Title: Linguistic and Medical Journalism in the Age of Covid-19: Helping Linguists Find Their Voice

Abstract: This paper discusses the role of general linguistics and public policy in light of recent articles which were published by medical journalists for US media outlets. These articles discuss the purported link between Covid-19, a respiratory disease responsible for a global public health crisis, and the use of particular languages and songs. The articles written by medical journalists and do not cite interviews with anyone within the field of linguistics. In some cases, the articles misrepresent the claims made in the original studies whereas in others they are based on poorly grounded research. In addition to analyzing the issues in these news articles, this paper discusses public opinion/public policy intervention efforts used by scholars in other fields and sociolinguistics which are not reliably employed in general linguistics. I propose that employing some of the intervention techniques used in these fields could potentially help linguists maintain an authoritative voice that allows them to disseminate their scholarly views to a broader non-specialist audience.

Keywords: Covid-19, respiratory disease, misinformation, journalism, public outreach

1. INTRODUCTION. This paper analyzes claims made in recent reports about Covid-19 that attempt to link language use to the spread of respiratory disease. Covid-19 is a highly infectious respiratory disease that has led to the death of over 400,000 people in the United States in the period from January 2020 – January 2021 and over 2,060,000 globally (WHO).[1] These articles, which are based on published academic work, inform readers about the potential dangers of speaking and singing in English. These articles were written by medical journalists and exhibit a range of problematic analyses and assumptions about language that could have been avoided by consulting a linguist. Reporting of this sort risks spreading misinformation and delegitimizing academic authority among the general public.

To contextualize the harm that can be done by inaccurate reporting on this topic, Covid-19 has been considered a public health crisis in the US since March 13, 2020 when the spread of the disease prompted the federal government to declare a national state of emergency. Unlike outbreaks of other severe acute respiratory syndrome (SARS) diseases, Covid-19 has a much broader global reach and has prompted a number of strict emergency orders that disrupt our day-to-day lives (e.g. closing international borders, government mandated quarantine, avoiding meeting members outside of one's immediate household, etc.).

Given the broad impact of the public health crisis and the disruptive nature of the measures necessary to contain it, the general public has been looking to statements made by authoritative voices to understand the direction of future public policy. The relationship between the news reports investigated in this paper and public policy became clear to the author on a Q-Anon conspiracy promoting webpage where the author first encountered these reports (i.e. Facebook). This particular thread shared these news reports and claimed that measures to mitigate the spread of Covid-19 had an ulterior motive of controlling individuals (via fear-mongering) and questioned the role of journalists, academics, and academic funding. In effect, because of the poorly grounded claims in these news articles, people who have developed a distrust of scholarly authority found an example that they were using to seed skepticism of scholarly authority in others.

In this paper, I aim to emphasize that in spite of the confident reporting by medical journalists, the scholarly community currently has very little understanding of how specific languages, songs, or phrases, aid the spread of respiratory disease. This means that the

information presented in these news reports should not be taken as actionable or indicative of the direction of public policy.

Finally, this paper looks at the reasons and potential remedies for the misalignment between the views held by the scholarly linguistics community and the views consumed by the public. While the reporting by medical journalists highlights an important problem, namely that linguists are absent in a public policy discussion where they should be present, this problem has historically been linked to our own community's attitudes as well.

This paper is organized as follows, the rest of section 1 outlines the background to the news reports and the concept that language has the potential to aid in respiratory disease transmission. Sections 2 and 3 provide analyses of the news articles. In these sections I (a) present the work underlying each news article, (b) assess the research as it relates to linguistics, and (c) assess the journalists' presentation of the academic work. This section emphasizes that much of what went wrong in the news report involves failure to incorporate basic knowledge of phonetics and phonology that is presented in section 1. Section 4 considers why these reports were able to circulate with little to no rebuttal from the linguistics community. This section highlights that linguists have faced this problem before, but other fields which face a similar problem have managed disseminating their point of view to the general public differently than the core field of general linguistics. Finally, Section 5 concludes with the take-aways from this report.

1.1. BACKGROUND TO NEWS ARTICLES. This paper investigates three news articles which purport to inform readers about the connection between using English and the spread of Covid-19. Forbes published an article on September 8 about the possible danger of spreading Covid-19 by speaking English (Escalante 2020). Escalante references a publication by linguists at RUDN University in the *Journal of Medical Hypotheses* and a publication by an epidemiologist at Otsuma Women's University in *Lancet*. Escalante and the scholarly work underlying her article assume that coronaviruses (including Covid-19 and SARS) are spread by aerosols, and that use of a language with aspiration spreads more aerosols than use of a language without aspiration.

Independent of the Forbes article, Fox News and Science Times both published articles on September 8 about the potential dangers of singing *Happy Birthday* based on research by

technical physicists at Lund University (McGorry 2020, P. 2020). Both articles focused on [b] and [p], which are claimed to project more droplets than other segments. Like the Forbes article, these articles assume that aerosols and their resulting droplets spread Covid-19. McGorry (2020) and P. (2020) were picked up by other media outlets including The New York Post and Science Daily among others. Some of the headlines flirt with the border between tongue-in-cheek and alarmist such as "Birthdays Kill: Experts Warn Singing Happy Birthday Increases Coronavirus Risk" from WIBC in Illinois.

All three articles cover topics that are directly relevant to linguistics, but the author bios provided by the news organizations indicate that none of the authors are linguists. In the case of Forbes and Fox News, the authors are medical correspondents with expertise outside of linguistics (one in Pediatrics and another in Physical Therapy). Science Times does not provide the qualifications of the author online. Even though the medical field and the field of science in general are both very broad, none of the articles indicated that the author consulted with a linguist to either (a) clarify their understanding of the works cited or (b) receive a second opinion on the published academic pieces.

1.2. CONCEPTUAL BACKGROUND TO SPEECH SOUNDS, PARTICLES, AND AIRFLOW. Underlying the different academic reports is the idea that the physical act of speaking may aid in the transmission of both disease carrying aerosols and droplets. Early in the pandemic, the American CDC emphasized that Covid-19 is spread via fomites, that is droplets which settle on surfaces, but in July of 2020 over 200 epidemiologist were signatories to an open letter addressed to the World Health Organization demanding that the agency recognize aerosol spread of Covid-19 (Morawska & Milton 2020). Regardless of the different scientific positions (which are not mutually exclusive, CDC 2020), the outward airstream mechanisms used for speech can carry both aerosols and droplets out of the speaker's body. For this reason, I treat the spread of aerosols and fomites as related from a linguistic perspective.

Different articulatory structures of sounds can influence how particles are emitted from the body. The most basic differences are related to pressure changes. When the muscles between the ribs are tensed and the diaphragm relaxes, the physical area of the lungs becomes smaller. This change in size results in an increase in pressure that forces air, and particles in the air, out of

the lungs. As the air travels out of the lungs (e.g. to the glottis or the oral tract) other pressure changes may also occur in the production of sounds.

For example, a phenomenon known as ASPIRATION occurs when the vocal chords are spread during the production of a segment, thus permitting high airflow to pass through the opening (Reetz & Jongman 2009). Crosslinguistically, aspiration tends to be the longest in consonants further back in the mouth (i.e. velars and uvulars) as opposed to those which are produced further forward in the mouth (Cho & Ladefoged 1999). The production of aspiration, [^{h}], is similar to the production of [h] (Johnson 1997; Reetz & Jongman 2009), but the independent segment [h] needn't be timed to the production of another consonant. With both aspiration and [h], the airflow becomes turbulent as it passes through the opening in the vocal chords resulting in a noise characteristic of a constriction in that location. The pressure needed to produce aspiration results in a more forceful airstream exiting the mouth than the corresponding segment without aspiration (e.g. pressure of [p^{h}] > pressure [p], Dixit 1987).

The timing of gestures can also result in pressure changes. For example, plosive segments, like [p] and [t], are produced by making a full closure in the mouth. During the closure, air escapes the lungs allowing pressure to build in the mouth before a sudden release. The sudden release of pressure results in an abrupt popping sound. Elongating the closure time of plosives increases the pressure build-up in the mouth before the release (Jaeger 1983). Some languages make systematic use of this type of timing difference with categories called SINGLETON, for short consonants, and GEMINATE, for long consonants. In languages with this system, plosives with short closures and lower pressure are singletons whereas plosives with long closures and higher pressure are geminates.

All spoken languages make systematic use of airflow variation wherein some parts of the speech signal are characterized as having higher airflow than others. Pressure differences are important because they can change the speed of the airstream which in turn can effect the airflow. There are two major airstream states: LAMINAR (involving multiple particle layers that do not mix) and TURBULENT (involving substantial mixing of particles across layers).[2] Slower airstreams are more likely to be laminar whereas faster airstreams are more likely to be turbulent (Catford 1982, Ohala & Solé 2010, Shadle 2010).

Studies on the relationship between particle deposit and airflow state indicate that

turbulent airflow is associated with a higher rate of particle deposition than laminar airflow (Guha 2008:333). Additionally, in laminar flows, particles fragment into large pieces whereas in turbulent flows particles fragment into many small pieces (Zhao et al. 2019). This suggests that moisture and droplets produced during speech production and respiration can have different particle sizes depending on the airstream state.

Catford (1982) categorizes sound types based on different airflow states:[3] vowels and voiced glides (e.g. [a] and [w]), which are produced with the widest opening in the mouth, have slower laminar airflow. Fricatives (e.g. [f], [v], [x]) and affricates (e.g. [p͡f], [k͡x]), which are produced with smaller cavity openings, have faster turbulent airflow. Among the fricatives and affricates, a subset known as SIBILANTS (e.g. [s], [t͡s], [ʃ], [t͡ʃ]) are characterized by an exceptionally high velocity turbulent airstream that creates a loud hissing noise as it flows through a narrow channel in the mouth and hits a barrier (the teeth) (Johnson 1997). Plosives (e.g. [p], [t], [k]) also have turbulent airflow after the release of a pressure built up in the mouth. This brings us to the following generalization: sounds characterized by an airstream which is fully blocked or impeded through narrow channels in the mouth (known as OBSTRUENTS) are likely to have turbulent airflow, whereas sounds characterized by an airstream which is relatively unimpeded (known as SONORANTS) are likely to have laminar airflow.

Some segments have variable degrees of openness and can be either laminar or lightly turbulent. Some fricatives, such as [h] (Rothenberg 1974) and some types of [ð] (Catford 1982, Olsen et al. 2020), are produced with a wide opening resulting in a more laminar airflow than the prototypical fricative. Voiceless glides, like regional American English [ʍ] in *white* [ʍaːt], are produced with a narrowing of the vocal tract which results in a more turbulent airflow than the prototypical glide (Catford 1982, Ohala & Solé 2010).

While there is variability in the production of some phonetic classes, no class exhibits as much variation as the rhotic or "r-sound class". In addition to whatever language-specific restrictions that one may find on r-sounds, the observable crosslinguistic phonetic variation of the class is so disparate that we cannot define a unifying articulatory structure to it (Navtig 2020).

Figure 1 summarizes the relationship of airflow state and segment types. Airflow state is represented from left to right. Segment groups on the left have a more turbulent airstreams than

segment groups on the right.[4] In this chart, segments are color coded for whether they are obstruents (red) or sonorants (blue). The obstruents with the most obstruction (the most prototypical members of the class) are deep red whereas ones with less obstruction are lighter red. For the sonorants, the segments with the most open production (the most prototypical members of the class) are deep blue whereas ones with less open production are light blue. The bottom half of the airflow chart shows the variation in r-sound production across a small selection of languages.

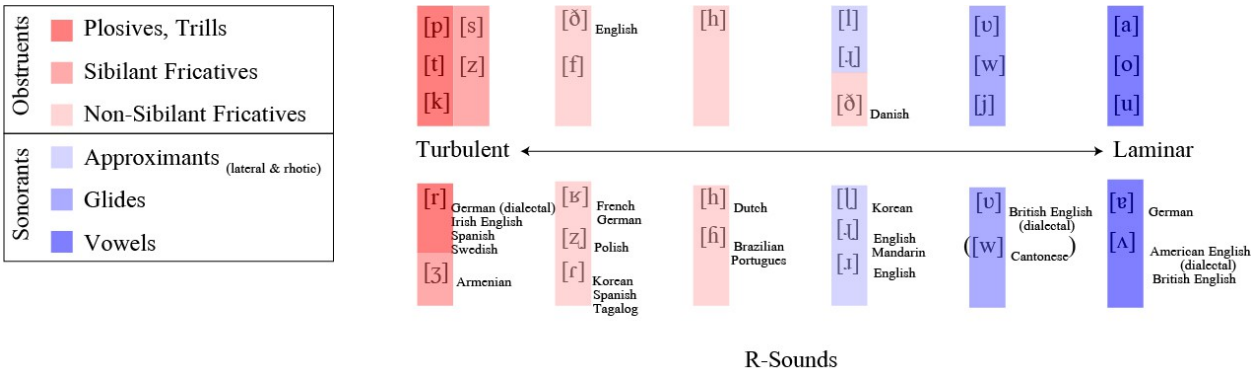

Figure 1. Turbulence Chart (based on Catford 1982:126, Chabot 2019, Navtig 2020)

As is shown in the chart, most prototypical sonorants have laminar airflow whereas the most prototypical obstruents have turbulent airflow. There is some crossover in the middle of the chart between segments which are not representative of the prototypical members of their sets (e.g. Danish [ð] which is more precisely written as the glide [ð̞]). R-sounds in particular have many physical variants. While some are like prototypical obstruents, others are like prototypical vowels. In some languages the variation is regional, in other languages the type of r-sound is used to distinguish different words, in others the differences are not used for word distinctions and are predictable based on word position, and yet in others the sounds freely alternate and have no implication for meaning. The careful reader will notice that two languages often referred to by the same cover term “Chinese” (i.e. Mandarin and Cantonese) have different realizations of r-sounds. More precisely, Cantonese does not have an r-sound, but when Cantonese dominant speakers replicate the American English rhotic ([ɹ]/[ɻ]), it is realized as [w] exhibiting a more open realization than the original English sound.[5]

2. ASPIRATION AND THE SPREAD OF CORONAVIRUSES. Languages which have aspiration vary considerably in how it is produced and used. In languages like Korean, the average duration of aspiration is longer than in languages like English. In some languages, like Korean, aspiration is a feature that can be used to contrast words as in [**t**a|] 'moon' and [**tʰ**a|] 'mask'. In English, aspiration is a conditioned and restricted phenomenon occurring only on voiceless segments /p, t, k/ in either word-initial or stressed syllable-initial positions. These conditions lead to the realization of two aspirated plosives in *tectonic* [**tʰ**ɛk.ˈ**tʰ**ɑ.nɪk], but no aspiration in *stegosaurus* [s**t**ɛ.gə.ˈsɔ.ɹɪs], *instigate* [ˈɪn.s**t**ə.geɪ**t**], or *steady* [ˈs**t**ɛ.di]. The distribution of aspiration matches the phonetic distribution of /h/ which surfaces in the same environments. This leads to a pattern where stress shifts in related words can change the realization of /h/ and aspiration in a similar way such as *vehicular* [və.ˈ**h**ɪ.kju.lə˞] ~ *vehicle* [ˈvi.ɪ.kl̩] and *record V* [ɹə.ˈ**kʰ**ɔɹd] ~ *record N* [ˈɹɛ.**kə˞**d]. Whereas English-speakers can decode aspiration as a predictable property of word position, Korean-speakers must be sensitive enough to the presence or absence of aspiration to know which word is intended.

In addition to variation in the distribution of aspiration, languages can also vary based on what type of aspiration they have. The most common type of aspiration is postconsonantal, such as in English and Korean. Some languages also have preconsonantal aspiration such as Icelandic and Swedish (Vennemann 1972, Riad 2014). While many languages have voiceless aspiration, some languages have both voiced and voiceless aspiration, like Hindi. Voiced aspiration has a lower pressure release than voiceless aspiration (Dixit 1987).

English has other segments with a more turbulent airflow than what is found in /h/ and aspirated plosives, namely the sibilant fricative and affricate series: /s, z/, ʃ, t͡ʃ, ʒ, d͡ʒ. The sibilant class in English occurs more freely across word positions than /h/ and the aspirated plosive series.[6]

2.1. ACADEMIC REPORTS. Georgiou & Kilani (2020) explore the link between aspiration and the spread of Covid-19 with a special emphasis on English. This work compiled Covid-19 infection rates across 26 countries with the highest rates as of March 23, 2020. Countries were divided into two groups: those where the official language has aspiration and those where the official

language does not.[7] Differences in infection rates were compared across the two groups in a t-test which yielded non-statistically significant differences between the two categories. Georgiou & Kilani (2020) acknowledge the non-significant results, but still insist that finding a non-significant trend of higher infection rates in countries with aspirating languages is important for the medical community.

Georgiou & Kilani (2020) based their hypothesis on a claim made in Inouye (2003). Inouye (2003) is not a study, but rather a proposal to account for why Japan and the US had different infection rates during the SARS 2000 outbreak. According to Inouye (2003), different infection rates at the onset of the epidemic might be attributable to phonological differences between English and Japanese. He proposes that Chinese merchants, presumably early carriers of the SARS 2000 coronavirus, spread the virus to Japanese and American tourists at different rates because they spoke different target languages to the tourists. Target Japanese resulted in low transmission rates due to the lack of aspiration in Japanese whereas target English resulted in a high transmission rate due to the prevalence of aspiration in English.

2.2. STUDY INADEQUACIES. Georgiou & Kilani (2020) and Inouye (2003) have similar flaws concerning (1) language assumptions, including failure to include other linguistic predictors, (2) population sampling, and (3) failure to take into account social considerations. The first reason why there are insufficient grounds to draw conclusions from these works involves assumptions about language. Inouye (2003) acknowledges that Japanese has an aspirated /p/, but he claims it is not a major factor contributing to the spread of the coronavirus due to its infrequency. Riney et al. (2007) show that Japanese has aspiration on all voiceless plosives and that /k/ has the longest aspiration of all Japanese segments (which follows the findings of Cho & Ladefoged 1999 mentioned in section 1.2).

Perhaps an even bigger issue with the language-specific assumptions is that while Inouye (2003) and Georgiou & Kilani (2020) both point to aspiration as the likely culprit in the spread of the two coronaviruses, they do not look at other linguistic factors that similarly involve changes in airflow. Neither papers considered the effects of fricatives in spreading aerosols. As mentioned above, fricatives and affricates are like aspiration in that both involve turbulent airflow. While about 26% of the world's languages surveyed in the University of California Los

Angeles Segment Inventory Database (UPSID) have aspiration encoded in words, over 66% of the languages encode affricates and over 93% of the languages encode fricatives. While the encoding of a feature in contrast probably doesn't matter for the spread of the virus, it is a good proxy for understanding how prevalent a particular feature is crosslinguistically.

If we believe that the forcefulness of the airstream is what creates the potential for disease spread, then the high velocity sibilant subset of fricatives and affricates should have been analyzed. Sibilants are crosslinguistically very common and can be found in Mandarin, Korean, Japanese, English, Russian, and Greek among other languages. According to UPSID, 92% of the surveyed languages encode sibilants.

In order to put into perspective the potential confound that this omission poses, we should think back to the relationship between velocity and particle structure (mentioned in Section 1.2). Sibilants are the highest velocity fricatives and are associated with the most turbulent airflow in segment production. That means that the production of sibilants has the potential to break up moisture into smaller pieces more effectively than non-sibilant fricatives. This means that if turbulent airflow is the primary factor underlying the spread of disease particles, aspiration should be less effective in disease transmission than sibilants. I should be clear: I do not necessarily endorse this point of view, I am only highlighting a conceptual oversight as the authors have attributed the forcefulness of the puff of air to the spread of particles.[8]

In addition to aspiration, there are other phenomena in language that involve an abrupt change in signal amplitude, but this is not given consideration in either Georgiou & Kilani (2020) or Inouye (2003). Intonational features of language can condition changes in airflow volume. Languages which encode stress, such as English, Greek, Russian, and Spanish, and word-level pitch accent, like Japanese, make use of amplitude (loudness) changes to signal prominence in a word. Slight increases in pressure on the lungs, which results in more air escaping the cavity, are in part responsible for the loudness variation used in stress (Reetz & Jongman 2009). Even for languages that do not use stress or word-level pitch accent, like Chinese languages which use tone, speakers still alter the loudness of their speech to convey information like conversational emphasis (e.g. focus).

Research by Asadi et al. (2019) shows that both increases in amplitude (loudness) and increase in pitch are positively correlated with increases in particle emission crosslinguistically.

Contrary to the basic premise of Inouye (2003) and Georgiou & Kilani (2020), Asadi et al. (2019) find that changes in particle emission are not language dependent. They are able to verify this by using English-Spanish, English-Arabic, and English-Mandarin bilinguals. Asadi et al. (2019) attribute their findings to the increased volume of air that escapes the body when we speak in a louder voice and the increased rate of vocal chord vibration (and therefore droplet production in the voice box) which occurs when we speak in a higher pitch.

A different issue concerning assumptions about language is that only Inouye (2003) considers the distribution of aspiration in the target languages. This consideration is incomplete because he fails to mention the restricted distribution of aspiration in English discussed above. Even if we believe that Inouye (2003) is correct in assuming both that /p/ is the only aspirated plosive in Japanese and that merchants spoke a non-Chinese target language to foreign nationals, there is no consideration of how linguistic patterns from the merchant's dominant language may carry over into the target language. Sound system transfer between linguistic systems of bilinguals is a long studied phenomenon (Haugen 1950, Thomason & Kaufman 1988, van Coetsom 1988), and important for a claim like the one made by Inouye (and even for the claims made in Asadi et al. 2019). If the Chinese-dominant merchants spoke Japanese, they may have produced aspiration in Japanese if they could not faithfully reproduce the Japanese phonological system. Georgiou & Kilani (2020) never discuss the restricted nature of English's aspiration pattern nor do they discuss the implication of different types of aspiration systems.

The second issue is a methodological issue involving sampling. First, neither study samples actual speakers. Both works assume that a national rate of infection serves as a proxy for infection rates in specific speech communities. Neither work indicates that English and non-English speaking populations of the same nationality were considered separately. An example of why this is problematic can be found in US Census Bureau data. Census data from 2006-2008 indicates that over 2 million US citizens spoke some form of Chinese as their primary language at home.[9] Approximately 55% of this population was not proficient in English. The same census data show that over 42 million US citizens spoke some form of Spanish as their primary language at home and approximately 47% of this sampled population was not proficient in English. This indicates an oversight concerning the nuances of language use, including bilingualism and lack of English proficiency. You cannot use raw national statistics as a proxy

for language use and rate of infections in the US because there are many residents and citizens who do not use English as a primary language. Additionally, you must know the language background of the people who are infected because aspiration may not be encoded in the language such as in the case of Spanish.

Another sampling issue in Georgiou & Kilani (2020) concerns assignment of the labels "aspirated" or "nonaspirated" based on the official language of a country. This approach is problematic because some countries lack official languages, notably in the US. English is generally assumed to be the defacto national language but without presenting a more explicit methodology, it is not clear if "defacto national languages" are treated the same as "official national languages". This distinction matters because by March 23, 2020, New York was an emergent global epicenter for Covid-19. Failure to define "official language" means that we lack sufficient information to know whether or not we should expect to find this spike in US cases represented in their data.

Inouye (2003) assumes that bilinguals were the early spreaders of Covid-19, but there is no indication that he considered differentiating foreign nationals in China who could speak Chinese from those who couldn't. As was mentioned above, some languages encode aspiration into basic word-level distinctions; Chinese languages are like Korean in doing this. If Japanese nationals were speaking a Chinese language, they would presumably be exposed to aspiration at a similar rate as US nationals speaking a Chinese language in the same region.

To the third and final point, neither study considers the role of social or cultural factors in the spread of the virus. Some cultures are known to differ with respect to the acceptable interpersonal space between individuals (Sorokowska et al. 2017), but these differences are not considered. Second, the role of economic need is not considered. Within the US, minority and low income populations have been hit particularly hard by Covid-19 such as the black community in New Orleans (Kemp et al. 2020). In March 2020, around the same time that New York was the Covid-19 epicenter, New Orleans was on track to surpass New York (Brooks 2020). The rapid spread of the virus through New Orleans, may be linked to the types of income opportunities that developed in the Post-Katrina economic structure of the city (see Vigdor 2008 for a discussion of the economic shift). Regardless of when the economic shift occurred, by the time the pandemic effected the city, there was an observable link between race, low income, and

infection (Mejia et al. 2020, Andersen et al. 2021). Similarly, other studies have found that working in low wage low skill jobs and the economic and housing insecurity associated with being low income are important factors aiding the spread of Covid-19 (Orozco Flores & Padilla 2020, Riley et al. 2020). The claims made by the original authors would be more robust if the role of social factors, either economic or otherwise, were acknowledged.

Since the time of originally writing this article, Georgiou et al. (2021) published a follow-up to Georgiou & Kilani (2020). Their follow-up article corroborated the initial report's findings: aspiration in a country's national language yields no statistically significant correlation to infection rate in that country. In their follow-up study, they acknowledged some of the limitations that I have outlined above including lacking knowledge about linguistic background of the infected individuals and failure to account for social behavior differences. In the second study, Georgiou et al. (2021) also attempt to remedy the lack of language use data by investigating the relative frequency of voiced and voiceless plosives across 16 distinct languages spoken in 16 countries (1 language per country). The added language data comes from a textual frequency analysis meaning that they still lack production data linking sound use to particle emission. This method still fails to take into account phonetic variation that deviates from the norm in predictable word contexts (which is not always represented in writing systems).

In the new study, Georgiou et al. (2021) identify [p] as the segment most likely to aid the spread of respiratory disease and claim that voiceless segments are better transmitters of droplets than voiced segments. This finding stands in direct conflict with the finding of Asadi et al. (2020) who measured droplet production during speech production. Asadi et al. (2020) investigate the dispersal of droplets among English-speakers and find that voiced segments transmit more droplets than voiceless segments. Similar to Asadi et al. (2019), Asadi et al. (2020) attribute this finding to the increase of droplets made in the voice box during the production of voicing.[10] Additionally, the findings of Asadi et al. (2020) suggest that voiceless fricatives (both turbulent and laminar) transmit fewer particles than voiced plosives (which involve both a turbulent airflow upon the release of the closure and presumably vibration in the vocal chords which creates moisture that is transmitted out of the mouth).[11] Overall, Asadi et al.'s (2020) findings contradict the claims made in Inouye (2003), Georgiou & Kilani (2020), and Georgiou et al. (2021). This is important because the research team involved in Asadi et al. (2019, 2020) have

better methodology than the other two research groups because they investigate particle transmission associated with real time speech production as opposed to using poorly defined proxies to infer information about transmission rates.

2.3. REPORTING. The Forbes report was written prior to the publication of Georgiou et al. (2021) and therefore only summarizes Georgiou & Kilani's (2020) hypothesis and its relationship to Inouye (2003). The report fails to mention that these works are not based on research of actual language users. It also fails to discuss the analytical inadequacies covered in the preceding section. Additionally, Escalante (2020) misrepresents basic phonetic and phonological facts of English aspiration. While she does mention that the voiceless plosive series has aspiration, she presents this as a general feature of the English sound system instead of a restricted phenomenon (see above).

Escalante (2020) exhibits a limited understanding of the statistical test used in Georgiou & Kilani (2020). While she acknowledges that Georgiou & Kilani's (2020) t-test did not reach statistical significance, she brushes this aside because of her interest in a long tail in a box-and-whiskers plot indicating higher infection rates in languages with aspiration which is not found in the box-and-whiskers plot for infection rates among languages without aspiration. This fixation indicates a basic misunderstanding of what a t-test does. A t-test reports whether differences in the behavior of two groups could have arisen by accident (i.e., if the two groups really represent a single group). It does this by considering all data points, including ones which are not close to the mean, such as those at the tail end of the distribution. In effect, the long tail was considered in the t-test, but did not result in meaningful differences between the two populations, a fact which Georgiou & Kilani (2021) reiterate. Effectively, the two different tested groups represent a single group and the long tail in the “aspirated” group may be attributed to factors unrelated to how aspiration influences infection rate, such as the social considerations raised above.

3. OBSTRUENTS AND THE SPREAD OF CORONAVIRUSES. The following background is needed to understand Alsved et al. (2020) and how it was reported in the media. As mentioned in section 1.2, obstruents are segments involving impediments to the oral airstream. The English obstruents include the plosive series /p, b, t, d, k, g/, the fricative series /f, v, θ, ð, s, z, ʃ, ʒ, h/, and the

affricate series /t͡ʃ ,d͡ʒ/.

In Swedish, the obstruents are /p, b, t, d, k, ɡ, f, v, s, ɕ, ʂ, ɟ, h/. With the exception of /ɕ, h/, Swedish obstruents can be either long (geminate) or short (singleton) (Kiparsky 2008, Riad 2014). Long consonants are produced by sustaining any given segment's gesture for a longer duration than the corresponding short segment. As mentioned in section 1.2, geminate plosives have an extended closure period which results in a greater build up of pressure in the mouth than for the corresponding singleton (Jaeger 1983). Research from Caucasian languages suggests the vocal chord vibration in the production of voiced geminates last for a longer duration in the closure than for singletons (Grawunder et al. 2010:227). While the author is unaware of any research on droplet emission concerning geminates vs. singletons, it is important to state that this could be relevant based on the mechanisms for droplet emission proposed by Asadi et al. (2020).

In addition to the obstruents listed above, Swedish has an apical trill for its r-sound which can be long or short.[12] Apical trills are similar in production to plosives except that trills involve multiple closures and releases whereas plosives have one closure and one release. These, and other trill segments, are characterized by turbulent airflow. The English r-sound is substantially different from the one in Swedish. The English r-sound is an approximant characterized by laminar airflow (either alveolar [ɹ] or retroflex [ɻ], see Zhou et al. 2007). Both English and Swedish have derived aspiration on voiceless plosives. Unlike English, derived aspiration in Swedish can be either pre or postconsonantal.

3.1. ACADEMIC REPORTS. Alsved et al. (2020) conducted a study investigating the role of loudness (amplitude) in the spread of aerosols while singing. This study has four basic test conditions: normal breathing, reading out loud from a book, singing a “consonant rich” song, and singing with a mask. The song used was the Swedish song *Bibbis pippi Petter* which is broadly transcribed in IPA in (1).[13]

(1) bɪbːis pɪpːi pɛtːɐ
hɔpːar oː piːpar oː sprɛtːɐ
hɔpːɐ frɔn pɪnːə tɪl pɪnːə
prɑːtɐ meː bɪbːi dɛrɪnːə

The singing and reading tasks had paired conditions for “normal voice” vs “loud voice”.

There were 12 participants total, 7 of whom were professional opera singers while the other 5 were amateur. Participants performed the tasks in an airtight chamber controlled for pressure, temperature, and humidity. The researchers measured the particle mass emission rate and the number of droplets per frame that were photographed during the task.

Alsved et al. (2020) found statistically significant differences in particle emission between the breathing, talking, and singing tasks. Normal singing produced significantly more aerosol particles than normal talking, and loud singing produced significantly more particles than normal singing. These findings are consistent with Asadi et al.'s (2019) findings concerning the relationship between pitch, amplitude, and particle transmission discussed in section 2.2. The major finding of Alsved et al. (2020) is that wearing a face mask can mitigate particle emission during loud singing and bring it down to the emission levels for normal talking (with no statistical significance differentiating particle emission between the two conditions).

The researchers did not conduct significance testing on the average particles per frame analysis, but the observed pattern followed the emissions pattern. Additionally, the researchers report “The singing of vowels does not provide high airflows for the dispersal of particles, but as shown in the video files, the articulation of consonants expels droplets with considerable forward velocity. Nevertheless, many of the largest droplets travel a limited distance (<0.5 m) before their movement become vertical due to sedimentation.” The consonants identified by the researchers are [p], [b], [t], and [r].

3.2. INADEQUACIES. Alsved et al. (2020) primarily investigate how changes in amplitude impact the spread of aerosols and what role, if any, masks have in mitigating their spread. On the face of it, this study is not a study about language, but the scholars dip into making claims about language when they report that [p], [b], [t], and [r] show higher spread of aerosols than other segments. This is an issue because they introduce a methodological confound by intentionally using a “consonant rich song” which is a tongue twister. This tongue twister emphasizes differences between the sets [p], [pː], [b] and the sets [t] [tː] and [r].

Goldrick & Blumstein (2006) analyze production errors found in tongue twisters. They

find that when segments have similar parameters of production, the parameter which distinguishes them, is sometimes erroneously applied to the wrong segment. Alsved et al. (2020) do not distinguish between long and short segments, but the long obstruents' extra pressure build-up could have erroneously transferred to the related segments in the set or the voicing parameter could have been erroneously applied to related segments in the set. This means that singleton consonants such as [p], [b], [t], and [r] could have exhibited more forceful releases, which are characteristic of geminates, or voiceless segments like [p], [pː], [t], and [tː] could have exhibited slight voicing unlike in normal speech. Overall, we do not know whether or not this effect occurred in the experiment because the linguistic task performed is not independent of the amplitude condition.

While Alsved et al. (2020) report that [p], [b], [t], and [r] exhibit higher spread of aerosols, they do not report whether or not this is task dependent. In addition to the confound concerning the use of a tongue twister, the singing task will likely produce more aerosols than other tasks because it involves active manipulation of the muscles between the ribs and the diaphragm which results in a much more powerful change in pressure than what is normally observed in spoken speech (Reetz & Jongman 2009). Increased pressure on the lungs is one of the mechanisms responsible for increased droplet transmission according to Asadi et al. (2020).

3.3. REPORTING. Fox News and Science Times both report the findings of Alsved et al. (2020) and the implications of wearing a mask in mitigating the spread of aerosols. Both news reports fail to mention that English and Swedish have different r-sounds. This is important because if Asadi et al. (2019, 2020) are correct in their hypothesis, it would be the combination of vocal chord vibration plus turbulent airflow that amplify the production and spread of droplets. This would mean that the English r-sound would produce fewer droplets than the Swedish r-sound.

Similar to the source article, neither Fox News nor Science Times note that Swedish has different types of p-like segments and b-like segments. The news reports go one step further in giving readers the false impression that Swedish and English realizations of /p/ and /b/ are the same when they are not. Singing *Happy Birthday* [hæ**p**i **b**ɚθdeɪ] in English is not equivalent to singing *Bibbis pipi Petter* [**b**ɪ**b**ːis **p**ɪ**p**ːi **p**ɛtːɐ] in Swedish. While the news reports make the assumption that English and Swedish production are functionally equivalent in this respect,

Alsved et al. (2020) never made this claim.

4. TOWARDS BUILDING INFLUENTIAL AUTHORITATIVE VOICES. The previous sections have highlighted the disconnect between scholarly research and the media reports that try to connect language use to the transmission of Covid-19. As a scholarly community, we are not in the position to know how exactly using of any specific language or song influences virus transmission. While some studies claim that some languages may be more effective at transmitting aerosols than others, without firm grounding, other studies with more rigorous setup have claimed the exact opposite. Effectively, the latter set of research claims that general crosslinguistically observed behaviors in speech production aid in the transmission of droplets (e.g. changing amplitude, changing pitch).

While public outreach has mostly been shouldered by the medical community, we know that it is not reasonable for any one medical correspondent to assume a deep expertise of every subject across such a broad field. At this point, we should ask ourselves as a discipline: how do we effectively communicate as authorities in our own field? While it seems logical that effective communication could be achieved by writing to the news agencies for clarification, the author tried this with Forbes in October 2020 and received no response.

The linguistics community has faced this type of problem before. A similar, albeit more extreme, version of this occurred in 1996 during the Oakland Ebonics Controversy (Wolfram 1998, Rickford 1999, Baugh 2000, Weldon 2000). The Oakland Ebonics Controversy references the social fallout which occurred after the Oakland Unified School District passed a resolution designating African-American Vernacular English (AAVE), more popularly called “Ebonics”, as a non-English language. The objective of this declaration, as stated in both the original and revised resolutions, was to provide financial assistance and resources to native AAVE speakers to learn standard American English, thereby granting them access to institutional support similar to that provided to nonnative English-speakers. The intended goals of the resolution were lost in the subsequent public discourse that focused on questions concerning the legitimacy of AAVE as a spoken linguistic form and questions of the appropriate fora where AAVE should (or should not) be spoken. Linguists wanted to express that from a professional standpoint, the overall goal of the school district was positive, however, input from linguists was absent in much of the

discourse that helped shape public opinion (Wolfram 1998, Rickford 1999).[14] Linguists recognized that their expertise was directly relevant to this public policy discussion, but they did not know how to break down the barriers to entering the discussion.

After this experience, sociolinguists introspected as to why they encountered difficulties in countering the social narratives surrounding the Oakland Ebonics Controversy. Rickford (1999) identified both journalists and linguists as key in shaping the negative public perception of AAVE and the resolution. On the one hand, many journalism outlets "manufactured consent" on the status of AAVE and the goals of the resolution (Rickford 1999:270). Linguists did themselves no favors with their collective reaction to the general population's understanding of linguistic variation.

> When the Ebonics controversy broke, many linguists expressed frustration at the extent to which the public still appeared to have misconceptions about this and other vernaculars which we thought we had long ago dissipated... However, in harboring this frustration, we seem to have forgotten what advertisers of Colgate toothpaste and other products never forget: that THE MESSAGE HAS TO BE REPEATED OVER AND OVER, ANEW FOR EACH GENERATION AND EACH DIFFERENT AUDIENCE TYPE, AND PREFERABLY IN SIMPLE, DIRECT AND ARRESTING LANGUAGE WHICH THE PUBLIC CAN UNDERSTAND AND APPRECIATE.
>
> (Rickford 1999:271, emphasis my own)

The combination of news outlets converging on a single narrative and linguists scoffing at public knowledge in the non-specialist community resulted in a wide gap between in public policy stances between the general public and linguists.[15] In writing this article, I talked to colleagues who have training in different fields regarding their experience learning how to maintain an authoritative voice in the public sphere. One colleague with a background in public health recalled being told in class by a professor that if they are giving interviews to the press, they must repeat themselves over and over again in order to get their point across (similar to what Rickford mentioned above). This colleague was not in the public policy specialization of public health and still received this information. As a linguist, I did not learn this tactic as a part of my

formal training, rather I learned it from relatives who work in the Hollywood entertainment industry.

While I am in no position to discuss whether or not different media outlets are engaging in manufactured consent (knowingly or unknowingly) in the production of the reports covered in sections 2 and 3, I have noticed echos of linguists making their own ability to influence public opinion harder to attain. Some linguists have expressed to the author that it's preaching to the choir to state that news outlets should have contacted linguists (thereby placing the blame on the media), but the same individuals have insisted that we do not need to use our own professional platforms to reach out to non-specialists and counter the misinformation about our field. Rickford (1999) recognizes that you cannot always rely on the media (1999:270-272); a fact which the author encountered when Forbes did not respond to the inquiry about their article. Without our own authoritative outlets to influence public opinion (and in turn public policy), we will have difficulty maintaining an authoritative position and passing our specialized knowledge to the general public. This confound is mitigated in other fields, such as the field of environmental science concerning climate change, by creating space for policy in professional journals. In these fields, multiple journals have a class of publications called “Policy Briefs”. These types of publications have the goal of presenting authoritative knowledge (with policy implications) in a manner that is easier for the general public to consume.

In the context of Covid-19, medical professionals have aimed to create public policy spaces to dispel misinformation, such as the *This Week in Virology* (TWIV) podcast and the specialty medical journal *Rapid Review Covid-19* (McKenzie 2020). Although these venues may be useful to linguists, they do not replace the approval of field-internal peer review. Fora that provide field-internal acknowledgment are important in cases like the one addressed in this paper because some of the problematic research involves a team with a linguist. It is notable that this team has never published in a linguistics journal, rather they seek approval in medical journals which may not have the same rigor concerning the field of linguistics. Some linguistics journals created Covid-19 special issues, but these journals are conflicted as to their role in shaping public policy. Although some editors want to produce the equivalent of a policy brief, others want special issues dedicated to a public health crisis to only include articles that directly inform theory. The following excerpt highlights the latter point of view:

> " Both reviewers agree that the questions raised in the paper are interesting, novel, and important. However, both have outlined concerns about the appropriateness and scientific contribution of the paper for [the journal].... [I]t seems like the apparent intended audience [of the paper] are not linguists. I would add to this point that there does not seem to be any type of linguistic analysis or discussion of data that can contribute to linguistic theory or our knowledge of language." (Redacted name editor of redacted name journal)

It is a mistake to believe that professional linguists are not the audience for policy brief-like documents. My experience as a media correspondent has shown that some of my colleagues have difficulty tailoring their message to non-specialists. People in this position can use field internal policy briefs to learn how to tailor information to non-specialists (e.g. avoid non-essential technical vocabulary like "larynx", "vocal folds", "intracostal", "oral cavity", "aperiodic", etc.).

In addition to the abdication of responsibility to engage in public policy, some linguists exhibit dismissive behavior towards identifying the source of misinformation.

> "[The author] should lay out of facts of the pandemic without waxing poetic about its social consequences... The reader doesn't care that the author became aware of these articles in a dark corner of the internet, and the reference to QAnon is totally beside the point here. The articles of interest for the analysis appeared in mainstream outlets, which is enough to give the paper high stakes without mentioning conspiracy theories and where the author was hanging out online." (Anonymous Reviewer 2)[16]

In the literature about the Oakland Ebonics Controversy, authors consistently identify the source of misinformation because it allows them to tailor their message. Reviewer 2's statement, and the editor's endorsement of this statement,[17] is dismissive of the fact that Q-Anon is highly effective in spreading and amplifying distrust of authorities through the use of gamification and social media engagement algorithms (US 2019, Cosentino 2020). Similar to the propagation of the Flat

Earth conspiracy theory on social media (Landrum et al. 2019) the circulation of scientific misinformation on a platform like Facebook has the potential to strip our own authoritative voice from us if we do not act early to dispel the belief that we endorse these reports (Landrum et al. 2019, Brazil 2020).

In the case of the poor reporting concerning language use and Covid-19, there appear to be two layers to the misinformation. While it may work to present the arguments in Sections 1.2, 2, and 3, to medical journalists to change how they see their own reports, this likely will not work for the people who are circulating the information on Q-Anon boards. Academics who study conspiracy theories and scientific misinformation have found that once someone buys into these beliefs, they adopt a distrust of authority. After someone has adopted such a position, you cannot counter their views by appealing to your own scientific authority and knowledge. Rather, you have to appeal to the believer's humanity and sense of belonging so that they trust you, the individual, which in turn can lead to the acceptance of information that you present from your authoritative perspective (Brazil 2020, NPR 2020). In the case of Covid-19, this involves, but is not limited to, acknowledging the frustration people feel from the current transmission intervention efforts and being clear that there are no reliable studies to date that would support new policy interventions targeting people based on the language that they speak or the particular songs that they want to sing.

To summarize, even though it may seem obvious to professional linguists that medical journalists should have consulted people from our profession before writing the articles discussed in Sections 2 and 3, the broader failure to disseminate our professional positions into the public sphere does not fall squarely on the shoulder of journalists. If general linguists want to have a say in public policy matters that involve our field, we can do two things: First, we can learn from sociolinguistics and other fields by which have created field-internal avenues for public policy outreach. Second, we can adopt outlooks that show the level of sophistication necessary to inform public policy that were called for over 20 years ago by Rickford (1999).

5. CONCLUSION. In this paper, I have identified problems in scholarly work claiming to link language use to the transmission of Covid-19. The underlying scholarly work in section 2 set out to make claims about language, but the underlying scholarly work in section 3 does not. The

research in section 3 originally set out to make claims about singing and reported an observance about language that arose during the investigation. While the work in section 2 has more underlying issues, the research discussed in section 3 could have benefited from consultation with a linguist.

Journalists have a responsibility to crossvalidate research referenced in their articles. Additionally, they should properly represent the different types of published academic work. The responsibility is especially great when they are representatives of academic knowledge which is a public trust. When journalists specializing in one field fail to seek feedback about claims relevant to a different field, they run the risk of misrepresenting information and in turn accidentally creating misinformation. In the case of Covid-19, the accurate representation of information is important because the public is generally exhausted with the measures necessary to mitigate the spread of the virus. Inaccurately attributing Covid-19's spread to something so instinctive as the use of a linguistic system can chip away at the general public's confidence in academic knowledge and feed the fire of conspiracy theories targeting academics.

Just as journalists have a responsibility, so do linguists. There are examples from our own field (the Oakland Ebonics controversy) and other fields (e.g. climate change denial, flat earth theory, etc.) which suggest that in order to maintain trust in our academic authority, and thereby effectively influence public opinions and public policy, we must engage with people and not be dismissive. Additionally, we must look to find ways to disseminate our own professional rebuttals of far flung claims about language in a way that the public understands is authoritative and in a manner that they will be able to internalize.

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1 At the time this article was originally written in October 2020, the death toll in the US was 200,000 and the global death toll was 1,000,000 according to the World Health Organization. By the time the author received feedback from peer review in December 2020, the death toll nearly doubled to 400,000.

2 The third airflow type, known as transitional or unstable, is seldom discussed in the articulatory phonetics literature. This state lies between laminar and turbulent airflow.

3 Assuming a constant pressure, the velocity of airflow through a larger opening will be relatively slower than the velocity of airflow through a narrow opening. Catford uses this relationship to characterize different airstream velocities of speech sounds based on the size of a constriction in the vocal tract.

4 Differences in the degrees of airflow change are not drawn to scale. Sequencing in the chart is based on Catford (1982).

5 The author, a native speaker of American English, has encountered the form [wɛt̄ watɪs] 'red radish' while shopping at Cantonese markets in the US and trying to distinguish between daikon/Korean radishes and radishes with red skin.

6 Scholars have noted that /ʒ/ has the lowest frequency of all contrastive consonants in English due to historical reasons.

7 Countries with multiple official languages of different types were excluded from the analysis. Countries with exceptionally high or exceptionally low rates of infection (e.g. Italy and Japan) were also excluded.

8 Measuring the forcefulness of the release burst is the topic of a follow-up study preformed by Inouye & Sugihara (2015).

9 The US census varies in its degree of specificity concerning language questionnaires over the years. Generally the US census bureau uses the term “Chinese” to cover what linguists consider to be many distinct languages in the Sinitic family including, but not limited to, Mandarin and Cantonese.

10 The methodology section in Asadi et al. (2020) does not provide a clear view of how the research team assessed voicing of English obstruents among the sampled speakers. While they state that they categorized sounds based on “IPA notation”, these types of transcriptions come in two sorts: *broad transcription*, which is closer to phonological categories, and *narrow transcription*, which is closer to phonetic detail. The use of phonological vs phonetic transcription is often distinguished by using slashes for phonological-level detail and brackets for phonetic-level detail. Although the authors mention “phones” in the text, they consistently use slashes suggesting phonemes.

The distinction between phonological and phonetic voicing is important to clarify because within the

obstruent class, English speakers do not always produce phonologically voiced consonants with phonetic voicing (i.e. the vocal chords do not always vibrate). In many cases, English speakers use secondary cues associated with the timing of adjacent sounds to give the perception of voicing without vibration of the vocal chords (e.g. [s] is physically longer than [z] and a vowel before [s] will be physically shorter than a vowel before [z]). This issue needs to be addressed for the word-initial context more so than for the postvocalic context.

11 Asadi et al. (2020) do not provide an explanation as to why voiced fricatives do not produce as many droplets as voiced plosives. Frication and voicing are known to involve gestures which are aerodynamically at odds with each other. In order to produce a fricative, the pressure in the mouth must be high whereas in order to produce voicing, the pressure in the mouth must be low (Ohala 1983). This aerodynamic conflict has been linked to the cross-linguistic observance that many languages lack voiced fricatives and many historical changes involving voiced fricatives will sustain either voicing and widen the constriction (e.g. Proto Germanic *z → r) or sustain the frication and lose the voicing (e.g. Rio de Platense Spanish [ʒ] → [ʃ]). Absent of more clarification by Asadi et al. (2020) concerning how they assessed the status of voicing on individual segments, it is not clear if this aerodynamic conflict played any role in their findings.

12 In some Swedish dialects, the r-sound is realized as a retroflex fricative or a uvular trill, all of which are characterized by turbulent airflow. Generally, the Swedish r-sound is realized as a vowel if it is not at the beginning of a syllable (similar to the r-sound in British English and stereotypical New York English *color*).

13 This transcription is based on a Youtube Video on the *Körkraft* 'Choir Craft' channel. In Standard Swedish orthography, the lyrics are: *Bibbis pippi petter; hoppar och piper och sprätter; hoppar från pinne till pinne; pratar med Bibbi därinne*.

14 A variety of authors including, Rickford and Baugh, note that some linguists tried to engage with the public and eventually were invited to senate hearings in the US.

15 Rickford acknowledges there were exceptions to the behavior of the media outlets and linguists, but the vast majority of each camp engaged in this way.

16 To the best of the author's knowledge, the number “2” was assigned to the reviewer automatically by the journal's submission platform.

17 “ I agree with the reviewers on their concerns.”