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WORD SENSES OF ACADEMIC VOCABULARY IN MEDICAL TEXTS AND DICTIONARIES

Abstract

The purpose of this study was twofold. First, we investigated whether academic words tend to show domain-specific meanings (e.g., *resident* as physicians trained in medicine) in specialized texts. Second, we offered suggestions for specialized dictionaries based on text analysis. We focused on the medical domain and adopted a computational approach to automatically identify academic words that are more likely to show domain-specific senses. Inspired by Yarowsky's (1995) "one sense per collocation" principle, our approach automatically compared word collocates in medical and general-purpose corpora. We applied this approach to nouns on the Academic Vocabulary List and collected 129 candidate words. However, only seven of them were judged to demonstrate medical senses. Although identifying only few technical word senses, our study found numerous specialized usages of multiword terms. We further checked candidate words and multiword terms in a medical dictionary. Consistent with the corpus results, the candidate words listed as dictionary entries mostly showed academic rather than medical meanings. Furthermore, half of the multiword terms identified in this study were not included in the dictionary. Suggestions for specialized dictionaries are offered based on our findings.

Key words

academic words, specialized word senses, specialized dictionaries, multiword terminologies, medical texts, medical dictionaries.

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1. INTRODUCTION

With the development of new professions and trades, English for specific purposes (ESP) areas have been increasing (Hyland, 2022). This poses great challenges to ESP instructors, as they must meet students' particular linguistic needs in each area. One of these challenges concerns words. Among all linguistic features, words demonstrate the greatest variation across professional disciplines (Hyland, 2022). Students who study in different professions are claimed to learn an entirely different vocabulary. Peters and Fernández (2013) investigated ESP students' lexical needs and identified the types of words that they required help with. The identified types included terms specific to each field of study (Type A), words commonly appearing in most scientific or academic disciplines (Type B), and words that are frequent in raw materials or everyday phenomena (Type C). Type A words, according to Alcaraz Varó (2000), can be further divided into (1) terms appearing only in a particular discipline and (2) words common in general language which adopt a specialized meaning in a field of study. Nation (2001) proposed similar classifications, in which words are generally categorized according to their levels of technicality, ranging from technical terms, academic or semi-technical vocabulary to words that are common not only in most ESP areas, but also in general-purpose English. However, the distinctions between the categories are not clear-cut (Chung & Nation, 2003; Peters & Fernández, 2013); thus, the technicality of ESP words should be regarded along a continuum in which different categories are more or less technical compared with each other (Ha & Hyland, 2017).

To address students' lexical requirements, researchers in the recent 20–30 years have produced lists of ESP vocabulary for various fields of expertise. These fields include engineering (Hsu, 2014; Ward, 2009), civil engineering (Gilmore & Miller, 2018), medicine (Yang, 2015), plumbing (Coxhead & Demecheleer, 2018), etc. In addition to discipline-specific lists, several cross-disciplinary word repertoires have been created to meet students' needs in most professional fields. As mentioned above, ESP students require help with various types of words, and their vocabulary load is heavy. However, they can benefit from a core set of words shared by most academic disciplines, such as English for academic purposes (EAP) words. Among previous EAP lists, arguably the most important and well-known are the Academic Word List (AWL) (Coxhead, 2000) and Academic Vocabulary List (AVL) (Gardner & Davies, 2014). Since their publication, these two lists have been widely used in EAP classrooms and included in numerous types of EAP teaching materials (e.g., Folse, 2023; Hollinger, 2004; Schmitt & Schmitt, 2005).

However, the AWLs of some EAP researchers are not without problems. One potential problem concerns polysemy. The AWL word *generation*, for instance, refers to several different senses (i.e., meanings), including the following:

(1) People of approximately the same age: *People retiring recently are richer than their earlier generations*.

(2) Process of producing things: *The wind can be used for electricity generation.*

According to Hyland and Tse's (2007) analysis, Sense (1) appears commonly in texts of social sciences but is rare in engineering or scientific writings. In contrast, Sense (2) is far more familiar to researchers in the fields of science and engineering. Based on such examples, Hyland and Tse (2007) further suggested that AWL should not be directly delivered to students in all disciplines; rather, students should be provided with word senses that are particularly common for their major or domain. The issue of polysemy might be even more complicated if we consider the "specialized senses" of academic words. For instance, the word *economy*, in most cases, refers to "a country's system of money and goods" or "some things people do in order to use less money." This word is quite common and frequently appears in the texts of most academic disciplines. However, *economy* also means "the operation system of anabolism and catabolism processes" to researchers in medicine. This specialized word meaning may be of little or no importance to EAP learners in most academic fields. Medical school students should prioritize other forms of common sense.

Hyland and Tse (2007) were the first to raise the issue of polysemous academic vocabulary. According to the authors, researchers in different domains tend to shape words for their own purposes. Consequently, academic words tend to refer to different specialized meanings in different fields. To the best of our knowledge, the issue of polysemy in academic texts has rarely been discussed or investigated in the EAP or ESP literature. Nevertheless, this issue is important for gaining a more complete picture of academic vocabulary. This issue has significant implications for EAP teaching and ESP dictionaries. If academic words are used to demonstrate different meanings across disciplines, learners should be provided with the senses that are particularly essential to them. Specialized dictionaries, likewise, should offer specialized meanings for academic words rather than their common and generalized meanings.

To explore the issue of specialized senses of academic words, our study focused on medicine and thoroughly investigated whether the targeted academic words tended to display specialized meanings. To identify candidate words that are more likely to contain specialized meanings, we employed word sense disambiguation or word sense discrimination (WSD) approaches, which have frequently been adopted in natural language processing (NLP) research. Specifically, these approaches enabled us to automatically and efficiently locate a target list of candidate words, which we then carefully examined and evaluated to determine whether they referred to specialized usage in medical texts. To contribute to lexicography, we further investigated whether these words were listed in medical dictionaries and, if so, we also examined the meanings of the entries. Based on these text and dictionary analyses, we offer practical suggestions for compiling specialized dictionaries.

2. ACADEMIC WORD LISTS: COMPILATION AND POTENTIAL LIMITATIONS

Since the 1970s, researchers have attempted to collect words assumed to be useful for EAP teaching or learning. Early attempts were mostly based on small-scale corpora of academic texts from which researchers identified high-frequency lexical words (e.g., Campion & Elley, 1971) or chose those that learners might find difficult (e.g., Ghadessy, 1979). These early works motivated Xue and Nation (1984) to compile the University Word List (UWL), which has been widely applied to English teaching and research over the following two decades. Although rather successful, the UWL was limited in its selection criteria (Coxhead, 2000). The UWL, as described by Xue and Nation (1984), was established by including words from four earlier lists. The early works, as indicated above, employed very small corpora; consequently, it is questionable whether their entries would be representative of an important lexis in most academic domains.

To overcome the limitations encountered by UWL and meet the EAP instructors' needs, Coxhead (2000) adopted strict criteria to create an AWL. Concerning textual resources, the author built a complete academic corpus consisting of various academic disciplines. The corpus comprised approximately 3.5 million word tokens extracted from 414 academic texts. In general, it contained four main research fields: Arts, Commerce, Law, and Science, each further consisting of seven disciplines (e.g., education, history, linguistics, philosophy, politics, psychology, and sociology in the Arts). However, the 414 texts were of different lengths and types. For example, most texts were journal articles, and some were taken from university textbooks or other academic corpora (e.g., the Lancaster-Oslo/Bergen Corpus). Although the length of the texts varied, Coxhead (2000) ensured that the four research fields on which she focused contained similar token numbers. In selecting the target words, Coxhead (2000) employed three main principles as follows:

(1) Common general-purpose words represented by items on the General Service List (GSL) (West, 1953) should be removed.
(2) A member of a word family must appear at least 10 times in all four research fields and at least 15 times in at least 15 of the 28 disciplines.
(3) In the entire academic corpus, the members of a word family must appear at least 100 times.

The last two principles were adopted to ensure that the selected words appeared frequently in academic discourse and across numerous disciplines. Specifically, Coxhead (2000) considered lexical dispersion (Principle 2) prior to lexical frequency (Principle 3) because, in corpus linguistics, word counts were sometimes found to be biased by long texts. Based on these stricter criteria and richer corpus resources, AWL has shown impressive coverage rates in academic texts. As the author found, on average, AWL accounted for 10% of all lexical items in her academic corpus. GSL and AWL achieved a coverage rate of 86%. This figure suggests that students in most disciplines know almost 90% of the words in academic articles if they master entries in the two word lists. Arguably, the AWL is the most popular and successful word list in the field of EAP. Since its publication, AWL has been commonly applied to textbook development, dictionary compilation, and classroom activity design, and has also been re-examined in many subsequent studies (e.g., Chen & Ge, 2007; Li & Qian, 2010; Yang, 2015). As Coxhead (2000) commented, AWL has had a far more profound influence than she imagined.

Gardner and Davies's (2014) AVL is another representative and important word list in EAP. Compared to the database underlying AWL, Gardner and Davies's (2014) corpus was much larger, containing more than 100 million running tokens. To make AVL more accessible to EAP teachers and students, the authors developed online query tools for users to explore their entries.[1] With convenient tools and abundant resources, AVL is expected to become one of the most valuable and popular vocabulary repertoires in the upcoming 10–20 years.

As Gardner and Davies (2014) criticized, the AWL exhibited critical limitations similar to the UWL. The first concerns the lexical units targeted by AWL word families. Although it might be efficient to evaluate text coverage rates based on word families, Gardner and Davies (2014) indicated that questions remain regarding whether word families are always composed of proper members. For example, in a family with the headword *react*, its members include *reaction*, *reactionary*, and *reactor*. Although these three are usually grouped into the same family, their word senses differ significantly. Furthermore, the parts-of-speech (POS) information (e.g., verbs or nouns) of the members in a family was not clearly marked on the AWL. In the *proceed* family, it is not clear as to whether the member *proceeds* is a noun or a verb. With different POS, *proceeds* would present extremely different meanings (i.e., "continues" as a verb and "profits" as a noun). As Gardner and Davies (2014) reported, the second limitation of AWL concerns the removal of all words from the GSL. Although it has been applied in many recent studies, the GSL was compiled approximately 70 years ago; it is doubtful whether the list is still representative of common daily words. In reality, GSLs include a number of lexical words that are frequent and important for academic use. For instance, *business*, *interest*, and *rate* are listed in the GSL and are important for EAP learners in business and finance. Although these words are commonly used in daily life, they should be included in vocabulary lists designed for academic purposes. The removal of all GSL also excluded words that were essential and frequent in academic texts. To avoid the limitations of AWL and extract words that are more representative, Gardner and Davies (2014) adopted four criteria as follows:

(1) A word needs to appear 1.5 times more frequently in academic texts than in non-academic texts.

[1] The Academic Vocabulary List is available at https://www.academicvocabulary.info/, which can be further explored on the webpage of Corpus of Contemporary American English: https://www.english-corpora.org/coca/

(2) A word must appear 20% higher than its expected frequency in at least seven of the nine targeted disciplines.
(3) A word needs to disperse rather evenly across an academic corpus.[2]
(4) A word should not be "discipline-specific"; consequently, it cannot be three times higher than its expected frequency in any of the nine targeted disciplines.

Instead of identifying word families, Gardner and Davies (2014) focused on "lemmas" in their study. Lemmas, commonly used as headwords in dictionaries, involve the important characteristics of POS and word senses and are rather easy to count in textual databases. To extract candidate words for academic vocabulary, Gardner and Davies (2014) consulted the Corpus of Contemporary American English (COCA) (Davies, 2008-). The COCA corpus, with its extremely large size (i.e., more than one billion word tokens), is the most representative American English database. Using the academic subsection of COCA, Gardner and Davies (2014) effectively collected a group of academic words that had a higher coverage of academic texts than AWL. According to them, AVL covered 13.8% of the academic part of COCA, which was markedly higher than the 7.2% rate achieved by AWL. By querying the COCA website, EAP teachers and learners can further access AVL and explore its use. For example, they could attempt to determine how AVL words are used in real contexts and understand how frequently words occur in various academic disciplines.

Although the AWL and AVL have been widely acknowledged and adopted, these are not without limitations. In our study, we focused on one of their potential restrictions – polysemy. Hyland and Tse (2007) listed eight AWL words that tend to have different meanings in different domains: *consist*, *issue*, *attribute*, *volume*, *generation*, *credit*, *abstract*, and *offset*. The word *volume*, for instance, tends to refer to "the total amount of something" in sciences or engineering but not in areas such as humanities and arts. However, sciences or engineering students are less likely to encounter the meaning "books or journal series" of *volume*. As Hyland and Tse (2007) emphasized, EAP learners should consequently be offered the meaning(s) of these words that are particularly important to their respective domains. As discussed above, the technical meanings of words are even more crucial and interesting for investigation. The AVL word *culture*, for instance, involves the technical meaning of "process of growing living things in nutrient media" particularly in medicine. Similarly, in baseball, several AVL words, such as *ball*, *strike*, *run*, and *slide* were identified as having specialized meanings (Riccobono, 2020). Such medical- or baseball-specific senses, which might not be important to learners in other areas, must be the ones required to be acquired early by learners who learn English for medical or baseball purposes.

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[2] Gardner and Davies (2014) employed the Juilland 'd' figure (Juilland & Chang-Rodríguez, 1964) to decide whether and how words were distributed evenly in their academic corpus. Following repeated tests, the authors adopted the 'd' figure at 0.8 as their dispersion criterion; technical and domain-specific words tended to demonstrate scores below it.

However, preferences for specialized meanings appear to exist not only in single words but also in multiword units (e.g., collocations and lexical phrases). For instance, Hyland and Tse (2007) argued that words have additional meanings when they co-occur with other words in particular disciplines. Green and Lambert (2019) propose a similar idea. By comparing the content word phrases extracted from the secondary school textbooks of eight subjects, Green and Lambert (2019) observed a low overlap in the most frequent phrases among the subjects. Marín-Pérez and Aguado Jiménez (2024) further investigated how to improve ESP learners' use of domain-specific multiword units. The domain targeted was business, and a data-driven learning (DDL) approach was adopted to familiarize learners with word sequences, such as *thank you for your* (…) and *I look forward to* (…) common in business letters. As Marín-Pérez and Aguado Jiménez (2024) demonstrated, the DDL methodology is highly effective. The learners trained to employ the approach not only quantitatively produced more multiword units but also showed improvement on a qualitative level by using more types of units.

Although acknowledging that linguistic features might be shared by different professions, Hyland (2022) argued that these features should be very limited. According to the researcher, different disciplines adopt distinct ways to talk about the world and, consequently, words tend to have different meanings across fields. As expected, the specialized sense of academic words has critical implications for EAP instruction. If it is true that many academic words do exhibit specialized word senses in domain-specific texts, EAP teaching should also be "domain-specific"; teachers have to first discover what academic words refer to in particular domains, and teach those specialized word senses according to their students' academic areas. Although Hyland and Tse (2007) only briefly discussed this issue, it has not been thoroughly examined in the EAP and ESP literature. Therefore, in this study, we addressed this issue by focusing on the medical domain. Specifically, we targeted a certain number of academic words and thoroughly examined how many of them revealed medicine-specific senses in medical texts. Discipline-specific senses, as discussed above, might display not only in single words but also multiword units. Thus, we investigated whether these words and their common co-occurring words constitute medical terms. Additionally, as indicated in the Introduction, we aimed to determine whether the tested words were contained in medical dictionaries to contribute to the lexicography. The two research questions (RQs) that we intend to address are as follows:

RQ1. How many of the tested academic words and multiword sequences containing them are medicine-specific terms in medical texts?

RQ2. How many of the tested academic words and multiword sequences containing them are listed in medical dictionaries?

3. METHOD

First, this study investigated the domain-specific senses of academic words in medical texts. More specifically, our aim was to investigate whether academic words in medical texts tended to show senses which were unique for the specific area. Based on the findings of this investigation, we further explored whether we could offer suggestions for the compilation of medical dictionaries. Accordingly, our research included (1) compilation of a database of texts that are representative of the medical domain, (2) selection of target words to investigate current AWLs, (3) evaluation of the words' senses in medical texts, and (4) examination of how the words are represented in medical dictionaries. At the second stage, particularly, we employed word-sense discrimination techniques to assemble a collection of words that are more likely to show specialized senses than others. Each stage of this study is detailed in the following subsections.

3.1. Compilation of medical corpus

To obtain a sufficiently large medical corpus to adequately evaluate word senses, we used web scraping techniques. They have enabled us to download a large number of research papers online automatically in a short time. Notably, in the ESP literature, Tomić (2021) has also attempted to analyze medical words using corpus resources. However, unlike Tomić (2021) who used a non-specialized corpus, we adopted a textual database which contained medical texts only. The focus on medical texts undoubtedly allowed us to examine word senses in medical discourse more reliably. We extracted medical papers from ScienceDirect,[3] a leading bibliographic database of scientific journals worldwide. In ScienceDirect, almost all recent articles were HTML format texts. Unlike PDF format texts that always involve conversion- and garbled-text problems, the HTML format enabled us to avoid these issues and easily distinguish the sections that we needed (i.e., abstracts and main texts) from those that we did not (e.g., acknowledgements and references). For this study, we created several Python scripts to download medical journal articles from ScienceDirect in an attempt to compile a corpus that was large enough to be representative of current medical texts.

In ScienceDirect, the medical area[4] involved 33 subdomains. To balance the words taken from these subdomains, we set a maximum word count (i.e., 5–5.5 million tokens) for each of them. Subsequently, from each subdomain, one to three journals that received the highest Journal Citation Report impact factors (IF) (Clarivate Analytics, 2019) were consulted, and their articles were automatically downloaded using our web scraping programs. Although high IF scores do not necessarily guarantee good journal quality (Seglen, 1997), IF was adopted as a

[3] https://www.sciencedirect.com/
[4] It is termed "Medicine and Dentistry" on the ScienceDirect website.

standard to ensure that the text being processed reaches a certain quality level. In total, our medical corpus comprised approximately 173.7 million word tokens, as detailed in Table 1. We applied the NLTK tokenizer, lemmatizer, and POS-tagger (Bird et al., 2009) to all our medical texts, which enabled us to correctly identify all forms of each target academic word.

3.2. Selection of target academic words

Due to the fact that both AWL and AVL contain thousands of words, it is not possible to analyze all the words on either list in our medical corpus. Consequently, we decided to concentrate on the nouns included in the core AVL, which included 1,140 words. First, we utilized NLP techniques to identify those which were more likely to exhibit a medical sense. Second, two experts, one researcher in medicine and one in lexicography, were hired to evaluate whether the identified words exhibited specialized senses in the medical texts.

SUBDOMAIN	NO. OF TOKENS	SUBDOMAIN	NO. OF TOKENS
Anesthesiology and Pain Medicine	5,269,999	Medicine and Dentistry (General)	5,261,947
Cardiology and Cardiovascular Medicine	5,264,467	Nephrology	5,248,911
Clinical Neurology	5,247,176	Obstetrics, Gynecology and Women's Health	5,270,587
Complementary and Alternative Medicine	5,258,914	Oncology	5,273,897
Critical Care and Intensive Care Medicine	5,277,656	Ophthalmology	5,259,378
Dentistry, Oral Surgery and Medicine	5,281,692	Orthopedics, Sports Medicine and Rehabilitation	5,266,988
Dermatology	5,264,824	Otorhinolaryngology and Facial Plastic Surgery	5,264,761
Emergency Medicine	5,241,780	Pathology and Medical Technology	5,242,912
Endocrinology, Diabetes and Metabolism	5,258,622	Perinatology, Pediatrics and Child Health	5,293,315
Forensic Medicine	5,260,185	Psychiatry and Mental Health	5,231,196
Gastroenterology	5,260,559	Public Health and Health Policy	5,254,123
Geriatrics and Gerontology	5,258,947	Pulmonary and Respiratory Medicine	5,281,430
Health Informatics	5,266,886	Radiology and Imaging	5,272,785
Hematology	5,255,229	Surgery	5,256,120
Hepatology	5,261,863	Transplantation	5,272,576
Immunology, Allergology and Rheumatology	5,279,575	Urology	5,250,964
Infectious Diseases	5,254,740		
TOTAL: 173,665,004			

Table 1. Subdomains of the medical corpus

The NLP techniques adopted in this study were the WSD approaches developed by Yarowsky (1995). The researcher proposed two important WSD principles that have profound implications for downstream research. The first is the "one sense per discourse" principle. According to this theory, if a word in a text appears more than once, most of its occurrences refer to the same meaning. This principle was examined in Gale et al. (1992), which recruited subjects to evaluate the meanings of nine polysemous words. Among the sentences containing polysemes, those extracted from the same text refer to the same word sense. The second principle is "one sense per collocation." As Yarowsky (1995) observed, words tend to have different meanings when they appear in different collocations. A classic example provided and discussed by the researcher is a polysemous word *plant*. When *a plant* appears in the collocate *life*, it usually refers to an organism living in the soil. However, *plant* is much more likely to mean "factory" when it co-occurs with the word *manufactory*. Yarowsky (1995) empirically demonstrated that this principle can reliably disambiguate polysemous words by automatically identifying and discriminating co-occurring words. Together, the two principles achieved a WSD accuracy rate of 90–96%.

Based on Yarowsky's (1995) inspirational ideas and research, we collected our target words by focusing on words that tended to have very different collocates in medical and non-medical texts. We used *culture* as an example. In non-medical texts (e.g., general-purpose texts), *culture* very often co-occurs with *live*, *establish*, *found*, *visit*, and *royal*, as well as certain regional terms such as *Asian*, *American*, and *African*. In the contexts where these words appear, *culture* refers to ideas or ways of behaving in a particular group of people. However, in medical textbooks, reports, and research papers, *culture* tends to co-occur with *stimulate*, *formation*, *form*, *cell*, *count*, and *factor*. This word then has a specialized or medical sense that refers to bacteria or cells that are grown for medical use. Based on these collocation usages, we developed our WSD algorithm to collect the words that showed the largest collocation differences in medical and general-purpose texts. The general texts used in this study were British National Corpus (BNC) resources, which also contain over 100 million words as our medical corpus.

The WSD algorithm is as follows. As we input a tested word (i.e., any word among the 1,140 AVL nouns) into our system, the algorithm began to extract all its collocating words from the medical corpus and BNC. The collocating words examined in this study were the lexical words (i.e., nouns, verbs, adjectives, and adverbs) showing up in ±5 windows of the tested word. Then, our algorithm determined the similarity between two groups of collocations. We assessed the similarities based on ideas from vector semantics (Jurafsky & Martin, 2019). For each word, we created a term-document matrix. The two corpora were represented as columns in the matrix, and by representing collocating words as rows, the cells represented the number of times the collocates occurred in the two corpora. Subsequently, the similarity can be obtained by computing the cosine score of the corresponding vectors, where *Xi* and *Yi* are the number of occurrences of the collocating words:

$$\frac{\sqrt{\sum_{i=1}^{N} X_i Y_i}}{\sqrt{\sum_{i=1}^{N} {X_i}^2}\sqrt{\sum_{i=1}^{N} {Y_i}^2}}$$

The cosine scores basically were able to inform us whether a word showed similar contexts in the two types of texts (i.e., a cosine score closer to 1) or very different behaviors (i.e., a cosine score closer to 0). In NLP literature, there are no research-recommended cosine scores for sense similarity. Repeated tests on our data suggested that scores lower than 0.01 performed well in identifying words that showed medical senses.[5] Using this threshold, our algorithm suggested 129 nouns that were most likely to demonstrate specialized senses in medical texts and were targeted as candidate words for further analysis.

3.3. Evaluation of word senses

To investigate whether the candidate words referred to medical senses, we hired two experts to evaluate the word senses of these nouns. One was a scholar of medical research and the other was a lexicographer. Both had rich academic experience of more than 15 years in their respective areas of study. We offered the two experts all the candidate words identified, with each being shown in four to five example sentences extracted from the medical corpus.

Specifically, for each candidate word, the experts had to express their opinions on two statements: (1) the word shows a medical rather than a general sense and (2) the word should appear as an entry in medical dictionaries. Moreover, all candidate words within the example sentences were accompanied by common collocates (i.e., the collocates identified in the second stage of our work). Two more statements were adopted to investigate whether the experts judged these collocations as medicine-specific multiword terms: (3) the word and its collocating word should appear as an entry in medical dictionaries and (4) the word and its collocating word should appear in example sentences in medical dictionaries. In response to these statements, the experts were required to follow a four-point Likert scale: 4 (strongly agree), 3 (agree), 2 (disagree), and 1 (strongly disagree). The evaluation form is shown in Figure 1.

[5] Words tested included, for example, *abduction*, *crown*, and *intervention*, which all refer to specialized meanings in medicine (i.e., *abduction*: removing a lime away from the body; *crown*: the top part of head or skull; *intervention*: a treatment or a procedure). All the three words got cosine scores lower than 0.01, as our algorithm demonstrated.

	(1) The word shows a medical rather than a general sense	(2) The word should appear as an entry in medical dictionaries	(3) The word and its collocating word should appear as an entry in medical dictionaries	(4) The word and its collocating word should appear in example sentences in medical dictionaries
TARGET WORD: **adaptation**	[ ] 1-4	[ ] 1-4	[ ] 1-4	[ ] 1-4
Therefore , a new concept is emerging from this and other studies that considers the **metabolic adaptations** occurring in skeletal muscles as disease modifier/controller (Baskin et al. , 2015) .				
Yet , **metabolic adaptations** in response to hypoxic preconditioning are hardly studied in cell transplantation strategies , although understanding whether and how preconditioned cells adjust bioenergetics and/or redox homeostasis to survive oxygen and nutrient deprivation is crucial to improve therapeutic strategies .				

Figure 1. Word sense evaluation form

3.4. Medical dictionaries consulted

In this study, we consulted *Merriam-Webster's Medical English Dictionary* [6] (MWMED), one of the most widely used medical dictionaries worldwide. Particularly, for each identified candidate word, we investigated whether the dictionary contained it as a headword and, if so, we examined the listed sense(s). In addition to the candidate words, as described in Section 3.3., the experts were required to evaluate whether the candidates and their collocates formed multiword medical terms. We also explored whether the medical dictionary contained these multiword units.

4. RESULTS AND DISCUSSION

Among the 1,140 AVL nouns, our algorithm suggested 129 words that were more likely to show specialized senses in medical texts. As discussed in Section 3.2., the cosine scores gathered for them were all < 0.01, which indicated that these words demonstrated extremely different collocation behaviors in medical and general-purpose texts. However, our two experts regarded fewer than ten of them as specialized terms in the medical field. The nouns considered as medical terms are listed in Table 2.

[6] In this study we used the 1st edition of the *Merriam-Webster's Medical English Dictionary*, which was published by Merriam-Webster Inc. in 2016.

WORD	MEANING IN MEDICAL TEXTS	MEANING IN GENERAL TEXTS
1. *Aspiration*	Drawing of something in or out	Strong desire to achieve something
2. *Bonding*	Force holding together atoms or ions in a molecule	Process of developing a special relationship
3. *Colony*	Mass of micro-organisms growing in a solid medium	Country under the control of another
4. *Labor*	Physical activities involved in childbirth	Physical work
5. *Rupture*	Membrane rupture	Something suddenly breaking apart
6. *Circuit*	Neuronal pathway in the brain	Circle for electric currents
7. *Radical*	Group of atoms as entity in various reactions	Someone with new and different ideas

Table 2. Words identified to show medical senses

As Table 2 demonstrates, only 7 of the 129 candidate words were found to be specialized terms for medicine. Although all candidate words co-occurred with very special words in medical texts, an enormously large proportion still referred to general and common rather than medical senses. In the evaluation task, the seven terms identified were the only nouns that received 3 or 4 points for both Statements 1 and 2. For the other 122 nouns, the two experts' responses were quite consistent; these nouns received only 1–2 points. In response to the first research question, we could thus indicate that the answer was false; very few academic words would display specialized senses in medical texts. In the EAP literature, this finding seems radically different from those reported by Lei and Liu (2016) and Roesler (2021). For example, Lei and Liu's (2016) intention was to gather academic words that were particularly important in medicine. They collected 819 academic words comprising 444 nouns, 133 verbs, 219 adjectives, and 23 adverbs. They claimed that those words not only were frequent and dispersed in medical texts, but all had "special medical meanings" (p. 46). Similarly, Roesler (2021) identified many specialized academic words, focusing on the area of computer science (CS), and extracted 904 frequent words from CS texts, which referred to "CS-specific meanings" (p. 1475). Unlike the current work, in which very few words were found to have specialized meanings, Lei and Liu (2016) and Roesler (2021) appeared to identify many such words. Therefore, we propose two explanations for these discrepant findings.

The first explanation concerns the "consistency" of word meanings in specialized and general texts. That is, both Lei and Liu's (2016) and Roesler's (2021) lists seem to include many words that show discipline-oriented meanings even in general-purpose texts. Some of these words are listed in Table 3. The words listed, such as *fertility* and *resilience*, have similar meanings (i.e., medical) in specialized and general texts. The words *predisposition* and *hemisphere*, which seem to be highly specialized terms in genetics and neurology, should also be considered in the general English vocabulary. Elkasović and Jelčić Čolakovac (2023) identified some words which show such discipline-specific meanings in both specialized and general-purpose English. They focused on maritime English and observed that maritime words such as *lighthouse* and *vicinity* were familiar to ESP students because of the high frequency of these words in general English. However, their study also determined that some of this type of specialized words would have low occurrences in general English (e.g., *excerpt* and *synopsis*). Their low frequency may prevent ESP students from effectively determining meaning using reading strategies. In short, similar to Elkasović and Jelčić Čolakovac's (2023) research, we also collected several words which showed specialized meanings in the respective area as well as in other fields. We do not consider these words to show specialized senses in specialized areas.

WORD	**MEANING IN BOTH MEDICAL AND GENERAL TEXTS**
Fertility	The ability to produce babies or seeds
Hemisphere	One half of the brain
Inheritance	Qualities inherited from family
Maturation	Period for developing or growing
Predisposition	Tending to suffer from a disease
Resilience	Ability to become strong or healthy again
Trait	Quality in a person's character

Table 3. Words showing medical senses across disciplines

The second and crucial explanation is that Lei and Liu (2016) and Roesler (2021) seemed to include many words that were academic and not specialized in reality. Specifically, to select lexical items for their target areas, both studies consulted specialized dictionaries. However, the researchers did not seem to completely examine the word senses offered in the dictionaries and, thus, overlooked the fact that specialized dictionaries also contained headwords that were academic rather than specialized. Our study used the words *observation* and *preparation* included in Lei and Liu's (2016) list as examples. According to MWMED, *observation* in medicine refers to "close watch or examination (as to monitor or diagnose a condition)." Nonetheless, this sense is not very different from its generalized sense (i.e., watching something closely for a certain period of time). *Preparation*, which is often preceded by *medicinal* in medical texts, is not completely different from its general or academic meaning (i.e., preparing for something in advance). The reason these two words appear in medical dictionaries might be that they are frequently found in medical texts. However, their medical perceptions are almost identical to those of other professional disciplines. For researchers interested in discipline-specific word senses, consultation with specialized dictionaries does not seem to be a reliable approach.

Subsequently, we addressed the second research question and investigated how academic words are represented in medical dictionaries. To address this, we attempted to determine the number of the 129 candidate words included in medical dictionaries and examined their listed senses. Interestingly, although only a few of the candidate words were found to specialize in medicine, many appeared in the medical dictionary that we consulted. In MWMED, 45 candidate words are shown as headwords. However, only seven words in Table 2 have a medical sense. As for others, MWMED offers all academic or general-purpose rather than medical senses. It appears that there is a contradiction between our findings and those of medical dictionaries—academic words that do not refer to medical senses would still be included in medical dictionaries. We suggest two plausible explanations for this contradiction. The first is the selection of words by medical dictionaries. According to the preface of the MWMED, the dictionary selects the words that are "most frequently used" in both human and veterinary medicine. Consequently, the selected words included items related to diseases, drugs, medical procedures, and names of persons involved in the medical field. However, because MWMED, like most modern dictionaries, adopts a corpus-driven and frequency-based approach to select words, it is likely that it includes certain academic words that are particularly common in medical texts. The second concerns ESP students' actual needs. According to Peters and Fernández's (2013) empirical investigation of dictionary use, ESP learners require more help with academic vocabulary than with professional terminology. Focusing on architecture, Peters and Fernández (2013) attempted to identify 110 postgraduate students' dictionary utilizations when required to complete an in-class reading assignment. Surprisingly, the participants looked up far more academic words than words unique to specific areas. Peters and Fernández's (2013) findings highlight the importance of academic vocabulary for ESP learners, and it is likely that specialized dictionaries, including MWMED, contain academic words as entries.

Additionally, as noted in Section 3.3., our study examined whether there were collocations that were important medical terms and worth listing as entries in medical dictionaries. Specifically, the collocations examined were composed of candidate and common collocating words. In total, the two experts identified 72 collocations that they believed were medical terminology. The word *elimination*, for instance, mostly refers to the general sense of "removal of something" in medical texts. However, the collocation "*half-life elimination*" is an essential term worth learning for students of both medicine and pharmacy. A similar phenomenon has been observed for the nouns *coherence*, *misuse*, and *resonance*. In general, these words do not contain any specialized sense of medicine. However, the collocations that they comprise are important practices or concepts in the medical field, including *optical coherence tomography*, *prescription opioid misuse*, and *magnetic* *resonance imaging*. However, concerning medical dictionaries, we noticed that only 38 of the 72 collocations appeared in MWMED. Many crucial collocations (e.g., *memory consolidation*, *sleep fragmentation*, and *genomic instability*) were not included in MWMED. Thus, our results suggest that medical dictionaries should contain more multiword terms, which are valuable learning resources for medical students. As noted in Section 2, the ESP field shows that each discipline is characterized by unique multiword units. Green and Lambert (2019) reported that different disciplines share very few content word phrases. Among the 7,468 phrases that they identified as useful for eight disciplines, only 8 were shared by all disciplines. Rees (2016) has reported similar findings in academic vocabulary research; using a corpus pattern analysis, the researcher demonstrated that academic words tend to take markedly different collocates in different disciplines. For example, *assemble* in history was more likely to co-occur with words which are of the semantic type "group" (e.g., *delegations* and *spectators*). However, in microbiology, it tends to appear with physical objects (e.g., *unigenes* and *contigs*). In our study, we identified several collocations unique to medicine, which are important specialized usages for medical students, and it has been suggested that medical dictionaries contain many of them.

5. CONCLUSIONS

Coxhead's (2000) AWL and Gardner and Davies's (2014) AVL have been widely applied in classroom teaching and material preparation for more than two decades. The main reason for their popularity is that EAP instructors require a common set of academic words that can be conveniently used to teach students from different disciplines. Ideally, these words should be used frequently and are important across disciplines. Based on these words, instructors can efficiently prepare vocabulary-learning materials that meet most, if not all, EAP students' needs. However, the word usage may change over time. As Mitra et al. (2014) demonstrated, in time-varying texts, it could be observed that some words generate new senses (i.e., sense birth) and some meanings split into multiple senses (i.e., sense split). According to Hyland and Tse (2007), it is likely that new senses appear in different disciplines regarding the sense birth and split.

Studies such as those of Martínez et al. (2009), Lei and Liu (2016), and Roesler (2021) have attempted to support Hyland and Tse's (2007) argument, offering examples which show that academic words demonstrate specialized senses in the texts of agriculture, medicine, and CS. However, these findings have not been systematically investigated. In this study, we focused on medicine and examined whether most academic nouns tended to demonstrate medical senses. In general, our results do not confirm Hyland and Tse's (2007) viewpoint; we identified only seven words containing specialized senses based on AVL nouns. By contrast, our findings support Coxhead (2011) and Nation's (Coxhead, personal communication, January 17, 2011) suggestions. According to them, few academic words have specialized senses in different disciplines. When academic words appear in specialized areas, their senses are similar to those in generalized texts. Practically speaking, our findings confirm the suitability of cross-disciplinary word lists as teaching materials for EAP learners. As academic words mostly do not have specialized senses in particular domains, teachers can deliver their academic senses to students across domains and do not have to worry that the words would show technical senses.

Furthermore, in this study, we found that collocations contained academic words rather than words themselves, which are important terms in medical texts. Consequently, medical dictionaries should list these multiword terms as entries, rather than single words. However, it should be noted that this study focused only on the medical field. Future studies should examine our findings in different academic disciplines, and only in this way, we can obtain a complete picture of whether the meanings of academic words are specialized in different disciplines.

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