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Inform and Entertain: An Oxymoron in Serious Science Communication?

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Abstract

The current study aimed to explore the nature of discursive strategies academics would use to share their specialist knowledge to both specialists and non-specialists. To this end, a corpus of 40 academic research articles and 40 popular science articles were randomly selected from the archive of four English international peer-reviewed journals and four English popular magazines and newspapers in the field of Nutrition. Appraisal Theory (Martin & White, 2005), a discourse framework to examine evaluative and/or persuasive language, was used to analyze the data. The results revealed significant areas of similarity and difference in terms of certain discursive elements leading to discernible degrees of persuasion. The findings imply that in order to develop a scientifically literate society, scientists should appeal to diverse discourse resources to provide the public with their findings in an informative and entertaining way. The results of the study carry some pedagogical implications for EAP courses held in EFL settings since being able to both comprehend and produce scientific texts of different professional levels at international scale seems to be a requirement for the future scientists.

Keywords: Academic research articles, Popular science articles, Science popularization Appraisal Theory, Evaluative writing, Persuasion.

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1. Introduction

1.1. Background

Nowadays, considering people's high degree of exposure to a huge bulk of knowledge about science and technology, the importance of the scientific literacy can hardly be overrated (Miller, 1998). Indeed, numerous technological and scientific advances have highlighted the role of science in human's life. Scientists try to disseminate their scientific findings primarily through academic papers (Russell, 2010, p. 54) which are understood by the scientists well-trained to follow and endorsee the professional products. Simultaneously, the public has also the right to be informed of the outcomes of scientific, technical, and social development (Ren & Zhai, 2010). This necessitates translation and transformation of scientific findings into meaningful phenomena to the intended audience (Russell, 2010, p. 88).

Both the public's interest and the need for recent scientific findings and the scientists' willingness to express their feelings about their scientific ideas and discoveries (Ben-Ari, 1999) and reach a wider group of audience (Ren&Zhai, 2010) have evoked popularization of science within the past decades. Science popularization results in the public's trust in scientists as "sources of information" (Turney, 1996, p. 1087) and present science as "a social construct" (Hyland, 2010, p. 118) favored and endorsed by different groups of audience with different tastes and interests. These all have recently prompted science communication on a global scale (Bucchi, 2013) and pushed the scientists to answer the public's scientific needs.

Professional and popular texts address various groups of audience with different worlds in terms of the professional understanding (Bowler, 2009). Popular science articles are supposed to present a user-friendly account of the scientific and technical discoveries and research articles are expected to target the experts in the scientific fields. These two sets of articles fulfill different communicative purposes through taking advantage of particular sets of linguistic resources (Martin, 1992). To accommodate the needs of these groups successfully, scientists are inevitably involved in making choices considering both the content and mode of information (Bowler, 2009) to present both the professional and unprofessional audience with new technical and professional concepts and findings. In fact, since knowledge circulates in various settings (Calsamiglia &

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Ferrero, 2003) and the writers in both conditions are inevitably involved in both informing and persuading the readers to acknowledge their scientific claims and evidence (Harris, 1991, p. 289), it seems necessary to scrutinize one of the resources which might contribute to serving these purposes, that is evaluative tools, which are explored and unraveled through Appraisal Theory (White, 2014). Appraisal theory aims to unfold the interpersonal meanings (Lee, 2006) through making use of three main categories including Attitude, Engagement, and Graduation.

Bearing this in mind, the current study strove to see how the interaction between the author and the reader was linguistically managed through the application of evaluative resources of Appraisal theory in English academic research articles and popular science articles. Nevertheless, particular relevant sets of scientific discoveries to the true and practical needs of the public are worth being popularized (Lievrouw, 1990) to enhance the public's scientific literacy (Ren & Zhai, 2010). In this regard, nutrition as a sub-domain of medicine was considered as it seems to gear to the needs and interests of a wide range of audience, both in professional and popular communities (Giannoni, 2008). Hence, the study tried to compare the frequency of Appraisal resources across English academic research articles and popular science articles to see if scientists address scholarly and the non-scholarly audience differently.

1.2. Science Popularization

Science and technology have influenced human's lives (Sapp, 1995) and have nurtured science communication and popularization (Ren & Zhai, 2014). Technological and scientific advances have led to enormous changes in the way the relationship between science, technology, and society is perceived. Furthermore, new communication tools such as the Internet have facilitated the science communication and popularization (Ren & Zhai, 2010). Within the twenty-first century, broadcasts, newspapers, and journals play a determining role in popularizing science and promoting the public's scientific literacy and broadening the scope of communication.

Science communication and popularization as "a social phenomenon" (Ren & Zhai, 2014, p. 2) strives to provide the public with the knowledge of communities which are the producers and

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owners of knowledge (Giannoni, 2008). This process sets the scene for the circulation of scientific findings in everyday discourse. In fact, the public is the point of departure for the development and growth of science popularization (Ren & Zhai, 2014). In addition, scientists are eager to share their own work with the public (Ben-Ari, 1999). They attempt to draw the public's attention through elaborating on their research findings in public terms. The public's lack of scientific information urges the scientific community to take advantage of the existing media and channels to focus on the public's understanding and engagement (Russell, 2010). However, science communication is a complicated process which requires "a shift between two types of discourse" (Giannoni, 2008, p. 213) and entails the discursive reconstruction of the scientific information for non-academic audience.

Research in the field of popularization of science has been given prominence due to its key role in enhancing the public's literacy. In this regard, Nwogu (1991) explored the discourse structure of the journalistic version of research articles in light of an expanded version of Swales' (1981) approach to the analysis of genres and extracted a schematic structure determined by pragmatic conditions including audience, purpose, and medium of discourse. The analysis of the texts in popular science magazine (The New Scientist), a general interest magazine (Newsweek), and a leading British newspaper (The Times) showed that journalistic version of research articles mostly included the following types of information: a brief statement of the problem, the main research problem followed by the limitations of previous efforts to solve it, introducing the researchers, positive results, methods of data collection and experiments, discussions and explanations of the scientific findings, conclusion and implications.

Later, Miller (1998) compared the use of visual elements in academic and popular texts in terms of the systematic linguistic concepts of interpersonal, ideational, and textual metafunctions and demonstrated that visual elements act as informative and persuasive elements while their application in popular texts is often luxurious and sometimes explanatory. In another study, the use of hedging devices was examined in a corpus of 15 academic research articles and 15 popular science articles in the domain of medicine (Varttala, 1999). The findings indicated that hedging devices were commonly used by science popularizers in order to depict the scientific information more clearly and adapt the scientific findings to the non-specialist readers' background.

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Furthermore, Parkinson and Adendroff (2004) used popular science texts as reading materials in a course of English for specific purposes, scientific writing and concluded that popular science texts are not appropriate models for scientific writing as extreme focus on them may lead to the students' focus on the use of active voice and non-scholarly citation of other scientists' works in the scientific genre. They argued that they can act as valuable sources for reading science classes but endanger the students' academic writing style.

In another study, Giannoni (2008) attempted to explore the generic features of popularization in 40 editorials in medicine and applied linguistics and extracted such popularizing features as personalization, contingence, and humor, and appeal to the reader through using second-person pronoun or an imperative verb in order to increase the readers' involvement. Similarly, Hyland (2010) compared the research papers and popular science articles to investigate how the authors share their expertise with the readers of different degrees of expertise and found that proximity in popular science articles targeted non-specialist audience in order to make the research findings accessible for them. In a recent study, Ngan and Lan (2020) analyzed the evaluative resources in two news story genre and the same topic and revealed the prevalence of negativity and quantification to inject the interpersonal meanings in terms of the attitude in this popular genre. As the review of the literature suggests, previous studies have focused on exploring the generic structure, textual features, application of visual elements, and pedagogical application of popular science texts. No study has yet aimed to reveal the linguistic representation of the evaluative resources in this genre in general, and vis-à-vis the academic research articles in particular.

1.3. Appraisal Framework: Theory and Practice

Appraisal theory is fundamentally related to the concept of evaluation which is "a broad cover term for the expression of the writer's attitude or stance towards, viewpoint on, or feeling about entities or propositions that he or she is talking about" (Hunston & Thompson, 2000, p.5). Appraisal theory includes three main categories: Attitude, Engagement, and Graduation. Martin and White (2005) define these categories as follows:

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> ATTITUDE is concerned with our feelings, including emotional reactions, judgments of behavior and evaluation of things. ENGAGEMENT deals with sourcing attitudes and the play of voice around opinions in discourse. GRADUATION attends to grading phenomena whereby feelings are amplified and categories blurred (p.35).

Attitude provides "a system of meanings" to express feelings and entails three main subcategories: affect, judgment, and appreciation (Martin & White, 2005, p.35). Affect is concerned with "resources for constructing emotional reactions" (Martin & White, 2005, p.35) and "emotional response" (White, 1998, p.75). Judgment includes "attitudes towards behavior, which we admire or criticize, praise or condemn" (Martin & White, 2005, p.42) and "evaluation of human behaviors" (White, 1998, p.75). Appreciation entails "evaluation of semiotic and natural phenomena" (Martin & White, 2005, p.43) and "evaluation of entities" (White, 1998, p.75).

The second main category of Appraisal Theory is Engagement which is represented in "negotiating heteroglossic diversity (*perhaps, it seems, he says, I declare, however, obviously, etc.*)" (White, 1998, p.75) and provides "resources for negotiating various convergent, alternative, and counter socio-semiotic realities or positions activated and referenced by every utterance" (p. 78). *Monogloss*utterances provide no space for other viewpoints while *heteroglos*sones entail alternative voices (Martin & White, 2005).

The third main category is Graduation which covers those resources "for scaling interpersonal force for the sharpening/blurring the focus of valeur relationships (*very, really, sort'v, somewhat*)" (White, 1998, p.75) and focuses on lexicogrammatical resources for strengthening or softening one's judgment and appreciation. It is divided into two subcategories. Force entails "grading according to intensity or amount" and focus includes "grading according to prototypicality and the preciseness by which category boundaries are drawn" (Martin & White, 2005, p.137).

Since its introduction, Appraisal theory has been used as the theoretical foundation of enormous bulk of research. Hyland and Tse (2005) attempted to explore the frequency, form, and function of the use of evaluative "*that* in 465 abstracts and concluded that it allows for presenting the evaluation of the materials and managing the discourse. Tutin (2010) analyzed various text types including research articles, theses, and course books in the fields of humanities and social sciences and found out the writers' lack of willingness to use subjective evaluation in scientific

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writing. Furthermore, Babaii (2011) scrutinized a corpus of book reviews published in leading physics journals in light of Appraisal theory and demonstrated the use of personal comments, mockery, sarcasm, and unhedged and blunt criticism and revealed the subjectivity injected into this academic genre. Comparing the research articles in the international and Iranian local journals, Naghizadeh and Afzali (2018) investigated the representation of engagement in the literature review section. They found out that the Iranian authors included more monoglossic resources while their international counterparts took more advantage of heteroglossic resources. Moreover, analyzing twenty introduction sections of research articles written by Indonesian and Chinese authors, Fitriati and Solihah (2019) demonstrated high frequency of appreciation, hetergogloss, and force in both corpora. However, Chinese authors tended to include a larger number of appraisal resources overall. Despite the wide range of studies on the use of appraisal resources across various text types, reviewing the existing literature indicates the paucity of research on the interactions in different generic contexts (Hyland, 2010) in terms of the evaluative resources of appraisal. Comparing academic and popular science articles would demonstrate the way scientists transfer their findings into different discourse types gearing to their intended groups of audience.

1.4. The Current Study

Notwithstanding the existing literature on Appraisal resources and science popularization, an obvious gap is felt considering the frequency of evaluative resources of Appraisal framework in academic research articles and popular science articles to see how knowledge circulates in various settings (Calsamiglia & Ferrero, 2003). Previously conducted studies have mostly focused on the generic features or pedagogical roots of popularized discourse. On the other hand, the existing literature seems to have failed to cover the use of appraisal resources in a comparative framework. According to Hyland (2010), patterns of interaction differ across generic contexts. Academic research articles are made accessible to enable the non-specialists to "recover the interpretive voice of the scientist" (p. 126). Accordingly, the linguistic representation of evaluation in these two genres reveals the interpersonal meanings implied in the author-reader interaction. Bearing this in mind, the current study tried to address the following questions:

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- Is there any significant difference between English academic research articles and English popular science articles published in peer reviewed journals in the field of Nutrition in terms of Appraisal resources?

The above major research question was divided into three minor research questions:

1. Is there any significant difference between English academic research articles and English popular science articles published in peer reviewed journals in the field of Nutrition in terms of Attitude resources of Appraisal Theory?
2. Is there any significant difference between English academic research articles and English popular science articles published in peer reviewed journals in the field of Nutrition in terms of Engagement resources of Appraisal Theory?
3. Is there any significant difference between English academic research articles and English popular science articles published in peer reviewed journals in the field of Nutrition in terms of Graduation resources of Appraisal Theory?

2. Method

2.1. Corpus

The corpus of the study consisted of 80 English articles including 40 academic research articles and 40 popular science articles comprising a total of 104,144words (88561 words in English academic research articles and15583 words in English popular science articles) (See Appendix for a list of both English academic research articles and popular science articles).

First, a comprehensive list of professional journals in the field of nutrition was collected from the following databases: www.journals.cambridge.org, www.online.sagepub.com, www.sceincedirect.com, and www.en.wikipedia.org/wiki/List_of_sceintific_journals≠Nutrition. Then, four associate professors (three Iranian and one American one) with research experience of more than 10 years and currently active in the field of Nutrition and five PhD students with research experience of more than three years were asked to provide expert judgment on the list of journals along with their impact factors. They were asked to add any other journal which was of high impact factor in the field if it was not included in the prepared list. They were also asked to write the list of both English popular sources in which experts write articles for non-expert readers.

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The common professional and popular sources were selected and included in a new list. The new list was given to 2 associate professors and 5 PhD students of nutrition to be reviewed for the last time. They were asked to rank the journals and magazines and newspapers included in the list. Four English professional journals were chosen for the purpose of sampling academic sources. Moreover, three English popular science sources were chosen to be included in the sample of popular science sources. It is worth noting that the academic journals with the highest ranking were selected taking into account both their ranking by experts in the prepared list and their impact factor values.

The ultimate selected English professional journals were *Public Health Nutrition, The Journal of Nutrition, American Journal of Clinical Nutrition,* and *European Journal of Clinical Nutrition* and the final selected English popular science sources were *WebMD, New York Times,* and *Science Daily*.

Accordingly, trying to take care of the time factor (Miller, 1998), 80 articles published from 2010 till 2015 were randomly selected from the archive of academic and popular science sources. Academic research articles in medical fields of study mostly have more than one author due to complicated experimental procedures. Hence, the academic research articles were not single-authored. As such, it seemed impossible to ensure that the authors were native speakers of English. However, since the journal from which the articles were selected, were ranked internationally in the field of nutrition, they surely undergo a very precise publication process and it seems necessary for the authors to be acquainted with English academic conventions (Mur-Duenas, 2011). Moreover, the members of editorial and advisory board were mostly both native speakers and professional experts in the field. These all seem to guarantee the precision of language and supervision over the quality of the papers. Despite the point that it seemed impossible to find single-authored academic research articles in the field of Nutrition, only those single-authored popular science articles were selected so that one article was included from each author in order to control for the possible influence of a single author's style on the results.

Besides, although the whole text of popular science articles, representing the findings and relevant explanations, was scrutinized (Fahnestock, 1986; Hyland, 2010), only the "Results" and "Discussion" sections of the academic research articles were considered. As Fahnestock (1986)

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maintained, "Results" and "Discussion" sections of academic research articles are "the best possible representation for the physical evidence the researcher generated" (p. 333). These two sections establish the validity of the findings and report the outcomes of a scientific procedure and the possible reasons justifying them.

2.2. Procedure and data analysis

All academic research articles and popular science articles were coded by the two researchers and the third coder and inter-coder reliability was estimated (r= 0.93). The third coder were an MA graduate of applied linguistics who had done her theses on Appraisal Theory. Then, the frequencies were determined for all categories (Attitude, Engagement, and Graduation) and subcategories (*Affect, Appreciation, Judgment; Monogloss, Heterogloss; Force, Focus*) of Appraisal resources.

In order to answer the research questions, the frequency and percentage values were determined. Then, the raw frequencies were normalized to 1000 words in order to make the academic research articles and popular science articles of various lengths comparable (Biber, Conrad, &Reppen, 1998). For normalizing, each raw frequency is divided by the number of words in that corpus and multiplied by the basis chosen for norming (in this case 1000) (NurAktas& Cortes, 2008). Several statistical non-parametric tests of Chi-square were conducted to see if there were any significant differences between English academic research articles and popular science articles in terms of Appraisal resources.

3. Results

The study addressed the frequency of Appraisal resources in English academic and popular science articles which concerned coding Attitude (*affect*, *appreciation*, *judgment*), Engagement (*monogloss* and *heterogloss*), and Graduation (*force* and *focus*) resources. Table 1 displays the frequency counts that indicate how Appraisal resources were distributed in English academic and popular science articles.

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Table 1. *Frequency of Appraisal resources in English academic and popular science articles*

Appraisal Resources	Total Frequency		Normalized Frequency	
	Academic	**Popular**	**Academic**	**Popular**
Attitude	2956	936	333.78	600.65
Affect	8	27	0.90	17.32
appreciation	2947	885	332.76	567.92
judgment	1	24	0.11	15.40
Engagement	462	236	52.16	151.44
Monogloss	0	74	0	47.48
Heterogloss	462	162	52.16	103.95
Graduation	1326	346	149.72	222.03
Force	1322	344	149.72	220.75
Focus	4	2	0.45	1.28
Total	4744	1518	535.67	974.13

The results revealed that the authors of both groups of articles had higher preference to employ Attitude resources and embedded their feelings in the texts. Out of 4744 identified Appraisal resources in academic research articles, 2956 (%62.30) were Attitude resources in comparison with 462 (%9.75) Engagement resources and 1326 (%27.95) Graduation resources. Likewise, Out of 1518 identified Appraisal resources in popular science articles, 936 (%61.65) were Attitude resources in comparison with 236 (%15.54) Engagement and 346 (%22.80) Graduation resources.

Among Attitude markers, the authors of English academic and popular science articles made the most use of *appreciation* resources (2947 (%99.69 and 855 (%94.55), respectively).

Academic Research Article Examples

1) *The nutrients of* ***great****est concern at 8 wk for the Atkins group included …*

(American Journal of Clinical Nutrition, 2010)

2) *…a diet* ***rich in****leucine and isoleucine compared with those …*

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(The Journal of Nutrition, 2014)

Popular Science Articles Examples

3) *…….to give you* ***super-human*** *nutrition, it seems that …….*
(Better Nutrition, 2013)

4) *……that breakfast is the most* ***important*** *meal of the day.*

(New York Times, 2014)

5) *Each kind of digestive disorder creates a* ***unique*** *set of dietary needs.*

(WebMD, 2014)

In all these examples, the authors used resources to build the values of things and provide an evaluation of the natural phenomena and entities. The *appreciation* resources were employed to reinforce the values of things and express the authors' positive or negative feelings towards products (Example 2, 4), processes (Example 3), and entities (Example 1, 5) (White, 1998).

Following *appreciation* resources, while few cases of *affect* resources were included in English academic research articles (8 (%0.27)), the authors of English popular science articles included more cases of *affect* resources (27 (2.90%)).

Academic Research Article Examples

6) *Mothers who are* ***worried*** *about the quality of their child's diet might …*

(European Journal of Clinical Nutrition, 2010)

7) *… that could help parents* feel ***good*** *about the way they feed their families.*

(Public Health Nutrition, 2011)

Popular Science Articles Examples

8) *……it seems that you're likely to be* ***disappointed****.*

(Better Nutrition, 2013)

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9) *……I was **pleased** with, including some delicious, moist ……*

(New York Times, 2013)

In these examples, the *affect* resources were realized in the form of "mental processes of reaction" and "attributive relationals of Affect" to reflect how the authors assigned positive and negative feelings to individuals (White, 1998, p. 75). The authors made use of such adjectives as *worried, disappointed, and pleased* and *good* to indicate individuals' affective reactions to different issues.

The least frequently used category of Attitude resources in English academic and popular science articles was *judgment* (1 (%0.04) and 24 (2.55%), respectively).

Academic Research Articles Example

10) *This seems to be in accordance with **consumers' perception that ready meals and fast food are not seen as appropriate for dinner meals**.*

(Public Health Nutrition, 2011)

In this example, the author confirmed the consumers' perception and expressed a positive evaluation by referring to its accordance with the results of the given study.

Popular Science Articles Examples

11) ***Scientists, like mothers**, have long suspected that midnight snacking is inadvisable.*

(New York Times, 2015)

12) *If you often eat for emotional reasons instead of because you're physically hungry, **that can be a problem**.*

(WebMD, 2014)

In Example 11, the author made an analogy between scientists and mothers and implicitly referred to scientists' concerns for the health of children as the mothers. In Example 12, the author somehow blamed what some people do, i.e. eating due to some emotional reasons rather than hunger.

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Considering the Graduation category, the authors of English academic and popular science articles included more *force* resources (1322 (%99.70) and 344 (%99.42, respectively) than *focus* resources (4 (%0.30) and 2 (%0.58), respectively) in their communication of scientific facts about nutrition.

Academic Research Articles Example

13) *…ranging from 42% in* ***the least*** *disadvantaged areas to 43% in* ***the most*** *disadvantaged areas.*

(Public Health Nutrition, 2012)

14) *…that arginine and lysine were not* ***very*** *effective in activating the CaSR …*

(The Journal of Nutrition, 2014)

15) *…this finding was* ***particularly*** *noteworthy because it …*

(American Journal of Clinical Nutrition, 2013)

Popular Science Articles Examples

16) *The Stanford study noted* ***significantly*** *low****er*** *levels of such bugs in organically raised stocks.*

(Better Nutrition, 2013)

17) *The whole fruit, though delicious, is* ***less*** *familiar to most people than juice and supplements.*

(Better Nutrition, 2010)

18) *"The nutrients in fruits and vegetables are* ***severely*** *depleted with boiling," ……..*

(WebMD, 2012)

In above examples, English academic and popular science articles authors employed *force* resources to strengthen or soften their *appreciation* (White, 1998) to imply the intensity of that characteristic they attributed to processes, products, and entities. They used such *force* markers as *the least, the most, very, particularly, less, severely* to calibrate their appreciation and judgment

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(White, 1998) and express either an increase or a decrease of the extent of a specific characteristic in a product, process, and entity. Indeed, through using some lexicogrammatical resources for grading the judgment or appreciation, the scientists tried to achieve proximity and provide the non-scholarly audience with new discoveries through recovering "the voice of the scientist which is absent in professional papers" (Hyland, 2010, p. 126).

On the other hand, in the following examples, the authors used *focus* resources to sharpen the focus and express the preciseness of the existence of an attribute (White, 1998).

Academic Research Articles Examples

19) Although red meat is an ***excellent*** *source of iron, …*

(American Journal of Clinical Nutrition, 2010)

20) …and overweight many ***genuinely*** *have begun to decline or …*

(Public Health Nutrition, 2010)

Popular Science Articles Examples

21) The largest mass-poultry-producing facilities are still farms ***of a sort****.*

(Better Nutrition, 2012)

With regard to Engagement category, English academic and popular science articles encompassed more *heterogloss* (462 (%100 and 162 (%68.65), respectively).

Academic Research Articles Examples

22) The present study supports ***findings by Lachat et al.*** *that providing …*

(Public Health Nutrition, 2011)

23) ***Several additional studies*** *reporting indispensable amino acid first pass…*

(The Journal of Nutrition, 2013)

24) ***In contrast to the study by Dawson-Hughes et al.,*** *our baseline dietary …*

(The Journal of Nutrition, 2014)

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Popular Science Articles Examples

25) Now, ***researchers at Chang Gung University*** *in Taiwan have found that …*

(Science Daily, 2015)

*26)****One of the best ways*** *to get more antioxidants is to eat a wide variety of fruits and vegetables.*

(WebMD, 2014)

In the above examples, the authors of English academic and popular science articles referred to the previously conducted research (Examples 22, 23, 24, 25) and provided resources (Example 26) to leave space for alternative positions to present the readers with new pieces of scientific findings and to persuade the readers to accept their ideas (Martin & White, 2005; White, 1998).As Gallardo (2005) mentioned, scientists cite other scientists, mostly more prominent figures in the field, to manage their arguments about their recent scientific findings and convey their intended message. It seems that the authors of English popular science articles follow the academic research article authors by citing other scientists and referring to previously conducted studies to convince their readers to accept "an advice which could otherwise be interpreted as intrusion into private life" (Gallardo, 2005, p. 832).

On the other hand, while the authors of popular science articles referred to some scientific facts or findings without referring to other voices or quoting or reporting an external voice (Martin & White, 2005; White, 1998) (See the following examples), their English academic counterparts included no *monogloss* in their communication of scientific facts.

Popular Science Articles Examples

27) It (Teff) ***contains no gluten****.*

(New York Times, 2013)

28) When fresh fruits and vegetables are stored correctly and eaten in a short period ***they have more vitamin C****.*

(WebMD, 2012)

Further, to see if there were any significant differences between English academic and popular science articles in terms of the main categories of Appraisal resources, several Chi-square

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tests were conducted. The results indicated that there was a significant difference between English academic research articles and popular science articles in terms of Attitude resources of Appraisal Theory (Sig.= 0.000, P≤0.05). Moreover, a significant difference was found between English academic research and popular science articles in terms of Engagement resources ((Sig.= 0.000, P≤0.05). Contrarily, considering Graduation resources, no significant difference existed between English academic research and popular science article ((Sig.= 0.410, P≤0.05).

4. Discussion

The frequency of appraisal resources in both academic research articles and popular science articles showed that despite the representation of academic writing as "dispassionate description of truth" (Penrose & Katz, 1998, p. 169, cited in Zhang, 2015, p. 9) for a long time, it seems inevitable that academic writers strive to both inform and persuade readers of the truth-value of their claims (Hyland & Tse, 2005; Zhang, 2015). So, they employ devices to "involve themselves in the written communication" and observe "the objective or impersonal convention of the academic community" (Zhang, 2015, p. 9). In line with previously conducted studies on the use of interpersonal resources in academic writing (See Zhang, 2015), the results of the current study demonstrated that Attitude resources, especially *appreciation* resources were included in order to invoke "academic persuasion" (Hyland, 2008, p. 2, cited in Zhang, 2015, p. 10).

The scientists seem to employ evaluative resources in order to convince their audience of the validity of their recent scientific discoveries (Miller, 1998), that is, even the scientists try to impress other scientists through tasking advantage of such resources as *appreciation*. Nevertheless, they are simultaneously engaged in the process of "establishing factual information" rather than "overtly providing value judgments" (Herriman, 200b, cited in Zhang, 2015, p. 10). The scientists' tendency to persuade and convince their audience on the one hand, and their intention to observe the norms, standards, and conventions of the scientific discourse community on the other hand, would result in making use of more cases of *appreciation* resources and few, and even no, cases of *affect* and *judgment*. It seems that scientists are cognizant of the power of appealing to "media rules" rather than the strict "institutional values of science" (Russell, 2010, p. 173) in order to address the scientific discourse community. As Hyland and Tse (2005) rightly asserted, academic

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arguments require "subjective judgments" and "interpretive statements" to be embraced by the other scientists. Simultaneously, academic research articles should be well-structured (Hampel & Degand, 2008) and represent "scientific activity as a set of procedures designed to test experimental validity" (Corbett, 2006, p. 755).

Moreover, making use of Attitude resources in general and *appreciation* resources in particular, on the one hand, might point to the "groundlessness of the myth that views professional biological writing as consisting only of impersonal, factual statements" (Crismore & Farnsworth, 1990, p. 118). On the other hand, the point that *affect* and *judgment* subcategories were rarely used in academic research articles might be attributed to the scientists' tendency to convince their audience that the research findings result from objective observations of a natural phenomenon rather than their subjective beliefs. Scientists never provide a negative judgment of their own ideas or those of other scientists in order to make an impression on the intended audience. Nevertheless, they seem to use the safest subcategory of Attitude resources, that is *appreciation* resources, to present an evaluation of products, processes, and entities rather than judging or attributing a characteristic to human participants.

As regards the popular science sample, the higher application of Attitude markers than that of the other two main categories of Appraisal resources might be justified considering the function of these resources, that is, "to express the attitude of the author rather than certainty or commitment to the truth-value" (Abdollahzade, 2011, p. 290). The authors of popular science articles should present the scientific discoveries as appealing to the readers (Giannoni, 2008) and strive both to inform and to persuade readers to welcome the latest scientific facts about nutrition and nutritional value of foods (Miller, 1998). Indeed, popular science articles provide the required setting for scientists to express their feelings about their works and findings (Ben-Ari, 1999). In order to keep the reader motivated to read through the popular science article, the authors should use such resources and present tough technical information in a smooth entertaining way (Ben-Ari, 1999). In fact, the point of departure is "human interest rather than scientific argumentation" (Miller, 1998, p. 31) in communicating scientific facts.

A successful popular science article is expected to make technical information accessible and comprehensible to the non-scholarly audience (Hyland, 2010; Sapp, 1995). This is why the authors intentionally insert their "passion for a subject" (Ben-Ari, 1999, p. 822). Indeed, it is

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required to highlight the merits and demerits of something for the readers (Fahnestock, 1998) to make an impression on their attitude (Bowler, 2009). To this end, scientists should accommodate the scholarly articles so that the "readers marvel at" the discoveries (Fahnestock, 1998, p. 335). Hence, it seems necessary to explicitly include evaluation of the scientific findings in popular science articles (Fahnestock, 1986, p. 279).

In addition to Attitude resources of Appraisal Theory, the authors of English academic and popular science articles used Graduation resources. The authors of both group of articles used *force* resources more frequently while few *focus* resources were coded. It is natural in scientific articles to present the results cautiously rather than claiming absolute truth (Hyland &Tse, 2005; Varttala, 1999). Indeed, scientists are inclined to stick to academic community norms, one of which is to avoid overgeneralization and to look at their findings as some probable phenomena, instead (Hyland &Tse, 2005). In popular science articles, the authors tend to present scientific findings and simultaneously persuade the audience to embrace their value (Lievrouw, 1990) rather than to convince it of the validity and credibility of the presented information (Miller, 1998). Hence, the preciseness of the boundaries seems not to be a priority (White, 1998).

The least frequently used category of Appraisal resources was Engagement. As it was expected, the authors made use of more *heterogloss* resources than those of *monogloss*. In this way, they try to follow the key to succeed by showing solidarity with community to which they belong and respecting the common goals and conventions (Abdollahzade, 2011; Parkinson &Adendorff, 2004). Using *heterogloss* resources, the scientists are enabled to "surpass their personal perspectives" and keep *authoritative* function of science (Parkinson &Adendorff, 2004, p. 389). On the other hand, since writer and reader seem to have equal power relations, that is, the writer addresses the research community as the reader of academic research articles, and thereby, convincing the audience appears to be much challenging (Parkinson & Adendorff, 2004). In this sense, scientists prefer to base their arguments on previously proven findings.

Although the intended audience of popularized sources lacks the relevant technical knowledge (Knudsen, 2003; Miller, 1998), their attention should be attracted so that they recognize the value of presented information more (Fahnestcok, 1986). Moreover, "science speaks with multiple, sometimes contrasting voices" (Russell, 2010, p. 178) and the authors seem to prefer to report the findings of authorized experts (Parkinson & Adendorff, 2004) and draw on their

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comments and "personalize human participants" (p. 388) in order to persuade their non-scholarly audience to appreciate what they try to convey. In Parkinson and Adendorff's (2004) terms, popular science texts address the general public and provide new discoveries without making science look either *authoritative* or *difficult* but appealing. The authors of popular science articles seem to be more cautious about the way they transfer a bulk of knowledge to a wide group of lay audience. Hence, it might be concluded that the value and belief systems of the academic and popular discourse communities of nutrition are quite the same among experts in the field, who address different groups of audience in the report of their recent discoveries.

Moreover, although the presence of Appraisal resources in general and Attitude resources in particular in English academic research articles refer to the existence of subjective statements and evaluative judgments (Hyland, 2000; Swales, 1990; cited in Hyland & Tse, 2005), the rare application of such resources as *affect* and *judgment* (two Attitude subcategories) and *monogloss* (one of Engagement resources) might explain that the author's use of the other resources (*appreciation*, *heterogloss*) were intended to convince the members of of the truth value of their claims (Hyland & Tse, 2005).

Hence, the obtained results would challenge "a widely held belief that academic writing is purely objective, impersonal and informational" (Hyland & Tse, 2005, p. 123) since it was revealed that even scientists are involved in a process of simultaneously informing and persuading their audience (Hyland, 2000, Swales, 1990; cited in Hyland & Tse, 2005). Indeed, the rhetoric of science communication has undergone a change and shifted from *understanding* to *engagement* (Russell, 2010, p. 87) and this might justify scientists' personal involvement in their works (Ben-Ari, 1999). In line with a bulk of studies which have demonstrated the use of interpersonal resources in academic writing (See Zhang, 2015) and called into question viewing academic research articles as a description of truth devoid of any passion or feeling (Penrose & Katz, 1998, cited in Zhang, 2015), the results of the current study also revealed that academic research articles include evaluative resources and entail subjectivity, albeit to a much lower extent (Zhang, 2015).

On the other hand, the analysis of popular science articles vividly reflects such a growing interest of scientists to make an attempt to draw the readers' involvement and attention (Giannoni, 2008) and "to seek wider audiences" (Lievrouw, 1990, p. 9) through popularizing their findings. In Miller's (1998) terms, the general public's interest is the point of departure for the authors of

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popular science articles and the underlying purpose of popular science articles calls for presenting an evaluative account of recent scientific discoveries they tend to convey (Fahnestock, 1998). It is the different nature of academic research articles and popular science articles which makes their application of resources serve different purposes (Zhang, 2015), that is academic writers take advantage of some categories of Appraisal resources to persuade their audience to embrace their findings while these resources are more frequently and widely employed in popular science articles to both inform and entertain the general public and to influence their attitude (Ben-Ari, 1999; Bowler, 2009; Sapp, 1995; Zhang, 2015).

For scientists, persuading the general public to accept a scientific idea seems to be more of a burden than sharing it with an academic discourse community to which they belong and have common conventions and values. This would lead the writers of popular science articles to appeal to Appraisal resources and employ linguistic tools to convince the public (Lievrouw, 1990). Popular science articles set the scene for scientists to fulfill their desire "to grapple with more personal feelings about their work" (Ben-Ari, 1999, p. 820) and thereby, they are more replete with evaluative resources.

In addition, to ensure that the general public grasps the significance of the presented findings, the authors of popular science articles should adjust new information and take advantage of persuasive devices (Fahnestock, 1998). To this end, the authors try to attach something to "a recognized value for an audience" (Fahnestock, 1998, p. 334) and pinpoint numerous attributes in order to make the scientific findings more accessible and comprehensible and lead the readers to "marvel at" presented information (p. 335).

The findings also showed that making use of Appraisal resources, similar to the application of visual elements (Estrada & Davis, 2015; Lightman, 2000; Miller, 1998; Riesch, 2015) contribute to the process of accommodating scientific findings for the intended audience of popular science articles. In order to introduce science "as an unmediated encounter with the natural world" (Corbett, 2006, p. 755), the authors of popular science articles use a set of devices which serve to establish a link between the scientists' new discoveries and the "audience's already held values and assumptions" (Fahnestock, 1998, p. 333) and thereby, to broaden the scope of the scientists' work (Paul, 2004).

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Moreover, the objectivity is actually valued in both academic research articles and popular science articles but it is reflected differently (Parkinson and Adendorff, 2004). In academic research articles, the authors rely on an objective account of scientific findings while in popular science articles, the authors try to validate the presented information through including experts' opinions. Indeed, they use citing other scientists as a tool to fulfill their own different purposes (Gallardo, 2005). Moreover, the authors of popular science articles seem to be "more overt in their evaluation of ideas" (Parkinson &Adendorff, 2004, p. 388) and allow "non-specialists to recover the voice of the scientist which is absent in professional papers" (Hyland, 2010, p. 126).

On the other hand, the quite similar pattern of the application of Graduation resources in both English academic and popular science and academic research articles might suggest that scientists are still fluctuating between academic norms and conventions and popularization techniques and tools and are cautious about using evaluative resources. Hence, they have not completely moved away from academic norms yet. Moreover, the authors of both groups of articles seem to prefer presenting information without highlighting the "preciseness" or "prototypicality" (Martin & White, 2005, p. 137).

5. Conclusion

The present study tried to explore the frequency of Appraisal resources in English academic research articles and popular science articles and to see if the frequency of Appraisal resources would differ between these two sets of articles. According to the findings, higher frequency of Attitude resources in both English and Persian popular science articles might point to the role of these resources in expressing the authors' attitude (Abdollahzade, 2011, p. 209). Popular science articles seem to be a locus for expressing scientists' feelings about their discoveries (Bowler, 2009; Hyland, 2010; Sapp, 1995). Accordingly, we might draw this conclusion that the authors of popular science articles seem to be, whether consciously or unconsciously, well aware of the valuable role played by Attitude resources for attracting their intended audience's attention.

The findings also demonstrated that although academic writing has been viewed as "dispassionate description of truth" (Penrose & Katz, 1998, p. 169, cited in Zhang, 2015, p. 9) which follows "objective or impersonal convention of the academic community" (Zhang, 2015, p.

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9), scientists seem to reconfigure the boundaries by injecting evaluative resources of Appraisal theory in order to influence other scientists through including "subjective judgments" and "interpretive statements" (Hyland &Tse, 2005, p. 124) in their arguments. Nevertheless, this application of evaluative resources, by no means, seems to challenge the truth value of scientific findings; scientists still stick to the academic norms of the community to which they belong but they are also cognizant of the way they should persuade their intended audience, members of their academic discourse community, to accept the newly found results of their studies and experiments. As a result, one might say that the findings of the current study cast some doubt on "the myth that views professional biological writing as consisting only of impersonal, factual statements" (Crismore& Farnsworth, 1999, p. 118).

Furthermore, these findings might point to the scientists' growing interest in using evaluative resources of Appraisal theory in order to draw the readers' involvement and attention (Giannoni, 2008). Indeed, they seem to make an attempt to broaden the scope of their discoveries and achieve wider audience (Lievrouw, 1999) through informing and entertaining the general public. They seem to have understood the potential of these resources for both influencing their intended audience's attention (Ben-Ari, 1999; Bowler, 2009; Sapp, 1995; Zhang, 2015) and fulfilling their desire "to grapple with more personal feelings about their work" (Ben-Ari, 1999, p. 820). In this way, they would be able to establish a link between their new discoveries and their "audience's already held values and assumptions" (Fahnestock, 1986, p. 333). In this regard, popular science articles seem to be "more overt in their evaluation of ideas" (Parkinson & Adendorff, 2004, p. 388) in comparison to academic research articles to allow the non-specialist readers "to recover the voice of the scientist which is absent in professional papers" (Hyland, 2010, p. 126).

In general, this conclusion might be drawn that achieving optimal science communication outcomes necessitates taking advantage of such resources as Appraisal ones. To have a scientifically literate society, which would lead to enhanced quality of life, scientists should appeal to as many resources as possible to provide the public with their findings in an informative and entertaining way. This seems to be a heavy burden on scientists' shoulder.

The results of the study carry some pedagogical implications for EAP courses held in EFL settings. As globalization necessitated "being heard internationally" (Shaw & Vassileva, 2009, p.

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292), being able to both comprehend and produce scientific texts of different professional levels at international scale seems to be a requirement for the future scientists. This would move the EAP students in an EFL setting beyond presenting simple accounts of scientific discoveries toward accommodating the scientific professional accounts and gearing them to their audience's professional level (Dafouz-Milne, 2008).

Despite all the merits of including samples of both academic and popular science articles in the EAP classes, though, EAP instructors are recommended to be cautious in employing popular science sources. Parkinson and Adendorff (2004) warned against mere reliance on popular science articles as it might lead students to confuse and misconceive the requirements of academic genres. Indeed, the instructors should be professional and experienced enough to transfer the differences between academic and popular science conventions precisely so that the students are socialized in their scientific community and make appropriate choices in addressing various groups of audience. One such exercise would be changing academic research articles into popular science articles and vice versa in order to gain a deeper and richer knowledge of both genres. These all seem to contribute to scientists, science students, science instructors, and EAP instructors to approach "one sign of a revolution in science", i.e. "the appearance of texts that are accessible to the general public" (Paul, 2004, p. 36).

The findings of the current study expand the currently available literature on both science popularization and communication and Appraisal theory. The results would also lead to new avenues of research adopting models of Appraisal for examining both academic and popular science genres in various fields of study in order to unravel the way scientists communicate scientific discoveries to different groups of audience. In this regard, several comparative studies can be conducted taking into account other linguistic and pragmatic features. taking a sample of articles in other fields of study e.g. Biology, Physical Education, etc.

In addition, a chronological study of both academic research articles and popular science articles can be conducted to see if time would influence the use and frequency of Appraisal resources in both academic and popular genres. Moreover, further studies can touch upon the oral mode of these two genres, e.g. presentations in academic conferences in which the scientists address the other members of their academic discourse community and presentations of scientific findings by the scientists for the non-scholarly audience on TV or radio. In addition, future studies

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can explore the use of Appraisal resources in academic research articles and popular science articles written in other languages.

Taking a more pedagogical approach, the Appraisal resources can be taught to a group of students in EAP classes in order to investigate its possible influence on their understanding and perception of the audience they address in their future job. Their writing ability to address the academic discourse community and the general public can be tested after presenting these resources.

6. References

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Appendix: List of Articles in the Corpus

A) List of English Popular Science Articles in the Sample

1) WebMD (All articles retrieved from www.webmd.com)

Benorach, R. (2013, December). Super-foods for new moms.

Derrer, D. T. (2014, September). Food allergies and your skin.

Dotinga, R. (2013, December). Could a supplement prevent weight gain?

Jacobson, M. T. (2012, April). How to maximize nutrition in vegetables.

Jaret, P. (2012, May). Healthy aging: Living long and well.

Manning, J. (2014, July). Emotional eating: What helps.

Nguyen, A. (2014, February). Juicing for health and weight loss.

Patural, A. (2014, July). What should I eat before working out?

Uscher, J. (2014, October). What are the best foods for your skin and the best ways to get the vitamins and other nutrients your skin needs?

Wait, M. (2014, May). Watching your children's nutrition and growth.

2) Better Nutrition (All articles retrieved from www.betternutrition.com)

Bowden, J., & Bessinger, J. (2014, August). Just beet it.

Bril, J. B. (2011, February). Heal your heart with food.

Feiring, A. (2015, November). Wine not?

James, K. (2015, December). Beyond Paleo.

Singh Khalsa, K. P. (2015, December). Tea Rx.

Smith, M. D. (2014, October). Medicinal food: Garlic and ginger.

Strausfogel, Sh. (2015, November). Potent pomegranate.

Turner, L. (2012, March). Hot tea.

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Tweed, V. (2010, December). Pomegranate: Nutritional jewel.

Zevnik, N. (2012, September). Chicken and the egg.

3) Science Daily (All articles retrieved from https://www.sciencedaily.com)

American College of Allergy, Asthma and Immunology (ACAAI). (2012, November). An egg a day to keep allergies away?

American Heart Association. (2010, June). Coffee or tea: Enjoy both in moderation for benefits, Dutch study suggests.

American Physiological Society (APS). (2015, April). Caloric restriction: A fountain of youth for aging muscles?

Cornell University. (2011, August). Weight loss without the hunger: Eat a lighter lunch, scientists say.

George Washington University Milken Institute School of Public Health. (2016, April). Fast food may expose consumers to harmful chemicals called phthalates.

Plataforma SINC. (2013, September). Experts confirm that fruit and vegetable consumption reduces risk of mortality.

The JAMA Network Journals. (2015, March). An apple a day won't keep the doctor away but maybe the pharmacist.

University of Gothenburg. (2013, October). Dietary intervention reduces stomach problems for diabetes patients.

University of Southern Denmark. (2014, December). Fat cells reprogrammed to increase fat burning.

University of California - Davis. (2015, April). Just two weeks of drinking sugary drinks boost risk factors for heart disease, study suggests.

4) New York Times (All articles retrieved from www.nytimes.com)

A.D.A.M. (2013, April). Cooking utensils and nutrition.

Bakalar, N. (2014, December). Mediterranean diet is good for your DNA.

Ballentine, S. (2011, August). Meal plan.

Bittman, M. (2015, March). Feeding kids well.

Brody, J. E. (2014, December). Why cafeteria food is the best.

Carroll, A. (2015, April). Simple rules for healthy eating.

O’Connor, A. (2014, December). Questioning the idea of good carbs, bad carbs.

North, A. (November, 2014). Should you pack your child’s lunch?

Parker-Pope, T. (2013, June). Small grains, big nutrition.

Reynolds, G. (2015, January). A 12-hour window for a healthy weight.

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B) List of English Academic Research Articles in the Sample

1) Public Health Nutrition

Abreu, S., Santos, R., Moreira, C., Santos, P. C., Mota, J., & Moreira, P. (2013). Food consumption, physical activity and socio-economic status related to BMI, waist circumference and waist-to-height ratio in adolescents. 17 (8), 1834-1849.

Banks, E., Jorm, L., Rogers, K., Clements, M., & Bauman, A. (2010). Screen-time, obesity, aging and disability: findings from 91266 participants in the 45 and Up study. 14 (1), 34-43.

Barros, E. G., Pereira, R., Sichieri, R., & da Veiga, G. V. (2012). Variation of BMI and anthropometric indicators of abdominal obesity in Brazilian adolescents from public schools, 2003-2008. 17 (2), 345-352.

Chapman, K., Innes-Hughes, Ch., Goldsbury, D. Kelly, B., Bauman, A., & Allman-Farinelli, M. (2012). A comparison of the cost of generic and branded foor products in Australian supermarkets. 16 (5), 894-900.

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Hamner, H. C., Tinker, S. C., Flore, A. L., Mulinare, J., Weakland, A. P., & Dowling, N. F. (2012). Modelling fortification of corn masa flour with folic acid and the potential impact on Mexican-American women with lower acculturation. 16 (5), 912-921.

Howel, D. (2010). Trends in the prevalence of obesity and overweight in English adults by age and birth cohort, 1991-2006. 14 (1), 27-33.

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