

サイエンティフィック・ライティング科目におけるエラー分析目的の診断テスト構築

The Construction of a Diagnostic Test for Error Analysis Purposes in Scientific Writing Courses

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ABSTRACT

本研究論文は、高等教育におけるサイエンティフィック・ライティング科目のための文法診断テストの構成概念上の妥当性を調査することに焦点を当てている。この目的のために、学習者によるサイエンティフィック・ライティングの文章の中に頻繁に見られるエラーを、文単位で分析した。文法診断テストのデザインの基本となるこれらのエラーは、以下の12カテゴリに渡る：代名詞、冠詞、名詞句、前置詞、接続詞、能動態／受動態、時制、主語動詞、不定詞／動名詞、不規則動詞、名詞化、修飾語。結果、文法診断テストの構成概念上の妥当性が認められ、客観的テスト形式（例：選択形式）において、エラー認識と文法理解度の両方を測ることが可能であることが示された。具体的には、文法診断テストで文法理解度を測るためには、選択肢の誤選択肢として“エラー認識”を含める必要性を示唆された。同様の文法診断テストの導入は、教育者が学習者の弱点を認識することで、より効果的な文法教育を提供することを可能にすると言える。

This study examines the construct validity of a diagnostic grammar test for scientific writing courses at tertiary institutions. For this purpose, a literary analysis of commonly encountered sentence-level errors in scientific texts was conducted. These errors formed the design-base for the diagnostic grammar test, for which 12 categories were identified: pronouns, articles, noun clusters, prepositions, conjunctions, voice, tense, subject-verb agreement, infinitive/gerund complements, irregular verbs, nominalizations, and modifiers. The results demonstrate the construct validity of a diagnostic grammar test when using objective testing formats

(i.e. multiple choice), provided that both error recognition and understanding of grammatical rules are tested. Specifically, findings show the need for “error recognition” distractors to be built within diagnostic tests in order to measure acquired grammatical proficiency. It is postulated that similar diagnostic grammar tests would allow instructors to offer more effective grammar instruction through identification of learner weaknesses.

1. Introduction

“In the modern world, every scientist who wants to publish their findings in an international, peer-reviewed journal must write in English. This [process] can be very challenging for people who are not native speakers of English” (Blackwell & Martin, 2011, p. 1). As this statement highlights, the emphasis on English writing skills places many non-native scientists at a distinct disadvantage compared to their native counterparts. This seems to be corroborated by findings from Bordage (2001) which revealed that well-written manuscripts accounted for 18.3% ($n=46$) of accepted medical education reports ($n=252$) by reviewers during the period of 1997 to 1998. This was second only to the importance and relevancy of the study at 20.2% ($n=51$). These findings help illustrate the relative importance that good English writing skills perform within the decision-making process for publication. Unfortunately, because scientific writing conventions place emphasis upon the conveyance of data through clear and concise language (Rogers, 2007), conventional writing teachers are often unable to support non-native scientists to the extent that they wish. This can be attributed in part to the training received by writing teachers during undergraduate writing courses which places primary emphasis on the development of rhetoric language and basic argumentative text structure. As Connor (1996) mentioned, it is only at the graduate-level where they are able to learn “the writing and argumentation [respective] of their specific disciplines” (p. 69). Therefore, unless significant changes can be brought

about to undergraduate writing courses at tertiary institutions, the only viable option left for many writing teachers is to help learners of scientific writing become aware of their own mistakes prior to fossilization. It is postulated that one of the more effective ways this can be achieved is through error analysis, even though error analysis itself has largely fallen into disuse amongst many scholars due to the impracticalities of differentiating “genuine” language errors from “normal” human error (Bebout, 1974; Corder, 1981; James, 1998; Lennon, 1991).

However, it is argued that emphasis should not be placed so much on explicitly defining learner errors as advocated by Lennon (1991), but rather on predicting potential areas of difficulties that are likely to cause problems to learners. Hence, what is being proposed is a shift away from interlanguage issues, and more towards improving learner writing skills through error awareness training. As James (1998) touched upon, one of the major benefits of error analysis is that it helps learners to notice their own errors. Taking this a step further, it can be hypothesized that this can be most effectively addressed in undergraduate writing courses through examination of specific sentence-level errors using a diagnostic testing format. As Hughes (2003) already highlighted, diagnostic testing provides an effective means for demonstrating not only what a learner already knows, but more importantly what a learner needs to know. This in turn has the merit of providing specific feedback to both the learner and the teacher. However, before we go into the construct of such a diagnostic grammar test, a literary analysis of some of the common sentence-level writing errors

found in scientific texts is a necessary prerequisite.

2. Common Sentence-Level Writing Errors in Scientific Texts

The following sections provide a summary of common sentence-level writing errors in scientific texts, as encountered within the literature. These errors were classified according to their grammatical function of which a total of twelve categories were identified: *pronouns* (2.1), *articles* (2.2), *noun clusters* (2.3), *prepositions* (2.4), *conjunctions* (2.5), *voice* (2.6), *tense* (2.7), *subject-verb agreement* (2.8), *infinitive/gerund complements* (2.9), *irregular verbs* (2.10), *nominalizations* (2.11), and *modifiers* (2.12). Although other forms of errors were also identified within the literature (e.g. jargon, punctuation, tautology), the above errors can be regarded as forming the “core” errors of scientific writing in terms of their central function in providing grammatical and semantic meaning to sentences. Where possible, primary emphasis was placed on employing examples of error directly cited from the relevant literature, as these have been sourced from actual errors found in student drafts and unedited texts in journal submissions (Hofmann, 2010). However, in cases where no suitable example was to be found, a hypothetical example illustrating the error under examination was modified from suitable texts. For illustrative purposes, secondary emphasis was placed on selecting examples with a medical or biomedical orientation in order to reduce the risk of topic variability from interfering with error analysis.

2.1 Pronouns

One of the most common sentence level errors found in scientific writing is the use of unclear pronouns (Gilpin & Patchet-Golubev, 2000; Hofmann, 2010). Pronouns can usually be classified according to their grammatical function in a sentence and includes amongst others: subject pronouns (e.g.

I, we), object pronouns (e.g. *it, them*), reflexive pronouns (e.g. *itself, themselves*), possessive pronouns (e.g. *its, theirs*) and demonstrative pronouns (e.g. *this, that*). They are often used to replace, or refer to nouns by occupying the same noun position in a sentence (Celce-Murcia & Larsen-Freeman, 1999). As a result, scientific writers have a tendency to use pronouns as a means to help reduce word redundancy in scientific texts (Lebrun, 2007). Unfortunately, this can often lead to sentences or passages becoming ambiguous as shown in Example 2.1a: (Hofmann, 2010, p. 62)

Example 2.1a with **Unclear Pronoun**: *Gram⁺ bacteria do not respond to these drugs. Thus, they were [deleted from the study].*

Example 2.1a with **Added Noun**: *Gram⁺ bacteria do not respond to these drugs. Thus, these drugs were [deleted from the study].*

In Example 2.1a, it is not clear to the reader what noun the pronoun “they” is referring to. Consequently, there are two possible interpretations of this sentence. One interpretation could be that because the *Gram⁺ bacteria* did not respond to the drugs, the *Gram⁺ bacteria* were dropped from the study. The other interpretation could be that because the *Gram⁺ bacteria* did not respond to the drugs, *the drugs* were dropped from the study. In order to avoid confusing the reader or editor, it is preferable in such cases to add a noun after the pronoun (i.e. *these drugs*). Apart from the use of unclear pronouns, scientific writers also commonly confuse usage of the relative pronouns *that* and *which* (Matthews & Matthews, 2008; O’Connor & Cargill, 2009; Rogers, 2007). A relative pronoun refers to a previous noun and is used to indicate the beginning of relative (i.e. subordinate) clause in a sentence (Radden & Dirven, 2007). As a result, relative pronouns serve to set apart the main clause from the subordinate clause (Dutwin, 2009). Because of this, the relative

pronouns *that* and *which* can be divided in most cases according to their clausal function. Thus, the relative pronoun *that* only occurs in conjunction with restrictive clauses (i.e. containing information that is essential to the meaning of the sentence) and does not take a preceding comma or preposition. In contrast, the relative pronoun *which* usually occurs in conjunction with non-restrictive clauses (i.e. containing information that is not essential to the meaning of the sentence) and takes a preceding comma or preposition (Matthews & Matthews, 2008; Rogers, 2007). While this general rule is useful for describing most situations, the relative pronoun *which* can also occur before restrictive clauses with a non-human subject (Haan, 1989; Radden & Dirven, 2007; Teschner & Evans, 2007). Because of this clausal overlap, many scientific writers tend to overuse the relative pronoun *which*, resulting in sentences similar to this hypothetical example modified from the *New England Journal of Medicine*: (Lallemant, Chang, Cohen, & Pecoul, 2011, p. 583)

Erroneous Example 2.1b: *The results of two recent studies^{4,5} generated strong evidence which protease-inhibitor-based therapies such as zidovudine, lamivudine, and lopinavir boosted with ritonavir should be used extensively in HIV-infected infants.*

Revised Example 2.1b: *The results of two recent studies^{4,5} generated strong evidence that protease-inhibitor-based therapies such as zidovudine, lamivudine, and lopinavir boosted with ritonavir should be used extensively in HIV-infected infants.*

In Example 2.1b, the main clause “*the results of two recent studies generated strong evidence*” is separated by the relative clause “*protease-inhibitor-based therapies...*”. Although the use of the relative pronoun *which* would appear to be appropriate at

first glance, it is inappropriate due to the following two reasons. Firstly, Lapaire and Rotgé (1996) have suggested that the relative pronoun *that* be used when presenting pre-established facts, and the relative pronoun *which* be used when presenting un-established facts that require preliminary explanations. Secondly, O’ Connor and Cargill (2009) have pointed out that usage of the relative pronoun *that* or *which* in restrictive clauses is dependent upon cultural practices, with American journals only accepting the former, while as British journals allow for both conventions. Consequently, Example 2.1b requires the relative pronoun *that* since a pre-established fact is being presented in an American journal.

2. 2 Articles

“The English article system is one of the most difficult aspects of English grammar for non-native speakers and one of the [last] to be fully acquired” (Master, 1990, p. 461). This statement effectively highlights the reason why errors involving article usage continually persists in L2 scientific writing (Day & Gastel, 2011; Glasman-Deal, 2010; Hofmann, 2010; Master, 1986; Matthews & Matthews, 2008; O’ Connor & Cargill, 2009; Skern, 2009). Furthermore, a survey conducted by Cho (2009) revealed that EFL graduate students in the sciences considered the English article system to be the most problematic area in their writing. For L2 writers, the difficulty in acquiring the English article system can be ascribed to the complexity governing its structural rules that allows for considerable overlap between article usage. The English article system is composed of the indefinite articles *a/ an*, the definite article *the*, and the zero (\emptyset) article. Articles primarily serve to indicate noun countability, with count nouns being able to take all three articles types (e.g. a test tube, the test tube, test tubes) and non-count nouns being restricted to the definite article *the* or the zero article (e.g. the water, water).

Additionally, articles also help to convey generic meaning (i.e. indefiniteness) or specific meaning (i.e. definiteness) in a sentence. Generic meaning can be defined as when the subject being referred to applies to a whole entity, as encountered in the context of general statements of validity. In contrast, specific meaning is derived when the subject being referred to applies to an individual element, as encountered in the context of specific references to a topic. (Celce-Murcia & Larsen-Freeman, 1999; Master, 1990; 1994; 1997). Unfortunately, even with this distinction, there is considerable overlap in terms of article usage as the definite article *the* can express both generic and specific meaning (see Example 2.2d). Rather than just focusing on structure or meaning, Celce-Murcia and Larsen-Freeman (1999) stressed that articles must be understood in terms of their usage. However, the wide variability in article usage makes its dissemination through specific errors unprofitable. Rather, the L2 writer should keep the following grammatical points in mind in order to minimize article errors in scientific writing:

- 1) The indefinite article *a/an*, the definite article *the*, and the *zero* article can be used interchangeably for generic statements without loss of grammaticality as shown in Example 2.2a: (Glasman-Deal, 2010; p. 55)

Indefinite Example 2.2a: *An electroencephalograph is a machine for measuring brain waves.*

Definite Example 2.2a: *The electroencephalograph is a machine for measuring brain waves.*

Zero Example 2.2a: *Ø Electroencephalographs are machines for measuring brain waves.*

- 2) Usage of the definite article *the* or the *zero* article can alter the semantic meaning of a sentence as shown in Example 2.2b: (Glasman-Deal, 2010; p. 55)

Definite Example 2.2b: *The [synaptic] nodes were attached to **the** two adjacent receptor sites.* (There are only two receptor sites).

Zero Example 2.2b: *The [synaptic] nodes were attached to **Ø** two adjacent receptor sites.* (There are many receptor sites).

- 3) Usage of the indefinite article *a/an* is governed by phonological stress, with consonant sounds being preceded by the article *a*, and vowel sounds being preceded by the article *an* as highlighted in Example 2.2.c (Glasman-Deal, 2010; p. 55)

Example 2.2c with stressed consonant /y/: *A UV light [was used to determine bacterial count].*

Example 2.2c with stressed vowel /ɛ/: *An MRI scan [was used to determine brain activity].*

- 4) Only the definite article *the* can be used for all generic and specific references to anatomical parts or organs as highlighted in Example 2.2d: (Celce-Murcia & Larsen-Freeman, 1999, p. 286)

Generic Example 2.2d: ***The** lungs [assist in the intake of oxygen].*

Specific Example 2.2d: *[We examined] **the** lungs [of the patient].*

While as anatomical parts or organs are restricted to the definite article *the*, pathological terms (i.e. diseases) tend to vary in terms of what article they can be collocated with. For example, *cold* can only be collocated with the indefinite article (e.g. a cold), *flu* can only be collocated with the definite article (e.g. the flu), and *influenza* can only accept the *zero* article (e.g. influenza). Moreover, it is possible to have the same disease taking both the definite and *zero* article (e.g. the cancer, cancer). This variability in collocation coupled with the count distinction often leads to such errors as highlighted in Example 2.2e: (Celce-Murcia & Larsen-Freeman, 1999, p. 286)

Erroneous Example 2.2e: [*The patient suffered from] a cancer [in the lower intestinal tract].*]

Revised Example 2.2e: [*The patient suffered from] cancer [in the lower intestinal tract].*]

In Example 2.2e, a non-count (mass) noun *cancer* is being incorrectly collocated with the indefinite article *a*. Because the indefinite article *a* can only be used for signaling a count noun, it cannot be used in conjunction with a non-count noun. Thus, in this context, only the *zero* article can be successfully applied to the non-count noun. In order to avoid errors of this type, Celce-Murcia and Larsen-Freeman (1999) advised that pathological terms and articles be taught as a combined lexical unit (e.g. a hernia, a headache) wherever possible.

2.3 Noun Clusters

A noun cluster (i.e. compound noun) occurs when a noun is used to modify (i.e. describe) another noun (Hofmann, 2010; Matthews & Matthews, 2008; Raimes, 1998; Zeiger, 2000). In the English language, this usually takes the form of two nouns being combined (e.g. *heart rate*, *heart disease*) to form a single word (Matthews & Matthews, 2008; Zeiger, 2000). However, as Matthews and Mathews (2008) have pointed out, both L1 and L2 writers have a tendency to combine three or more modifiers in an effort to form concise sentences. Unfortunately, this can lead to sentences becoming unclear or confusing as shown in Example 2.3a: (Hofmann, 2010, p. 61)

Example 2.3a with **Unclear Noun Cluster**:
When the strips were exposed to Leishmaniasis diseased patient's sera, we found the bands of 112 and 45 kDa.

Example 2.3a with **Broken-up Noun Cluster**:
When the strips were exposed to sera of patients with Leishmaniasis disease, we found the bands of 112 and 45 kDa.

In Example 2.3a, the noun cluster “*Leishmaniasis diseased patient's sera*” tends to be difficult to read due to the lack of prepositions. As a result, the exact relationship between the nouns is left unclear; leading to the reader's attention being focused on the post-positional noun cluster “*patient's sera*”. To avoid this type of problem, it is always preferable (and easier) to break-up such noun clusters by the use of prepositions (Hofmann, 2010; Lindsay, 2011; Zeiger, 2000). Sometimes, however, the simple addition of prepositions is not enough. This is particularly true for ambiguous noun clusters as shown in Example 2.3b: (Halliday & Martin, 1993, p.77)

Example 2.3b with **Ambiguous Noun Cluster**:
[Results show that] lung cancer death rates are clearly associated with increased smoking.

Example 2.3b with **Separated Noun Cluster**:
[Results show that] high death rates from lung cancer in adults are linked to an increase in smoking.

In Example 2.3b, the noun cluster “*lung cancer death rates*” is ambiguous as it can be interpreted in several ways. As Halliday and Martin (1993) have pointed out, there exist three possible meanings for this noun cluster: “i) how many [adults] die from lung cancer, ii) how quickly [adults] die when they get lung cancer, or iii) how quickly [adult's] lungs die from cancer” (pp. 77-78). In such cases, it is often necessary to separate noun clusters through the addition of pertinent information needed to complete the meaning of the sentence.

2.4 Prepositions

While as L1 and L2 writers both have a tendency to omit prepositions in noun clusters, L2 writers are also prone to preposition overuse with respect to simple prepositions (Celce-Murcia & Larsen-Freeman, 1999; Hinkel, 2004). In the English

language, simple prepositions are one-word prepositions (e.g. *to*, *in*, *of*) that serve to delineate spatial, temporal, and logical relationships between words by preceding the object of a sentence. In addition, some simple prepositions only co-occur with certain nouns, verbs, or adjectives such as *to substitute for* or *on the basis of* to form multiword (i.e. complex) prepositional clusters (Celce-Murcia & Larsen-Freeman, 1999; O' Dwyer, 2006). Because scientific writing relies heavily upon the use of prepositional clusters to explain the relationship of one thing to another, determining whether the preposition modifies the following noun (i.e. injection of sample) or preceding verb (i.e. injected in sample) can be particularly challenging (Rubens, 2001). Additionally, Skern (2009) suggested that the difficulty in using prepositions in scientific writing could be as a result of grammatical differences between American and British English, with American journals (e.g. *Science*) requiring on average fewer prepositions per sentence than British journals (e.g. *Nature*). As a result, it is possible to assume that American editors would be stricter towards preposition overuse compared to their British counterparts. Taking this a step further, it can be hypothesized that overuse of prepositions amongst L2 scientific writers (Hampton, Emerson, & Mackay, 1999; Hofmann, 2010; Rogers, 2007; Rubens, 2001) is an indirect result of the dominance of American journals in the scientific literature. H-index data from the *Scientific Journal Rankings* (SJR) would seem to support this hypothesis (SCImago, 2007). Simply defined, h-index is a citation-based index that measures the number of papers produced over the number of citations received (Kelly & Jennions, 2006). For example, an h-index of 100 means that 100 papers were published, each of which has been cited over 100 times. An h-index comparison (SCImago, 2007) between the U.S. and U.K. in 2010 reveals the following numbers per discipline: Medicine (784

vs. 508), Chemistry (447 vs. 255), Engineering (433 vs. 213), and Mathematics (281 vs. 148). Since the probability of a publication or citation being derived from an American journal will be higher, it can be expected that overuse of prepositions would be a common and recurring source of error amongst L2 writers. Among the prepositions commonly overused in scientific writing, are the simple prepositions: *by*, *in*, *of*, *on*, *to*, and *with* (Hampton, Emerson, & Mackay, 1999). Preposition overuse can be especially noticeable in the passive voice, resulting in an unbalanced ratio of prepositions per word as evident in Example 2.4a: (Rogers, 2007, p. 71)

Erroneous Example 2.4a: *The data from the participants of younger age in this study were compared with those of subjects of older age by an analysis of variance.*

Revised Example 2.4a: *In the study, we compared the data from the younger and older subjects by an analysis of variance.*

In the original example, the number of prepositions ($p=8$) per words ($w=25$) results in a ratio of 1:3 ($r=3.13$). Consequently, a high ratio of prepositions per word often leads to sentences becoming syntactically complex and difficult to read. In order to achieve an acceptable balance between the number of prepositions per word, Rogers (2007) stressed the need to employ a ratio of less than 1:4. This method can be a useful means for checking prepositional coherence in re-worded sentences. If we apply this rule to the revised example, we find that the number of prepositions ($p=4$) per words ($w=18$) results in a ratio of 1:4 ($r=4.50$). Therefore, it can be stated that the revised example is structurally coherent in terms of prepositional usage. It should also be noted that the use of the active voice also helps to reduce prepositional use, thereby considerably shortening the sentence.

2.5 Conjunctions

Like prepositions, conjunctions help to link words, phrases, or clauses in a sentence. However, unlike prepositions, conjunctions are used to illustrate the relationship of one concept or idea to another (Young, 2009). As such, it is possible to classify conjunctions into three separate categories: coordinating conjunctions, correlative conjunctions, and subordinating conjunctions (Fogiel, 1984). Coordinating conjunctions are sometimes preceded, but never followed by a comma. Amongst the most commonly used coordinating conjunctions in the English language are: *and*, *but*, *for*, *nor*, *or*, *so*, and *yet*. These mainly occur in the middle of the sentence and are expressively used to connect elements that have a similar or equivalent (i.e. parallel) grammatical structure (Celce-Murcia & Larsen-Freeman, 1999; Fogiel, 1984; Young, 2009). In addition, certain transitional words also function as coordinating conjunctions in the English language such as: *accordingly*, *consequently*, *hence*, *however*, *moreover*, *then*, *therefore*, and *thus*. These can be distinguished through the usage of a preceding semicolon (instead of a comma) when connecting two independent clauses (Quirk, Greenbaum, Leech, & Svartvik, 1985; Terryberry, 2005). Correlative (i.e. paired) conjunctions are similar to coordinating conjunctions as they also help join parallel elements in a sentence. Amongst the most commonly used correlative conjunctions in the English language are: *both...and*, *either...or*, *neither...nor*, *not...but*, *although...yet*, and *not only...but also*. Because correlative conjunctions co-occur in different parts of the sentence, they are the most syntactically complex form of conjunctions (Celce-Murcia & Larsen-Freeman, 1999; Fogiel, 1984). Unlike coordinating or correlative conjunctions, subordinating conjunctions are used to make one element of a sentence subordinate (i.e. dependent) to the other. Thus, an independent clause can be turned into a dependent clause through the use of

a subordinating conjunction (Feigenbaum, 1985; Williams, 1999). Commonly used subordinating conjunctions includes: *as*, *after*, *because*, *if*, *since*, *than*, *though*, *unless*, *when*, *whereas*, *while*, and *until*. Subordinating conjunctions can occur at the beginning or in the middle of a sentence. However, the latter position tends to be more prevalent in scientific writing as subordinating conjunctions are mainly used when illustrating causal or comparative relationships between objects (Young, 2009). In scientific writing, errors involving conjunctions tend to mainly occur when a comparison is being made or a list is being presented (Hofmann, 2010; Matthews & Matthews, 2008; Rogers, 2007; Zeiger, 2000). In particular, L2 scientific writers have a tendency to shorten sentences by omitting the comparative clause (Hofmann, 2010). This can lead to incomplete comparisons being made as shown in Example 2.5a: (Zeiger, 2000, p.41)

Erroneous Example 2.5a: *Cardiac output was higher in the experimental group.*

Revised Example 2.5a: *Cardiac output was higher in the experimental group than in the control group.*

In Example 2.5a, it is not clear to the reader what the experimental group is being compared to without prior information. In order to avoid having the reader guess the content of the sentence, a dependent clause is required. In addition, the dependent clause needs to be preceded by the subordinating conjunction *than* followed by the preposition *in*, if a parallel sentence structure is to be maintained. As Hofmann (2010) stressed, the main merit in keeping a parallel-comparative sentence structure is that the reader is able to focus more on the content than on the grammar. In contrast, correlative conjunction errors tend to occur more frequently in lists that follow a parallel structure as shown in Example 2.5b: (Zeiger, 2000, p.44)

Unclear Example 2.5b: *The mechanical response of heart muscles depends on both the absolute osmolal increase and on the species studied.*

Revised Example 2.5b: *The mechanical response of heart muscles depends both on the absolute osmolal increase and on the species studied.*

In Example 2.5b, the preposition *on* precedes the first correlative conjunction *both*, but follows the second correlative conjunction *and*, thereby resulting in a non-parallel structure. Although not grammatically incorrect, a non-parallel list structure tends to increase cognitive load making the sentence harder to read (Zeiger, 2000). In order to maintain a parallel structure, the correlative conjunction must precede the preposition in both cases (e.g. *both on, and on*). Alternatively, the preposition can be fronted before the first correlative conjunction, but must be deleted in the second correlative conjunction (e.g. *on both...and*). As can be seen from this example, correlative conjunctions and prepositions are to a certain extent mutually inclusive entities. From an instructional viewpoint, it is possible to hypothesize that integrated lessons focusing on preposition and conjunction usage for scientific writing would be more conducive for learning than separate instruction.

2. 6 Voice: Passive vs. Active

A linguistic feature that often recurs in both academic (Hinkel, 2002) and scientific (Hofmann, 2010) writing is the concept of voice. Voice is used to highlight the subject in a clause, and can take an active or passive form. In the active form, the subject carries out the action expressed by the verb. Thus, the verb is immediately preceded by a noun subject, thereby forming a direct sentence or statement. In the passive form, the subject undergoes the action expressed by the verb. Hence, the verb is immediately preceded by an auxiliary verb (e.g. *be, have, or get*), thereby forming an indirect

sentence or statement (Celce-Murcia & Larsen-Freeman, 1999; Matthews & Matthews, 2008). Consequently, the passive voice can be useful when it is desirable to write in a neutral manner as the focus is shifted away from the agent or cause (Stuart, 2007). Unfortunately, L2 scientific writers have a tendency to overuse the passive voice (Gilpin & Patchet-Golubev, 2000; Hofmann, 2010; Matthews & Matthews, 2008; Rogers, 2007). This can be detrimental to the writing process since the passive voice is limited to only transitive verbs (i.e. requiring a following object) such as “*Aspirin relieves pain*”. As a result, intransitive verbs (i.e. do not require an object) such as “*He smokes*” cannot be used in the passive, thereby limiting verb choice (Celce-Murcia & Larsen-Freeman, 1999). While it is true that some verbs can only be written in the passive (e.g. *be hospitalized, be scheduled, be born*), it is generally preferable to write using the active voice as it is more precise and requires less words (Hampton, Emerson, & Mackay, 1999; Matthews & Matthews, 2008; Rogers, 2007; Stuart, 2007; Yang, 1995). Furthermore, the use of the passive or active voice can significantly alter the meaning of a statement in terms of its validity as can be seen in this modified example: (Celce-Murcia & Larsen-Freeman, 1999, p. 348).

Passive Example 2.6a: *Pain is relieved by Aspirin.* (Inconsistent statement, pain can be also relieved by other types of drugs or physical therapies).

Active Example 2.6a: *Aspirin relieves pain.* (Consistent statement of all brands/forms of Aspirin).

In scientific writing, problems between selecting the passive or active voice often occurs in in-text citations as shown in Example 2.6b: (Matthews & Matthews, 2008, p. 142)

Passive Example 2.6b: *The genetic relationship [between milk yield and reproductive performance] was studied by Berger and Shanks (1981).*

Active Example 2.6b: *Berger and Shanks (1981) studied the genetic relationship [between milk yield and reproductive performance].*

In Example 2.6b, the use of the passive voice places emphasis on the topic (i.e. *genetic relationship*) rather than on the study (i.e. authors). From this, the citation can be misconstrued to imply that the “genetic relationship between milk yield and reproductive performance” was first discovered by the authors. In contrast, the use of the active voice highlights the study rather than the topic. Therefore, emphasis is shifted onto the findings of a particular study, than on its discovery.

2. 7 Tense: Simple Present vs. Simple Past

Compared to contemporary ESL/EFL grammar textbooks which advocate the teaching of tenses through the tense-aspect system (Celce-Murcia & Larsen-Freeman, 1999), tenses can usually be treated in isolation for scientific writing. In particular, the two main tenses commonly encountered in scientific texts are the simple present and simple past (Burrough-Boenisch, 2003; Hofmann, 2010; Matthews & Matthews, 2008; Rogers, 2007). The simple present tense is mainly used by the writer

to present previously validated knowledge, usually in the form of either published results or general statements of validity. In contrast, the simple past tense is used to describe all events yet to be validated and includes the writer/author’s findings, observations, and explicit conclusions (Burrough-Boenisch, 2003; Hofmann, 2010). Therefore, correct tense usage is perhaps the single most important aspect of scientific writing as tense is used to delineate the status of work in scientific texts (Matthews & Matthews, 2008). Table 1 exemplifies tense usage in scientific writing per journal section (Rogers, 2007, pp. 43-44).

While these tense conventions generally apply to academic writing as well, there are certain differences which need to be pointed out. In particular, Swales (1990) noted that the simple present tense tends to be used almost exclusively in the discussion and conclusion sections of academic texts, while as the simple past tense tends to predominate in the literature review section. Hinkel (2002) took this a step further by pointing out that both tenses tend to co-occur in the introduction section, with the simple present being used for descriptions and the simple past being used for literary references. Additionally, because academic writing places more emphasis on rhetoric, it allows for a greater degree of tense variability to occur within paragraphs. However, this significantly complicates any transition from

Table 1
Tense Usage per Journal Section

Journal Section	Tense Usage*
Abstract	Simple Past
Introduction	Simple Present
Methods/Materials	Simple Past
Results	Simple Past
Tables/Figures	Simple Present
Discussion/Conclusion	Simple Present + Simple Past

*Future and perfect tenses omitted since rarely used (Rogers, 2007).

academic to scientific writing. Hence, a common problem amongst many scientific writers with ESL backgrounds is the mixing up of the simple present or simple past tenses in the introduction as shown in Example 2.7a: (Rogers, 2007, p. 140)

Erroneous Example 2.7a: *It has long been known that smoking increased the risk of cardiovascular disease.*

Revised Example 2.7a: *It has long been known that smoking increases the risk of cardiovascular disease.*

In Example 2.7a, previously validated knowledge is being presented as can be evinced from the phrase “has long been known”. Therefore, the verb *increase* needs to be changed from the simple past *increased* to the simple present *increases*. Failure to do so would imply that the writer is either challenging a known fact or principle, or worse, claiming credit for someone else’s work (Hofmann, 2010). This could lead to the reader misinterpreting facts, as well as breaching journal ethics standards with regards to plagiarism. The problem of mixed up tenses is further compounded in the Discussion section, when both tenses can be presented in the same sentence or paragraph as shown in Example 2.7b: (Hofmann, 2010, p. 54)

Erroneous Example 2.7b: *Sultan (1991) observes that certain species of bacteria responded to light stimuli.*

Revised Example 2.7b: *Sultan (1991) observed that certain species of bacteria respond to light stimuli.*

In Example 2.7b, an attempt was made to combine the findings of an experiment with previously validated knowledge. However, because the findings have yet to be validated, the verb *observe* needs to be changed from the simple present *observes* to

the simple past *observed*. Conversely, the phrase “bacteria respond(s) to light stimuli” is a general statement of validity, thus the verb *respond* needs to be changed from the simple past *responded* to the simple present *respond*.

2. 8 Subject–Verb Agreement

Aside from incorrect tense usage, another form of error that is semantically detrimental to scientific texts is subject-verb count agreement (i.e. concordance). In scientific texts, errors of this type can mainly be categorized into either incorrect usage of the third person singular inflection –s or improper concordance of the verb (Hofmann, 2010; Rogers, 2007). Incorrect usage of the third person singular inflection –s can be particularly evident amongst writers whose first language does not inflect subject-verb agreement as in the case of topic-prominent languages like Japanese, Korean, or Chinese (Celce-Murcia & Larsen-Freeman, 1999). Consequently, scientific writers coming from an EFL background tend to be more prone to neglecting or overusing the third person singular inflection –s, as shown in this revised Example 2.8a: (Hofmann, 2010, p. 96)

Erroneous Example 2.8a: *This patient require a blood transfusion.*

Revised Example 2.8a: *This patient requires a blood transfusion.*

In Example 2.8a, the writer has simply omitted to apply the third person singular inflection –s rule to the verb *require*. Celce-Murcia and Larsen-Freeman (1999) have suggested that inflectional errors tend to be a reflection of the linguistic level of the learner, with beginning L2 writers being more prone to omit the third person singular inflection. Taking this a step further, it is possible to hypothesize that intermediate L2 writers are therefore more apt to overuse the third person singular inflection as they slowly acquire proficiency in its usage as can be seen in Example

2.8b: (Hofmann, 2010, p. 96)

Erroneous Example 2.8b: *EcoRI does not cuts RNA.*

Revised Example 2.8b: *EcoRI does not cut RNA.*

In Example 2.8b, the writer has over-applied the third person singular inflection *-s* rule to the verb *cut*. Instead, because the main verb *cut* is preceded by an auxiliary verb (i.e. *do*), it takes an infinitive form, thereby dropping the third person singular inflection *-s*. It should also be pointed out that while Example 2.8b can be classified as an overuse of the third person singular inflection *-s* rule, this type of error can equally be brought about through a lack of understanding in the use of infinitives. Unfortunately, inflectional errors tend to be difficult to rectify due to the wide range of situations where verb forms remain uninflected as in the case of modal auxiliaries or verbs following modals (Celce-Murcia & Larsen-Freeman, 1999; Leki, 1992).

In contrast, concordance errors tend to be easier to rectify since it is usually the case of simply matching the singular or plural noun form with its verb equivalent (Rogers, 2007; Yang, 1995). Improper concordance of a verb often arises when there are two or more different nouns within a single sentence, resulting in the writer losing track of subject-verb agreement (Matthews & Matthews, 2008). In this respect, both L1 and L2 writers alike tend to confuse count agreement between the subject and the verb as shown in Example 2.8c: (Hofmann, 2010, p. 75)

Erroneous Example 2.8c: *The blood, urine, and stool of each patient was examined.*

Revised Example 2.8c: *The blood, urine, and stool of each patient were examined.*

As can be seen in Example 2.8c, the writer mistakenly assumes the subject of the sentence as being the singular noun form “patient”, therefore

changes the verb *be* into its past tense, singular form *was*. However, because “patient” is the object of the preposition “of”, it cannot be the subject of the sentence. Hence, the subject of the sentence is the plural noun form “blood, urine, and stool”, therefore the verb also must take the plural form. Consequently, the verb *be* needs to be changed into its past tense, plural form *were*. To avoid errors of this type, it is suggested that particular attention either be paid to singular and plural verb forms (Hofmann, 2010) or to attach the subject and verb by temporarily omitting all words in between (Matthews & Matthews, 2008; Yang, 1995).

2. 9 Infinitive to–vs. Gerund–ing Complements

As previously mentioned, L2 scientific writers sometimes struggle with verb complements (Hofmann, 2010). In the English language, complementation of a verb (or adjective) is required before a noun phrase or embedded clause. Hence, a main verb can be followed by another verb taking the form of an infinitive or gerund. An infinitive is classified as the base form of the verb, and is normally preceded by the preposition *to*–. Conversely, a gerund is a verb form taking an *–ing* inflection, and is used to express an action that has been completed in the past or is presently ongoing (Celce-Murcia & Larsen-Freeman, 1999). While most verbs can only be used in the infinitive or gerund form, there are certain situations when both the infinitive and gerund can be used. These overlapping verbs can be categorized according to semantic function with verbs such as: *attempt, begin, cease, commence, continue, hate, intend, like, love, omit, prefer*, and *start* displaying little or no change in meaning, while as verbs such as: *forget, regret, remember, stop*, and *try* having a significant impact on the meaning of a sentence (Alexander, 1988; Celce-Murcia & Larsen-Freeman, 1999; Hofmann, 2010). Even though one is able to eliminate the use of emotive verbs (i.e. *hate, like, love, regret*) in

scientific writing, this area still proves to be a major source of concern amongst L2 scientific writers (Cho, 2009). Thus, depending upon whether the infinitive or gerund form is used, the meaning of the sentence can differ to a significant degree. This in turn can lead to potential misinterpretation or confusion on the part of the native English-speaking editor or reader (Celce-Murcia & Larsen-Freeman, 1999). Furthermore, differences in semantic meaning can sometimes become more pronounced if an overlapping verb such as *try* is complemented with a concrete verb (i.e. *mix*) as can be seen in Example 2.9a: (Hofmann, 2010, p. 97)

Example 2.9a using **Infinitive to-**: *We tried to mix hydrochloric acid (HCl) with sodium hydroxide (NaOH).*

Example 2.9a using **Gerund -ing**: *We tried mixing hydrochloric acid (HCl) with sodium hydroxide (NaOH).*

In Example 2.9a, the semantic meaning of the sentence is entirely dependent upon either the use of the infinitive or gerund form. If the infinitive was to be used, the sentence can cast doubt on whether or not the experimenters were actually able to undertake the action of mixing hydrochloric acid with sodium hydroxide, thereby suggesting an element of uncertainty. Consequently, the reader is left guessing as to the outcome of the experiment due to the sentence being presented in a neutral manner. In contrast, if the main verb was to take the gerund *-ing*, the sentence affirms that the experimenters were able to undertake the action of mixing hydrochloric acid with sodium hydroxide, thereby suggesting an element of certainty. Hence, the reader is able to envisage the outcome of the experiment due to the sentence being presented in an active manner. However, semantic meaning can also become unclear if an overlapping verb such as *continue* is used in conjunction with an abstract

verb (i.e. *measure*) as can be seen in Example 2.9b: (Hofmann, 2010, p. 97).

Example 2.9b using **Infinitive to-**: *We continued to measure changes in blood pressure.*

Example 2.9b using **Gerund -ing**: *We continued measuring changes in blood pressure.*

In Example 2.9b, the semantic meaning of the sentence can be subtly altered by the use of either the infinitive or gerund form. If the infinitive was to be used, the sentence can be construed to imply that the focus of the study was to measure for any changes in blood pressure. Therefore, there is a degree of uncertainty since it is not clear whether a change in blood pressure occurs. In contrast, if the main verb was to take the gerund *-ing*, the sentence can be construed to imply that the focus of the experiment was to measure for the change in blood pressure. Hence, there is a degree of certainty since a change in blood pressure does occur. As can be seen in both examples, there is a correlation between events of uncertainty for infinitives and events of certainty for gerunds. This correlative principle was first suggested by Bolinger (1968) as a means for distinguishing between the use of the infinitive or gerund in the case of most overlapping verbs. Consequently, to reduce errors of this type, it is suggested that L2 writers receive further training in semantics in order to help improve awareness and understanding of the differences between infinitive and gerund verb complements (Celce-Murcia & Larsen-Freeman, 1999).

2. 10 Irregular Verbs

Although less frequent than tense, concordance, or complementation errors, irregular verbs can also cause confusion for some L2 scientific writers. Verbs are classified as being irregular if tense variation occurs in its infinitive (i.e. base form), simple past, or past participle forms. Turton (1995) expressed tense

variability as taking the form of either: 1) verbs that share the same simple past and past participle forms (e.g. *find, found, found*); 2) verbs that share the same infinitive, simple past, and past participle forms (e.g. *spread, spread, spread*); and 3) verbs that differ in their infinitive, simple past, and past participle forms (e.g. *show, showed, shown*). In addition, compound verbs also exhibit tense variation and are often classified as irregular verbs within the literature. For example, the compound verb *understand* shares the same simple past and past participle form (e.g. *understand, understood, understood*). However, because there are over 188 irregular verbs within the English language (Lester, Franklin, & Yokota, 2010), a detailed analysis of irregular verb errors would be impractical. Rather, it is proposed to focus on errors involving irregular verbs that share the same infinitive, simple past, and past participle forms since these seem to recur often in scientific writing as evinced in Example 2.10a: (Hofmann, 2010, p. 94)

Erroneous Example 2.10a: *The insert was cutted by EcoRI.*

Revised Example 2.10a: *The insert was cut by EcoRI.*

As can be seen in Example 2.10a, the writer has mistakenly applied the past participle *-ed* ending for regular verbs to the verb *cut*. However, since the verb *cut* is irregular and does not exhibit change in either its infinitive, simple past, or past participle forms, it needs to be left in its base form. In order to reduce errors of this type, L2 scientific writers first need to be aware of the differences between regular and irregular verbs with respect to form, and receive additional training in irregular verb recognition. Additionally, it can be postulated that a frequency chart of irregular verbs in scientific writing would be highly beneficial for training purposes.

2. 11 Nominalizations

In addition to standard verb form errors, L2 scientific writers have a tendency to overuse nominalizations, particularly when defining well-established scientific processes using passive clauses (Cohen, Palmer, & Hunter, 2008; Halliday & Martin, 1993; Hofmann, 2010; Matthews & Matthews, 2008). This is because nominalizations provide the writer with a means to delete information with respect to time, participants, and modality (Billig, 2008; Fowler, 1991). Gledhill (2000) takes this a step further by pointing out that the use of nominalizations in scientific writing is used deliberately in order to obscure authorial responsibility and agency. Broadly defined, nominalizations can be classified into two distinct syntactic categories: derivationally marked and morphologically unmarked nominalizations (Cohen, Palmer, & Hunter, 2008; Levin, 1993). In derivationally marked nominalizations, the base form of a verb (or adjective) functions as an abstract noun through the addition of a derivational suffix (e.g. *react* → *reaction*). Commonly encountered suffixes in scientific writing include: *-ance*, *-ion*, *-ing*, *-ment*, and *-tion* (Hampton, Emerson, & Mackay, 1999). However, in morphologically unmarked nominalizations, the base form of a verb (or adjective) still functions as an abstract noun without the need for a suffix (e.g. *increase* → *increase*). Even though nominalizations can be useful when referring to a previous statement (i.e. *This observation led us to conclude...*), they should generally be avoided as they do not express tense (Hofmann, 2010, p. 59). This can lead to sentences becoming syntactically complex and ambiguous, since the tense (action) is no longer expressed by the main verb as shown in Example 2.11a: (Matthews & Matthews, 2008, p. 141)

Nominalized Example 2.11a: *Results showed **protection** by the vaccine, but **degeneration** of*

lymphocytes occurred.

Improved Example 2.11a: *Results show that the vaccine **protected** the patients, but their lymphocytes **degenerated**.*

In Example 2.11a, the semantic meaning of the sentence becomes blurred through the use of derivationally marked nominalizations (i.e. *protection, degeneration*), because the verb being acted upon (i.e. *show, occur*) is not the main verb. This makes the sentence difficult to understand, as the reader or editor usually associates the action of the sentence with the main verb (Celce-Murcia & Larsen-Freeman, 1999). In addition, an abstract subject (i.e. *results*) is being collocated with an indirect object (i.e. *protection*). Thus, without prior knowledge, it cannot be determined from the sentence what is being protected. In order to reduce ambiguity, one should alter the sentence by replacing all nominalizations with the active form of the verb (i.e. *protected, degenerated*) and collocate a concrete subject (i.e. *the vaccine*) with a direct object (i.e. *the patients*) in the independent clause. Furthermore, the dependent clause needs to be modified through the addition of a possessive pronoun (i.e. *their*). Because such sentences often require the sentence to be rewritten, correcting nominalization errors can be a difficult and time-consuming process. To simplify the process, Hofmann (2010) suggested an eight-layered analysis approach which includes identifying the central topic of the sentence as the subject, changing all nominalizations into its active verb form, and rewriting the sentence in order to form independent and dependent clauses through the use of conjunctions.

2. 12 Modifiers

A modifier is a word or group of words that help describe the meaning of another word by providing grammatical or lexical information. As such, most modifiers can be classified into two categories:

adjectives (i.e. *large sample*) and adverbs (i.e. *statistically significant*). In addition, certain nouns (i.e. *tissue graft*) and prepositional phrases or clauses can also function as a modifier (Fowler, 1980; O'Dwyer, 2006; Hopper, Gale, Foote, & Griffith, 2010; Stilman, 2004). In scientific writing, modifiers are frequently either overused or misplaced resulting in sentences becoming unclear or ambiguous (Gilpin & Patchet-Golubev, 2000; Hofmann, 2010; Humphrey & Holmes, 2009; Matthews & Matthews, 2008; Rogers, 2007, Yang, 1995). Taylor (2005) takes this a step further by pointing out that excessive usage of modifiers is a predominant feature in clinical notes as a result of the writer trying to condense information in a limited amount of time, and that these are sometimes inadvertently carried over into research articles. However, usage of modifiers in scientific statements should always be reduced to a bare minimum since the main goal of scientific writing is the reporting of data in a clear and concise manner (Matthews & Matthews, 2008, Rogers, 2007). Failure to do so can result in the content of scientific statements becoming obscure as shown in Example 2.12a: (Rogers, 2007, p. 74)

Erroneous Example 2.12a: *These impressive as well as clinically and statistically significant data are of great and unique importance to this rather poorly researched field of neurobiological science and will substantially add to the presently still modest knowledge of cognitive processing in the elderly.*

Revised Example 2.12a: *These statistically significant data substantially add to our understanding of cognitive processing in the elderly.*

In Example 2.12a, a total of 10 modifiers are being used to form a concluding statement consisting of 41 words. In contrast, the revised example uses only 4 modifiers to form a concluding statement of 16

words. From this, it is possible to draw the following three inferences: 1) excessive usage of modifiers significantly adds to the overall length of a sentence or paragraph, 2) excessive usage of modifiers prevents the reader from focusing on the key parts of the conclusion such as *statistically significant data*, *add to*, and *knowledge of cognitive processing in the elderly*, and 3) excessive usage of modifiers tends to occur throughout the sentence with no definitive pattern. In contrast, misplaced modifiers, also known as dangling modifiers, tend to occur at the beginning (i.e. as an introductory clause) or at the end of a sentence (Hofmann, 2010; Matthews & Matthews, 2008). Errors involving misplaced modifiers transpire when its implied subject differs from the subject of the main clause, often as a result of the modifier being separated from the word or phrase that it directly modifies (Hofmann, 2010; Matthews & Matthews, 2008; Rogers, 2007). This can lead to grammatical ambiguity as it is no longer evident whether the subject or object of a clause is being modified as shown in Example 2.12b: (Hofmann, 2010, p. 77)

Dangling Example 2.12b: *While incubating at 30 °C, we added another 10 ml of buffer K to the samples.*

Dependent clause Example 2.12b: *While the samples were incubating at 30 °C, we added another 10 ml of buffer K.*

Subjects agree Example 2.12b: *We added another 10 ml of buffer K to the samples while they were incubating at 30 °C.*

In Example 2.12b, the modifying phrase *while incubating* has been incorrectly fronted before the subject of the main clause *we*, causing its implied subject *the samples* to become separated. As a result, grammatical construct would imply that the researchers (i.e. *we*) were incubating at 30 °C, instead of the samples. To prevent such errors from

occurring, it is recommended that the sentence either be turned into a dependent clause or have both subjects agree with each other (Matthews & Matthews, 2008). If the sentence were to be turned into a dependent clause, the noun being modified upon (i.e. *the samples*) needs to be fronted with the modifier to form an introductory clause (i.e. *while the samples were incubating at 30 °C*). In contrast, to have both subjects agree within the same sentence, the sentence first needs to be changed into the active voice and the noun being modified upon needs to be collocated with the modifier through the addition of a personal pronoun (i.e. *they*).

3. Results

In order to assess a learner's grammatical competence, Hughes (2003) urged the usage of diagnostic tests as it offers learners the possibility to examine "what gaps exist in their grammatical repertoire" (p. 173). Additionally, compared to tests of overall writing ability that are often narrow in scope, diagnostic tests allow for a broader range of items to be tested which helps to improve content validity. Unfortunately, good diagnostic language tests tend to be rare, with very little consensus amongst experts on how it should be constructed (Alderson, 2007; Alderson, Clapham, & Wall, 1995). The only general agreement on construct seems to suggest that diagnostic tests be designed to allow for the consistent scoring of items as found under discrete testing formats (e.g. multiple choice), in order to ensure some degree of test reliability (Alderson, 2005; Hughes, 2003). However, because there is always the risk of the learner correctly guessing an answer under a multiple choice format, it is proposed that both error recognition and understanding of grammatical rules be evaluated in diagnostic grammar tests. In this way, it is possible to reduce the risk of the learner correctly guessing an answer as both the error type and problem need

to be correctly identified (see Table 2). Moreover, the inclusion of “error recognition” distractors within diagnostic tests of this type also needs to be considered in order to prevent the learner from predicting error patterns. However, because it is not possible to simply adapt an existing diagnostic language test (e.g. DIALANG) due to a number of constraints (e.g. CALL limitations, lack of scientific content, copyright restrictions), a specifically designed diagnostic test for learners’ enrolled in scientific writing courses needs to be constructed. Although by no means complete, Table 2 helps to illustrate how such a diagnostic grammar test for scientific writing courses might be constructed. As can be seen in Table 2, a total of 15 test items with

a biomedical or medical orientation were selected from various literary sources for the construct of this diagnostic test. Of these, 3 test items (no. 3, 8, & 14) serve as “error recognition” distractors as they illustrate examples of acceptable scientific writing. Although it is possible to envision a longer test with additional “error recognition” distractors to help improve construct validity, it was deemed more conducive for instructional purposes if the number of test items were limited to a bare minimum for it to be effectively administered during a 60–90 minute undergraduate scientific writing class.

Table 2
Sample Diagnostic Grammar Test for Scientific Writing Courses

Item	Example*	Error Type		Problem
1	<i>The patient suffered from a cancer in the lower intestinal tract.</i> (Celce-Murcia & Larsen-Freeman, 1999, p. 286)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
2	<i>The data from the participants of younger age in this study were compared with those of subjects of older age by an analysis of variance.</i> (Rogers, 2007, p. 71)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
3	<i>We used cultures of endothelial cells from the tracheas of rats.</i> (Hofmann, 2010, p. 61)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None

4	<i>The mechanical response of heart muscles depends on both the absolute osmolal increase and on the species studied.</i> (Zeiger, 2000, p.44)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
5	<i>We tried to mix hydrochloric acid (HCl) with sodium hydroxide (NaOH).</i> (Hofmann, 2010, p. 97)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
6	<i>Sultan (1991) observes that certain species of bacteria responded to light stimuli.</i> (Hofmann, 2010, p. 54)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
7	<i>The genetic relationship between milk yield and reproductive performance was studied by Berger and Shanks (1981).</i> (Matthews & Matthews, 2008, p. 142)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
8	<i>We used an aliquot to determine DNA concentration.</i> (Hofmann, 2010, p. 93)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
9	<i>The blood, urine, and stool of each patient was examined.</i> (Hofmann, 2010, p. 75)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None

10	<i>The insert was cutted by EcoRI.</i> (Hofmann, 2010, p. 94)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
11	<i>These impressive as well as clinically and statistically significant data are of great and unique importance to this rather poorly researched field of neurobiological science and will substantially add to the presently still modest knowledge of cognitive processing in the elderly.</i> (Rogers, 2007, p. 74)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
12	<i>Results showed protection by the vaccine, but degeneration of lymphocytes occurred.</i> (Matthews & Matthews, 2008, p. 141)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
13	<i>Results show that lung cancer death rates are clearly associated with increased smoking.</i> (Halliday & Martin, 1993, p.77)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
14	<i>Acetylcholine was released in precisely controlled amounts from synaptic vesicles.</i> (Hofmann, 2010, p. 98)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None
15	<i>Gram+ bacteria do not respond to these drugs. Thus, they were deleted from the study.</i> (Hofmann, 2010, p. 62)	a) Article b) Conjunction c) Infinitive/Gerund d) Irregular verb e) Modifier f) Nominalization	g) Noun cluster h) Preposition i) Pronoun j) S-V agreement k) Tense l) Voice m) No error	a) Ambiguity b) Count agreement c) Count distinction d) Infinitive verb e) Mixed tense f) Non-parallelism g) Overuse h) None

*Examples derived from various literary sources.

4. Discussion

While Table 2 provides an example of what a diagnostic grammar test for scientific writing might look like, several design limitations need to be pointed out. Foremost, usage of such a diagnostic test presupposes that learners are at least aware of basic grammatical structures and their linguistic terminology. As such, it is perhaps preferable to limit usage of this kind of diagnostic test to ESL/EFL learners at tertiary institutions since it is questionable whether they would have acquired the necessary writing skills prior to completing secondary education. Additionally, it is unclear how far error recognition would be affected by learner understanding of scientific content within the items used. Thus, it might be preferable if learners were given an opportunity to review some of the scientific terminology prior to taking the diagnostic test. Furthermore, although the construct of this diagnostic test was developed around items derived from literary sources, it is possible to postulate that the use of actual examples produced by learners would significantly help to improve task authenticity. Another factor that needs to be considered is whether the large number of distractors (d) for the error type section ($d=12$) and the problem section ($d=7$) would adversely affect learner concentration levels, thereby mitigating the usefulness of performing this type of diagnostic test. Certainly, it can be expected that while a larger number of distractors would significantly reduce the chances of a learner guessing an answer correctly, the likelihood of a learner failing to identify an error simply due to inattention is likely to increase proportionately. As Hughes (2003) stressed, it is not possible to differentiate from these types of errors under a multiple choice format, thereby imposing some limits to any results obtained through this type of diagnostic test. In hindsight, it might be worthwhile to investigate the possibility of using other discrete testing formats

(e.g. gap filling, cloze) in conjunction with multiple choice for the construct of diagnostic grammar tests. As a final note, it must also be remarked upon that all 15 test items must undergo further moderation (i.e. evaluation) through informal trialing on both native and non-native speakers of English, before it can be used for diagnostic purposes. In particular, items which prove to be too difficult to learners or are likely to generate inappropriate responses must be rewritten or replaced (Alderson, Clapham, & Wall, 1995; Hughes, 2003). In the long-term, this can only be achieved through additional parallel studies involving formal trialing on a large number of learners enrolled in scientific writing courses. Despite these limitations, Table 2 still provides educators with some insight into the design construct of diagnostic grammar tests for scientific writing. Central to the construct of diagnostic grammar tests is the requirement to test both the learner's acquired and un-acquired grammatical knowledge through objective testing formats (Alderson, 2005). In the present study, Table 2 has demonstrated the construct validity of a diagnostic grammar test using a multiple choice format by testing for both error recognition and understanding of grammatical rules. It has also demonstrated the necessity for including "error recognition" distractors (i.e. examples of error-free writing) within the construct as an indicator of a learner's acquired grammatical proficiency. Furthermore, the emphasis towards recognition and explanation of grammatical problems through the usage of erroneous writing items sets it apart from other objective writing tests (e.g. cloze passages) that only emphasize production of error-free writing. It can be argued that part of the problem of poor scientific writing skills among Japanese scientists is due to the over-emphasis in undergraduate writing courses on language (i.e. written) production, and not enough on acquisition of key grammatical structures. Hence, the usage of diagnostic grammar tests such as Table 2 may offer educators with a partial

solution to this problem. However, further research needs to be conducted on its construct validity and reliability before it can be successfully put into practice in undergraduate writing courses at Japanese universities.

5. Conclusion

Usage of diagnostic grammar tests could potentially revolutionize grammar instruction at tertiary institutions by making acquisition of sentence-level structures more efficient. Rather than the current system of teaching grammar holistically regardless of the learners' strengths or weaknesses, it is possible to envision learners receiving more targeted instruction based on their grammatical needs (i.e. weaknesses). For example, if a diagnostic grammar test was to show that 50% of learners had problems with articles but only 25% had problems with conjunctions, the instructor could decide to increase the number of classes on articles by 2 and decrease the number of classes on conjunctions by 1. By being able to predict potential areas of difficulties in learners, the instructor is able to offer specific feedback to learners through grammar instruction that is specifically adjusted to their needs, thereby making meaningful acquisition more likely to occur. Thus, diagnostic grammar tests offer educators with an additional tool for improving the acquisition of sentence level structures, which in turn would likely translate towards an improvement in overall scientific writing skills amongst learners.

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