Fall and Rise of Discourse Connectives: A Cross-language Study

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Abstract

Recent studies have claimed that the amount of discourse connectives or discourse markers has risen in multiple languages. However, the thesis has seldom been evaluated using comprehensive empirical data evidence. This study investigates the historical changes of frequencies in discourse connectives in the Chinese, English, French, German and Spanish over the last two hundred years. We find that the frequencies of the majority of discourse connectives showed a marked decrease in the latter four languages. These research results show that the frequencies of discourse markers in these languages have not in fact increased over the last two centuries. However, an increase of frequencies can be seen after 1980. Our findings are consistent with the changes of rationality in language recently reported. However, we believe that such phenomena are caused by the “colloquialization” trend. The current study can make contributions to a better understanding of the changes in language and their underlying mechanism, and it helps us to draw a bigger picture on evolutionary patterns of human society and human behavior.

Keywords: frequency changes; decline trend; implicit discourse relation; historical development; colloquialization

1 Introduction

Discourse connectives are words or phrases connecting or relating discourse units. They are used to indicate discourse relations. A discourse relation is the semantic or logical meaning of the connections between discourse units. Discourse connectives play an important role in creating coherent discourse because they mark the semantic relation between discourse units and then help language users to attain an understanding of textual coherence. Put it simply, discourse connectives play a central role in creating coherent texts. Besides linking sentences or clauses at the surface level, discourse connectives can facilitate the processing of discourse relations by helping comprehenders to infer the intended coherence relation holding between two text spans.

For example, “*As he stood on the harbour thinking about his son (1), he wondered if the family would ever get to make the journey(2). However, soon after this disappointment (3) the father discovered how lucky the family had been (4).*”. In this example, “as” provides the link between clause (1) and (2). This discourse connective allows readers/listeners to know that the two clauses have a temporary relation. Similarly, “soon after” allows readers to know that clause (3) and clause (4) are linked by a temporary relation. Finally, “however” connects the two discourse units made up by (1)-(2) and (3)-(4) respectively and expresses the contrast between them. Without these discourse connectives, it is likely to cause an incoherent text. More seriously, the underlying logical relation from this text may become unclear or vague for listener or reader without them. Pragmatic inference (or effective communication) is not easy to make when the logical relation is not clear.

Such pragmatic inferences happening above sentence level include relations of contrast, contingency, expansion and temporality. They are often facilitated by the use of explicit connectives, which function as processing instructions. This facilitation has been repeatedly evidenced in comprehension and processing studies (Sanders and Noordman, 2000; Van Silfhout et al., 2015). Moreover, a large amount of discourse research has focused on how discourse connectives are processed (Torabi Asr and Demberg, 2020; Köhne-Fuetterer et al., 2021). Through fMRI evidence, Prado et al. (2015) found that that pragmatic processing interacts with logical inference-making when understanding arguments in narrative discourse. Although these discourse connectives also play a logical role in language and they are central to everyday conversation, few studies have been investigated.

Moreover, discourse connectives play a critical role in establishing theoretical discourse analysis and computational discourse studies. For exam-

39 ple, one influential discourse corpus, the Penn Discourse Treebank (PDTB)
40 (Webber et al., 2019), uses discourse connectives to annotate English dis-
41 course structures. The PDTB uses discourse connectives as heads to form
42 dependencies concerning local discourse structure. In this sense, discourse
43 connectives play an essential role in this corpus. The PDTB has greatly
44 affected theoretical discourse analysis, discourse corpora building and a

45 Discourse connectives and their relevant concepts (e.g., discourse mark-
46 ers, discourse particles) have been become quite popular (Lenk, 1998; Fraser,
47 1999) in studies of pragmatics and discourse. The main reason is that these
48 studies have found that discourse connectives provide necessary discourse
49 and pragmatic information in language as mentioned above. This has led to
50 the thesis of “the Rise of Discourse Markers”, which has gradually become
51 accepted (Heine et al., 2022). Although discourse connectives are one es-
52 sential part of discourse markers, this nonetheless gives rise to the illusion
53 that the use of discourse connectives has increased and thus that discourse
54 connectives have risen in frequency. Although frequency effects have been ex-
55 tensively and intensively studied in language variations, language processing
56 and language acquisition (ref. Ellis, 2002; Grainger, 1990). However, the di-
57 achronic change of frequency has seldom been investigated to associate with
58 usage of a language phenomenon. If we say that a language phenomenon is
59 on the rise, it implies that language users have been using it more frequently.
60 If its frequency is decreasing, it is difficult to say that it is on the rise. A
61 frequency increase in one language phenomenon at least suggests that there
62 is a motivation for this language phenomenon and that there is an increase
63 in its usage (Sun and Baayen, 2021). In other words, if it is known that the
64 frequencies of discourse connectives have in fact increased significantly, it is
65 plausible to believe in “a rise of discourse connectives”. In order to test this
66 hypothesis and the surrounding issues, we need to examine the historical data
67 on discourse connectives, and the historical data on discourse connectives can
68 provide empirical evidence to test this hypothesis.

69 So far, few has examined historical changes of discourse connectives
70 comprehensively. Most of such historical studies focused on English rather
71 than cross-language studies. Although previous studies have investigated
72 the diachronic changes of frequencies in specific discourse markers, we do
73 not think that such investigations are comprehensive enough to represent
74 all discourse connectives (Lenker and Meurman-Solin, 2007; Claridge, 2013;
75 Rysová, 2017). In order to see the bigger picture, we will examine the di-
76 achronic changes in all discourse connectives derived from large-scale corpora
77 and make a quantitative analysis across different languages. This study is
78 possible thanks to the growing interest in discourse analysis and the avail-

79 ability of large-scale corpora.

80 In addition, recently the tremendous influence of computational ap-
81 proaches has been widespread and rapidly increasing. The quick growth and
82 development of digital humanities reflects how computational approaches
83 have influenced the humanities (Berry, 2011). For instance, “culturomics”
84 uses computational lexicology to study human behavior and cultural trends
85 through the quantitative analysis of digitized texts (Michel et al., 2011). Re-
86 searchers can mine large digital archives to investigate cultural phenomena
87 as reflected in language and word usage. With the digitization of written
88 language, cultural trend analysis based around methods to extract quanti-
89 tative patterns from word counts has the potential to provide novel insights
90 into the development of human society. For example, Scheffer et al. (2021)
91 used emotion words/ratio of fact-related words dropped while emotion-laden
92 language surged, a trend paralleled by a shift from collectivistic to individu-
93 alistic language. The other study (Iliev and Axelrod, 2016) used the similar
94 method to find an increase in the use of causality over history. As discourse
95 connectives represent logical connection and pragmatic inference to some ex-
96 tent, their historical changes also reflect how people employed such logical
97 device to show their cognitive interest in language and communication. We
98 wonder whether the present study will have some connections with them to
99 gain a bigger picture.

100 The present study looks at the majority of discourse connectives com-
101 prehensively from the diachronic point of view and the perspective of cross-
102 language investigations. To our knowledge, this is the first time such an
103 investigation has been made. We believe that by drawing upon the data on
104 the historical development of this linguistic phenomenon, the current study
105 can reveal much about general tendencies in the use of present-day discourse
106 connectives and human cognitive interest in discourse. Our research ques-
107 tions are as follows:

- 108 1) Have the frequencies of discourse connectives in English increased or de-
109 clined significantly over the last two centuries?
- 110 2) Can we see such similar changes in the other languages (i.e., Chinese,
111 French, German and Spanish)?
- 112 3) Do the diachronic changes of frequencies in discourse connectives provide
113 empirical evidence to support the claim concerning a rise of discourse con-
114 nective? Could these diachronic changes provide us with a bigger picture on
115 evolution of human society?

116

117 2 Materials and Methods

118 First, we need to obtain a comprehensive list of discourse connectives. The
119 release of the PDTB (Webber et al., 2019) provides a high-quality and large-
120 scale discourse resource for the English language. Corpora annotated with
121 discourse relations for eight languages were developed following the release
122 of the PDTB. The most recent release is PDTB3.0. This version contains
123 a manual which provides a detailed list of discourse connectives (Webber
124 et al., 2019). In this manual, an individual discourse connective is specified
125 with its different semantic meanings as well as its frequencies. Such data
126 are very important and valuable for historical studies and especially in the
127 present context, given that we want to know the frequencies of different
128 semantic meanings for this specific discourse connective. More importantly,
129 the release of PDTB has been extremely influential because such styles have
130 been adopted to annotate in the other languages, such as Chinese, French
131 and German. By adopting the classification of discourse relationship from
132 PDTB, we can classify discourse connectives into several types according to
133 their meanings. In this case, we could examine the historical changes of each
134 type of these discourse connectives among these languages.

135 Secondly, after obtaining the list of discourse connectives, we need to
136 capture the data on the historical frequencies for these discourse connectives.
137 The Google Books Corpora (Michel et al., 2011) provide historical data for a
138 number of languages. These Google Books corpora can help us make a cross-
139 language study. Google Books corpora provide historical data for Chinese,
140 English, French, German, Hebrew, Italian, Russian and Spanish. Modern
141 Hebrew has been spoken after 1945. When Italy was unified in 1861, the
142 decision was taken to make Tuscan the official language of the country, and
143 modern Italian became the main language spoken in Italy due to the growing
144 use of radio, television, and newspapers. Russian also has undergone various
145 reforms. Similarly, Chinese also has been reformed greatly in 20th century.
146 Because of these, we choose English, French, German and Spanish to examine
147 their historical changes in last two centuries. We choose Chinese to compare
148 with the former four languages. The following gives a detailed account of
149 how to select discourse connectives and extract their historical data for these
150 languages.

151 2.1 English

152 Figure 1 shows the hierarchy of semantic labels for discourse connectives. All
153 clause relationships (i.e., semantic meanings) in PDTB3.0 can be classified
154 into four main senses: *Comparison*, *Contingency*, *Expansion* and *Temporal*,
155 and each main sense consists of smaller relations. The whole classification
156 contains three levels: *SENSE*, *CLASS* and *TYPE*. Such annotation system
157 was adopted in other languages such as French and German. We could clas-
158 sify discourse connectives in these language into four senses (i.e., Comparison,
159 Contingency, Expansion and Temporal) and examine their relative historical
160 changes in these languages.

161 In PDTB3.0, a discourse connective can be either explicit or implicit.
162 An explicit discourse connective is realized in the form of lexical items, but an
163 implicit discourse must be inferred from the adjacent discourse units. Most
164 explicit discourse connectives are subordinate and coordinate conjunctions as
165 well as discourse adverbials. The discourse connectives are mostly explicit in
166 English, yet approximately 40% of the discourse connectives are implicit. In
167 the present study, we will investigate the diachronic changes in frequencies of
168 explicit discourse connectives. We can obtain 160 discourse connectives from
169 PDTB3.0. The number of two-word phrase is 50, and that of three-word(or
170 more) phrase is 20. Additionally, we get the most frequent 40 discourse
171 connectives to make comparison.

172 However, we think it does not suffice to just obtain the historical fre-
173 quencies of an individual discourse connective. As is well-known, a discourse
174 connective can work in different discourse relations, that is, it can have dif-
175 ferent semantic meanings in the PDTB. It is difficult to obtain the data on
176 the frequencies of these different meanings for a specific discourse connec-
177 tive. For example, the frequency of “although” was “158” (by one million
178 words) in 1880s. However, the semantic meanings of “although” include con-
179 trast, concession, exception, and temporary. We want to know the frequency
180 of those occasions where “although” is used with a contrast meaning or a
181 concession meaning. In this case, the data from the PDTB3.0 manual can
182 be used to calculate the weights of these different semantic meanings for a
183 specific discourse connective. The following discusses how to calculate the
184 frequency weights of different classes (semantic meanings) for the same dis-
185 course connective. All discussions about it be summarized into Table 1 in
186 the supplementary materials (MS). In additionally, we can also classify dis-
187 course connectives into three types according to their orthography forms. For
188 instance, “ however” is monogram, and “ because of” is bigram, while “ as

Figure 1: The hierarchical classification of clause relationships in PDTB3.0 (three levels: sense, class, and type)

189 soon as” is trigram.

190 English data on historical frequencies is derived from Google Books (N-
 191 gram) corpora (eng_2019) and the Corpus of Historical American English
 192 (COHA). We can obtain the data on historical frequencies from Google Books
 193 corpora, and we choose the period from 1800 to 2019. The two sub-corpora:
 194 English and English fiction. In order to cross-verify Google data, we also
 195 obtain the data on the historical frequencies of these discourse connectives
 196 from a large-scale historical English corpus. The COHA is a good candidate.
 197 This corpus consists of a number of balanced genres and represents real-
 198 world English language use over a long period of time. This corpus can
 199 provide the data on frequencies of an individual word by decade from 1820
 200 to 2010. Parts of speech (PoS) of the majority of discourse connectives are
 201 conjunctives or prepositions. If a discourse connective has multiple PoSs, we
 202 will exclude those PoSs that cannot act as discourse connective. For example,
 203 when “like” works as verb, it cannot act as discourse connectives, so when
 204 we search the COHA, “verb” will be excluded.

2.2 French and German

An inventory of most frequent discourse connectives (n=40, e.g., “sondern”, “weil”, “inzwischen”, “außerdem”) in German can be obtained from the Potsdam contemporary corpus. However, a complete list of discourse connectives (n=135) can be obtained from [Connective-Lex.info](#) (Stede et al., 2019). In the two databases, the PDTB-style annotations were adopted, that is, we can classify these German discourse connectives into four senses which were taken in English. That means that we can examine historical changes of each sense of German discourse connectives. However, unfortunately, we only have to extract frequency data from the Google Ngram Viewer (ger_2019). There is not a historical corpus like COHA in German to provide historical data with us to cross-verify with each other.

Similarly, an inventory of most frequent discourse connectives (n=40, e.g., “et même”, “ensuite”, “comme pour”) in French can be obtained from the ConcoLeDisCo corpus. Similarly, a complete list of discourse connectives (n=175) can also be obtained from [Connective-Lex.info](#). The PDTB-style annotations were adopted in the two French databases, suggesting that we can classify these French discourse connectives into four senses which were taken in English. Unfortunately, we only have to extract frequency data from the Google Ngram Viewer (fre_2019). There is not a historical corpus like COHA in French to provide historical data with us to cross-verify with each other.

However, as German and French discourse corpora do not provide a detailed account of frequencies on different classes of discourse connectives, we could not compute the weights of these different classes in English. Additionally, we just examine historical changes of each sense of discourse connectives in either German or French rather than those at the class level of discourse connectives.

2.3 Spanish and Chinese

We have not found any discourse corpora or databases in Spanish to extract a list of discourse connectives. We just find some relevant studies concerning discourse connectives in Spanish. Considering this, we just extract an inventory of the 40 most common discourse connectives rather than a complete list (e.g., “por ejemplo”, “en cambio”, “de ahí”)(Sáez, 2003)also from (<https://happylanguages.co.uk/lesson/spanish-connectives/>), and frequency data can be extracted from the Google Ngram Viewer(spa_2019).

We can extract a complete list of discourse connectives (n=128) from CDTB Zhou and Xue (2015) for Chinese. In order to make comparison, we also extract 40 the most frequent ones in Chinese (e.g., “因为”, “不管”, “但是”). The frequency data can be extracted from the Google Ngram Viewer(chn_sim_2019). We have to be aware of the fact that classical Chinese referring to the written language of the classical period of Chinese literature, was used from the end of the Han dynasty to the early 20th century, when it was replaced by vernacular written Chinese. Between 1920 to 1950, a mix use of vernacular written Chinese and Classical Chinese existed. The vernacular written form has been dominated after promoting the campaign of pǔtōnghuà (simplified Chinese, or “common speech”) after 1955 (Norman, 1988). The last two centuries’ history of Chinese is quite different from English, French, German and Spanish.

The following table overviews the materials we used in the current study.

Table 1: *Languages, Items and Data Sources*

Language	All Discourse Connectives	Most Frequent Discourse connectives	Discourse Connectives Source	Four Senses	15 Classes	Frequency Data Source
English	Yes (n=160)	Yes (n=40)	PDTB	Yes	Yes	Google Books Corpora & COHA
English Fiction	Yes (n=160)	Yes (n=40)	PDTB	Yes	Yes	Google Books Corpora
French	Yes (n=175)	Yes (n=40)	Connective-Lex.info, Potsdam Corpus	Yes	No	Google Books Corpora
German	Yes (n=135)	Yes (n=40)	Connective-Lex.info, ConcoLeDisCo	Yes	No	Google Books Corpora
Spanish	No	Yes (n=40)	Relevant Studies	No	No	Google Books Corpora
Chinese	Yes (n=128)	Yes (n=40)	CDTB	No	No	Google Books Corpora

3 Results

3.1 English

First, we represented the historical changes in frequencies for discourse connectives extracted from Google Books Corpora and COHA respectively. The results from Google Corpora are shown in Figure 2. Figure 2 shows that English and English fiction underwent a significant decline in frequencies. In each case, we also examined all discourse connectives and the 40 most frequent ones. The regressive statistical analysis in each case shows that the slope is negative and the p value (<0.001) is significant. This indicates that

English users have significantly reduced their use of explicit discourse connectives over the last two hundred years. However, after 2000, the four cases began to increase dramatically. Overall, the four cases are greatly similarly in change patterns.

Figure 2: English and English fiction from Google Corpora have similar trends. Here y-axis represents scaled normalized frequency. Y-axis in Figures 2-5 represents scaled frequency. p-value in the legend text represents the simple regression model result. Specifically, when p-value is smaller than 0.001, it is significant with three stars. Here “EngFic_All” represents all discourse connectives in English Fiction from Google Books Corpora. “EngFic_Mostfreq” represent the 40 most frequent discourse connectives in English Fiction from Google Books Corpora. “Eng_All” represent all discourse connectives in the English language from Google Books Corpora. “Eng_Mostfreq” represents the 40 most frequent discourse connectives of the English language from Google Books Corpora.

We represented the historical changes in frequencies for discourse connectives extracted from COHA. In each case, we also examined all discourse connectives and the 40 most frequent ones. The regressive statistical analysis in each case shows that the slope is negative and the p value (<0.001) is significant, shown in Figure 3. We find that Figures 2 and 3 are completely consistent. That suggests that the data from Google is consistent from the one from COHA.

Moreover, we also represented the historical changes in frequencies for

Figure 3: All English discourse connectives and the most frequent ones from COHA have similar trends. x-axis represents year, and y-axis represents the scaled frequency data. p -value in the legend text represents the simple regression model result. Specifically, when p -value is smaller than 0.001, it is significant with three stars. Here “All discourse connectives” represents all discourse connectives in the English language from the COHA. “Mostfreq discourse connectives” represents the 40 most frequent discourse connectives of the English language from the COHA.

all discourse connectives as classified into the four senses in Figure 4, which will be discussed in the following subsection. As discussed in the section of methods and materials, we examined 16 classes in English. Due to the space limit, we put the results in the supplementary materials. However, we can report the main findings here.

According to [Asr and Demberg \(2012\)](#), *implicitness* represents the proportion of implicit frequency to the total frequency. When a discourse relation with high implicitness, it indicates that language users tend to use explicit form of discourse connectives less frequently. For example, People seem to need more cues to help them understand adversative relations between clauses and sentences. That is why the relations of concession, condition and exception have low implicitness. Language users should not reduce the use of discourse relations with low implicitness. Otherwise, it will lead to incoherence and vagueness in discourse. However, Table 2 shows that such discourse relations have also reduced the use of explicit forms from a histor-

291 ical perspective. Overall, the decrease of frequencies have been seen in the
 292 majority of 16 classes of English.

Table 2: *Different types of relations in the PDTB3.0 and their historical changes*

Discourse relation classes	Implicitness	Diachronic trend
Level-of-detail	92.74%	down
Equivalence	92.56%	down
Instantiation	82.52%	up
Purpose	80.91%	down
Cause	73.96%	stable
Manner	64.32%	down
Contrast	44.34%	down
Asynchronous	38.9%	down
Conjunction	33.29%	down
Synchronous	24.86%	down
Concession	23.74%	down
Similarity	23.31%	down
Exception	12.5%	stable
Condition	11.82%	down
Disjunction	8.96%	down

293 3.2 French, German and Spanish

294 We put English, French and German together to find their similarity of the
 295 change patterns. There are six different cases. First, we examined changes
 296 by looking at all discourse connectives and the 40 most frequent ones in
 297 these languages. Second, we examined changes of frequencies of discourse
 298 connectives in terms of four senses of discourse relations by the PDTB style.
 299 This panel is completely consistent with Figures 1 and 2.

300 As shown in Figure 4, the panel of “most frequent” shows the historical
 301 changes of 40 most frequent discourse connectives in English, French, Ger-
 302 man and Spanish over the last two centuries. This panel shows the great
 303 similarity among the four languages. The panel titled with “All discourse
 304 connectives” shows the frequency changes of all discourse connectives in En-
 305 glish, French and German. The other four panels titled with *Comparison*,
 306 *Contingency*, *Expansion* and *Temporary* examine the four different types

307 of discourse connectives (by PDTB) over the last two centuries in English,
 308 French and German. These five panels also see the general similarity pattern:
 309 first, the simple regression model shows all of the cases have a significant decline
 310 (p-value is smaller than 0.001). Second, at the initial stage (1800-1850),
 311 English, French and German saw an increase in frequencies. However, after
 312 1850, the decline was obvious. By contrast, after 2000, all cases have seen a
 313 rise. Nevertheless, after 2000, the increase in French and German has been
 314 more remarkable than English.

Figure 4: Four languages show similar trends in different cases. p -value in the legend text represents the simple regression model result. Specifically, when p -value is smaller than 0.001, it is significant with three stars. Eng=English, Fre=French, Ger=German.

315 **3.3 Chinese**

316 The changes of Chinese have a perfect fit to historical events. As mentioned
 317 in section of methods and materials, the modern written form of Chinese
 318 was dominated after 1955. The period of 1920 and 1955 saw the mixed use
 319 of modern Chinese and classical Chinese. Before 1920, the use of classical
 320 Chinese was dominant in written form. The left panel in Figure 5 clearly
 321 show such changes. We used discourse connectives from modern Chinese
 322 to explore how their frequencies changed. During the period of 1920 and

1950, the use of modern Chinese discourse connectives began to increase but increased dramatically after 1950.

Figure 5: Historical changes of discourse connectives in Chinese. “Chn_All”=All discourse connectives in Chinese, “Chn_mostfreq”= the 40 most frequent discourse connectives in Chinese. The time span in the left panel is from 1920 to 2009, and that in the right panel is from 1950 to 2009.

However, such an increase began to drop quickly after 1960 because of the “cultural revolution” and a series of political campaigns in China. The books published during the period were likely to propaganda the leader’s thoughts, ignoring the coherence and logical connection in them, and this could be reflected in the right pannel of Figure 5. After the “cultural revolution” ended (1976), the frequencies of discourse connectives increased dramatically. In 1980s, the changes kept stable. The difference is that after 2000, the frequencies have been fluctuated relatively stably. By contrast, an more obvious increase has been seen in English, French, German and Spanish after 2000.

4 Discussion

It would be easy to accept that the frequencies in explicit discourse connectives concerning contingency declined over the course of time because the causality-by-default hypothesis supports the view that people do not need extra cues in understanding causality. For instance, Jin and de Marneffe (2015) proposed that expansion should be treated as being the default option as it is explicitly marked far more often than causation in English. It is

clear that causation is not the least marked relation. We can also see that contingency and comparison are often implicit. Furthermore, many other language devices are capable of replacing such discourse connectives. For example, causality verbs can indicate the causal relation between two sentences. However, our finding on historical changes of adversative connectives (contrast, concession) seem to contradict our intuition. People seem to need more cues to help them understand adversative relations between clauses and sentences. Despite this, our data supports that language users tend to be historically less reliant on the use of adversative connectives. Additionally, the downward trend of discourse connective is not limited in some specific genres, and it can be found in academic genre. [Biber and Gray \(2010\)](#) found there is also evidence that this style of discourse is spreading to a less explicit marking of meaning relations generally in academic texts. They found that linking adverbials were quite common in academic writing in the 18th and 19th centuries, but they have decreased rapidly in use in the 20th century. The finding is consistent with the one in the current study.

As mentioned in the section of introduction, the thesis of “the Rise of Discourse Markers” has gradually become accepted. This nonetheless gives rise to the illusion that the use of discourse connectives has increased and thus that discourse connectives have risen in frequency. However, our data demonstrates that the frequencies of discourse connectives have been declined significantly over more than two hundred years. However, the rise of them can be seen from 1980. Given the overall change and the recent change of their frequencies, we cannot support the hypothesis of a rise of discourse markers from a historical perspective.

The following will discuss the relevant issues more broadly so that we can gain bigger picture. [Scheffer et al. \(2021\)](#) reported an historic rearrangement, occurring in the late 20th century, of the balance between reason and emotion. Note that their study just focuses on the period between 1850 and 2019. Its approach is part of a new trend in the psychological sciences that uses extremely large volumes of text to study basic patterns of human cognition. Such methods have been used in exploring the universal properties of gender representations ([Charlesworth et al., 2021](#)), the rise of causal thinking ([Iliev and Axelrod, 2016](#)) and a cognitive bias towards positivity in language itself ([Dodds et al., 2015](#)). The current study can also be associated with these previous researches and contributes to the knowledge of human cognitive changes in history.

[Scheffer et al. \(2021\)](#) found a shift from the intuitive pole to the rational pole (the “rise” of rationality) and then back (the “fall”) . The rise has

381 begun by the start of their data in 1850, and unfolds over the course of a
 382 century or more. The fall begins in 1980, and is more rapid than the rise: by
 383 2020, the balance is similar to that seen in the early 1900s. The fall appears
 384 to accelerate in the early 2000s. By contrast, Scheffer et al. (2021) found
 385 sentiment words and intuition related words have undergone the reversed
 386 process. They began to fall from 1850 but rose from 1980 but increased
 387 quickly after 2000s. Interestingly, the changes of emotion and intuition words
 388 are consistent with the ones of discourse connectives in the current study. We
 389 wonder why this coincidental change happened.

390 The distinction between rational words and emotional (intuition) words
 391 can roughly be taken as the difference between formal words and informal
 392 words, that is, language style difference. In terms of Scheffer et al. (2021),
 393 rational words are related to rationality, science, and quantification. These
 394 rational words are actually used in *formal* situations, particularly in writ-
 395 ing for professional or academic purposes. Emotional words concerned with
 396 intuition, believing, and spirituality are more likely used in *informal* circum-
 397 stances than formal ones (e.g., *imagine–envisage*, *fear–apprehension*). We
 398 collected 210 pairs of formal words and their corresponding informal words
 399 (<https://engdic.org/formal-and-informal-words/>). After having ob-
 400 taining their historical frequencies from Google Books corpora (1850-2019),
 401 we used the second principal component (PC2) shows an asymmetric U-curve
 402 in terms of the method by Scheffer et al. (2021). Shown in Fig.6, the histor-
 403 ical change trend of formal words is basically identical with that of rational
 404 words. The same are with informal words and emotional words.

405 The historical changes of formal/informal words are in fact in line with
 406 the trend of “colloquialization”. Recent numerous studies found that “col-
 407 loquialization” has become a trend in the development of language (Leech,
 408 2004). Mair (2006):187 proposed that “a significant stylistic shift in twen-
 409 tieth century English” is due to which the written language becomes more
 410 similar to the spoken language and more tolerant to various degrees of infor-
 411 mality. Overall, colloquialization is able to explain these changes in Scheffer
 412 et al. (2021). This simpler approach can be used to explain the phenomenon
 413 of language change more effectively.

414 Similarly, the colloquialization trend is well capable of explaining the
 415 changes of discourse connectives. When the written language becomes more
 416 similar to the spoken language, language speakers tended to use less discourse
 417 connectives. The other evidence could also prove it. Recent years saw the
 418 fact that the sentence length is gradually becoming shorter in history (Liber-
 419 man, 2011; Rudnicka, 2018; Sun and Wang, 2019). It is known that discourse

Figure 6: Historical changes of informal words and formal words in English. y-axis represents second principal component of change in z-scores of frequencies.

connectives are mainly used to connect between clauses and sentences. The shorter length of sentence indicates that people have used less discourse connectives. The trend of using shorter sentence can be found in French, German and Spanish. However, the trend has kept stable since 2000s, which could be verified in Google N-gram viewer using period, exclamation mark, question mark and colon. It means that the sentence length change is consistent with the frequency change trend of discourse connectives. However, using shorter sentence length is a result of colloquialization. It is a tendency for the written language gradually to acquire norms and characteristics associated with the spoken conversational language. This trend is the main motivation to the decrease of discourse connectives.

The other possibility of using less discourse connectives is that some similar expressions in language could have replaced specific discourse connectives. For example, Iliev and Axelrod (2016) found an increase in the use of causal language (“causality”) from 1800 to 2000. The causality expressions in Iliev and Axelrod (2016) also includes some contingency discourse connectives, but most of them are verbs and nouns. The data from Iliev and Axelrod (2016) shows that there is an decrease from 1980s but a quick drop has been seen after 2000. It could be possible that some *causality* expressions in language could have replaced some discourse connectives used for *contingency*. This example can support our argument that discourse connectives could be partly replaced by some Note that the function *causality* within a sentence does work as causality discourse connectives. A causality discourse

connective could impact several clauses even a text (e.g., “because”, “consequently”). By contrast, intra-sentential causality expressions (e.g., “enable”, “prevent”) just influence one sentence. In short, the two types of causality expression are distinct. From the data from [Iliev and Axelrod \(2016\)](#), intra-sentential causality has been increasing from 1800 to 2000. This does not conflict with our finding on a decrease of contingency discourse connectives. When intra-sentential causality was used more frequently, the less frequently the contingency discourse connectives could occur. Clearly, “causality” is treated as one type of rationality in language. It could explain why “causality” increased but contingency discourse connectives decreased.

When language users are historically less reliant on the use of discourse connectives, we need to consider whether this has led to incoherence in discourse more seriously or not. However, the colloquialization trend allows language user to introduce other different expressions to compensate this gap.

In the present study, in German and French, the trends in discourse connectives suddenly accelerate around 2000. One possible explanation could be that the standards for inclusion in “to” to “from a publisher that directly deposited with Google” after 2004 to 2007. It means that from 2004, more reprinted books could have added to ngram corpora, so that some expressions frequencies accelerated ([Schmidt et al., 2021](#)). That is why some discourse connectives have rocketed after 2004. However, such a trend is not so strong in English as German and French.

We have discussed the possible factors to cause a decrease of discourse connectives from different perspectives. The following will discuss what more factors cause language change from broader perspectives. Many studies show that word correlations, occurring across time and between words, are largely influenced by coevolutionary social, technological, and political factors, also including population size, literary education and other factors ([Koselleck, 1989](#); [Wichmann and Holman, 2009](#); . The impact of historical context on language dynamics is not limited to emerging languages, but extends to languages that have been active and evolving continuously. For example, Changes of discourse connectives in Chinese was greatly influenced by historical events and broader social-cultural changes. This provides a perfect example to illustrate the co-evolution of social, political factors with language ([Petersen et al., 2012](#); [Jablonka et al., 2012](#); [Sun et al., 2021](#)). Additionally, we find that the distribution of discourse connectives growth rates significantly broadens during times of balance among different factors, revealed through English, French, German and Spanish during the last two centuries.

482 The recent peak in German and French is almost as high as that 150 years
483 ago. This can be understood as manifesting from the unification of public
484 interests over the last 150 years.

485 5 Conclusion

486 This study made historical corpora to examine diachronic changes of dis-
487 course connectives in Chinese, English, French, German and Spanish. We
488 found that there has been a clear decline of frequencies of these discourse
489 connectives in English, French, German and Spanish. More interestingly, an
490 increase of frequencies can be seen after 1980s, and such increase facilitated
491 after 2000s among the five languages. In the present study, our diachronic
492 data on frequency in discourse connectives does not support the hypothesis
493 of rising of discourse connectives mentioned in Introduction. We believe that
494 the diachronic changes of discourse connectives have been mainly influenced
495 by the trend of “colloquialization”. The other factors also contributed to this
496 language phenomenon. The current study reveals a cultural and human be-
497 havior trend analysis based around changes of discourse connectives, and it
498 provides novel insights into the development of human society.

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Supplementary Materials

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Table 3: *Example of calculating frequency weights for differfor different PDTB classes of this discourse connective*

discourse connective	sense	class	frequency
Although	Comparison	Concession.Concession.Arg1-as-denier	206
Although	Comparison	Concession.Arg2-as-denier	105
Although	Comparison	Contrast	104
Although	Expansion	Exception.Arg2-as-except	2
Although	Temporal.Synchronous	Comparison.Contrast	1(0.5+0.5)

↓

Table 4: weights for different PDTB classes of this discourse connective

discourse connective	sense.class	weight
although	Comparison.Concession	$(206+105)/311= 0.9482$
although	Comparison.Contrast	$(14+0.5)/311=0.04421$
although	Expansion.Exception	$2/311=0.0061$
although	Temporal.Synchronous	$0.5/311=0.0015$

608 A Weights on different classes for discourse 609 connectives

610

611 The total frequency for “although” is 311 (per one million words), as
612 shown in Table 3. We merge the items shared with the same sense and
613 class regardless of types. For example, the first and second “although” are
614 merged to be treated as “Comparison.Concession”. The last “although” is
615 annotated as “Temporal.Synchronous|Comparison.Contrast”. In this case,
616 the two types of “sense.class” will be split with equal frequency. Here, we
617 split it into “Temporal.Synchronous” and “Comparison.Contrast” with the
618 frequency of 0.5 respectively. Generally, “although” can be classified into
619 four types according to its “sense.class”. Each item has their own different
620 frequencies. We are interested in the weight of each item. However, we have
621 obtained the frequency for “Comparison. Constrast”, so the frequency on
622 this item (i.e. 0.5) is put into the one above. The weight of an individual
623 “Sense.Class” is calculated by its frequency divided by the total frequency.
624 For example, the weight of “Comparison.Concession” can be computed by
625 its frequency (206+105), divided by the total frequency (311), that is, its
626 weight is 0.9482. The data on the weights of the four different meanings

627 (Sense. Class) is shown in Table 4.

628 The total frequency of “although” for each decade can be obtained in
629 COHA. However, we are more interested in knowing the frequency of each
630 type of “sense.class” for this word. It can be easily calculated using the
631 equation of “the total frequency * the weight”. For example, the total fre-
632 quency (per million words) of “however” in 1900 is 378.76. In this case, its
633 frequency of “Comparision.Concession” is $378.76 * 0.9481707 = 359.13$, the one
634 of “Comparision.Concession” is $378.76 * 0.04420732 = 16.74$, the one of “Ex-
635 pansion. Exception” is $378.76 * 0.0060975 = 2.31$, the frequency of “Tempo-
636 ral.Synchronous” is $378.76 * 0.001524 = 0.58$.

637 Using COHA, we can gain data on the frequencies (standard frequency,
638 by one million words) of all discourse connectives derived from PDTB3.0
639 from 1810 to 2010. An individual discourse connective can be classified
640 into several types according to the PDTB3.0 annotation manual, as shown
641 in Table 1. We can calculate their frequencies in each decade using the
642 corresponding frequency weights of the different classes for the same discourse
643 connective (1820-2010). Note that the weights of the different classes of
644 this discourse connective are based on the PDTB3.0, which used WSJ texts
645 published in 1990s. That means these weights only reflect usage in the 1990s.
646 However, the weights must have been somewhat different in each decade of
647 the last two centuries. Nonetheless, the semantic changes in these discourse
648 connectives are much smaller than nouns, verbs, and adjectives. The reason
649 for this is that the majority of discourse connectives are conjunctions and
650 prepositions. It is well-known that function words undergo a lesser degree
651 of historical semantic changes than content words (Kutuzov et al., 2018).
652 Bloomfield (1933) defines function words as “innovations which change the
653 lexical meaning rather than the grammatical function of a form.”. In view
654 of the fact that these small semantic diachronic changes in these discourse
655 connectives have been basically ignored, we maintain that the weights based
656 on the PDTB can be used to calculate the frequencies over all decades. This
657 can be done if we use the same weights for each decade between 1810 and
658 2010

Figure 7: Changes of four senses from COHA

Figure 8: Changes of comparison classes from COHA

659 B Historical changes of different classes in 660 English from COHA

661 The four classes under “expansion” show a significant decline in their fre-
662 quencies. The linear regressive analysis (negative slopes and significant p-

value <0.001) also confirm this observation. By contrast, the increase in the frequency of “instantiation” may suggest that English users have preferred to use more examples. This preference leads to an increase in the use of discourse connectives involved in exemplification. The exception is “exception”. The regression analysis shows that there is no significant change in this case. It indicates that the frequency of “exception” remains relatively stable.

What is very interesting is that the three classes under the category “comparison” show different trends. As is well-known, the proportion of explicit discourse connectives regarding “comparison” is relatively high. In other words, language users usually have to employ discourse connectives to express comparative meanings.

Figure 9: Changes of contingency classes from COHA

As shown in Figure 9, the frequency of the three classes shows a clearly declining trend. Due to the need for discourse connectives, the declining frequency of “concession” could indicate that language users tend to employ less concession-relationship clauses over the course of time. The regression

Figure 10: Changes of expansion from COHA

analysis shows that the p-value is greater than 0.05, which suggests there is no dramatic changes in frequencies of contrast.

In the following, we examine the frequency changes from an orthographic perspective. As is well-known, some discourse connectives are just one word, but the others may consist of two or three (or more) words. “N-gram” here means one word, a two-word combination or a three-(or more)-words combination. Figure 10 represents the diachronic changes in different types of discourse connective from the perspective of n-gram.

Here “Bigram” represents two-word phrase such as “due to”, “in fact”. Trigram refers to three (or more than three) word phrases, such as “in any case”, “on the other hand”. “Lemma” refers to one-word discourse connectives (e.g., “similarly”, “nevertheless”). Only Bigram shows an increasing trend in frequency. This could mean that English users tend to use two-word discourse connectives more frequently although the overall trend is a less frequent use of discourse connectives.

Figure 11: Four languages show similar trends in different cases