

Reading Popular Science Magazines:

A Systemic Functional Perspective on Choosing Teaching Materials toward Academic Reading

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Abstract

This present paper is an attempt to show the lexicogrammatical characteristics of articles in popular science magazines. It focuses on the following items: lexical density (the organization of nominal groups) and grammatical intricacy (the nature of clause complexes). The purpose of this paper is to show whether or not reading articles in popular science magazines can help students understand scientific papers written in English. Thus, the characteristics found in articles in popular science magazines are compared with those of scientific papers. As a result of the analysis, critical differences between the two text types are found: different complexity of nominal groups and different usage of clause complexes, especially projection. It has become clear that although popular science magazines may share the same topics with scientific papers, their lexicogrammatical nature is different. Therefore, this paper concludes that if an English teacher wants their students to improve their academic reading ability, choosing articles in popular science magazines as reading materials does not seem to be effective.

1. Introduction

When an English teacher chooses her/ his reading materials for students, it is likely that s/he focuses on the topic that the text provides. For example, for

freshmen, who are going to read scientific papers in their senior, s/he might be tempted to choose reading materials that cover scientific topics, such as articles in *Popular Science* and *Scientific American*. It seems desirable for these freshmen to be familiar with the latest science and technology. However, it should also be considered whether or not reading articles in popular science magazines contributes to students' reading skills.

This paper explores articles in popular science magazines from the perspective Systemic Functional Linguistics (e.g. Butt, *et al.*, 2012; Eggins, 2004; Halliday, 2014; Halliday and Matthiessen, 1999; Thomson, 2014). Its focuses are on the followings: lexical density, which is derived from the organization of nominal groups; and grammatical intricacy, which is related to the nature of clause complexes). Its goal is to answer the question: can reading articles in popular science magazines help students understand scientific papers written in English? Thus, the results of the analysis are compared with those of scientific papers.

Examples are extracted from articles in *Scientific American* and *Popular Science* and open assess papers in *Nature Medicine* and *Nature Cell Biology*. All of the texts are available on the Internet and deal with symptoms or treatments of COVID-19.

2. Lexicogrammatical Analysis of Popular Science Magazines

Popular science magazines, such as *Popular Science* and *Scientific American* introduce science and technology to the general public. Since their readers are assumed to be common people who are interested in science and technology, the way to construct knowledge is presumably different from that of scientific papers whose intended readers are scientists.

I explored two articles from *Popular Science* and *Scientific American*, focusing on two types of complexity (lexical density and grammatical complexity) and found two lexicogrammatical features: the way to organize nominal groups and to form clause complexes. In this section, I will analyze the two items and compare the results with lexicogrammatical characteristics of scientific papers.

2.1 Lexical Density and Organization of Nominal Groups

The complexity of a text can be discussed in two ways: lexical density and grammatical intricacy. Lexical density is the proportion of content words to the text, and grammatical intricacy shows the length and depth of clause complexes (Halliday, 2002). When we try to understand a text, we have to consider this tendency: “Written language tends to be lexically dense, but grammatically simple” (Halliday, 2002: 336) and “while spoken English is marked by intricacy in the clause complex, written English is marked by complexity in the nominal group (Halliday, 2002: 343).

According to Halliday (2004a: 33), “a mean value of around 1–2 in casual speech and around 6–10 in technical writing is typical of many samples that I have counted”. In addition, “in scientific writing the lexical density may go considerably higher” (Halliday, 2004b: 168).

Lexical density can be measured as the number of lexical words (content words) per clause. The value of lexical density that I counted in articles from popular science magazines is around 6–8; while that in scientific papers is over 12. Popular science magazines are less complex from the viewpoint of lexical density. However, degree of lexical density is not the only crucial point; we need detailed analysis to show how complex the nominal groups are.

According to Halliday and Matthiessen (2014), a nominal group in English can interpreted as Figure 1.

Figure 1: An interpretation of a nominal group

<i>text</i>	these	two	splendid	old	electric	trains	with pantographs
<i>function</i>	Deictic	Numerative	Epithet		Classifier	Thing	Qualifier
			Attitude	Quality			
<i>class</i>	determiner	numeral	adjective	adjective	adjective	noun	prepositional phrase

(adapted from Halliday, 2014: 388)

‘Thing’ is the semantic core of the nominal group. It can be characterized by the following elements. Most generally, ‘Deictic’ indicates whether the thing is specific or not. In addition to it, another Deictic element called ‘post-Deictic’ may occur, which identifies a subset of the thing by referring to its fame or familiarity, or its similarity and dissimilarity. ‘Numerative’ indicates numerical features. ‘Epithet’ indicates qualities which are either experiential (Quality) or interpersonal (Attitude). ‘Classifier’ indicates subclasses of the thing. ‘Qualifier’ follows the thing and function as post-modifier. Qualifier is either a clause or phrase, and they are rankshiftedⁱ and ‘embedded’ in nominal groups. (Halliday, 2014: 364–388).

Here are two examples extracted from two popular science magazines, *Scientific American* (Example 1) and *Popular Science* (Example 2).

Example 1

He points out that another second-generation vaccine that offers many of the same logistical selling points as CureVac’s, such as long-term refrigerator storage, has stood up to the variant challenge well. Earlier this week, Novavax in Gaithersburg, Maryland, reported that its protein-based vaccine was more than 90% effective at preventing COVID-19 in a large US trial, run at a time that the Alpha variant was prevalent. (Dolgin, 2021)

Example 2

A team of researchers in the United Kingdom analyzed the health outcomes of adults who contracted COVID-19 and then used a voluntary symptom-tracking mobile app. The participants who received one of two doses of the Pfizer, Moderna, or AstraZeneca vaccines between December 2020 and July 2021 were compared against a control group of unvaccinated individuals. (Seo, 2021)

These examples show a typical characteristic of articles in popular science magazines: When the value of lexical density is high, they tend to use ‘embedded’ clauses and embedded phrases/ groups.

Embedded clauses and phrases/ groups are ones that are shifted down a rank to lower level. For example, *that offers many of the same logistical selling points as CureVac’s, such as long-term refrigerator storage* in Example 1 does not have the same status as a clause but functions as part of a nominal group. Since embedded elements are ‘rankshifted’, we also use the term ‘rankshifted’ (See e.g., Butt, 2012: 200–201; Eggins, 2004: 131–133; and Thomson, 24–25 for further details).

Example 1, whose lexical density is 9.0 uses 3 embedded clauses; and Example 2, whose lexical density is 16.5 uses an embedded clause complexⁱⁱ, an embedded clause and an embedded phrase.

The followings show the analyses (In accordance with the convention of Systemic Functional Linguistics, [[[]]] is used as the boundary marker of embedded clause complexes, [[]] as that of embedded clauses and [] as that of embedded phrases and groups):

Figure 2: An analysis of a nominal group in Example 1

another	second-generation	vaccine	that offers many of the same logistical selling points as CureVac's, such as long-term refrigerator storage
post-Deictic	Classifier	Thing	Qualifier (embedded clause)

In the analysis in Figure 2, *another* serves as post-Deictic, *second-generation* as Classifier, *vaccine* as Thing. In addition, the rankshifted clause, *that offers many of the same logistical selling points as CureVac's, such as long-term refrigerator storage* serves as Qualifier of the nominal group.

Figure 3: Analyses of nominal groups in Example 2

the	health	outcomes	of adults [[[who contracted COVID-19 and then used a voluntary symptom-tracking mobile app]]]
Deictic	Classifier	Thing	Qualifier (embedded phrase with embedded clause complex)

The	participants	who received one of two doses of the Pfizer, Moderna, or AstraZeneca vaccines between December 2020 and July 2021
Deictic	Thing	Qualifier (embedded clause)

In the first analysis in Figure 3, *the* serves as Deictic, *health* as Classifier and *outcomes* as Thing. In addition, the prepositional phrase with a rankshifted clause complex, *of adults who contracted COVID-19 and then used a voluntary symptom-tracking mobile app* is rankshifted and serves as Qualifier. In the second analysis, *The* serves as Deictic, *participants* as Thing, and the rankshifted clause, *who received one of two doses of the Pfizer, Moderna, or AstraZeneca vaccines between December 2020 and July 2021* as Qualifier.

On the other hand, in scientific papers, different components of nominal groups seem to contribute to the high value of lexical density. In order to illustrate the difference, I will explore the examples extracted from *Nature Medicine* (Example 3) and *Nature Cell Biology* (Example 4).

Example 3

COVID-19 can have an unpredictable clinical course. Patients might suddenly deteriorate into severe respiratory failure, defined as a respiratory ratio (partial oxygen pressure (PaO₂)/ fraction of inspired oxygen (FIO₂)) below 150 mmHg, necessitating non-invasive ventilation (NIV) or mechanical ventilation (MV). Early recognition of patients at risk of progressing to severe disease and timely onset of targeted treatment are of utmost importance. (Kyriazopoulou, E. *et al.*, 2021)

Example 4

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection is at the origin of coronavirus disease 2019 (COVID-19), characterized by a first phase of benign flu-like symptoms with an efficient control of the infection in most case. In a second phase, disease aggravation may lead to acute respiratory failure, sepsis and death. This is due to a multiplicity of factors: (1) an exacerbated inflammatory reaction, with systemic and organ-specific manifestations, (2) persistent viral load and (3) defective antiviral defence pathways. (Saichi, M. *et al.*, 2021)

The analyses of characteristic nominal groups in Example 3 and 4 are shown in Figure 4 and 5:

Figure 4: Analyses of nominal groups in Example 3

an	unpredictable	clinical	course
Deictic	Epithet	Classifier	Thing

Early	recognition	of patients [at risk [of progressing to severe disease]]	and	timely	onset	of targeted treatment
Epithet	Thing	Qualifier (embedded prepositional phrases)	Conjunction	Epithet	Thing	Qualifier (embedded prepositional phrase)

In the first analysis in Figure 4, three elements precede and characterize *course*, Thing: *an* serves as Deictic, *unpredictable* as Epithet and *clinical* as Classifier. In the next analysis, *Early* serves as Epithet, *recognition* as Thing, and *of patients at risk of progressing to severe disease* as Qualifiers. To look at the Qualifiers, three prepositional phrases show multi-layered organization, which makes this nominal group more complex. This nominal group is followed by another nominal group, *and timely onset of targeted treatment* to form a nominal group complex. Here, *timely* serves as Epithet, *onset* as Thing and *of targeted treatment* as Qualifier.

Figure 5: Analyses of nominal groups in Example 4

Severe	acute	respiratory	syndrome	coronavirus-2 (SARS-CoV-2)	infection
Epithet 1	Epithet 2	Classifier 1	Classifier 2	Classifier 3	Thing

an	exacerbated	inflammatory	reaction,	with systemic and organ-specific manifestations
Deictic	Epithet	Classifier	Thing	Qualifier (embedded prepositional phrase)

defective	antiviral	defence	pathways
Epithet	Classifier 1	Classifier 2	Thing

In the first analysis of Figure 5, *Sever* and *scute* serve as Epithets and *respiratory*, *syndrome* and *coronavirus-2 (SARS-Co-V-2)* as Classifiers. All of the five elements precede and characterize *infection*, Thing. In the next analysis, *an* serves as Deictic, *exacerbated* as Epithet, *inflammatory* as Classifier and *reaction* as Thing. In addition, the rankshifted prepositional phrase, *with systemic and organ-specific manifestations* serves as Qualifier. In the third analysis, three elements precede *pathways*, Thing: *defective* serves Epithet and *antiviral* and *defence* as Classifiers.

Nominal groups in articles in popular science magazines can be complex because they tend to use embedded clauses and embedded phrases. On the other hand, complexity of nominal groups in scientific papers often comes from

elements that precede Thing. This difference seems significant because the type of nominal groups seen in scientific papers can be related to ‘grammatical metaphor’, especially ‘nominalization’ (e.g. Halliday, 2014; Halliday and Matthiessen, 1999)ⁱⁱⁱ.

Nominalization includes ‘transcategorization’ (or ‘shift’) and ‘fusion’ (or ‘junction’) (Halliday and Matthiessen, 1999). For example, *an exacerbated inflammatory reaction* in Example 4 is ‘metaphorical’ expression in that an event which is ‘congruently’ realized by a clause is realized by a nominal group. Looking at *reaction* which is congruently a process, it is ‘transcategorized’ to a thing. In addition, its original status, ‘process’ and transcategorized status, ‘thing’ are fused. As a result, it has two statuses: ‘process + thing’.

In order to understand such nominalized expressions, readers may have to ‘unpack’ the text (Halliday, 2004a). However, the interpretation can be ambiguous. For example, the nominalized expression, *an exacerbated inflammatory reaction* can be unpacked at least in two ways: *inflammation reacts (to something) worse* or *(a patient) reacts to inflammation worse*. A problem concerning nominalization is such ambiguity in interpretation^{iv}. Specialized knowledge in the field in question as well as linguistic knowledge seems to be required to clear up such ambiguity.

In addition, there are nominalized expressions whose metaphors are ‘dead’ and cannot be unpacked (Halliday, 2004a: 44; Halliday and Matthiessen, 1999: 261). For example, *infection* in Example 4 is a virtual entity created and consumed in the language of science. Thus, its metaphor is ‘dead’ and is interpreted as a ‘congruent’ form. Experts can determine whether or not the metaphor in the nominalization in question is ‘dead’ but students and English teachers may have to ask for help of specialists^v.

As illustrated above, complexity in nominal groups in scientific paper are characteristically related to nominalization. However, since this paper’s focus

is on reading articles in popular science magazines, I should leave aside further discussion of this question.

On the other hand, in the embeddings appeared in Example 1 and 2, a clause and a phrase function as part of element in lower rank (typically, nominal group) but they do this *as they are*: they do not create fusion^{vi}. “Class shift becomes metaphorical when the “shifted” term creates a **semantic junction** with the original” (Halliday and Matthiessen, 1999: 260).

Nominal groups in both popular science magazines and scientific papers are complex. However, they are complex in different ways: complexity of nominal groups in articles in popular science magazines is characteristically due to Qualifier, which is related to embedding; while that of scientific papers tend to be derived from elements preceding Thing, which may be related to nominalization and may require further analysis.

2.2 Grammatical Intricacy: The Nature of Clause Complexes

Grammatical intricacy is another aspect of complexity of a text. Articles in popular science magazines tend to use clause complexes. I counted 251 clauses in sample texts and found 193 clauses are combined into clause complexes.

There are various types of relation to form clause complexes: two types of taxis (hypotaxis and parataxis); and five types of logico-semantic relations (expansion with three subtypes and projection with two subtypes). When clauses are potentially independent and linked equally, the relation is called parataxis (expressed by the notations: 1 2 3); on the other hand, either clause is dependent and clauses are linked unequally, the relation is called hypotaxis (notations: $\alpha \beta \gamma$). Logico semantic relation can be grouped into two general types: expansion and projection. In expansion, the secondary clause expands the primary clause by elaborating it (notation: \Rightarrow), extending it (notation: $+$) or enhancing it (notation: \times). In projection, the secondary clause is projected

through the primary clause as a locution (notation: “) or an idea (notation: ‘).

Projection is related to two process types, mental and verbal^{vii}. In a mental process clause, an obligatory participant, Senser (the one that senses) and the other participant Phenomenon (the one that is sensed) participate in the process of emotion, cognition and perception. What is sensed can be another clause: a mental clause can project another clause as an idea. In a verbal process clause, an obligatory participant, Sayer (the one that send out a message) participates in the process of saying. The process of saying can be accompanied by other participants, Receiver (whom the saying is directed), Verbiage (what is said) and Target (what is targeted by the saying). A verbal clause can project another clause as a locution (Halliday, 2014).

Articles in popular science magazine is unique in that they tend to use more projections: out of 193 clauses combined by clause complexes, 86 clauses are linked by projection. For example, in both of the clause complexes in Example 1, clauses are linked by projection (see Figure 6):

Figure 6: Analyses of clause complexes in Example 1

He points out	that another second-generation vaccine that offers many of the same logistical selling points as CureVac’s, such as long-term refrigerator storage, has stood up to the variant challenge well.
α	“ β ”
Earlier this week, Novavax in Gaithersburg, Maryland, reported	that its protein-based vaccine was more than 90% effective at preventing COVID-19 in a large US trial, run at a time that the Alpha variant was prevalent.
α	“ β ”

In both clause complexes, the first clause projects the second clause as a locution.

In another example, one of the most intricate clause complexes in analyzed articles, clauses are linked by hypotactic ideas and a paratactic expansion (see Figure 7):

Figure 7: An Analysis of a Clause Complex in Example 1

Many had hoped	that it could help to expand the reach of mRNA-based vaccines in lower-income countries,	and European countries were expecting	to order hundreds of millions of doses.
1		+2	
α	' β	α	' β

The first clause projects the second clause as an idea to form a clause complex, and the third clause projects the fourth clause as an idea to form a clause complex. In addition, the two clause complexes are linked by paratactic expansion.

While articles in popular science magazines tend to use clause complexes, especially projection, scientific papers do not: as far as I observed sample scientific papers, 95 clauses out of 204 form clause complexes; and only four clauses project others. The following examples are four clause complexes with projection that I found in sample texts:

Example 5

We previously showed that circulating monocytes in critical COVID-19 present with complex immune dysregulation characterized by decreased efficiency of antigen presentation and inappropriate maintenance of the potential for excess cytokine production, which were restored upon exposure to tocilizumab.

Example 6

In conclusion, the SAVE-MORE trial showed that early start of treatment with anakinra guided by suPAR levels in patients hospitalized with moderate and severe COVID-19 significantly reduced the risk of worse clinical outcome at day 28.

(Kyriazopoulou, E. *et. al*, 2021)

Example 7

It has been suggested that production of IFN- α , a major antiviral cytokine, is decreased in these patients compared to those with moderate disease.

Example 8

However, a recent study argued that increased IFN- α production might contribute to the pathogenic inflammatory response.

(Saichi, M. *et al.*, 2021)

The analyses are shown in Figure 8 to 11:

Figure 8: An analysis of a clause complex in Example 5

We previously showed	that circulating monocytes in critical COVID-19 present with complex immune dysregulation characterized by decreased efficiency of antigen presentation and inappropriate maintenance of the potential for excess cytokine production, which were restored upon exposure to tocilizumab.
α	“ β ”

Figure 9: An analysis of a clause complex in Example 6

In conclusion, the SAVE-MORE trial showed	that early start of treatment with anakinra guided by suPAR levels in patients hospitalized with moderate and severe COVID-19 significantly reduced the risk of worse clinical outcome at day 28.
α	“ β ”

Figure 10: An analysis of a clause complex in Example 7

However, a recent study argued	that increased IFN- α production might contribute to the pathogenic inflammatory response.
α	“ β ”

Figure 11: An analysis of a clause complex in Example 8

However, a recent study argued	that increased IFN- α production might contribute to the pathogenic inflammatory response.
α	“ β ”

It is worth mentioning that unlike verbal process clauses in articles in popular science magazines, Sayers in Example 5, 7 and 8 (in bold) are not human

speakers but semiotic objects that are interpreted as conscious speakers.

From the perspective of grammatical intricacy, popular science magazines are more complex than scientific papers in that they tend to use more clause complexes, especially projection.

2.3 Other Lexicogrammatical Characteristics

As has already been pointed out in 2.1, nominalization is a most significant characteristic of the language of science and it can be a problem in reading. However, nominalization does not seem to be a serious obstacle to reading articles in popular science magazines.

As far as I explored, peculiar usage (Washitake, 2021), which are often seen in scientific papers was not found in sample articles in popular science magazines.

3. Conclusion

Now that characteristic grammatical features of articles in popular science magazines have been cleared, we can answer the question: can reading articles in popular science magazines help students understand scientific papers written in English? From the perspective of lexicogrammar, the answer is 'No'. Although articles in popular science magazines may share the same topics with scientific papers, the lexicogrammatical nature is different at least in two ways: 1) while nominal groups in articles in popular science magazines are complex typically due to Qualifier, those of scientific papers are complex characteristically by elements preceding Thing; 2) and more clause complexes, especially projection are characteristically used in popular science magazines.

Since Systemic Functional Linguistics provides various perspectives for more

comprehensive research, there is room for further investigation. However, more important in this paper is to show the significant lexicogrammatical differences between articles in popular science magazines and scientific papers.

If the teaching goal is to have students be familiar with a particular topic before reading a scientific paper, reading articles in popular science magazines might be a reasonable choice. However, if an English teacher wants their students to improve their academic reading ability, choosing articles in popular science magazines as reading materials does not seem to be effective. What s/he should focus on in choosing her/his teaching materials is their lexicogrammatical characteristics as well as topics.

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Notes

- i In the hierarchy in grammar, the rank of the clause is higher than that of the group; and the rank of the phrase is equal to that of the group. However, in Qualifier, both the clause and phrase function as constituent of the nominal group. Such down-ranking phenomenon is referred to as ‘rankshift’.
- ii Clauses can be kinked to one another to form the clause complex.
- iii This does not mean that rankshifted clauses and rankshifted phrases are not related to nominalization. For example, the nominal group, *Early recognition of patients at risk of progressing to severe disease* in Example 3 is nominalization and can be unpacked as: *(Doctors) recognize patients early whose disease could progress severely*.
- iv For problems reading scientific papers, see Washitake (2021).
- v For problems of determining kinds of nominalization, see Washitake (forthcoming).

- vi Potentially, prepositional phrases can be metaphorical. For example, *Early recognition of patients at risk of progressing to severe disease* in Example 3, the prepositional phrase, *of patients* is metaphorical: It is ‘congruently’ realized by a nominal group, *patients*.
- vii Clauses in English construe experiences through Process with obligatory and optional participants and optional circumstances. There are five process types in English: material, mental, relational, verbal, behavioural and existential. For more details, see e.g. Butt *et al.* (2012), Eggins (2004), Halliday (2014) and Thomson (2014).