On the Transitivity Analysis of Research Article Abstracts from *Science*

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***Abstract*—Based on Halliday's Systemic-Functional Grammar and transitivity theory, this study carries out an analysis in article abstracts of English for Science and Technology (EST), and randomly selects 30 abstracts as the original data from the latest periodical *Science* (Dec. 2022–Mar. 2023) with the instruments Qualitative Coder 1.1 and SPSS 22. Findings indicate that: 1) 30 abstracts only cover 5 transitivity processes; 2) constituent ratio differentiation of selected transitivity processes are statistically significant ($X^2 = 86.506$, $P < 0.05$) ; 3) the study analyzes high-frequency verbs of transitivity processes aiming at offering English non-native scholars some guidelines in the writing of research article abstracts.**

***Keywords*—abstract, high-frequency, transitivity**

I. Introduction

As National Standards Institute pointed out, "a well-prepared abstract enables its readers to identify the basic content of a document quickly and accurately, to determine its relevance of their interests, and thus to decide whether they need to read the document in its entirety". Ventola suggested that "the study of the comprehension of the abstracts written by non-native writers, for example, is seen as a very important area for future linguistic study" [1]. Along with the increase of international academic exchange and development of the Internet, English abstract is becoming more and more important in search of academic papers. To some extent, whether the articles can be accepted by international retrieval mechanism depends on the quality of the English abstract, which directly influences the communication and exchange of scientific research achievements. This study aims at finding the features of transitivity in abstracts and offering English non-native researchers appropriate transitivity verbs and phrases in scientific writing, which could offer references when submit to top journals.

II. Literature Review

A. Theoretical Foundations

M. A. K. Halliday gave the description about the theory of Systemic-Functional Grammar (SFG) in a comparative way. Compared with formal linguistics, Systemic-Functional Linguistics (SFL) regards language as a tool for performing different functions in social interactions.

It is primarily paradigmatic, interpreting a language as a network of relations, with structures coming in as the realization of these relationships [2].

Transitivity is also termed as "transitivity system". The term "transitivity" used in SFG is a semantic category, which is a reflection of human beings' recognition at the lexicogrammar level both in written and spoken form with the choice of process type and participant and circumstantial element. Halliday classifies processes into six types and gives examples of related process verbs [2].

SFG sheds new lights on the term "transitivity". Scholars in this field deem that traditional view on transitivity neglects the semantic differences between verbs, and also overlooks the differences between various kinds of clauses. It is Halliday who first brought forward that transitivity should be regarded as a property of clauses rather than verbs. Thompson [3] introduced that transitivity is used in a broad sense in SFG compared with the traditional grammar. It indicates a system for describing the whole clause, rather than the verb and its object only.

B. Previous studies on Transitivity

In the early 1970s, M. A. K Halliday conducted a transitivity analysis on William Golding's novel The Inheritor, since then, transitivity analysis as an approach for discourse analysis came within our sight. It is widely applied to various kinds of genres, literature works, news, and speech.

1) Literature features like characters, the implied philosophy, cultural orientations, and the like are revealed via researchers' efforts in applying transitivity in literature works on the lexical and syntactic levels. Chen and Qu [4] focused on novels; Gao and Dai [5], Cheng and Zhao [6] contrasted English and Chinese poems; besides, literature works retrieved from college English textbooks begin to win researchers' favor in recent years, like Xia [7], and Kong [8].

2) News reports are of absolutely prevailing proportion in the genres that transitivity analysis is applied. One group pertains to current events. Through the analysis of the distribution and occurrence of transitivity in news reports, the connotation of language, like violent sport language [9], disastrous accident language (Sun and Guo [10]), ecological related language [11], is decoded. The other group centers on ideology construction related news aims at construing the implied intention to subjectively build a certain nation's image [12, 13], and transitivity analysis is effective in uncovering these hidden intentions.

3) Researches [14–16] casting interests to speeches tend to reveal the government's position or leader's image.

C. Review of Article Abstract

An abstract is defined as a brief summary of the source article and is of great importance to the successful circulation of the article. Brusaw [17] held that "an abstract is a condensed version of a long piece of writing enabling

the prospective reader to decide whether it will be worthwhile to read the work in full"; To further classify abstract, American National Standards Institute (ANSI) assorts abstract into three types: informative abstract, indicative abstract and informative-indicative abstract.

Among the three types of abstracts, the indicative and informative abstracts are more condensed than the third one and are the interests of the present study in that they are mainly written for articles to be published. So based on this, the English for Science and Technology (EST) research paper abstracts can be regarded as a point cut in this study. From what have been analyzed, few scholars have studied on EST research article abstracts in terms of transitivity. This study is not only fresh to some extent, but also could be served as evidence for experiential practice in hopes of helping English non-native scholars in writing high-standard abstracts.

III. Research Methodology

A. Research Subjects

In this study, the sample is derived from research articles abstracts from *Science*，which is the world's leading journal of original scientific research, global news, and commentary, and it belongs to the official journal of American Association for the Advancement of Science (AAAS). This study will select 30 abstracts randomly from the latest periodical (Dec. 2022–Mar. 2023) as the original data selection.

B. Research Questions

This study intends to answer the questions like "which types of processes occur in abstracts", "whether the constituent ratio of processes has significant differences" and "how does the transitivity analysis based on highly-frequency verbs carry out".

C. Rresearch Instruments

In order to ensure validity and reliability in qualitative analysis, the study takes the Qualitative Coder 1.1 software and SPSS 22 software as research instruments.

Qualitative Coder 1.1 is a qualitative analysis software application which assists in the analysis of textual data such as written texts and transcripts. In this study, it offers qualitative analysis based on texts coding.

For quantitative analysis, the study takes SPSS 22 as research instrument to do the Chi-square test for testing whether the significant difference exist between the selected transitivity processes.

D. Research Procedures

Firstly, the study will use Qualitative Coder 1.1 software to get the primary data. Then, SPSS 22 analyzes the data and gives the inferential statistics. Finally, based on the statistics, the study will do both qualitative and quantitative analyses. All the steps are equally important to answer the questions.

Before coding, it is necessary to prepare a master code list (a.k.a. coding scheme in qualitative analysis), and the code list can be modified in codelist.ini at any stage of the coding. For the sake of convenience of analysis, each item is abbreviated as Table 1:

After highlighting text segment, the author chooses the corresponding code from the coding panel and the highlighted segments will be marked in coding format. Once the coding is done, a matrix of coding statistics can be exported for follow-up analyses. The following is the sample of analysis in one abstract. Figs. 1 and 2 are related screenshots of Qualitative Coder 1.1.

Table 1. Abbreviation of transitivity system

Processes	Participants
Material Process (Ma.P)	Actor (A) Goal (G) Beneficiary (B) Range (R)
Mental Process (Me.P)	Senser (S) Phenomenon (Ph)
Relational Process (Re.P)	Carrier (Ca) Attribute (At) Token (Tk) Value (Va)
Verbal Process (Ve.P)	Sayer (Sy) Receiver (Rv) Verbiage (Vb)
Behavioral Process (Be.P)	Behavior (Bh)
Existential Process (Ex.P)	Existent (X)
Circumstantial Elements	Extent (Cex) Location (Clc) Manner (Cmn) Cause (Cca) Angle (Can) Contingency (Cco) Role (Cro) Matter (Cmt) Accompaniment (Cac)

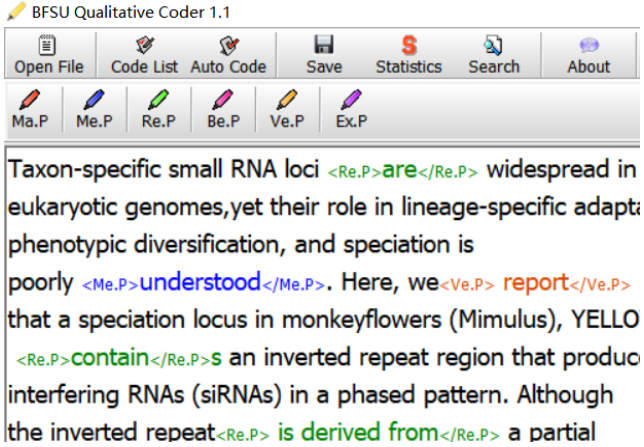

Fig. 1. Screenshot of qualitative Coder 1.1 in coding part.

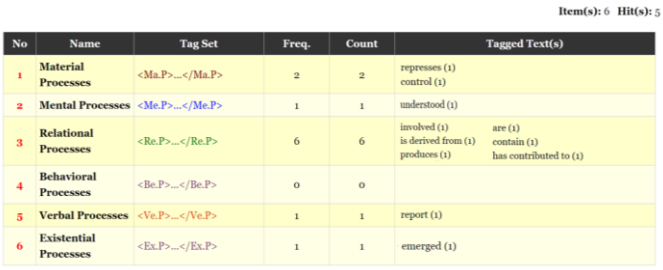

Fig. 2. Screenshot of qualitative Coder 1.1 in statistics part.

Taxon-specific small RNA loci **are (Re.P)** widespread in eukaryotic genomes, yet their role in lineage-specific adaptation, phenotypic diversification, and speciation is poorly **understood (Me.P)**. Here, we **report (Ve.P)** that a speciation locus in monkeyflowers (Mimulus), YELLOW UPPER (YUP), **contains (Re.P)** an inverted repeat region that **produces (Re.P)** small interfering RNAs (siRNAs) in a phased pattern. Although the inverted repeat **is derived from (Re.P)** a partial duplication of a protein-coding gene that is not **involved (Re.P)** in flower pigmentation, one of the siRNAs targets and **represses (Ma.P)** a master regulator of floral carotenoid pigmentation. YUP **emerged (Ex.P)** with two protein-coding genes that **control (Ma.P)** other aspects of flower coloration as a "superlocus" in a subclade

of Mimulus and **has contributed to (Re.P)** subsequent phenotypic diversification and pollinator-mediated speciation in the descendant species [18].

IV. Transitivity Analysis of Abstract

A. Analysis based on descriptive and inferential statistics

Table 2 shows that Re.P and Ma.P are two main processes in Science with the constituenth ratio of 84% (60.3% in Re.P and 23.7% in Ma.P) . Meanwhile, Behavioral Process doesn't occur in these 30 abstracts. Besides, Me.P, Ve.P and Ex.P own a very small proportion respectively with 7.8%, 3.9%, and 4.3% .

Table 3 shows the SPSS statistics, Ma.P and Re.P constituent ratio differentiation are statistically significant ($X^2 = 86.506$, $P < 0.05$).

Table 2. Descriptive statistics of six processes

Transitivity Processes						
	Ma.P	Me.P	Re.P	Ve.P	Be.P	Ex.P
Count	61	20	155	10	0	11
Freqency	49	14	86	4	0	9
Constituent ratio (%)	23.7	7.8	60.3	3.9	0	4.3

TABLE III: Inferential statistics of SPSS

	Observed N	Expected N	Residual
Ma.P	61	85.7	−24.7
Re.P	155	85.7	69.3
The rest processes	41	85.7	−44.7
Total	257		
Test Statistics			
Chi-Square		86.506[a]	
df		2	
Asymp. Sig.		0.000	
Exact Sig.		0.000	

Note: 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 85.7.

Firstly, among the six processes, Be.P never appeared. The reason is that the participant of Behaviour (Bh) must be human being, and the process must be physiological activities, such as cough and dream, etc. It is obvious that the contents of these 30 abstracts have nothing related to physiological activities. As to Ve.P, the participant of Receiver (Rv) never appeared. Rv is the one to whom the verbiage is directed, and the absence here can reflect the feature of EST writing that scientists just focus on the truth or fact that need to be explained or illustrated, and by this way they can also draw attention to the scientific results or major findings. Actually, readers or those who concentrate on the expression are the potential participants of Rv to some extent. Mental processes did not appear frequently either, for researchers do their best to keep the expression be more objective and impersonal when narrate the facts and natural phenomena, which is also the writing feature of EST research articles.

Secondly, all these abstracts adopt identifying style more than attributive style in Re.P, which shows that when researchers want to express the relationship between entities in EST research papers, they would prefer to illustrate relationship between identifier and the identified rather than relationship of some attributions of their carriers, which is also the manifestation of objectivity.

Finally, as to the circumstantial elements, the high frequency of Local element can reflect that the researchers focus on the objectivity of the process and try to make the articles be more convincing through offering the information about when and where it happened. Besides, the element of Manner consist four subcategories which are Means, Quality, Comparison and Degree. So the high frequency of this element shows the emphasis of prerequisites and existential state of occurrences, which is just the reflection of scientific and rigorous academic attitudes.

B. Analysis of High-Frequency Verbs

In the abstracts from *Science*, copular "be" (26 hits), "show" (9 hits), "identify" (7 hits), report (7 hits) and "demonstrate" (5 hits) are main verbs used frequently. In order to analyze the usage of high frequency verbs based on transitivity for offering Chinese scientific and technical worker some verb-using guidelines in the writing of EST abstracts, the study cites the following clauses as examples.

Clause 1: *Emotional contagion is* the *most ancestral form of empathy [19].*

Clause 2: *Atomic-scale ferroelectrics are of great interest for high-density electronics [20].*

In the clauses "is" and "are" can respectively reflect the relationship between two participants. In Clause 2, the participant "great interest" is an Attribute of the other participant "Atomic-scale ferroelectrics", which belongs to attributive classification of relational process. However Clause 1 belongs to identifying classification of Re.P, for "emotional contagion" can make sure the identification of "empathy".

Clause 3: *We show that oxytocin is both necessary and sufficient for observer zebrafish to imitate the distressed behavior of conspecific demonstrators [19]*

Clause 4: *Clock transcripts showed conserved timing relationships and tight synchrony across the body [21].*

These three clauses belong to Re.P because the verb "show" can reflect "a process of identifying". The subject "we" can be regarded as Identifier who can make "what happened" be Identified, the relationship between "we" and "what happened" belongs to identifying classification of relational process.

Clause 5: *Using mass spectrometry, we identified a panel of cysteine residues differentially modified by carboxymethylation [22].*

Clause 6: *We demonstrate gate-tunable negative refraction at mid-infrared frequencies using hybrid topological polaritons in van der Waals heterostructures [23].*

Clause 7: *These discoveries demonstrate how the genetic basis of climate change adaptation can inform conservation [24].*

As to the usage of the verb "identify", the relational process of identifying can reflect that researchers have found or discovered something in scientific field, and from this point of view, the semantic function of "identify" is the same with verb "find" in active voice. For those participants are impersonal subject which stands for the fact or scientific results. In Clauses 6 and 7, the participants "we", who can

be regarded as "people who retails", interpret the scientific judgment to readers through the verb "demonstrate", which reflects the existing phenomena.

Clause 8: *We report a structural editing protocol for layered carbides (MAX phases) and their 2D derivatives (MXenes) [22].*

Clause 9: *Here, we report on the structures of cauliflower Pol V in the free and elongation conformations [25].*

Another high-frequency verb is "report" in Ve.P. Both two participants of Sayer in clauses are "we", and the participants of Verbiage in Clause 7 is "the structures". In the clauses, researchers give readers the scientific and technological information they have got with the way of establishing professional structures, and the word "report" can reflect that they have accumulated much data or experimental results, and they are showing their whole process of researching through taking advantage of verbal process, which can spread the knowledge and make the popularization of science and technology become true.

V. Conclusion

A. Major Findings

1) 30 abstracts from *Science* only cover 5 transitivity processes with Ma.P, Me.P, Re.P, Ve.P, and Ex.P; 2) constituent ratio differentiation of Re.P and Ma.P are statistically significant ($X^2 = 86.506$, $P<0.05$), which shows that in *Science*, the writing of research article abstracts highly takes Re.P as transitivity way of expounding; 3) the study analyzes the usage of high-frequency vocabulary in transitivity processes like" copular be", "show", "identify", "report" and "demonstrate", aiming at offering English non-native scholars some guidelines in the writing of research article abstracts.

B. Limitations

First, EST research article abstracts involve many professional words and phrases related to physics, chemistry, or biology etc., the ability of authors, people are not majored in science, is deeply limited in understanding the discourses. Thus, the analysis of this study may not be as rigorous as the authors expect.

Another limitation is that whether some other factors, such as the disciplines diversity, will affect the use of transitivity processes are not considered in this study.

Besides, in order to select the latest periodicals, the study takes 30 abstracts, which only achieve the minimum amount of data for linguistic research. Further study could increase data volume.

C. Recommendations For Future Research

Regarding to the transitivity, other parts of EST research articles, such as introduction, methodology, and conclusions, are also worth of researching. Besides, the future study could pay attention to EST research articles in terms of different subjects, like biology, chemistry, and physics etc. From that, the relationship between transitivity and disciplinary differences could lead to more research results.

For students of science and engineering in China, EST writing is always the bottleneck of their academic research. The weakness often exists in the organization of the content and the expression of the scientific research results. Along with the increase of international academic exchange, Chinese scholars shoulder the mission of communicating the scientific research and achievements with their counterparts abroad. As is known to all, academic research articles need to meet the higher requirement of preciseness and objectivity.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Rong Lin conducted the research and analyzed the data; Mi Zhao and Jing Guo offered the study with the help of giving insightful guidance; Wenwen Liu, Qiong Jin and Zijie Ma collected targeted research articles. All authors had approved the final version.

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