Using language models for holistic language variety comparisons*

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June 30, 2021

1 Introduction

One of the goals of scientific research is to discover generalizable facts, and work on language variation is no different. Variationists are often interested in describing language varieties and distinguishing between language varieties. This task is typically accomplished by analyzing several salient linguistic variables in fine detail and either generalizing to whole varieties from these several variables. The focus on deeply analyzing a small number of variables has advanced the understanding of language variation in more ways than can be mentioned here. While this paradigm shift from the broad analyses of many variables done dialectology, out of which language variation developed, has been valuable, modern technological advances have made it possible to once again consider analyzing broad swaths of linguistic variables at once. The objective for this study is thus to develop a method for holistically quantifying the distance between language varieties in a way that can account for practically all potential linguistic variables.

Some work on language variation has to already returned to its dialectological roots at least in spirit, and so a look at what has been done recently will help situate the method being proposed here. As such, section 1.1 will discuss some advantages and disadvantages of traditional methods of analyzing language variation to show what can be gained from a more holistic approach, and section 1.2 will review the limits of how holistic such traditional studies tend to get. Section 1.3 will explain a bit of what is done in the field of natural language processing (NLP), and section 1.4 will review how such technological advances have been applied to variationist studies, leading to the inclusion of many more variables than was previously practical.

*Data and code available at https://osf.io/9cjpw/.

1.1 Generalizing from saliency

In traditional variationist work, generalizations about whole varieties are sometimes drawn from a relatively small set of linguistic variables, perhaps as few as five. The assumption underlying that makes this possible is that the variables analyzed are salient and so have social meaning and so are what really distinguish varieties. This connection between saliency and social meaning has indeed been acknowledged in variationist literature (Podesva, 2011, p. 235) and has at least been implicit in variationist theory since its foundations.

Labov (1972) himself introduced the idea of saliency into language variation in proposing the concepts of linguistic variables being either indicators, markers, or stereotypes, the latter two carrying saliency. It was later claimed that most linguistic variables are markers (Bell, 1984), carrying saliency but not being explicitly commented on by speakers when describing one variety versus another. The importance of saliency for classifying types of linguistic variables was also part of the concept of orders of indexicality (Silverstein, 2003), where second and third order indexicals would be somewhat equivalent to markers and stereotypes, respectively, in terms of saliency.

Saliency has not only been a consistent aspect of variationist theorizing, but it has proved useful for analyses. One example is in analyzing how varieties comes to be social constructs, recognized as existing in the minds of speakers, which has been referred to in language variation as enregisterment (Agha, 2003). In essence, the process of enregisterment is based on features increasing in saliency. This was initially applied to Received Pronunciation (Agha, 2003) but has also been applied to the development of Pittsburghese based mostly on an analysis of (aw) monophthongization, though some other features are discussed also such as the term *yinz* 'you (pl.)' (Johnstone et al., 2006). Additionally, the saliency has been used to distinguish varieties spoken by different groups within a single geographic area in that residents will explicitly describe linguistic features that they associate with each group. This was the case in a study of Beijing where two types of Beijingers and one type of non-Beijinger were associated with one linguistic variable each (Zhang, 2005).[1]

The sort of explicit commentary noted in Zhang (2005) is one way to establish whether a linguistic variable is salient or not. To quantify such commentary requires developing indices where perhaps certain types of commentary each count in the index or commentary in general is counts as just one item among other types in the index. In fact, saliency has sometimes even been quantified on purely linguistic grounds (Podesva, 2011, p. 237).[2] Perhaps a more common way of identifying saliency has come through experimentation, however. Perceptual studies that invovle experimentation fall under paradigms such as eye-tracking (e.g., D'Onofrio, 2015) or matched-guise experiments (e.g., Campbell-Kibler, 2009; Delforge, 2012). Findings in such studies include showing that preconceptions of Valley Girls and Californians

[1] Technically, one group, the "smooth operators", was associated with two variables, but each variable involved [ɹ] (Zhang, 2005, pp. 441-444).

[2] Podesva (2011) does of course acknowledge social saliency, as well.

can impact perceptions of the TRAP vowel (D'Onofrio, 2015), that the alveolar variant of (ing) is judged differently depending on the listener (Campbell-Kibler, 2009), and that vowel devoicing in Andean Spanish is less noticeable by listeners when they do not want to notice it, as those who denied having the feature still had it at similar rates to those from elsewhere in whom the feature was regularly perceived (Delforge, 2012).

The point is that saliency does indeed exist, can be measured, and carries import for analyses, particularly if one is interested in social meaning. To the extent that varieties are social constructs, it is also a rather safe assumption to say that salient variables are what distinguish varieties as that which is not socially meaningful could not be a defining feature of a social construct. However, when looking at varieties more as concrete systems that are coherent, consistent, and objectively different from each other, comparing salienct variables alone may miss even a large number of distinctions that a more holistic comparison could capture. Furthermore, being able to compare between varieties both holistically and by looking at only salient variables opens the possibility of finding contrasts that may be enlightening, such as the possibility that two varieties different in many more ways than what is noticeable to speakers, yet the focus in variationist work has mainly been on salient variables alone.

1.2 Looking at clusters of linguistic variables

Language variation studies have of course examined clusters of variables and systems of interrelated variables. The focus in these cases is still linguistic variables that are thought to be salient, though the number of variables analyzed has at times approached a relatively larger scale. This is particularly true when the analysis focuses on "features", which are effectively treated as linguistic variables that have two realizations: present or absent.

Studies of African-American English (AAE)[3], perhaps due simply to there being so many, include both analyses of small clusters of variables but also larger sets of features. In some cases, there is an apparent relationship between the variables, such as in Rickford and McNair-Knox (1994) where the analysis included the zero copula, habitual invariant *be*, the plural *-s* morpheme, the 3rd person present *-s* verbal inflection, and the possessive *-s* morpheme. The first two of these both implicate the verb *to be* whereas the last three all involve homophonous suffixes. Such relationships are not always present, however, as in an examination of Martin Luther King, Jr's language that included the zero copula, (ing), (t/d) deletion, (r), word-final consonant cluster reduction, and prosody (Wolfram et al., 2016). If a structural relationship exists between these linguistic variables, it is not evident at first glance.

When sets of features from AAE are studied, the number of variables grows substantially. In the case of Van Hofwegen and Wolfram (2010), 32 features were tallied in individuals' speech as a way to measure how heavily AAE their

[3]I am including what researchers may refer to as African-American Vernacular English (AAVE) under this term as the distinction is not particularly important for the present study.

speech was. The measure itself, along with the chosen features, was developed in research on speech pathology and education and where it is referred to as the dialect density measure (DDM). While the proposal of an appellation such as DDM suggests something of a novel approach, similar measures have in fact been used elsewhere, as well. In a study looking into the use of AAE features in gay British men on Twitter, 25 AAE features were analyzed according to their frequencies (Ilbury, 2020). Also involving Twitter, over 30 non-standard spellings thought to be associated with AAE were analyzed in order to draw AAE dialect maps in the US (Jones, 2015). While these feature-conceptualized studies include far more than the typical five to seven clustered variables, they still fall well short of including all possible variables in these varieties.

If studies of AAE sometimes include clusters of linguistic variables that appear structurally related, it is not always clear that this structural relationship is what drove the choice of variables. In many other cases, there is little question that the researchers are interested in a cluster of variables because of their structural relationship. This is particularly evident in examinations of vowel systems or large portions of vowel systems, where there is often though not always a chain shift involved. This has been done since the foundational variationist work in New York City (Labov, 2006) and has continued in studies of other areas such as Belfast (Milroy, 1987), King of Prussia (Payne, 1980), Syndey (Horvath & Sankoff, 1987), the Detroit area (Eckert, 2000), and Philadelphia (Eckert & Labov, 2017). Similarly, though without implicating a chain shift, the majority of the pronoun system of Louisiana French as spoken in Houma has been analyzed as a whole (Rottet, 1995) as well as chunks of the verbal morphology system and and copula system in Cajun English (Dubois & Horvath, 2003). Finally, perhaps one of the most explicit treatments of a system of covariation was Guy's (2013) analysis of Brazilian Portuguese as spoken in Rio de Janeiro which had the explicit goal of examining the existence or non-existence of distinctive sociolects by determining if four linguistic variables covaried. While these sort of studies go further towards covering all the variables of particular linguistic systems, there is once again much left to be described if one wishes to compare the distance between varieties in their entireties. Furthermore, not all subsystems of varieties are contained in such a relatively small number of variables. For instance, it is not possible the lexical system of a variety with five, ten, or even one hundred variables.

1.3 Advances in NLP

A significant part of what has made it possible to analyze much larger numbers of linguistic variables at once is the continued development of NLP technology. Indeed, not only has development in NLP become more and more active, NLP has also made its way into other fields. This includes sociolinguistics, where the resulting interdisciplinary field has become known as computational sociolinguistics (Nguyen et al., 2016). While a thorough discussion of NLP is beyond the scope of the present study, a brief overview of the basics of what can be done and how is relevant to make the holistic method of comparing vari-

eties proposed here more understandable. NLP has certainly found its way into language variation, but not every variationist is a computational sociolinguist.

The building of large corpora is not purely an activity related to NLP, but they are central to the development of NLP tools and sizes have exploded over the last decade. Sociolinguistic interviews themselves yield corpora, of course, and the first corpus to be over one million words of written English, the Brown corpus, was collected already in the 1960s (Francis & Kucera, 1964). Efforts to digitize written language have continued through the present day with corpora such as the British National Corpus (BNC) consisting over just under 100 million words (Burnard, 2007), the Corpus of Contemporary American English (COCA) consisting of over 400 million words at its start (Davies, 2010), and Google Books consisting of over 40 million books (Lee, 2019).

In addition to digitized written language, data mining techniques have made collecting large contemporary corpora from social media platforms so prevalent that there is more of a question about the ethics behind such activities than about how to accomplish the task (D'Arcy & Young, 2012). Corpora from Twitter, for instance, have reached sizes such as 62 million tweets (Hong et al., 2011, p. 519) or 114 million tweets (Eisenstein, 2013, p. 13) or even 924 million tweets (Huang et al., 2016, p. 244), each tweet containing up to 140 characters[4]. Depending on the scope of the sort of data the researcher wishes to collect, such corpora can be constructed in relatively little time, as well, with even the largest example given taking only a year to finish. Of course, the extent to which such large corpora present opportunities for linguistic research is limited by the tools available to deal with so much data. NLP provides a number of tools that help expedite the sort of analyses that variationists might carry out, including part of speech tagging, sentence parsing, and document classification.

Corpora have been tagged for parts-of-speech (POS) since at least the development of the Brown corpus, which was done by hand. A common NLP task then is to perform POS tagging automatically on new corpora. This typiocally involves training a tagger on documents that were first hand-coded for POS, such as the aforementioned Brown corpus. The general idea behind training is to construct a dictionary made up of each word that has been seen in the hand-coded corpus with its most likely POS tag. This can be as simple as associating the most frequent POS tag for each word to that word but can also get much more complex, perhaps by taking into account the POS of the surrounding words, as well. For example, training might lead to listing *run* as most likely a verb, but if taking into account context, it might also list *run* preceded by a determiner as a noun. There are many possibilities and approaches, but the key point is that hand-coded data is always used as input for the training algorithm.

Related to POS tagging is the task of parsing sentences, which is also a classic task in NLP. This is done in much the same way as POS tagging where some training data is used to train a parser that can then automatically parse

[4]The character limit for tweets was subsequently raised to 280 characters (Rosen, 2017).

new sentences, though naturally the training data must be annotated for no just POS tags but also syntactic structures. Fortunately, like the hand-coded POS tags in the Brown corpus, there are today a number of corpora hand-coded with syntactic structures. These are referred to as treebanks, perhaps the most well-known example being the Penn Treebank for English (Prasad et al., 2019). Both automatic sentences parsers and POS taggers are useful for variationists looking at syntax but also potentially any other variationist whose linguistic variables may be syntactically conditioned. For instance, one may want a POS tagger if one is studying the (ing) variable and suspects it to varying according to lexical category (Houston, 1985).

A common NLP task that is particularly relevant to the current study is that of document classification, where a "document" is understood as any amount of text that acts as a unit, be it a tweet or a book. A classic example of this task is that of identifying the topic of a document. The goal in these cases might be to spot spam in e-mail (Dada et al., 2019), to classify news articles, to mine opinions in text, and so on (Minaee et al., 2021). The general approach to this problem is to take a collection of documents that have already been classified by hand and once again use them as input for a training algorithm in order to train a classifier that can be used on new documents. The training algorithm may draw conclusions from the input data such as the use of the word "senator" over a certain number of times increases the likelihood that a new article is about politics. The result is not entirely different from the dictionaries generated by POS tagging.

The classification task related to the current study is that of language variety identification, which as it sounds, refers to classifying the language variety in which a document is written. There is a related task called language identification, but the former involves varieties that are quite similar and the latter varieties that are quite different. Language variety identification is not as old of a task in NLP as some of the others, but work has been done on Arabic varieties during the MADAR workshop (Bouamor et al., 2019), and Balkan languages, Indonesian versus Malaysian, Portuguese varieties, Spanish varieties, French varieties, and Persian versus Dari during the VarDial workshop (Zampieri et al., 2017). A particularly effective approach to the tasks involved in the VarDial workshop made use of n-gram language models (Duvenhage, 2019). An n-gram language model is generated from training documents in that the training algorithm makes a list of all the n-grams found in the training documents along with their frequencies. An n-gram itself is some n number of consecutive symbols, which are typically consecutive characters or consecutive words. For instance, in sentence 1 below, the word bigrams are ⟨this is⟩, ⟨is a⟩, and ⟨a sentence⟩, whereas the character 4-grams are ⟨this⟩, ⟨his ⟩, ⟨is i⟩, ⟨s is⟩, ⟨ is ⟩, and so on. An n-gram language model then would be a list of all the n-grams of whichever type the researcher decides to use from all the documents that are known to be in a particular language variety. The classifier would then make a decision on the language variety of new texts based on their relationship to the n-gram language models that were constructed. In the case of Duvenhage (2019), he achieved very good results by using a combination

of word unigrams and bigrams and character bigrams, 4-grams, and 6-grams which influenced the use of these language model types in the present study, as will be discussed further in section 2.1 of the Methods section.

1. ⟨this is a sentence⟩

These tools help variationists relegate much work that used to be done by hand to a machine, allowing the scale projects to increase substantially. Admittedly, it is still prudent to go through samples of data that has been automatically coded for quality assurance, but doing so is much quicker than coding by hand. Additionally, perhaps the biggest yet simplest technological advancement that has aided variationists, particularly when considering how many variables can be analyzed at once, has just been counting. A few lines of basic code can return counts for tokens of linguistic variables from millions to even billions of words of text, something that would have taken an enormous amount of time in the early days of the field.

1.4 The impact of NLP on language variation research

1.5 Generalizing from n-gram language models

2 Methods

2.1 Language models

3 Results

4 Discussion

5 Conclusion

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