier to process relations interpreters may have more mental space to think about alternative formulations which then results in more varied translations of the connectives. As interpreters sometimes diverge more from the source than translators do, this could then explain why some causal and expansion connectives show more variation in the alignments in interpreting compared to written translations.

Turning to comparing alignment in interpreting and written translations in the bottom two graphs of Fig. 4, it can be observed that overall, the English connectives are aligned to more connectives in interpreting than in translation. However, this does not contradict H2 as the alignment from the translation-to-source perspective is different from the one described above. Here, dark colors and high numbers mean that the English connective was often triggered by the German connective. The figure therefore shows that in interpreting, more English connectives are triggered by a variety of German source connectives than in written translations, where more connectives are triggered by one or a few specific connectives.

This picture is also confirmed by the right-hand graph of Fig. 5. Here, high entropy means that a target connective has been triggered by many different source connectives. The figure shows that interpreting has more connectives that are triggered by many different source connectives compared to written translation. In written translation, the connectives have very few correspondences. This supports the expectation that interpreting is simpler than written translation insofar that it could be an indicator that interpreters have a limited repertory of connectives which they use to translate a wide range of source connectives. Written translations then show smaller entropy as they use a more individual translation for each connective. Another factor that plays into this is that interpreters add more and a greater variety of connectives than translators and zero-alignments count as a translation alignment.

5. CONCLUSION

The current study investigated explicitation and implicitation of discourse connectives in English written and spoken data. We used an automatic parser to identify discourse connectives in spoken and written English originals and translations, using word-alignment to align them with their German source item or translation. The parser also identified the discourse relation of the connective. The automatic approach allowed us to annotate a wider variety of discourse connectives and relations than other studies that rely on costly manual annotation, providing more comprehensive insight into explicitation and implicitation patterns in translation and interpreting.

Our first hypothesis H1a based on the Asymmetry Hypothesis was confirmed on various levels. In both spoken and written data, more connectives were added in one translation direction (DE ->EN) than were omitted in the other (EN->DE). This was even true when we split up the data across the relations and also when we looked at relative frequencies of additions and deletions across discourse relations. Furthermore, our second hypothesis H1b that there would be more connectives added and omitted in interpreting compared to translations was confirmed. We also found overall more connectives in translations and interpreting compared to the comparable original texts.

We also found support for the notion that the discourse relation affects the rate of explicitation and implicitation of the connectives. In line with our hypothesis H1c and Hoek et al. (2015), we found that cognitively complex comparison connectives are less often explicitated and implicitated compared to the cognitively easier causal and expansive connectives. This was true for both written and spoken data, which is remarkable, since it contradicts our hypothesis H1d and the findings of Lapshinova-Koltunski, Przybyl, and Bizzoni (2021). Having said that, we did not find the expected effect for cognitively complex conditional connectives, which we put down to annotation differences from those used by Hoek et al. (2017).

Although we found an effect of discourse relations on both written and spoken data, contradicting H1d and the findings by Lapshinova-Koltunski, Przybyl, and Bizzoni (2021), we did find some differences between the modes. In the translated data, we found that the source language seems to have had an effect on the absolute frequencies of the connectives and the concrete connective used. In interpreting, a greater number and percentage of connectives is added and omitted, which was both a consequence of interpreters adding and omitting a great amount of ambiguous and polysemous connectors and of reformulating the source.

When we compared alignments and entropy across written and spoken data, we obtained mixed results regarding our hypothesis H2 that interpreters use a smaller variety of discourse connectives compared to translators. We observed that an individual connective and the relation it conveys play a role in the range of translation options by interpreters and translators. Cognitively complex comparison connectives showed lower entropy in spoken compared to written connectives, whereas the picture was mixed for causal and expansive connectives.

On a methodological note, we have shown that using automatic annotation is becoming a feasible alternative to cumbersome manual annotation of discourse relations. Our data confirmed results of earlier studies and provided novel insights into explicitation and implicitation patterns in translation and interpreting. However, the automatic parser performed poorly on deeper-level annotations like the difference between contrast and concession. Since these relations have also been shown to be of different cognitive complexity, the parser does not yet provide a solution to investigate finer-grained differences between discourse relations. Furthermore, the parser is also limited in that it cannot identify implicit discourse relations that are not marked by a connector. This kind of annotation would benefit translation and interpreting studies as it would distinguish between cases where interpreters and translators make an implicit relation in the source explicit in the target (and vice versa) and cases where they add a relation that was not there before. In the future, we plan to parse the German data to analyse specification on the level of senses as Yung et al. (2023) did.

ACKNOWLEDGEMENTS

This paper is based on research conducted in a project funded by the Deutsche Forschungsgemeinschaft – SFB 1102/Projects B2 and B7, ID 232722074.

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