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Some notes on the use of relatives in nineteenth-century scientific prose: A quantitative study*

Questo contributo discute l'uso delle subordinate relative nella prosa scientifica del 19° secolo, sulla base di un corpus di 30.000 parole compilato all'uopo e tratto da testi relativi alla meccanica e all'elettricità. Attraverso l'impiego di *Wordsmith Tools*, sono state tratte precise informazioni in merito a distribuzione e frequenza delle occorrenze registrate. L'articolo presenta dunque dati statistici concernenti a) le occorrenze dei pronomi relativi; b) la loro funzione sintattica (cioè la loro *gerarchia di accessibilità*); e c) la posizione delle subordinate relative in relazione alle proposizioni principali (ovvero il *principio del peso finale*). Da ultimo, questi dati sono confrontati con quelli tratti da un corpus di prosa scientifica del 20° secolo, così da mettere in evidenza differenze e analogie.

1. *Introduction*

Scientific texts have been a challenging field of research in recent times because of the growing interest in English for Specific Purposes (ESP), and especially the language of science and technology. Scientific texts have been approached from different perspectives such as register, discourse or genre analysis. The diachronic approach, however, has proved to be somewhat neglected, notwithstanding those publications on the field of diachronic stylistics such as Gordon (1966) or Adolph (1968) describing the linguistic and rhetorical features of old texts from a literary perspective.

Therefore, the aim pursued in these pages is to offer a quantitative analysis of relative clauses in the late nineteenth century. Taking register analysis as the theoretical frame, this paper offers some statistical data on 1) the occurrence of relativisers; 2) the syntactic functions which are

more easily relativisable (e.g., *the accessibility hierarchy*); and 3) the position of relative clauses with respect to the main clause (e.g., *the principle of end-weight*). For this purpose, a nineteenth-century corpus was constructed with excerpts taken from Mendenhall's *A Century of Electricity* (1887: 151-201), Goodeve's *Principles of Mechanics* (1891: 241-251), Thompson's *Elementary Lessons in Electricity and Magnetism* (1895: 397-425), and Lodge's *Elementary Mechanics* (1897: 192-200). The corpus, of over 30,000 words, was analysed statistically using WORDSMITH TOOLS 3.0 (Scott 1996). The data thus obtained were later collated with a twentieth-century homologue (see section 3 below), in order to find out what changes have occurred.

2. *Relative clauses*

2.1. *Relativisers*

Relative clauses totalise 210 occurrences in the nineteenth-century corpus under investigation. The commonest relative pronoun is *which* (169 occurrences, 80.47%; 87 in restrictive, 78 in non-restrictive and 4 in sentential relative clauses), followed by *that* (14 occurrences, 6.66%; 13 in restrictive and 1 in non-restrictive clauses). Next, 12 clauses are introduced by *of which* (5.71%), 9 by *whose* (4.28%) and 6 by *who* (2.85%).

These percentages are revealing on account of the minimal frequency of *that*. In contrast, these results partially diverge from those observed in texts of the previous century. The history of relatives in Modern English is characterised by the progressive generalisation of *wh*-pronouns, which already outnumbered *that* in the eighteenth century, especially in restrictive clauses, because in such a way the animate vs. inanimate reference could be perfectly stated (Bately 1965: 245-250; Dekeyser 1984: 68-80). Accordingly, Tejada argues that at the time both "*that* and zero relative […] were considered colloquial barbarisms" (Tejada 1991: 161; Görlach 2001). However, *that* was still frequent in that century - in *The Spectator* it was claimed to have been frequent even by the educated members of society; as shown below, the author complained about the use of *that* as a relative because it had ousted *which* and *who* (see Traugott 1972: 182-183):

> How often have we [i.e. *which* and *who*] found ourselves slighted by the Clergy in their Pulpits, and the Lawyers at the Bar? Nay, how often have we heard in one of the most polite and august Assemblies in the Universe, to our great Mortification, these Words, *That* THAT *that noble Lord urged*; which if one of us had had Justice done, would have sounded nobler thus, *That* WHICH *that noble Lord urged*. Senates themselves, the Guardians of *British* Liberty, have degraded us, and preferred THAT to us; and yet no Decree was ever given against us (*The Spectator*, May 30th, 1711; Morley s.d.: 126).

In the nineteenth century, relative clauses show a similar distribution: the corpus shows *which* to be prevalent, *that* being somewhat scant. Apart from an intrinsic proneness to the use of *wh*-pronouns in that century, this may be justified on the grounds of the frequency that nominal *that*-clauses also have. As a matter of fact, they have been found elsewhere in the corpus, especially in subject and object positions[1] and, therefore, *which* could have been favoured with inanimate reference to discriminate between nominal and relative clauses, especially when the relative depends on a nominal clause. Secondly, prepositional relatives could also have played their part because *that* generally requires preposition stranding in such circumstances. Dekeyser (1968: 93-105) argues that this restriction in the use of *which* and *that* is crucial for the later development of relatives into the modern period as it undoubtedly favoured the spread of *wh*-relatives to the detriment of *that*, as they allowed both stranded and pied-piping positions. Finally, *which* is the only relativiser capable of introducing a sentential relative clause, thus enhancing its outstanding occurrence throughout.[2]

As for their uses, they resemble those found in Present-Day English (henceforth PDE), that is to say, *which* and *who* are systematically chosen for inanimate and animate reference respectively, both in restrictive and non-restrictive clauses. Accordingly, *that* also takes personal and non-personal antecedents, especially in restrictive subordination (12 ex-

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[1] For example: *That this remarkable example has been reached in so short a time is unquestionably due to the fact that the science of electrodynamics was greatly in advance of the art* (Mendenhall 1887); *it may be arranged by suitable mechanism that one bucket shall stop a little before the other, and the result is that the column of water raised is never quite at rest, and that the buckets are believed from the shock due to the inertia of a heavy mass of water* (Goodeve 1891), etc.

[2] Apart from *which*, some other prepositional phrases have been found, such as *from which fact*, *from which time*, *during which time*, *in which case*, *for which reason*, etc.

amples). However, the following example stands out in the corpus as the only one where this relativiser is found in a non-restrictive relative clause (Dekeyser 1984: 69):

> This latter part of the electromotive-force is called the lost volts; the remainder being the useful or externally available volts, *that* would be measurable by a voltmeter set across the terminals (Thompson 1895: 399).

On the other hand, as predictable in a written corpus, zero-relatives do not appear at all - the explicit relativiser occurs in all cases, although the Late Modern period was crucial in the development of zero relatives. In the seventeenth century, they were restricted to non-subject positions, being standardized at the beginning of the following century when the relativiser was an object/complement or governed by a clause-final preposition (Rissanen 1999: 298-299). Nevertheless, the texts in our corpus quite intentionally use explicit relativizers, even when they might have been elided to avoid any possible ambiguity (see Traugott 1972: 184). This is a typical feature of scientific writing, where the unambiguous transmission of the message is of primary importance for scientists, hence causing frequent in-text repetitions.

> The method of generating electricity *which* he first gave to the world, in addition to supplying new demands *which* it itself created, is rapidly being substituted for the voltaic battery, although it is not likely ever to entirely takes its place (Mendenhall 1887: 159).

Indeed, the characteristic redundancy of scientific texts, as opposed to what is observed in general usage, has been highlighted by many studies (for instance, see Alvares 2000: 81-96; 2001: 81-101). To a broad extent, this might be explained as a cognitive process in the scientist's mind to facilitate the reader's task and thus avoid any possible misunderstanding.

Lastly, adverbial relative clauses are expressed by means of a non-finite clause, both *-ing* and *-ed* depending on whether the action is thought of as active or passive. As in contemporary scientific writing, these clauses are very frequent in the nineteenth-century corpus, as they were found in 92 examples (74 in *-ing* clauses and 18 in participial clauses).

2.2. *Whose / of which*

The synthetic genitive relativiser *whose* appears to be slightly more frequent than the analytic prepositional *of which* (with occurrences in 57.15% of cases, as opposed to 42.85%). Although both forms are used in similar syntactic contexts, Quirk (1985: 1249) argues that in PDE *whose* is customarily avoided with inanimate reference because it is considered the genitive case of the relativiser *who*, thus favouring the use of the form *of which* with non-personal references, traditionally considered more formal and cumbersome. In the nineteenth century, however, this personal vs. non-personal nuance between *whose* and *of which* does not hold true, since both work in the same co-referential contexts, as in the following examples:

> The magnetic field in which this armature revolves is produced by a powerful electromagnet, generally excited by the current which the machine itself produces, *the opposite poles of which* lie at the extremity of a diameter of the armature (Mendenhall 1887: 178).

> At points a quarter of a circumference from these it is neutral, so that the action is nearly the same as if the coils were rapidly moved around a ring magnet *whose poles* were at the ends of a diameter (Mendenhall 1887: 178).

There is only one difference in the use of these relativisers. *Whose* is more likely to occur when its antecedent functions as the subject or the direct object of the subordinate clause, while *of which* occurs when the antecedent is the subject, as in the following examples:

> Another form largely in use is the Maxim lamp, *the filament of which* is cut out of cardboard by means of a die of the proper form and afterward carbonized (Mendenhall 1887: 194).

> If we remove the wire R, and substitute in its place in *the circuit wires whose* resistances we know, we may, by trying, find one which, when interposed in the path of the current, gives the same deflexion on the galvanometer (Thompson 1895: 412).

> Then connect *the cell X whose* E.M.F. is to be measured, and slide its contact along the wire until it also is balanced (Thompson 1895: 422).

With regards to their position, *of which* shows two options. In PDE it is generally placed before its head, then imitating the pattern of its counterpart *whose* (Quirk *et al.* 1986: 1250). Nonetheless, this order is seldom attested in the nineteenth-century corpus, where the pattern *of which* plus head prevails, thus obtaining a proportion of 10:3. See the example below:

> Consider the case of a circuit *of which the resistance* is made up of two parts, an external resistance R consisting or wires, lamps, etc., and of a smaller resistance r internal to the battery or dynamo (Thompson 1895: 399).

2.3. *Syntactic function*

Following the analysis of their occurrence in the corpus, the various functions of these relatives will be analysed so as to determine the prevailing type of subordination. Methodologically, Keenan and Comrie's principle of *accessibility hierarchy* (1977: 63-99) is used. According to this principle, some syntactic functions are more easily relativisable than others and, for this purpose, a *continuum* is offered where the functions are arranged according to the frequency with which they are relativised: *subject → direct object → indirect object → prepositional complement → determiner → adverbial*. In the light of this, the subject relative pronoun is more accessible than that found in the direct object position; likewise, the latter becomes more accessible than that functioning as the indirect object, and so on rightwards with all the other functions in the continuum.

The *accessibility hierarchy* in PDE has been widely corroborated in the literature; for instance, Yamashita (1994: 73-84), using a spoken English corpus, found 204 examples in subject position (61.82%), 52 in object position (15.76%), 22 in a prepositional phrase and 6 of them in genitive/determiner positions (1.82%). Likewise, Díaz Pérez (1997) analysed a written corpus including 180 relative clauses, eventually obtaining the following results:

> In 82 examples the relative pronoun is the subject of the clause, which means 45.55% of the total. The number of relative pronouns which func-

tion as object is 46 (= 25.55%). Twenty-two relative pronouns (= 12.22%) fulfil the function of prepositional complement, 28 (= 15.55%) that of adverbial and two are determiners (= 1.11%) (Díaz Pérez 1997: 75).

A similar investigation has been carried out to check the validity of the *accessibility hierarchy* one century earlier and, quite interestingly, the findings do not appear to match. Although relatives in subject positions predominate, totalling 91 occurrences (50.84%), relative pronouns in adverbial and determiner positions represent relatively high accessibility, with a higher frequency than those functioning as prepositional and/or direct object; indeed, there are only 10 occurrences of the latter in the corpus (see Table 1).

TABLE 1 - *Percentage of relativisers according to function.*

	Occurrences	*Percentage*
Subject	91	50.84
Direct object	10	5.59
Prepositional complement	24	13.41
Determiner	26	14.53
Adverbial	28	15.64

This may be justified on account of the number of passives found in technical texts which, obviously, cause object relative pronouns to be less numerous. Thus, in order to check the validity of the foregoing statement, passive sentences with the relativiser in subject position were counted, totalling 38 occurrences. In addition to this, *-ed* adverbial relative clauses were also considered insofar as they are passive relative clauses where, from a syntactic viewpoint, the omission of the relativiser along with the subject and the auxiliary verb has been carried out. These participial clauses amounted to 18 examples. Therefore, the sum of both structures yielded 56 occurrences which, together with the 10 examples found in object position, gives 66. Therefore, were some of them in the active voice, the accessibility hierarchy would be validated in our corpus.

2.4. *Position of relative clauses*

A clause-level analysis will be carried out in this section so as to check the various positions that relative clauses take with respect to the main one. For this purpose, *the principle of end-weight* proposed by Kuno (1974: 120) will be tested, in order to verify whether it holds true in the nineteenth century as it does in PDE. This principle, also termed *the closure strategy* (Díaz Pérez 1997: 78-81), is concerned with the position of relative clauses in an utterance, assuming that they are mainly favoured in final position. In PDE, the principle of end-weight has also been validated both in written and spoken English (Díaz Pérez 1997: 79 and Yamashita 1994: 82, respectively).

Methodologically, my analysis only considers those clauses whose relatives function as subject and/or direct object. Prepositional complements and adverbials have been deliberately disregarded, as they are systematically stranded and therefore of no use for our purposes. Thus, the corpus provided a total of 101 examples which were accordingly classified. The results obtained comply with those from PDE, since 77 examples were counted in final position (36 restrictive and 41 non-restrictive) vs 24 occurring medially (5 restrictive and 19 non-restrictive).

Kuno argues that the principle of end-weight is basically a cognitive process of the human mind aimed at reducing misunderstandings because, as he explains, it is closely "related to the limitation of the human capacity of temporary memory" (1974: 120). The speaker then is bound to reject centre-embedding in order to avoid additional data somewhere in the middle of an utterance: the more information is included within the main clause, the more interference there will be for the reader/listener.

If understanding is considered the key issue for using either centre or final embedding, then it is implied that the number of words of the subordinate clause will clearly influence the position of the relative clause itself. Therefore, the smaller the number of words in the relative clause, the more likely this is to occur in medial position. To check this statement, the number of words of those centre-embedded relative clauses were counted and compared with those in final position. Our results closely resemble Yamashita's (1994: 82), since relative clauses in centre-embedding rated 6.68 words while final-embedding account-

ed 9.64 words per clause. See the following examples both in restrictive and non-restrictive relative clauses:

> The amount of heat expended under the boiler of the engine *which ran it* exceeded so much that which could be obtained at the paying end of the machine, [°] (Mendenhall 1887: 167).

> In a common school he learned the rudiments of reading, writing, and arithmetic; but his apprenticeship, *which lasted for eight years*, afforded some opportunities for satisfying his keen thirst for knowledge (Mendenhall 1887: 152).

> Its filament is of cotton thread, *which receives a preliminary parchmetizing by being immersed in a solution of sulphuric acid and water*, after which it is carbonized (Mendenhall 1887: 194).

> And, in fact, no method of producing electricity has yet been devised *which has not been assumed to furnish a current of peculiar value as a curative agent* (Mendenhall 1887: 166).

Finally, as in PDE, it is frequent for a non-finite clause to be embedded in a relative clause (Quirk *et al*. 1986: 1299). Rissanen (1999: 297-298) argues that these structures have been very common since late Middle English, peaking in the eighteenth century. From a syntactic point of view, they may be explained as real coordinating links, since they seem to introduce a coordinate clause rather than relative subordination. However, there is no consensus as to their origin. Visser (1972: §534) postulates that their emerging use in English is the result of the Latin influence during the Middle and Early Modern periods. Moessner (1992: 336-351), on the other hand, argues that it is of French origin, as this type of embedding appeared in the fourteenth century, when the French impact on English was particularly intense. See some examples below:

> The filament of the glow-lamp, which *when cold* was 230 ohms, was only 150 when white hot (Thompson 1895: 403-405).

> We may, by trying, find one which, *when interposed in the path of the current*, gives the same deflexion on the galvanometer (Thompson 1895: 412).

2.5. *Prepositional relatives*

When the relativiser is found in a prepositional phrase, nineteenth-century scientists do not make use of *preposition stranding* as the preposition always precedes the relative pronoun. The relativiser in these cases is always *which*. This may be explained by the fact that since the Early Modern period these structures had been considered vulgar and substandard (Tejada 1991: 161). In the light of this, Bergh and Seppänen (2000: 295) state that prepositional relatives have undergone a particular trend of development, being characterised by continuous diachronic fluctuations:

> In the course of their history, English wh-relatives are known to have undergone a syntactic change in their prepositional usage: having originally occurred only with pied-piped prepositions, they came to admit preposition stranding as an alternative pattern. [There was] a modest beginning of stranding in Late Middle English, an increase in Early Modern English, and then a clear decrease in the written language of today, against a more liberal use in spoken English, standard as well as nonstandard.

Our results are thus similar to Bergh and Seppänen's. Methodologically, their study and ours carry out an historical analysis of prepositional relatives in three different periods of the history of English: Late Middle English, Early Modern English and Late Modern English. The data obtained for the Early Modern period totalises 88% of pied-piping structures as opposed to the 12% in stranding positions while in the Late Modern period 98% of cases are found in pied-piping versus 2% in preposition stranding positions.

3. *Concluding remarks*

As stated above, a statistical investigation of relative clauses in nineteenth-century scientific texts had been carried out, in order to identify typical features and subsequently compare them with PDE usage. For this purpose, we collected a PDE corpus of similar texts (i.e., pertaining to the field of science and technology) and of comparable size (ca.

40,000 words); the corpus was constructed comprising five 1999 issues of *The Electricity Journal* and four 1998 issues of *Principles of Mechanics*. The following data were obtained:

1) Unlike in the nineteenth century, *which* and *that* are statistically equalled in restrictive subordination, although the former still prevails. *Which* represents 52.32% of all the relatives in the corpus while *that* amounted to 40.68%, hence being more widely used than in the previous century. Indeed, these results comply with Yamashita's (1994: 73-84) who obtained 102 occurrences of *which* and 64 of *that* from the analysis of the Lancaster/IBM spoken corpus.

2) Zero-relatives do appear in the corpus whilst they are absent in the nineteenth century. Nonetheless, their use is still infrequent. Statistically, those cases where the relativiser is in non-subject position have been counted so as to rate their occurrence more precisely. As a result, zero-relatives totalise 10.24%: a very small figure, especially when compared with data from spoken English corpora. As commented above, this is common practice with scientists, who are especially concerned with securing the unambiguous understanding of their message.

3) In PDE the *whose* vs. *of which* contention is systematically resolved by the use of *whose*. To corroborate this, an alternative search was carried out in a corpus of scientific English containing almost three million words[3] and just 72 occurrences could be found compared with 286 with *whose*.

4) Finally, as in the nineteenth century, contemporary science also opts for *pied-piping* rather than *preposition stranding*. Thus, the calculation of the number of all relative clauses found in a prepositional phrase corroborates this historical proneness to pied-piping positions. That is, with the evidence of a total of 63 examples in the corpus, the preposition precedes the relativiser in 45 cases while being stranded in only 18.

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[3] Three scientific journals were chosen for this purpose (namely, *The Electricity Journal*, *Electric Power System Research* and *Solid State Electronics*), taking the issues published in 1998 and 1999.

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