POLYSYLLABIC STRATUM ORDERING ANALYSIS IN SCIENTIFIC TEXT: A MORPHOLOGICAL STUDY

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Abstract:
The word formation is largely influenced by derivational affixes. These affixes however have certain level orderings called stratum ordering that lead to the formation of new words hierarchically. The study focuses on the investigation of the possible stratum ordering of derivational morphemes in scientific texts and the analysis of how these stratums form polysyllables derivational words. Qualitative research methodology is applied to this study. The data source of this study was taken from http://ijiemjournal.uns.ac.rs/v11/v11-01.html. This journal concerns Industrial Engineering and Management. The intended data are randomly taken from five journals published on Volume 11 | Issue 1 | March 2020 limited to polysyllables of scientific terms. The data were analyzed using the theory of Francis Katamba proposing that the central to lexical morphology is organized in a series of hierarchical strata and also Spencer (1991) supported by Plag and Baayen (2008). This paper concludes in general that the addition of derivational affixes to scientific terms is hierarchically structured based on the theory, such as the placement of strata 1 affixes closer to the root word, the neutrality of stress placement of strata 2 suffixes, and non-netrality of strata 1 suffixes. However, it is also found some inconsistencies in the placement of derivational suffixes in which the second strata are placed closer to the root. This happens when suffix -able is combined with *-ity* in **availability** (adjective to noun) or when suffix *-ize* is combined with -ion to form verb to noun in parameterization. The most formations found is the use of suffixes -ion, -ity for nouns, -ize for verbs, -ive and -able for adjectives.

Keyword:
Polysyllables; stratum ordering; affixes; derivational; morphology

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INTRODUCTION

Words are used to communicate with others in spoken and written forms. These words are conveyed or combined in how to deliver the messages effectively. However, have we ever thought how these words are formed to be meaningful and grammatical words to create groups of words which are later used in sentences? When we come to this question, it is correlated to the term of morphology and then syntax. Morphology refers to the field of how words are formed. Booij (2010) states that morphology is the study of word formation. It rules the internal structure of words. In ruling the word, affixes can be added to fulfill the need of grammatical words and sentences.

Affixes are divided into two major parts; they are inflectional and derivational affixes. However, the study would only focus on derivational affixes which are randomly taken to represent scientific terms in scientific writing. Scientific writings use terminologies which are different from general languages. Arya D. J (2011) stated that the occurrence of rare words is one of the characteristics of science courses. Then this is one of the objectives of the study, to analyze how the word formations happen to the terminologies used in scientific articles through the analysis of the affixes strata which are specified to polysyllabic words. The data were taken from Industrial Engineering and Management journal as a random sample of credible writing relevant to the study.

Morphology cannot be separated from the fact that it helps to enrich vocabulary that is used in terms of writing or spoken. This enrichment exists through the attachment of affixes to certain words that forms new words, functions and meaning. This is called the derivational system. Derivation means a process of forming new words from the stem of bare words by adding prefixes, a prefix or suffix, or even both of them at the same time. Suffixes are the most productive in word formations in which they can shift the syntactic category and meaning of the root after any additions. However derivational prefixes only have the possibility to shift the meaning but not the lexical category (Tariq, et. al, 2020).

Although derivation has helped to enrich new words, not all speakers realize or comprehend the derivational affixes they use. In fact, derivational affixes have certain orderings which are also called stratum orderings that have to be obeyed when deriving new words. Therefore, the writer was interested in discussing the stratum ordering of derivational morphemes. There are two research questions that lead the writers to accomplish the study, they are the investigation of the possible stratum ordering of derivational morphemes in scientific texts and the analysis of how these stratums form derivational words. The theory used to analyze the result of the data was taken from Francis Katamba's theory (1993) proposing that lexical morphology consists of rules which are governed by hierarchical strata while attaching certain bound morphemes to the root which was supported by Plag and Baayen (2008) which have classified of stratum ordering into two levels (stratum 1 and 2).

LITERATURE REVIEW

Morphology

The term morphology refers to the word formation study of a language. According to Katamba (1993), morphology studies how words are formed and how internal structure of words are created. This was supported by Fromkin (2011:41) who said that morphology concerns about how words are formed through certain rules. Nida in Wibowo and Suyud (2014) . furthermore defined that morphology is the study of morphemes and their arrangements in word formation. Let's say 'organization'. This word is formed through the attachment of suffix '-ion' to the word base 'organize'. Studying morphology cannot be separated from understanding morphemes. One word might consist of one or more than one morphemes. Here are some examples;

One morpheme	sleep, create
Two morpheme	sleep + less, create + ive
Three morpheme	sleep + less + ness, create + ive + ity, clean-ly-ness
Four morphemes	un+ clean+ li + ness, un + desire + able + ity
more than four	un + gentle + man + li + ness, anti + dis + establish + ment + ari + an + ism

Morphemes

It has been described above that morphology is related to morphemes as the minimal unit of a word that has a meaning. Fromkin (2011) conveyed that a morpheme might consist of one syllable like 'big, dog' or maybe more than one syllables such as 'tradition, celebration' and other words which can be later proved through the use of transcription. Morphemes are categorized into two divisions, morphemes which are bound and free. Tariq et. al (2020) stated that free morphemes are those which can stand alone and have a complete meaning. It can be in a form of root words or other lexemes. Free morphemes are roots which can stand independently. For example: man, book, love, pain, walk, etc. Bound morphemes vice versa cannot stand alone but they have to be

attached to free morphemes to create meaningful words. Free morphemes are related to affixes both affixes and suffixes. For instance, the word 'homeless' consists of two morphemes, *'home'* as a free morpheme and '+ *less'* as a suffix belongs to a bound morpheme.

The enrichment of words can be done through the attachment of certain morphemes which are called affixes. Affix is a morpheme that cannot be the basis of word formation (Chaer in Kalee, Rasyid, & Muliastuti, 2018). Affixes in English are divided into two kinds: they are prefixes and suffixes. They are all categorized to bound morphemes because they cannot stand without base words. Prefixes are attached before the root and suffixes are put after based on words. For instance, the word 'insecurity' consists of *in-* as the prefix, *secure* is the root, *-ity* is the suffix. This example shows that prefix *in-* and suffix *-ity* cannot stand alone because they don't give full meaning.

Then prefixes and suffixes are also categorized into two based on their functional categories, the are inflectional and derivational morphemes. Inflectional morphemes can be prefixes or suffixes. Inflectional morphemes are those which do not change the grammatical category of root words. Bauer in Halawa, Raflis & Fetri (2017) stated that inflectional morphemes only add grammatical information to the words attached without changing the meaning of the lexical classification. Let's consider several examples to see the use of inflectional affixes in sentences.

1. The scientists make a breakthrough in technology.
2. The scientist makes a breakthrough in technology..
3. The scientist made a breakthrough in technology..
4. The scientist has made a breakthrough in technology.

From the sentences, the word 'make' comes through some changes grammatically depending on the subject and tense used. However, the lexical category of 'made' stays unchanged or it remains in 'verb' class despite some additional morphemes to the root. So this is called inflectional. Inflectional morphemes (*jenis-jenisnya*)

Unlike inflectional morphemes, derivational morphemes are suffixes or prefixes which possibly change the meaning and the class of words when they are attached to word stems. Tariq et. al (2020) stated that derivation could modify the meaning and also shift the syntactic category of the root.. For example, the word 'make + er' becomes 'maker'. The shifting of lexical category occurs in which 'make' as a verb becomes 'maker' as a noun. The word formation verb to noun happens to this process. Consider the following examples

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Noun to Adjective	**Verb to Noun**	**Adjective to Adverb**	**Adjective to verb**
boy + -ish	creat + -or	happy + - ly	en- + sure
delici+ -ous	occur + ance		dark + -en

From the above processes, it can be seen how derivational morphemes play parts in the changing of lexical categories of a word. In addition to the shifting of grammatical categories, derivation leads possibility in the shifting of word meaning like create (verb) to make something becoming creator (N) someone who makes something. There are a lot of kinds of derivational morphemes like -ive, -ous, -ness, -ity, -er, -ist, and other kinds of derivational morphemes which can be explain more clearly in the hierarchy strata.

Polysyllabic

Polysyllabic words describe a phenomenon where mostly words consist of more than three syllables. It can be formed through the result of monosyllabic, disyllabic, and trisyllabic. Further, prefixes and suffixes increase the syllables and the density of the words. The words in Polysyllabic come from other languages such as French and Latin. For example, architecture, calculation, derivation, evaluation, and verification. In this stage, prefixes or suffixes must be aligned with a good comprehension of basic rules to create polysyllabic words such as sustain, sustainable, and sustainability.

Polysyllabic describes how the process of the individual parts of the words are formed. In this case, the description of academic texts measures the complexity of syllables per word and the average words per sentence. Batovski (2009) states that a polysyllabic contains a detail pattern of

the word. The using of polysyllabic can be described as a way to examine the complexity of the text and the complexity of presentation. In writing, the sentences must be written to give an interpretation towards the content of the text. The variation of polysyllabic adjective to a noun form are allowed in several sentences in order to convey the different meanings.

The increase number of polysyllabic is attributed to the expansion of technical fields. Polysyllabic words which are presented in the popular publications are familiar for the readers. In introducing a long polysyllabic in writing, the paragraphs should be contained of synonym, acronym, or special symbols.

The Hierarchical Lexical Strata

Katamba stated that English prefixes and suffixes can be determined to be neutral or non-neutral through the nature of phonological foundation. It is called neutral as the attachment of the bound morphemes to base words doesn't affect phonologically. Vice versa, non-neutral bound morphemes of affixes give impact to the position of word stressing when addition of affixes happen. In addition, seen from the terms of productivity, strata two suffixes are more productive than those of strata one.

The concept of cyclic rule application has been built by Siegel (1974) and Allen (1978), who assume the existence of two levels of strata I English derivational morphology. This is the list of a number of affixes according to the level to which they supposedly belong (cf. also Spencer 1991:79) . Spencer (1991:79) in Plag and Baayen (2008) stated that English has certain level ordering which is said to be strata that can be seen in the following;

Level 1 suffixes: +al, +ate, +ic, +ion, +ity, +ive, +ous
Level 1 prefixes: be+, con+, de+, en+, in+, pre+, re+, sub+
Level II suffixes: #able, #er, #ful, #hood, #ist, #ize, #less, #ly, #ness, #wise
Level II prefixes: anti#, de#, non#, re#, sub#, un#, semi#

Plag and Baayen (2008) also said that suffixes in strata 1 are generally attached to bound roots but they have tendencies to be less transparent phonologically and semantically compared to those of stratum 2 suffixes. Macaulay (2005) stated that affixes in stratum one can be attached to the root more than one here are three kinds of shiftings caused by the attachment of the stratum 1 suffixes; they might be the movement of word stress, resyllabification, and other morpho-phonological changes. However, stratum 2 suffixes do not cause these shifts in words' stress. Furthermore seen from productivity, stratum 2 suffixes are more productive in creating words compared to those in level one. Then suffixes of stratum 1 do not occur outside stratum 2 suffixes. Therefore, the combination of suffixes has to be made according to their hierarchy in order that the right combination of affixes is acceptable in the sense that the attachment of the same stratum or lower strata to the root words.

Katamba (2013) states that lexical morphology predicts that, when both stratum 1 and 2 derivational affixes are present in a word, stratum 1 affixes are closer to the root than stratum 2 affixes. Or it can be summarized as follows:

1. If neutral (stratum 2) occurs simultaneously in one root, restriction to their hierarchy is governed. For instance the root *help* (N) -less(A) -ness (N) compared to help(N)-ness (N) -less (A). Another example is care (N)-ful-(A)-ness (N) compare dot care (N)- ness (N) ful-(A)
2. Affixes belonging to the first strata are placed nearer to the bare words than those of the second strata when derivational affixes of first and second strata appear.
For instance *'athlete - ath'letic - ath'letic-ism*
or *'human - humani't-arian - human-i'tarian-ism.*
This means that the entire strata 1 affixes have to be placed prior to the addition of the second strata affixes
3. Morphemes which belong to similar strata, derivational or inflectional, also have a hierarchy. Inflectional affixes precede the derivational ones or inflectional will be attached nearer to the root. For example, *farm+er+s* (farmers) not *farm+s+er*. Another example can be seen in *happy+ness+es* (happinesses) not (happiesness)
4. Derivational prefixes are affixed between the bare words and the inflection. For example *en-sure-s.* Prefix *en-* comes before the root and suffix *-s* to show singularity comes after the root.

METHODS

This study applied qualitative research as it is believed that a quality research of investigators is the central of the study (Bogman and Biklen, 1992:36). The data are taken from a text which is relevant to the study; it contains derivational morphemes. The analysis of the data is done in several steps in order to meet the research objective formulated in the previous sections which are designed to analyze the stratum ordering of derivational morphemes in scientific writing and to find out the possible formation of derivational affixes strata in polysyllabic words in scientific text. The algorithms of the analyses would be dones with the following steps;

1. Selecting a scientific text containing derivational morphemes. The choice fell upon an international journal which can be downloaded from http://ijiemjournal.uns.ac.rs/v11/v11-01.htm
2. Classifying each sentence containing derivational morphemes
3. Analyzing the stratum ordering of derivational morphemes specified to polysyllabic words found in the text.
4. To analyze the formation of the derivational word strata using phonetic transcription.

The data source of this study was taken from http://ijiemjournal.uns.ac.rs/v11/v11-01.html. This journal concerns Industrial Engineering and Management. The intended data are randomly taken from five articles in the journal published on **Volume 11 | Issue 1 | March 2020**. To obtain the data, a descriptive analysis is applied in this study and then the writer analyzed each sentence which has derivational morphemes. This study is expected to be beneficial for them to understand how exactly derivational affixes are arranged according to their strict rules. Then, since the study deals with linguistics, it may have several benefits for the language study and people who are interested in deepening English.

RESULTS AND DISCUSSION

This study focused on the stratum ordering of derivational affixes attached to some words. The data are limited to noun formation of polysyllables. The polysyllables are also limited to technical terms found in academic writing which were downloaded from IJM journal on http://ijiemjournal.uns.ac.rs/v11/v11-01.html. The analyses of the data can be seen below.

Datum 1: ***minimization***

Minim	-al	-ize	-ion
Root	Stratum 1	Stratum 2	Stratum 1
ˈmi-nəm	ˈmi-nə-məl	/ˈmi-nə-ˌmīz /	/ˌmınıməˈzeıʃn/
Adjective	Adjective	Verb	Noun (suff)

There are three suffixes attached to the root 'minim'. The first derivational suffix is *–al* positioned as stratum 1 affixed which forms an adjective. The second is *–ize* as stratum 2 suffix. The third suffix belongs to stratum 1. From the theory given, this sentence matches the rule that stratum 1 is placed more closely to the root than that of the second strata. The third, suffix *–ion*, belongs to stratum 1 (non-neutral) because it affects the segmentation of both consonant and the vowel sound in the word; /ˈmi-nə-ˌmīz / to /ˌmınıməˈzeıʃn/. Furthermore, it also affects the position of stress in the word. Let's see the placement of the stress from the transcription, from the first syllable to the third syllable (/ˈmi-nə-ˌmīz/ becoming /ˌmınıməˈzeıʃn/).

Datum 2: ***congestion***

Congest	-ion
Root	Stratum 1

/kən-ˈdʒest/	/kənˈdʒestʃən/
Verb	Noun (suff)

The datum showed the formation of verb to noun by adding suffix *–ion* which belongs to stratum 1 or non-neutral. Even though a non-neutral affix, the suffix *–ion* existence doesn't affect the location of the word stress stress (/kən-ˈjest/ to /kənˈdʒestʃən/). It can be seen that the stress remains in the first syllable regardless of the attachment and it also doesn't have an impact of phonology to the root of the word.

This datum was taken from the article entitled Criticality evaluation to support maintenance management of manufacturing systems.

Datum 3: ***Criticality*** .

Critic	-al	-ity
Root	Stratum 1	Stratum 1
/ˈkrɪtɪk/	/ˈkrɪtɪkl/	/ˌkri-tə-ˈka-lə-tē /
Verb	Adjective (suff)	Noun (suff)

There are two derivational suffixes found in word criticality (*-al* and *–ity*). Both of them are stratum 1 affixes. However a constraint of strata ordering appears in which the first stratum 1 affix (*-al*) doesn't affect the placement of the stress. Vice versa to the second suffix *–ity*, the stress shifts from /ˈkrɪtɪkl/ to /ˌkri-tə-ˈka-lə-tē /. This is accordance to the rules that the presence of stratum 1 is also called non-neutral as it changes the location of the stress.

The next data were taken from the article entitled A framework for food traceability: case study – Italian extra-virgin olive oil supply chain.

Datum 4: ***traceability***

Trace	-able	-ity
Root	Stratum 2	Stratum 1
Trās	ˈtrāsəb(ə)l	ˌtrāsəˈbilədē
Verb	Adjective (suff)	Noun (suff)

The first suffix (*–ion)* is categorized as stratum 2 (neutral) because its existence doesn't affect the placement of the word stress (it remains in the first syllable regardless of the attachment of *–able*) and it also doesn't have phonologicals effect on the root. Furthermore, the suffix –ty belongs to stratum 1 or non-neutral because it changes the location of the stress. However, an inconsistency happens to the strata ordering where strata one should have been placed closer to the root. But here, strata 2 is added near to the root.

Datum 5: ***prioritization***

Prior	-ity	-ize	-ion

Root	Strata 1	Strata 2	Strata 1
/ˈprī(ə)r/	/prīˈôrədē/	/prīˈôrəˌtīz/	/ˌprīˌôrədəˈzāSH(ə)n/
Noun	Noun (suff)	Verb (suff)	Noun (suff)

The suffix –*ity* belongs to stratum 1. It doesn't have any effect to the pronunciation of the bare word. Then, the suffix –*ize* belongs to stratum 2 or neutral since it doesn't change the location of the stress. And the last suffix (–ion) belongs to level one. Then, from the tree suffixes attached to the word, strata one nearer to the root followed by the second strata, and the last suffix is strata one. For several findings, strata 1 is possible to be attached after the second strata if there are more than 2 suffixes added to one word. This might not be a constraint to the strata ordering in which it is said that the level one derivational affixes should be placed nearer to the root.

Datum 6: ***sustainability***

Sustain	-able	-ity
Root	Stratum 2	Stratum 1
/səˈsteɪn/	/sə-ˈstā-nə-bəl/	/səˌsteɪnəˈbɪləti/
Verb	Adjective	Noun (aff)

The attachment of suffix –*able* as level 2 derivational affix to the stem word forms an adjective while the second affix forms a noun. Then the second comes –*ity* as the first level of affix order. Stratum 2 are neutral while the first strata is non-neutral which can be seen from the shift of the stress from the second syllable to the third syllables.

Datum 7: ***digitalization****.*

Digit	-al	-ize	-ion
Root	1st strata	2nd strata	1st strata
/ˈdi-jə-t/	/ˈdi-jə-tᵊl/	/ˈdi-jə-tə-ˌlīz/	/ˌdɪdʒɪtəlaɪˈzeɪʃn/
N	Adjective	Verb (aff)	Noun (aff)

The addition of -*ize* has changed the root to a verb formation and the presence of –*ion* as level one strata has created a noun. In this datum the presence of stratum 2 doesn't violate the rule that the stress has to be the same with the root. There are two strata 1 affixes found, one is closer to the root and the other is close to stratum 2 affix.

Datum 8 ***visualization***

Vision	-al	-ize	-ion
Root	Stratum 1	- Stratum 2	Stratum 1

ˈvi-zhən	ˈvi-zhə-wəl	ˈvi-zhə-wə-ˌlīz	\ ˌvi-zhə-wə-lə-ˈzā-shən
Noun	Adjective (suff)	Verb (suff)	Noun (suff)

There are three processes happening to the stem word where the final formation is strata one noun forming from noun toadjective- and verb. One stratum 2 and two strata 1 affixes are attached to the word.

Datum 9: ***systematization***

System	-ize	-ion
Root	Stratum 2	Stratum 1
/ˈsɪstəm/	/ˈsɪstəmətaɪz/	/ˌsɪstəmətaɪˈzeɪʃn/
Noun	Verb	Noun (aff)

The existence of stratum 2 affix *(-ize*) to the word system as the bare word has led to the verb formation of neutral affixation. The affixization of 'system' to 'systematize' doesn't shift the place of stress. This is different to the second addition, stratum one, which changes the stress to the fifth syllable.

Datum 10: ***productivity***

Product	-ive	-ity
Root	Stratum 2	Stratum 1
/ˈprä-(ˌ)dəkt/	/prə-ˈdək-tiv/	prō-dək-ˈti-və-tē/
Noun	Adjective (aff)	Noun

Stratum 2 suffix is placed nearer to the root than the first strata. The constraint here happens not only to the placement of the derivational affixes but also to the shifting of the stress which moves from the initial to the second syllable. The last suffix forms noun positioning as the first stratum. To make it simple, the next data would be analyzed in the following table

Table 4.1 *The Analysis of polysyllabic words in scientific terms*

Word	**Root**	**Stratum**	**stratum**

optimization	Optimism /ˈäp-tə-ˌmi-zəm/ Noun	-ize /ˈäp-tə-ˌmīz/ Stratum 2 Verb	-ion /Äp-tə-mə-ˈzā-shən/ Stratum 1 Noun
parameterization	**Parameter** /pə-ˈra-mə-tə/ Noun	-ize /pə-ˈra-mə-tə-ˌrīz/ Stratum 2 Verb	/pə-ra-mə-tə-ˌrī -ˈzā-shən/ Stratum 1 Noun
availability	**Avail** /ə-ˈvāl/ Noun	-able /ə-ˈvā-lə-bəl/ Stratum 2 Adjective	-ity /Ə-ˌvā-lə-ˈbi-lə-tē/ Stratum 1 Noun
randomization	**random** **/**ˈran-dəm/ Adjective	- ize /ˈran-də-ˌmīz/ Stratum 2 Verb	-ion /ˈran-də-ˌmī-ˈzā-shən/ Stratum 1 Noun
effectiveness	**effect** /i-ˈfekt/ Verb/Noun	-ive /i-ˈfek-tiv/ Stratum 1 Adjective	-ness /i-ˈfek-tiv-nəs/ Stratum 2 Noun
approximation	**approximate** /ə-ˈpräk-sə-mət/ Verb/Adjective	-ion /ə-ˌpräk-sə-ˈmā-shən/ stratum 1 Noun	-
reliability	**rely** /ri-ˈlī/ Verb	-able /ri-ˈlī-ə-bəl/ Stratum 2 Adjective	-ity /ri-ˌlī-ə-ˈbi-lə-tē/ Stratum 1 Noun

From the table, it can be seen the varieties of the attachment of derivational affixes, especially suffixes, to the root that form 'new words'. If flashing back to the given theory that stratum 1 affixes should be placed close to the root, it is generally relevant to the theory. But there is a

violation where stratum 2 are placed near to the root which can be seen in '**randomization, availability, reliability, optimization'** and other words. This inconsistency still intrigues the writers as to make further research referring to any conditions that allow this constraint. The shifting word stress occurs quite consistently in the first level or strata which can be seen in /ə-ˈpräk-sə-mət/ to /ə-ˌpräk-sə-ˈmā-shən/ and other words. Strata 1 affixes are said to be non-neutral as it shifts the placement of stress.

CONCLUSION

This study focuses on the analysis of stratum ordering of derivational affixes on scientific writing to see how some terms apply the ordering strata to form new words . From the random text, it is analyzed .. sentences containing derivational affixes which have been analyzed by using tables. Therefore from the analysis, it can be concluded that:

1. From the data, the study found several formations of derivational affixes like verb formed to noun, adjective becoming noun, noun changed as adjective, adjective to verb and verb to noun. Affixes mostly found is is the use of suffixes *-ion, -ity* for nouns, *-ize* to form verbs, *-ive* and *-able* to form adjectives. The examples of this formation can be found in **optimization, minimization, reliability, ect.**
2. There are two strata of derivational affixes; they are stratum 1 (non-neutral) and stratum 2 (neutral). Neutrality and non-neutrality is shown from the shift of stressing in a word after being attached by the suffixes. Stratum 1 is called non-neutral as it leads to the change of the consonant and vowel segment and so does the position of stress of the root; however stratum 2 is said to be neutral because its existence doesn't affect the location of stress and doesn't have impact to the phonology as seen in the transcription of the word.
3. Stratum 1 would be placed directly after the root when two different strata appear in a word.. However, there are some inconsistencies in the placement of derivational suffixes in which the second strata are placed closer to the root. This happens when suffix *-able* is combined with *-ity* in **availability** (adjective to noun) or suffix *-ize* is combined with *-ion* to form verb to noun in **parameterization.**
4. Further research is required to investigate the possible violation.

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