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Academic Naming: Changing Patterns of Noun Use in Research Writing

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Abstract

In this paper we explore the ways academics name processes as things and how these practices have changed over the past fifty years. Focusing on nominalization, noun-noun sequences, and acronyms, we document an increase in these features across a corpus of 2.2 million words within a consistent set of journals from four disciplines. Our results show that nominalizations and acronyms have increased in all four fields, particularly in applied linguistics and sociology, and that while noun-noun sequences have fallen in electrical engineering, they have risen in the other disciplines, especially sociology. We also suggest that noun-noun phrases have increasingly come to name methodological approaches, rather than concepts or objects, and we seek to account for these changes. We observe that these increases in naming are related to the need for succinctness in modern research writing and the advantages of endowing named objects with a real existence which can then be credited with explanatory authority. We question, however, the appropriacy of these practices for interpretation in the social sciences.

Keywords

nominalization, acronyms, noun phrases, academic writing, naming practices

1. Introduction

Academic writing, it is generally agreed, is an extremely noun-heavy register. While nouns are overwhelmingly the most frequent word class in English, occurring about every fourth word, the Longman grammar (Biber, Johansson, Leech,

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Conrad & Finegan 1999:573-580) observes that they are particularly prevalent in academic prose. This is, in part, because academic discourse, particularly in the physical sciences, concerns itself with "things," with the constitution of the natural world. Science is interested in entities, objects, and results, concerning itself with the outcomes of behavior and experiments rather than those activities themselves. A predominance of nouns is therefore to be expected (Halliday & Martin 1993). This "nouniness" also contributes to the sense that academic writing is highly informational, abstract, lexically dense, and impersonal (Taavitsainen & Pahta 2000; Degaetano-Ortlieb, Kermes, Khamis & Teich 2019). This predilection for nouns, then, is one of the main ways in which the language of a scholarly communication distinguishes itself from other genres or domains of English.

However, as linguists have long pointed out (e.g., Halliday 2004; Banks 2008; Sword 2012), academics are not content with the nouns that are available to them but actively create new ones—or at least devices which function like nouns in naming things. Naming new concepts and technological advances is commonplace in everyday life, so *herd immunity* and *video assistant referee* will be familiar to most of us, but academics are extremely partial to the process. These phrases, moreover, are often transformed into acronyms, which are also common in academic texts. As academics, we live in a world of acronyms, rarely referring to the names of universities, campus buildings, departments, committees, or government bodies by their full names (which are noun phrases). We publish, for example, work on CDA or DNA in high IF SCI journals such as TQ or the BMJ to gain credit for the REF.

In addition, new or unfamiliar words are added to the general pool through nominalization, the process of turning verbs or adjectives into nouns, so that *to characterize* becomes *characterization* and *to make something beautiful* becomes *beautification*. In this paper we refer to these ways of creating new names by stringing nouns together or adding suffixes as "naming practices." In academic writing they allow authors both to pack information into fewer words and, more importantly, to linguistically reorganize everyday experience into new categories that can be further discussed and elaborated (Halliday & Martin 1993; Halliday 2004; Degaetano-Ortlieb & Teich forthcoming). At the same time, however, these naming practices increase specialization and abstraction, ever further removing academic insights from everyday life and risking obfuscation to all but the most experienced insiders (Schleppegrell 2004; Biber & Gray 2010).

In this paper we examine the role of naming practices and whether these have increased in recent academic writing by studying the use of nominalizations, noun-noun sequences, and acronyms. To this end, we analyze a diachronic corpus of journal articles from four disciplines to answer the following questions:

I) Have naming practices increased and in which disciplines?
II) What types of naming practices have become more frequent?
III) What are the most frequent forms of nominalization in each field?
IV) What aspects of research are most frequently named by noun-noun sequences?

First, though, we discuss the concept of naming and its functions.

2. Noun Formation and Use: What, Why, and with What Effect?

Nominalization has attracted particular attention as a key feature of academic writing, where it occurs far more frequently than in other registers and accounts for about 15 percent of all nouns (Biber & Gray 2016:106). But while we are far more likely to find words such as *lexicalization* and *nominalization* in academic texts, we will also encounter a sequence of noun modifier + noun head (Biber, Johansson, Leech, Conrad & Finegan 1999:589), which act like a single noun, such as *conversation analysis* and *trade wars*. Together, nominalization and noun-noun sequence construction are a defining feature of academic prose (Biber, Johansson, Leech, Conrad & Finegan 1999; Halliday 2004), and there are three main reasons for this.

First, they allow a great deal of information to be packed into a few words, which is extremely useful when writing succinctly to the word limits of journals (Halliday 2004; Biber & Gray 2011, 2013). We can see this in the following examples of nominalization, which pithily express meanings which would require much more space to elaborate. Thus, (1) replaces something like 'the action or process of making something more acidic,' while (2) means roughly 'the process by which the division of labor has relegated women into housewives.'

(1) Cellular IP3 levels exhibit a biphasic increase in the cell after *acidification*. (Biology: JEB, 1990, vol 154, issue 3, p. 32)[1]
(2) The "*housewifeization*" of labor as the real model of capitalistic exploitation [. . .] (Sociology: AJS, 1990, vol 96, issue 2, p. 44)

But while these formulations are more concise, they require more processing effort to decode (Biber & Gray 2013; Degaetano-Ortlieb & Teich forthcoming).

Similarly, the use of noun-noun sequences, by grouping together several nouns to form a single unit, can reduce the number of words required to convey an idea. Thus, (3) might be unpacked as "a first-year university student who speaks English as a first language," but uses twice as many words as the nominal group.

(3) A native English-speaking *university freshman* has been acquiring vocabulary at a rate of [. . .] (Applied linguistics: FLA, 1965, vol 1, issue 2, p. 45)

This is of course, something which is highly developed in the hard sciences, as illustrated in (4) and (5).

(4) Genetic variation in key characteristics such as longevity, dormancy and antimicrobial properties may confer a *persistence benefit* on a population or species. (Biology: BR, 2015, vol 90, issue 3, p. 51)
(5) This *multilayer structure* complicates the *network survivability system design*. (Electrical engineering: A, 2015, vol 62, issue 3, p. 81)

These examples draw on disciplinary insider knowledge to refer to a particular object (4) or approach (5) assumed to be known to readers.

This insider knowledge is even more evident in the need to decode acronyms, so examples like (6) and (7) are economical but opaque.

(6) *MTAv* Strategy involves a conscious attempt by learners to limit the mother tongue [. . .] (Applied linguistics: TQ, 2015, vol 49, issue 3, p. 72)
(7) Briefly, *cDNAs* corresponding to *MAP2c* or mature *MAP2* were cloned. (Biology: QRB, 1965, vol 40, issue 2, p. 51)

A second reason for the prevalence of these naming processes is that compacting and summarizing entities in this way enables writers to systematically organize, compare, and comment on them (Halliday & Martin 1993; Schleppegrell 2004). By bundling a great deal of information into a single unit, writers can use it as the subject or object of a sentence to say more about it. They can therefore expand on it and connect it to other processes and things through concise chains of reasoning. Therefore, the process enables clauses to be used as participants of other clauses to organize sequences of messages that gather information as they proceed. Thus, in (5) above, agency is assigned to the entity *This multilayer structure*, which acts on another noun phrase *the network survivability system design*, so that this new information in the second nominal structure can be taken up in the following sentence. This is a central semiotic resource in organizing scientific texts (e.g., Lemke 1998).

A final reason why naming subjects in these ways is common in academic writing is that they help to reconstrue, or semiotically reconstruct, human experience. They do this by turning congruent processes, in which actors do things, into static entities (Halliday 1998). Thus, as shown in (8), the congruent action-oriented language of "it is possible to treat the Ps-electron" and "electrons are indistinguishable" can be reconstrued into a nominal group *possibility* and *electron indistinguishability*, respectively. This not only enables the writer to package a quality as a thing to say more about it (e.g., "electron indistinguishability is evident in materials and compounds exhibiting a single lifetime component [. . .]"), but also creates scientific meaning. It categorizes the world in a different way than we typically experience it, backgrounding human agency and foregrounding a world of things and relations rather than personal actions. In other words, forming nominal structures allows writers to construct theories about processes.

(8) The *possibility* of treating the Ps-electron in a different way comes from PALS experiments in materials showing different lifetime signatures, whereas *electron indistinguishability* is evident in materials and compounds exhibiting a single lifetime component. (Electrical engineering: A, 2015, vol 62, issue 4, p. 38)

As a result, Halliday (2004) believes there has been increasing preference for nominalized forms in scientific writing over the past 300 years, as science has steadily

moved from congruent forms, where meanings correspond with grammatical categories, to a reliance on a dense array of nouns representing qualities and processes as well as entities. Degaetano-Ortlieb and Teich (forthcoming) offer empirical evidence of this in the physical and biological sciences after analyzing 10,000 articles from the *Transactions and Proceedings of the Royal Society of London*.

Biber and Gray (2016) not only confirm this linear increase using a much larger corpus, but also note a massive rise in the use of common nouns in the twentieth century; they are now eight times more frequent than nominalizations in science texts. Many of these common nouns, moreover, function as nominal pre-modifiers, which have risen by over 400 percent in academic prose in the last one hundred years. This allows writers to combine nouns to construct the, often lengthy, phrases (such as *enzyme purification procedure*) discussed above. Thus, Biber and Gray (2010:17) note that "virtually every sentence in a present-day written academic text illustrates the use of complex noun phrase constructions."

Biber and Gray (2010) see this as the most important grammatical development in academic writing over time, contributing decisively to its distinctive style. However, interest remains in the way that naming practices have evolved in recent years and how these nominal patterns reflect some of the changes of modern scientific communication.

3. Noun Use and Disciplinary Values

While we have been talking of "academic writing," this is not a uniform and monolithic practice but the outcome of a range of shared professional contexts. Academic discourses evoke a social milieu where the writer activates specific recognizable and routine responses to recurring tasks, so that texts are constructed in terms of how their authors understand reality. These understandings are, in turn, influenced by their membership in social groups which have objectified, in language, certain ways of experiencing and talking about phenomena. Assumptions about what can be known, how it can be known, and how certainly it can be known all inform and shape discourse practices. In the natural sciences, which seek to characterize, describe, and help explain aspects of the physical world, use of nominalization and noun phrases thus helps to create an environment of technical terms systematically related to each other (e.g., Halliday 1998; Hyland 2004).

In the sciences, interpretations are underpinned by precise measurement, deterministic laws, and invariant patterns of phenomena which are supposed to be independent of the observing scientist. The theories which support scientific conclusions mean that experiments should always yield the exact same results, irrespective of the context or experimenter. The sciences have therefore developed a style of writing to not only report research but to present a set of values: a way of seeing an objective world which operates independently of human intervention and mediation. Naming ideas, activities, and processes as things therefore contributes to both the ontology and epistemology of science, of assumptions about the form and nature of reality as well as how it can be understood.

In the social sciences, however, writers are dealing with a very different kind of universe, one of familiar human experience which addresses people and what they do. It seeks to explain interactions between people, the processes and results of these interactions, and how societies work as a result. Wignell (1998) believes that writing in the social sciences contains features of both the sciences and the humanities, turning an initial abstract construal of experience into a technical framework for interpretation. But even here, there has been a trend toward increased use of nominal structures, with nominalizations perhaps outpacing the rise in the sciences (Biber & Gray 2013, 2016). While new interpretations of familiar experiences might require new ways to describe them, this increasing technicality carries topics further from everyday common-sense experience. So, the use of nominal groups does not only produce names like *colony hybridization* and *gas embolism formation* for scientists, but also *commodity fetishism* and *language acquisition device* for social scientists.

We are, then, interested in naming practices and also concerned about the direction academic communication seems to be taking. We recognize, of course, that academic research is becoming more specialized, and, together with the explosion of topics and researchers, that means there is an increasing need for new names. This process of adding names to the scholarly lexicon, however, increasingly reifies how we understand concepts and processes and means that science becomes more abstract and inaccessible. We hope that examining the development of these naming practices and investigating their forms and disciplinary variability over the past fifty years can help us understand an interesting, important, and relatively neglected aspect of academic life. We now turn to our data and the ways we set out to explore this issue.

4. Corpora and Methods

To trace changes in naming practices over the past fifty years we created three corpora, taking research articles from the same five journals in four disciplines spaced evenly at two twenty-five-year intervals over fifty years: 1965, 1990, and 2015. The fact that journals come and go, that they undergo topic splitting and specialization, and that they are replaced by new ones over time places some constraints on diachronic research, but we sought to select robust journals at the top of their respective fields (as defined by the Thompson-Reuters categories) and with a long history.

We selected journals from disciplines which offered a cross-section of academic practice, representing soft and hard sciences: applied linguistics, sociology, electrical engineering, and biology. From each of these four fields we took six papers at random from each of the five journals for each year which had achieved the top ranking according to their five-year impact factor in 2015 (ninety papers in each field). The journals are listed in Appendix 1. Two journals, *TESOL Quarterly* and *Foreign Language Annals*, began only in 1967, and so papers were chosen from issues in that year. Single and co-authored papers were chosen in equal numbers, and table headings and footnotes/endnotes, which often contain truncated syntax, were removed. Overall, the corpus comprises thirty articles from each discipline from each year, for a total of 360 papers amounting to 2.2 million words (Table 1). There is a massive increase in the length of articles over the period, which has had an impact on the use of nominal patterns.

Table 1. Corpora by Discipline and the Mean Word Length of Papers

Discipline	1965	1990	2015	Change (%)
Applied linguistics	3694.4	4857.1	7915.1	114.2
Biology	8157.9	8009.5	7933.3	–2.8
Electrical engineering	3069.7	4154.4	7856.0	155.9
Sociology	4993.9	6841.3	8740.1	75.0
Total words	597,388	715,836	973,334	62.9

To search for nominalizations, we used Nini's (2019) Multidimensional Analysis Tagger (MAT), which is based on the Stanford Tagger (Socher, Bauer, Manning & Ng 2013), to parse syntactic and part-of-speech information in the texts. MAT is useful for our purposes as it replaces some basic Stanford Tagger tags with those that are specific to the features identified in Biber's (1988) multidimensional functional analysis of English texts. The program generated a grammatically annotated version of our four corpora allowing us to search for items tagged by NOMZ, which identifies nominalizations ending in *-tion*, *-ment*, *-ness*, or *-ity*, plus their plural forms (combining US and UK spellings).

With the tag NN indicating nouns, we identified noun-noun sequences by a regular expression query (\w+_NN\s\w+_NN), and acronyms by their capitalization. We should point out here that we decided at the outset to include noun phrases with only nominal pre-modifiers and exclude prepositional phrases as postmodifiers (e.g., *the consumption of energy*) and adjectives as premodifiers (e.g., *excessive consumption*). This was partly to make the study more manageable, but also because noun-noun sequences (e.g., *energy consumption*) have increased dramatically since the turn of the twentieth century in academic prose and represent the main noun phrase pattern (Biber & Gray 2011, 2016; Biber, Egbert, Gray, Oppliger & Szmrecsanyi 2016). We decided, therefore, to focus on this extremely versatile and productive structure which not only facilitates a wider range of meaning relations than those with prepositional phrases as postmodifiers (Biber, Johansson, Leech, Conrad & Finegan 1999:589-592) but also enables "an extremely dense packaging of referential information" (Biber, Johansson, Leech, Conrad & Finegan 1999:590). Finally, we used the tags PRIV (private verbs), PUBV (public verbs), SUAV (suasive verbs), VBD (past tense), and VPRT (present tense) to search for verbs and verb phrases in order to see if these had declined with any increase in noun use.

Having tagged the corpora, we conducted wildcard searches to identify any word with the above tags and then manually checked all the concordances to exclude extraneous examples. For example, we were able to find and exclude cases such as *city*, *station*, and *moment*, which are tagged with NOMZ but are not nominalizations. Finally, in order to explore the referential functions of noun-noun sequences, we scrutinized a 10-percent sample of cases to identify their main referential functions, finding that they referred to theoretical concepts (e.g., *sound symbolism*), methodological approaches (e.g., *conversation analysis*), or physical objects (e.g., *Language Learner Factors Questionnaire*).

Table 2. Changes in Naming in Research Writing over Fifty Years per 10,000 Words

Feature	1965	1990	2015	% change
Nominalizations	298.3	301.6	310.3	4.0
Noun-noun sequences	192.4	170.2	143.8	–25.2
Acronyms	9.7	21.1	39.9	311.3

Table 3. Most Common Nominalization Suffixes over Time per 10,000 Words

Suffix	1965	1990	2015	% change
-ness	5.3	6.4	7.9	49.9
-ity	50.6	53.1	59.4	17.4
-ion	203.9	205.5	208.8	2.4
-ment	38.4	37.6	36.2	–5.8

Both authors worked independently on a 10-percent sample of cases of each search item and achieved an inter-rater agreement of 96 percent on nominalization, 95 percent on noun-noun sequences, 96 percent on acronyms, and 97 percent on verb/verb phrases. Full agreement was reached after discussion. Then the results were normalized to 10,000 words to allow comparison across the corpora, and log-likelihood tests conducted to determine statistical significances, with effect size (ELL) also considered (Johnston, Berry & Mielke 2006).

5. Patterns of Naming

Overall, we found substantial increases in the raw numbers of nominalizations and noun-noun sequences over the period with 30,201 nominalizations and 14,000 noun-noun sequences in 2015, increases of 69.5 percent and 21.8 percent, respectively. We also observed a huge increase in acronyms, another major feature associated with naming and the dominance of nouns in academic writing, with an increase of 570 percent to 3885 cases in the 2015 corpus. While these rises are significant, we also have to consider the massive increase in the length of papers over the period, and norming the frequencies produces a slightly different picture, as seen in Table 2.[2]

All three features show statistically significant changes: nominalizations (log-likelihood = 17.40, $p < .001$, ELL < .001), noun-noun sequence (log-likelihood = 527.27, $p < .001$, ELL < .001), and acronyms (log-likelihood = 1395.42, $p < .001$, ELL < .001).

Considering nominalizations first, we note that there have been significant changes in the preferred suffixes, as shown in Table 3. The suffix *-ness* is the most common way of forming nouns from adjectives (Quirk, Greenbaum, Leech & Svartvik 1985) and seems to have increased its productivity dramatically in academic writing (log-likelihood = 38.73, $p < .001$, ELL < .001), while *-ity* has also shown a significant

increase (log-likelihood = 51.76, $p < .001$, ELL < .001). Both typically transform a quality or state into an abstract noun (e.g., *usefulness*, *preparedness*; *corrosivity*, *abnormality*). The predominance of *-ity*, however, is largely because it combines almost exclusively with bases from the Romance languages that academic writing generally favors, while also denoting qualities of abstract entities or relations, essential in academic prose, rather than qualities of persons and things, which are usually denoted by *-ness* (Biber, Johansson, Leech, Conrad & Finegan 1999:325).

The most frequent noun suffix in academic prose, by a considerable margin, is *-tion* (Biber, Johansson, Leech, Conrad & Finegan 1999:324), comprising over 200 cases per 10,000 words in our 2015 corpus. This works to nominalize a verb into an abstract entity (*fixation*, *ratification*) and has also seen a slight rise. Finally, nominalizations with the suffix *-ment*, which transform an action or instance of doing into a resulting state (*equipment*, *sediment*) have declined (log-likelihood = 4.98, $p < .05$, ELL < .001), perhaps because of its tendency to combine with concrete nouns.

What is perhaps most surprising about Table 2 is that noun-noun sequences have actually fallen per 10,000 words. We will discuss this in section 7, but this is entirely due to a massive decline of 33 percent (per 10,000 words) in electrical engineering, which seems to suggest a movement toward a more inclusive and comprehensible style of communicating research with fewer noun-noun sequences. The other disciplines in the study have all shown increases in their use, however, and, as shown in Figure 1, this has corresponded to a decline in verbs and verb phrases across all four fields (log-likelihood = 375.33, $p < .001$, ELL < .001).

Thus, an already noun-heavy register has become even more dependent on nouns and noun phrases to carry the weight of arguments. Verbs are rarely accorded the status of key concepts, as this honor is almost always given to nouns. Although every sentence must contain a verb and academics depend on them to create their arguments, they generally go unnoticed. As Billig (2013:70) puts it: "verbs are the great absentees."

Finally, we examined what noun-noun sequences mainly refer to and found they fell into three principal groups: theoretical concepts (as in 9), methodological approaches (in 10), and physical objects (in 11).

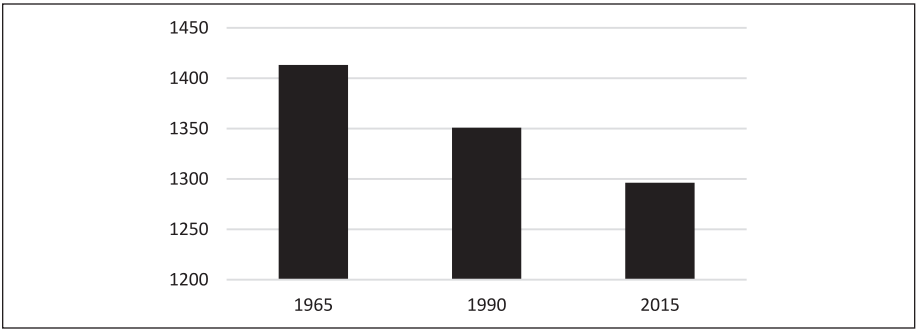

Figure 1. Change of Verb/Verb Phrases over Time per 10,000 Words

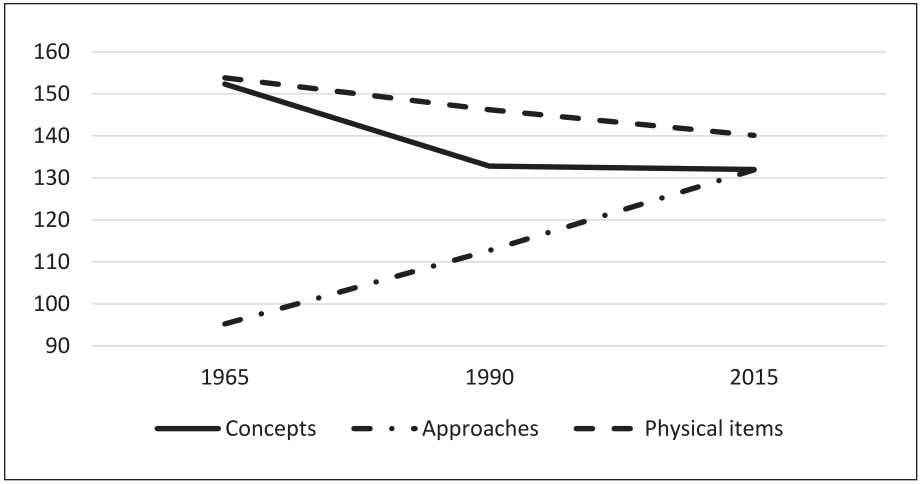

Figure 2. Changes in Referents of Noun-Noun Sequences per 10,000 Words

(9) *Language anxiety* continues to be a primary concern that needs to be addressed in language learning and teaching. (Applied linguistics: LL, 2015, vol 65, issue 3, p. 56)
(10) A *network model* with a *homophily parameter* would produce simulated networks with similar block structure to that of the observed network. (Sociology: SP, 2015, vol 62, issue 4, p. 77)
(11) Work on *blood antigens* offers hope that we may learn more about the manner in which hormones and genes act in the formation of those antigens. (Biology: BS, 1965, vol 15, issue 1, p. 31)

Figure 2 shows that while there have been significant falls in the use of noun-noun sequences to name theoretical concepts (log-likelihood = 108.02, $p < .001$, ELL < .001) and physical items (log-likelihood = 47.48, $p < .001$, ELL < .001), there has been a massive increase of nearly 40 percent in their use to describe methodological approaches (log-likelihood = 435.43, $p < .001$, ELL < .001).

We can see that, in the past, academics mainly used strings of nouns to create new concepts, to describe phenomena, and to name newly discovered or identified substances, materials, and other physical items. While these continue to be the main targets of naming practices in research writing, they have declined substantially when we norm for the increase in words. Most strikingly, we see a substantial rise in the naming of methods, adding prestige and insider authority to ways of approaching research questions, so that new methods such as *text decoding*, *text encoding*, and *text discussion* (12), *chromatography analysis* (13), and *coralline algae modelling* (14) now rank alongside concepts and physical things in frequency.

(12) Students are encouraged to construct new language knowledge through *text decoding*, *text encoding*, and *text discussion*. (Applied linguistics: TQ, 2015, vol 49, issue 4, p. 52)
(13) *Chromatography analysis* was performed using a Varian 450 GC system equipped with a Varian Autosampler 8400. (Electrical engineering: JSC, 2015, vol 50, issue 9, p. 49)
(14) One may investigate the importance of parrotfish grazing as a selective agent favouring the (co)evolution of larval settlement cues from *coralline algae modelling*. (Biology: JEB, 2015, vol 218, issue 3, p. 74)

These overall diachronic movements in naming practices conform to the general claim that language changes occur "in the same direction, essentially towards reduction and tighter integration of form" (Croft 2000:62). But while there is certainly a need for increasing economy of expression in modern academic writing (e.g., Hopper & Traugott 2003:71-73; Hyland 2015), there is also a desire among writers to reinforce the reality and importance of what they name. The entities, methods, and ideas produced and anointed in these ways are invested with the status of things and given a privileged standing in the discourse of one's discipline. We will now discuss each feature in turn, looking at nominalization, noun-noun sequences, and acronyms in terms of disciplinary practices.

6. Nominalization: The Growth of Things and Certainties

Nominalization, as we noted above, has attracted considerable attention due to its salience and visibility in academic research writing, growing massively over the history of science writing and during the fifty-year span of our own data. We should point out here, however, that in many cases it is the use, rather than the creation, of these structures which has increased. Many of the nominal patterns we have found have not been coined in the last fifty years, and many of the concepts they refer to may also have existed prior to this. So, while it is possible that some forms appear for the first time in our data, many do not. The nominalization *acidification*, in our first example, for instance, is recorded in the *OED* (s.v. *acidification*) for the first time in 1788.[3] We believe that many nominalizations, together with nominal sequences and acronyms, do appear for the first time in the last fifty years, but we have not set out to answer this question directly. What is important to us here is how scientists are embracing this feature to more enthusiastically name and promote their ideas.

We can see from Table 4 that all the disciplines considered here have increased their use of nominalization significantly, with changes in the soft science disciplines being the most dramatic. Scholars of applied linguistics (log-likelihood = 49.21, $p < .001$, ELL $< .001$) and sociology (log-likelihood = 57.70, $p < .001$, ELL $< .001$) have both been enthusiastic users, employing nouns to name new phenomena or ideas.

Table 4. Changes in Disciplinary Use of Nominalization per 10,000 Words

Disciplines	1965	1990	2015	% change
Applied linguistics	240.0	256.4	274.0	14.2
Sociology	267.5	280.1	309.4	15.7
Electrical engineering	262.5	271.9	289.4	10.2
Biology	357.0	363.0	378.1	5.9

Clearly, the potential to create new meanings is greatly expanded by using language to represent actions as objects. This has always had particular appeal to scientists, allowing them to shorten references to a process and avoid repetition by making it into a thing, so instead of repeating clauses about cells repressing the synthesis of enzymes, in (15), the writer simply uses one word—*repression*. Moreover, this object can then be presented as the cause, "to enable," another thing, "gene expression":

(15) Carbon catabolite *repression* enables the cell to regulate *gene expression* in response to its metabolic status. (Biology: RR, 2015, vol 184, issue 4, p. 81)

Thus, a process, so named as a real object, can take on agentive functions and do things, such as enable cell regulation. It becomes a central link in an explanatory chain.

Table 4 shows that the formation of what Halliday (2004:123) calls "virtual phenomena" remains a pillar of science writing, with both biology and electrical engineering recording substantial rises. Biology has long been a heavily nominalizing discipline and continues to depend on this naming process far more than the other fields we studied. This is a discipline with elaborate and complex systems for naming items, and while the pace of this process has slowed in recent years, it remains the most nominalized field in our study. One reason for this is that, in using nominalized terms, biologists are able to progress their arguments by summarizing ideas as they go and by packing information more tightly. This is extremely valuable in the fast-paced publishing world of the sciences where quick publishing times and short papers are the norm. Readers are looking for reliability of the method and the bottom line results to see if they can use them in their own research, so nominalized terms facilitate the kind of succinctness this model demands.

Moreover, discussing processes as established things in this way enables theories and models to be built on them, so that *repression* and *expression* become explanatory concepts. These items take on a life of their own so, for example, modulation and oscillation are responsible for the buildup of "the 2p Stokes line" and genes act out of "selfishness," as seen in (16) and (17).

(16) The 2p Stokes line is built up by *modulation* of the Stokes line due to the *oscillation* of the ruby laser and the v Stokes line. (Electrical engineering: PIEEE, 1965, vol 53, issue 2, p. 63)

(17) Its *selfishness* would always be defined in relation to its single ultimate interest, the replication of its own genes. (Biology: QRB, 2015, vol 90, issue 3, p. 51)

This faith in the causal agency of named processes means that it can be noticed even in its absence, as indicated in (18).

(18) In amphibians, however, *vacuolization* is observed comparatively seldom in the cytoplasm, and very rarely in the nucleus. (Biology: QRB, 1965, vol 40, issue 2, p. 50)

Interestingly, however, we found the greatest increases in nominalization in our social science data. Table 4 shows around 15 percent rises in both sociology and applied linguistics as authors seek to establish objective certainties for their results, erasing human agency to attribute causality to named phenomena. Thus, in (19), it is *markedness* which hypothesizes the idea, while the call girls in (20) do not enact a role but find themselves the objects of a dominant thing, enactment, labeled as a fact.

(19) *Markedness* posits that certain features are inherently more difficult than others, regardless of the learners' language backgrounds. (Applied linguistics: FLA, 2015, vol 48, issue 3, p. 87)
(20) The fact that the *enactment* of the call girl role requires little training [. . .] (Sociology: SP, 1965, vol 12, issue 3, p. 71)

Fowler (1991:80), for one, is deeply suspicious of this grammatical sleight of hand. For him, it is through nominalization that "processes and qualities assume the status of things: impersonal, inanimate, capable of being amassed and counted like capital, paraded like possessions."

Moreover, there is a tendency for nominalized processes to "hunt in packs," each additional use reinforcing the others and strengthening the sense that the named features have a reality beyond their status as concepts to explain behaviors in the real world. This use is illustrated in (21)-(23).

(21) The axioms of *linearity* and *arbitrariness* entail *compositionality* (i.e., *segmentability* and hierarchical *projectibility* of segments) of linguistic 'material' [. . .] (Applied linguistics: MLJ, 1990, vol 74, issue 2, p. 61)
(22) Street homeless people may negotiate this *transgressivness* and *vulnerability* by attempting to neutralise their perceived *dangerousness* and mask their *neediness*. (Sociology: BJS, 1990, vol 41, issue 3, p. 91)
(23) The *accessibility*, *desirability* and *plausibility* of the ideal L2 self explain a sizeable proportion of 54.1% of the variance [. . .] (Applied linguistics: LL, 2015, vol 65, issue 4, p. 27)

The preponderance of *-ity* suffixes in these examples reflects the 50 percent rise in this form in both these disciplines, the biggest rises among forms with more than a handful of cases in any field. Transforming qualities into abstract states, then, is a useful way of underlining the existence of these states and, at the same time, make it harder to argue with them (e.g., Halliday & Martin 1993).

Nominalizations thus not only serve to form physical things from actions or qualities to name scientific phenomena, but this process also endows them with a more important status, helping to reinforce writers' arguments and make them less open to question. Thus, in (24), the authors have not merely described something but offered a description, resplendent with a definite article and having a substance which a verb would lack. Similarly, the research subjects in (25) do not simply *comprehend* or *appreciate* but have *comprehension* and *appreciation*; they possess these qualities as part of their characters rather than simply carrying them out as momentary actions.

(24) The *description* we have provided above questions the simplicity of an image of precisely identifiable 'delinquent areas.' (Sociology: AJES, 1990, vol 49, issue 3, p. 53)
(25) [. . .] evidence that people's *comprehension* of English in advertising messages is positively correlated with their *appreciation* of the English used. (Applied linguistics: TQ, 2015, vol 49, issue 3, p. 31)

7. Noun-Noun Sequences: Naming Concepts, Methods, and Things

Noun-noun sequences were virtually unknown in eighteenth century science texts but have emerged, particularly in the last one hundred years, as a highly frequent and productive aspect of research writing (Biber & Gray 2011). We can, however, see considerable disciplinary variation in their use, as indicated in Table 5 (log-likelihood = 17114.0, $p < .001$, ELL $< .001$ for 2015). The table shows that the writers in the physical sciences have always been, and remain, heavy users, but electrical engineers have significantly reduced their dependence on this structure (log-likelihood = 240.1, $p < .001$, ELL $< .001$), and sociologists have increased theirs (log-likelihood = 53.8, $p < .001$, ELL $< .001$).

Noun-noun sequences are prolific in the sciences as they allow researchers to not only name something, but to simultaneously imbue it with factual status. Coining new words or energizing old ones is vital to gaining control of one's arguments in academic writing and also to gaining control of the thoughts of one's readers, encouraging an acceptance of what is named by presenting it as a tangible thing possessing a real presence capable of agency (as in 26) or an authoritative existence which might rebuff challenges (as in 27).

Table 5. Changes in Use of Noun-Noun Sequences by Discipline per 10,000 Words

Discipline	1965	1990	2015	% change
Applied linguistics	11.0	11.2	11.7	6.3
Sociology	3.5	4.9	9.6	172.7
Electrical engineering	280.4	211.2	189.7	–32.3
Biology	357.0	364.2	378.1	5.9

(26) *Actin filaments* may contribute to establishing the correct *microtubule orientation*. (Biology: BS, 1990, vol 40, issue 4, p. 49)
(27) We used the *Sperry method* to freeze the upper leaves of [. . .] (Biology: BS, 2015, vol 65, issue 3, p. 37)

Using these named objects confers prestige on the thing named, each repetition giving it a greater solidity and impression of explanatory or descriptive authority as a recognized and recognizable entity. At the same time, using the term bestows know-how and insider status on the user: an academic who is familiar with topical and valued disciplinary terms (Halliday & Martin 1993; Lemke 1998; Hyland 2004). Noun-noun sequences are thus a badge of in-group membership demonstrating the knowledge and legitimacy of the writer to participate in this discourse and have their arguments taken seriously.

Despite this, electrical engineering shows a massive 32 percent fall in the use of noun-noun sequences over the period (see Table 6). This may be due, we suspect, to the very different environment the applied sciences are working in today compared to fifty years ago. This is now a much more commercial and entrepreneurial context for electrical engineers who are, like academics in many other disciplines, encouraged to engage in the business world. There is a greater professional imperative to talk to external funders, company sponsors, and other non-specialists. Thus, a recent survey of over 18,000 academics in the UK showed that 30 percent actively work with private-sector companies and that nearly two-thirds of engineers are involved in applied work (Hughes, Lawson, Kitson, Salter & Hughes, 2016). In response, engineers have sought to make their research more accessible to these new readers, following institutional imperatives demanding outreach, impact, and alternative funding sources. Hyland and Jiang (2019), for example, have found a massive increase in the use of first- and second-person pronouns, possibility modals, attitude markers, boosters, and discourse particles, as well as a heavy fall in agentless passives, changes that contribute to social interaction and more inclusive relationships with readers.

Table 6. Changes in Referents of Noun-Noun Sequences by Discipline (% of Total)

	Theoretical concepts			Methodological approaches			Physical items		
Discipline	1965	1990	2015	1965	1990	2015	1965	1990	2015
Applied linguistics	36.1	40.8	53.4	33.6	38.2	44.4	30.3	15.5	2.2
Sociology	79.2	60.2	45.5	20.8	41.5	54.5	0.0	0.0	0.0
Electrical engineering	17.9	11.6	9.7	20.5	21.2	23.1	61.6	63.9	67.2
Biology	18.7	19.6	21.9	20.0	11.7	8.5	61.3	66.4	69.6

This reduction in their previously heavy use of noun-noun sequences might appear, therefore, to be part of this gradual move toward a more reader-engaged style: a way to make their work more comprehensible and persuasive to non-specialists. We should also be mindful of the fact that the fall in the use of noun-noun sequences has occurred during a time when there has been a massive 156 percent rise in the length of papers in these electrical engineering journals, averaging just 3069 words per paper in 1965 to 7856 words in 2015. While the greater number of words might offer more opportunities for naming, presumably there are a limited number of processes and items to name, thus reducing the proportion of phrases to total words.

Despite this decline in engineering, Table 6 shows that the noun-noun sequence has lost none of its appeal for the other disciplines, and, indeed, sociologists have taken up the structure with some enthusiasm, nearly trebling their use. Typical examples are seen in (28) and (29).

(28) This gender differential may be due to the *intercaste measure* coming from a self-report. (Sociology: AJS, 1965, vol 70, issue 5, p. 44)
(29) These results suggest that females are noticeably more accurate in recalling network information than males, even after controlling for the availability of *compression heuristics*. (Sociology: SQ, 2015, vol 56, issue 3, p. 81)

Clearly the use of such technical, noun heavy names demonstrate the proficiency of the writer and a familiarity with specialized terms. But once again, rendering processes as entities also erases human agents, and in the human sciences this risks reifying actions carried out by people, and qualities of people, as abstractions.

The attraction of naming through noun-noun sequences can also be seen in the fact that these combinations seem to be getting longer, so that one noun not only qualifies a second but often even a third and sometimes a fourth. Whereas phrases of three words or more represented only 4.5 percent of all noun combinations in our 1965 data, by 2015 these had climbed to 9 percent. Perhaps unsurprisingly, four-word phrases were especially salient in the science corpora, illustrated in (30) and (31).

(30) In the case of no model mismatch, the optimization problem leads to the *system transfer function matrix*. (Electrical engineering: TIT, 2015, vol 61, issue 8, p. 44)
(31) Later, in the ventral bud, ascl1b expression is turned on when the *endocrine cell differentiation program* is induced through the blocking of Notch signalling. (Biology: JEB, 2015, vol 218, issue 4, p. 21)

Three-word forms, as a proportion of noun-noun sequences, were almost equally spread across the disciplines, with sociologists doubling their use and applied linguists increasing their creation of them from no cases in 1965 to over 7 percent in 2015. These longer forms seem to carry an additional authority in creating and naming new phenomena, an extra gravitas which give the concepts an almost official aura, a taken-for-granted "scientific" status with their existence assumed and unproblematic. Thus,

a nouny label like *ego network structures* in (32) implies something more than the phrase "all the people with whom an individual has a social link." Similarly, in (33), the noun phrase suggests a tangible set of recognized factors rather than what might be a nebulous group of unidentified and changing issues.

(32) We then repeat the analysis to characterize *ego network structures*, and compare the results obtained with the two different methodologies. (Sociology: SQ, 2015, vol 56, issue 4, p. 76)
(33) We expected that *language use factors* would explain possible statistical differences among these children's foreign accent ratings. (Applied linguistics: LL, 2015, vol 65, issue 3, p. 44)

There have also been disciplinary differences in the naming focus of the phrases. We saw in Figure 2 that references to methodological approaches have increased at the expense of those concerned with concepts and physical items, but Table 6 shows that this pattern is most salient in sociology. In fact, sociology and applied linguistics show the biggest changes.

Sociology has dramatically increased its use of noun-noun sequences to name methods (see 34 and 35), slowing its development of newly named concepts. This reflects the plethora of conflicting sub-disciplines in that field, each with its own preferred way of conducting social research.

(34) Courneya et al. (2002) describe exercise adherence in cancer survivors using a *personality factor model* [. . .] (Sociology: AJS, 2015, vol 121, issue 2, p. 62)
(35) The dataset is still a valid representation of Facebook social network for the purpose of *ego network analysis*. (Sociology: SQ, 2015, vol 56, issue 3, p. 47)

Applied linguistics has also been active in generating new methods and creating new names for them. This is because the field has expanded massively from personal accounts of teaching practices with little empirical foundation at the beginning of this period to a scientific area of inquiry with over 750 journals on the Scimago list today.[4] The growth and increasing specialization of the field, with each niche building its own body of literature, concepts, and methods, has been attended by a movement toward greater technicality and a trend toward scientific reporting styles, particularly the use of noun-noun sequences to describe methods, as seen in (36)-(38).

(36) Therefore, *network analysis* can be applied in a variety of socio-educational and professional contexts. (Applied linguistics: CCC, 2015, vol 66, issue 3, p. 51)
(37) All items exhibited good predictive validity as reflected in their significant correlations with the *criterion measure*. (Applied linguistics: LL, 2015, vol 65, issue 3, p. 29)
(38) *Appraisal analyses* of student texts have proven useful for teasing out how student writers select and configure various appraisal options. (Applied linguistics: CCC, 2015, vol 66, issue 4, p. 62)

For applied linguists and sociologists, then, noun-noun sequences have become an important way of encoding technicality in the ways disciplinary topics are approached and analyzed, and in demonstrating insider membership and competence.

The sciences, on the other hand, have shifted to naming physical objects in this way, moving from a more conceptual focus in electrical engineering and from methodological approaches in biology, seen in (39) and (40).

(39) We observed an increase of the blood cells in the principal islet and the appearance of *endocrine cells* in the pancreatic tail. (Biology: BR, 2015, vol 90, issue 3, p. 45)
(40) The *control circuit* for the boost converter needs to be controlled for mismatch which makes the small Formula hard to detect. (Electrical engineering: JSC, 2015, vol 50, issue 10, p. 51)

It should be remembered, of course, that we are simply pointing to trends here and that the frequencies for electrical engineering and biology are massively higher than those in the soft fields as noted above (Table 6). There does, however, seem to be a shift toward naming things in the world rather than ways of conceptualizing them.

8. Acronyms: Naming Compression

Acronym creation is the ultimate insider naming practice, completing the transformation of processes into entities through the formation of noun phrases and then compressing these into a series of letters. In strict linguistic terms, we are also talking about initialisms here as not all abbreviations are pronounced as words. However, what is common among them for our purposes is that they all name something, act syntactically as nouns, and exercise discoursal agency, exemplified in (41) and (42).

(41) *TIA* converts input current to output voltage Formula, which is digitized using an *ADC*. (Electrical engineering: JSC, 2015, vol 50, issue 9, p. 29)
(42) *CIRP* is required for high-amplitude circadian gene expression in fibroblasts (Biology: BS, 2015, vol 65, issue 4, p. 41)

As we have noted with other naming practices, acronyms enable writers to pack a lot of information into a single term while avoiding tedious repetition of long, cumbersome labels, and this is one reason they have increased significantly in all disciplines we studied, as shown in Figure 3. Leech, Hundt, Mair, and Smith (2009) suggest that the growth of acronyms is one of the biggest changes in academic writing in modern times, but their claim of a 200 percent rise since 1961 seems somewhat conservative as we found figures of 500 percent for electrical engineering and 340 percent for biology.

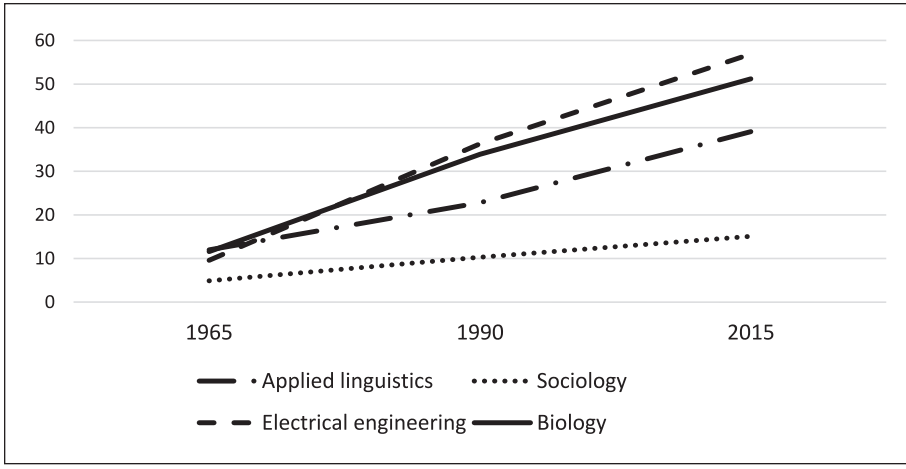

Figure 3. Changes in Use of Acronyms by Discipline per 10,000 Words

Clearly, the hard sciences have long been fervent users of the form and have increased this usage significantly. While we did not count the number of different acronyms in each corpus, and many cases are multiple uses, they averaged 40.6 cases per paper in the 2015 biology corpus and 44.7 in electrical engineering. Forms like in (43) and (44) appear in every paper.

(43) The electrical reference generator, which is used during the test, is simply a *CMOS* circuit retrieving the signal from an off-chip source. (Electrical engineering: JSC, 2015, vol 50, issue 10, p. 18)
(44) Sections were flat embedded with *ACLAR* film and placed in a 60°C oven for 48-72 hr. (Biology: BS, 2015, vol 65, issue 4, p. 49)

There is, however, a greater variety of acronyms in the science papers (type/token = 0.21), especially when compared with applied linguistics (type/token = 0.09), which relies heavily on a limited number, principally those referring to courses and students as in (45) and (46).

(45) Researchers have also investigated the various ways *ESL* and *EFL* writing teachers conceptualize the curriculum of their courses. (Applied linguistics: TQ, 2015, vol 49, issue 3, p. 50)
(46) As teachers in an *EAP* program, we approached this study with an interest in how our *L2* students negotiate the demands of their written assignments. (Applied linguistics: TQ, 2015, vol 49, issue 4, p. 27)

While academic acronyms are usefully economical from a syntactic viewpoint, this is not the only, or even main, reason for their stunning rise in popularity. As Billig

(2013:86) points out, they not only save space but promote concepts and approaches, especially in the social sciences. Acronyms stress the value of a concept by encouraging readers to remember and use them. After all, if something is important enough to be acronymized, then it must be widely used and be playing a key role in the discipline. Acronyms imply the term is being taken seriously by others. There is, then, a promotional aspect to their use. For emerging sub-disciplines and factions, they can imply an established and accepted set of terms around which devotees can cohere and be mobilized, setting agendas and attracting others. More, acronyms can play a part in promoting individual academics themselves. As our frequency information suggests, the majority of these acronyms did not exist fifty years ago and have been brought into the scientific lexicon in recent times. Naming your own conceptual apparatus or methodological approach as a noun phrase and then turning this into an acronym can be a powerful way of making a claim for professional status: a reputation as an innovating and influential academic.

More than this, by using these specialized and arcane terms, other authors are able to buy into the perspectives of the faction or group by using its preferred discourses. Academics can mark out where they stand in the academic spectrum and earn a badge of membership. The other side of this, of course, is that the use presents a barrier for newcomers, students, and outsiders. Understanding and knowing how to use acronyms such as the ones in (47) and (48), from sociology, is a requirement for entry into the field of study.

(47) I infer the role of efficiency concerns from components of the kidney allocation scheme, such as *ABO* and *HLA* matching and *PRA* considerations. (Sociology: BJS, 2015, vol 66, issue 4, p. 58)

(48) We estimate that approximately 64 percent of all mortgage loans originated between 2004 and 2006 in the Baltimore *MSA* were by institutions covered under *CRA*. (Sociology: SQ, 2015, vol 56, issue 3, p. 39)

These linguistically created things have a privileged discursive status because of their presumed existence, and one cannot understand, let alone participate in, the discussion without gaining control over them.

9. Conclusions

We have, in this paper, explored changes in the use of naming practices in four contrasting disciplines over fifty years. Focusing on nominalizations, noun-noun sequences, and acronyms, we have shown that nominalizations and acronyms have increased in all four fields, particularly in applied linguistics and sociology, and that, while noun-noun sequences have fallen in electrical engineering, they have risen in the other disciplines, particularly in sociology. All this has been at the expense of verbs and verb phrases which have fallen in all fields. We have also described how noun-noun sequences have increasingly come to name methodological approaches and sought to account for some of these changes. Finally, we have attempted to argue that

these naming practices are intimately related to the values and characteristics of academic groups and how such practices reveal something of how the scholars of those disciplines themselves want to be seen by others.

The changes we have documented follow those discussed by Seoane and Hundt (2018), Biber and Gray (2016), Degaetano-Ortlieb, Kermes, Khamis, and Teich (2019), and others, who have tracked academic writing over time. Together this research confirms that time has witnessed increased levels of "scientization" in terms of socially differentiated, diachronically specialized, and phrasally standardized communication. Academic discourse is increasingly conventionalized, and we have argued that the greater use of naming is one way this has been achieved.

These naming features show that writers increasingly seek to present their arguments in ways which allow for faster, more efficient processing by expert readers. They originated in the political establishment of a scientific community and the emergence of a network of scientists which required institutionalized standards of public debate. We have noted the exception of noun-noun sequences in electrical engineering in these changes, as this seems to be a discipline responding to a changing commercial imperative. Overall, however, by labeling entities and facilitating information flow, these naming practices now contribute to the ways writers communicate increasingly complex concepts while allowing them to "semiotically reconstruct" (Halliday 2004) experience and bring into being new ways of seeing the world. Today, then, they play a key role in constructing the concepts which populate scientific disciplines, and which help legitimate a scientific elite in modern society.

A negative aspect of this process, of course, is that these naming practices have created ever greater abstractions which have become increasingly removed from concrete experience. They have generated knowledge which has become ever-more specialized and exclusive, making texts opaque to all but the initiated. The ability to write, and read, such texts requires a long apprenticeship of specialization, and this shift can be extremely challenging for students and newcomers (e.g., Liardet 2018) and exclusionary to a public with a growing thirst for an understanding of academic research (e.g., Hyland 2009). It therefore reproduces a social context of inequality (Billig 2013) as those who use this specialized, nominalized language act as the gatekeepers, ensuring that novices write in the appropriate way and outsiders must turn elsewhere for information. Thus, Thompson (2010), for example, found that students who had some mastery of these naming processes got better grades on their MA dissertations. Clearly, if you want to be a biologist or applied linguist, or even graduate in higher education, then you have to use the correct names.

There is also some debate about the appropriacy of these practices for interpretation in the social sciences and whether analysts should use simpler, less technical prose that credits agents with actions (e.g., Martin 2008; Fairclough 2008; Billig 2013). The social sciences, concerned with events in the human, rather than the natural, world, builds knowledge far more on personal interpretations and negotiations with readers than the sciences, so rhetorical maneuvers and textual interaction are critical to achieving academic persuasion (e.g., Hyland 2004). However, the

traditionally discursive disciplines now seem to be making far more use of the features discussed here. Long, nominalized terms, acronyms, and noun-noun sequences are useful in generalizing about, abstracting from, and classifying actions and events, but they assume the real and necessary existence of the things they conjure up. This not only makes the named concepts harder to contest, thus promoting the greater certainty of claims, but also contributes to the reification of human actions, a problem which has been leveled at the texts of the powerful since the origins of critical linguistics forty years ago (Fowler, Hodge, Kress & Trew 1979).

We are, of course, aware that academic inquiry requires theory, abstraction, and even the "technical jargon" of nominalization and noun phrases, to avoid simply applying "common sense" to social problems. Academic language names new concepts, approaches, and physical entities to avoid mistaking appearance for reality. Most scientific fields are too technical for laypeople to follow, but the social sciences would benefit enormously from a reversal of the trends we have observed in this paper. The soft knowledge fields have a responsibility to undermine elitism and bring ideas and knowledge arrived at in academic work into public discussion and debate, and this involves using a language which a wide public can engage with.

Appendix 1: Journal List

Applied Linguistics

TESOL Quarterly [TQ] (volume 1, issues 1, 2; volume 24, issues 2, 3; volume 49, issues 3, 4)

Language Learning [LL] (volume 14, issues 1, 2; volume 40, issues 2, 3; volume 65, issues 3, 4)

Foreign Language Annals [FLA] (volume 1, issues 1, 2; volume 23, issues 2, 3; volume 48, issues 3, 4)

Modern Language Journal [MLJ] (volume 49, issues 1, 2; volume 74, issues 2, 3; volume 99, issues 3, 4)

College Composition and Communication [CCC] (volume 16, issues 1, 2; volume 41, issues 3, 4; volume 66, issues 3, 4)

Sociology

American Journal of Sociology [AJS] (volume 70, issues 5, 6; volume 96, issues 1, 2; volume 121, issues 1, 2)

Social Problems [SP] (volume 12, issues 3, 4; volume 37, issues 1, 2; volume 62, issues 3, 4)

The British Journal of Sociology [BJS] (volume 16, issues 1, 2; volume 41, issues 3, 4; volume 66, issues 3, 4)

American Journal of Economics and Sociology [AJES] (volume 24, issues 1, 2; volume 49, issues 3, 4; volume 74, issues 3, 4)

The Sociological Quarterly [SQ] (volume 6, issues 1, 2; volume 31, issues 3, 4; volume 56, issues 3, 4)

Biology

The Quarterly Review of Biology [QRB] (volume 40, issues 1, 2; volume 65, issues 3, 4; volume 90, issues 3, 4)
Biological Reviews [BR] (volume 40, issues 1, 2; volume 65, issues 3, 4; volume 90, issues 3, 4)
Radiation Research [RR] (volume 24, issues 1, 2; volume 123, issues 3, 4; volume 184, issues 3, 4)
BioScience [BS] (volume 15, issues 1, 2; volume 40, issues 3, 4; volume 65, issues 3, 4)
The Journal of Experimental Biology [JEB] (volume 43, issues 1, 2; volume 154, issues 3, 4; volume 218, issues 3, 4)

Electrical Engineering

Proceedings of the IEEE [PIEEE] (volume 53, issues 1, 2; volume 78, issues 5, 6; volume 103, issues 7, 8)
Automatica [A] (volume 3, issues 1, 2; volume 26, issues 3, 4; volume 62, issues 3, 4)
IEEE Transactions on Automatic Control [TAC] (volume 10, issues 1, 2; volume 35, issues 5, 6; volume 60, issues 8, 9)
IEEE Journal of Solid-State Circuits [JSC] (volume 1, issues 1, 2; volume 25, issues 3, 4; volume 50, issues 9, 10)
IEEE Transactions on Information Theory [TIT] (volume 11, issues 1, 2; volume 36, issues 3, 4; volume 61, issues 8, 9)

Appendix 2: Summary of Changes by Normalized and Raw Frequencies

Changes in Naming in Research Writing over 50 years per 10,000 Words (Raw Frequency in Parentheses)

Features	1965	1990	2015	% change
Nominalizations	298.3	301.6	310.3	4.0
	(17820)	(21590)	(30203)	(69.5)
Noun-noun sequences	192.4	170.2	143.8	–25.2
	(11494)	(12184)	(13997)	(21.8)
Acronyms	9.7	21.1	39.9	312.5
	(579)	(1510)	(3884)	(570.2)

Most Common Nominalization Suffixes over Time per 10,000 Words (Raw Frequency in Parentheses)

	1965	1990	2015	% change
-ness	5.3	6.4	7.9	49.9
	(317)	(458)	(769)	(142.9)
-ity	50.6	53.1	59.4	17.4
	(3023)	(3801)	(5782)	(91.3)
-ion	203.9	205.5	208.8	2.4
	(12181)	(14710)	(20323)	(66.8)
-ment	38.4	37.6	36.2	–5.8
	(2294)	(2692)	(3523)	(53.6)

Change of Verb/Verb Phrases in Research Writing over Time per 10,000 Words (Raw Frequency in Parentheses)

Feature	1965	1990	2015	% change
Verb/verb phrases	1413.2	1351.0	1296.3	–8.3
	(84423)	(96709)	(126173)	(49.5)

Changes in Referents of Noun Phrases in Research Writing per 10,000 Words (Raw Frequency in Parentheses)

	1965	1990	2015	% change
Concepts	152.3	132.8	132.0	–13.3
	(9098)	(9506)	(12848)	(41.2)
Approaches	95.2	112.7	131.9	38.6
	(5687)	(8067)	(12838)	(125.7)
Physical items	153.8	146.2	140.1	–8.9
	(9188)	(10466)	(13636)	(48.4)

Changes in Disciplinary Use of Nominalization per 10,000 Words (Raw Frequency in Parentheses)

Discipline	1965	1990	2015	% change
Applied linguistics	240.0	256.4	274.0	14.2
	(2660)	(3736)	(6506)	(144.6)
Sociology	267.5	280.1	309.4	15.7
	(4007)	(5749)	(8113)	(102.5)
Electrical engineering	262.5	271.9	289.4	10.2
	(2417)	(3389)	(6821)	(182.2)
Biology	357.0	363.0	378.1	5.9
	(8736)	(8721)	(8999)	(3.0)

Changes in Use of Noun-only Phrases by Discipline per 10,000 Words (Raw Frequency in Parentheses)

Discipline	1965	1990	2015	% change
Applied linguistics	11.0	11.2	11.7	6.0
	(122)	(163)	(278)	(127.9)
Sociology	3.5	4.9	9.6	172.7
	(52)	(101)	(252)	(380.1)
Electrical engineering	280.4	211.2	189.7	–32.3
	(2581)	(2632)	(4471)	(73.2)
Biology	357.0	364.2	378.1	5.9
	(8736)	(8750)	(8999)	(3.0)

Changes in Use of Acronyms by Discipline per 10,000 Words (Raw Frequency in Parentheses)

Discipline	1965	1990	2015	% change
Applied linguistics	12.0	22.8	39.1	225.7
	(133)	(332)	(928)	(598.1)
Sociology	4.9	10.3	15.1	210.7
	(73)	(211)	(396)	(439.4)
Electrical engineering	9.6	36.3	56.9	495.7
	(88)	(452)	(1341)	(1417.3)
Biology	11.6	33.9	51.2	341.0
	(284)	(33.9)	(1219)	(329.3)

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Notes

1. Examples are annotated as to discipline, abbreviated name of journal, year of publication, volume, issue, and page number.
2. This journal requires authors to provide raw numbers, and, rather than clutter the tables, we have included these in Appendix 2.
3. We are grateful to the editors of *JEngL* for pointing this out.
4. https://www.scimagojr.com/journalrank.php?area=1200&category=1203.

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