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Introduction: Tracing the origin of /s/ variation

Abstract: This paper provides an introduction to the papers in this special issue on the sociophonetics of /s/. We begin by reviewing some of the principal findings on variation in the production and perception of /s/, summarizing studies in sociolinguistics, experimental phonetics, and laboratory phonology. We go on to identify similarities in the meanings associated with /s/ variation cross-linguistically, and briefly describe how theories of sound symbolism may help us to account for these patterns. We conclude this introductory article with a summary of the contributions to the special issue and a discussion of how together these articles help us to better understand that origin and trajectory of socially meaningful sociophonetic variation.

Keywords: /s/, sociophonetic variation, social meaning, sound symbolism

1 Locating variation

The question of where variation comes from has long been of interest to scholars throughout linguistics. Within phonetics, systematic alternations between sub-phonemic variants have traditionally been assumed to derive from articulatory differences between (groups of) speakers (e.g., average length of the vocal tract) or from coarticulation effect in online speech production. A great deal of research has been devoted to documenting these types of effects, as well as to examining how listeners compensate for this variation when processing a speech signal. Within sociolinguistics, in contrast, research has tended to focus on variable patterns once they have been systematized in an individual's and/or a community's grammar. The focus for many sociolinguists is thus not so much on the origins of variation, though this is an issue that has also received a great deal of attention in the literature over the years as well (e.g., Weinreich et al. 1968; Trudgill 1986;

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Kerswill and Williams 2000; Woolard 2008). Instead, much sociolinguistic research is aimed at understanding what variables do once they are already in the system: how they demarcate different (sub)communities from one another; how they are recruited by speakers for specific interactional functions; and how they both diffuse across social and geographical space and are transmitted over time.

In this special issue, we bring these two approaches to variation together in a comprehensive examination of a single segment that has been the subject of a great deal of scholarly interest cross-linguistically: the voiceless alveolar sibilant /s/. We focus on /s/ both because of the attention it has received in the field, and because we believe that the study of /s/ can shed light on more general questions regarding how variable patterns emerge and acquire meaning across a range of social and linguistic contexts. In this introduction to the issue, we briefly contextualize the articles that follow by first summarizing some of the principal variable acoustic parameters of /s/ that have been described in the literature before turning to a brief introduction to some of the broader theoretical issues at stake. We conclude the introduction with a brief summary of the seven contributions to the issue.

2 The (socio)phonetics of /s/ variation

A number of studies of the acoustics of fricatives have found that place of articulation may to a large extent be established through analysis of the spectral properties of the frication noise itself (Strevens 1960; Stevens 1998), even for sibilants (Hughes and Halle 1956; Behrens and Blumstein 1988; Shadle 1990). Currently, the most widely used method for analyzing the spectral properties of sibilants is through the use of spectral moments analysis (Forrest et al. 1988). Here, FFT-spectra of portions of the noise phase of the sibilant are treated as probability distributions and the first four moments – center of gravity, variance, skewness and kurtosis – are extracted. These measures can be used for the description of any kind of probability distribution, but when applied to acoustic spectra, they are referred to as spectral moments. In addition to the four spectral moments, the spectral peak, defined as the frequency with the highest amplitude in a long-term average spectrum of the frication noise, has also been shown to correlate with place of articulation, especially among sibilants. Jongman et al. (2000) conducted an extensive study of the usefulness of spectral moments and spectral peak (among other acoustic measures) to distinguish between place of articulation in English fricatives, including the distinction between /s z/ and /ʃ ʒ/. Through statistical analysis of data from 10 male and 10 female speakers, Jongman et al. (2000)

found that both spectral peak and all four spectral moments were useful in distinguishing place of articulation between the two groups of sibilants. This finding is in line with work by Shadle and colleagues (cf. Shadle 1990, 1991; Shadle et al. 1991), who have shown that the first high amplitude peak in the spectrum of /s/ corresponds to the resonances of the cavity in front of the constriction needed to produce a sibilant. The relationship between the frequency and the size of the front cavity follows the familiar pattern of speech acoustics with high frequency resonances being associated with small cavities and low frequency resonances with larger ones. Thus, the frequency of the peak amplitude (and the first spectral moment, center of gravity) is inversely related to the size of the front cavity, meaning that the alveolar sibilants /s z/ have a higher spectral peak and a higher mean frequency than the palatal sibilants /ʃ ʒ/. Both Jongman et al. (2000) and Shadle et al. (1991) also found a difference between the placement of peak frequency between male and female speakers: peak frequency was higher for female speakers than for male speakers. This has been interpreted as a function of differences in overall size of the vocal tract between women and men, in line with the classic findings of differences in formant frequencies between male and female speakers (cf. Peterson and Barney 1952; Fant 1973; Stevens 1998).

Several studies support the finding that a difference in men's and women's spectral peak frequencies/centers of gravity of the sibilant spectrum may be attributed to an overall physiological difference, i.e., a simple matter of differences in the size, particularly the length, of the front cavity, rather than a difference in place of articulation between male and female speakers. According to the review of acoustic studies of /s/ presented in Flipsen et al. (1999), a total of 6 previous acoustic studies of /s/ reported the effect of sex described above, i.e., in all 6 studies male speakers were observed on average to have a significantly lower spectral peak or a significantly lower spectral center of gravity than female speakers from the same sample. Flipsen et al. (1999) also found this difference in their own study, and report an overall difference for center of gravity at sibilant midpoint of "about 1.1 kHz" between the 14 male and 12 female speakers (aged 9 – 15 years old.) they tested. Some perceptual studies have also found that listeners are able to identify a speaker's sex on the basis of isolated sibilants (e.g., Schwartz 1968), and Johnson (1991) found that listeners were more likely to accept a synthetic sibilant as a token of /s/ (rather than /ʃ/) when the vowel context indicated that the speaker was male, rather than female. All of these studies can be taken as support for a direct link between sibilant acoustics and vocal tract anatomy as a function of speaker sex: because female speakers generally have smaller vocal tracts than male speakers, they will also have a shorter cavity in front of the constriction that is formed for the production

of sibilants and hence show a tendency for higher spectral peaks (or center of gravity). The perceptual studies noted above indicate that listeners are attuned to this anatomical difference between men and women and make use of it both for the identification of speaker sex and in compensation for coarticulation.

However, as noted in Flipsen et al. (1999), the observed difference may also be due to female speakers having a somewhat fronter place of articulation for /s/ than male speakers, something which would also result in a shorter front cavity and hence a higher peak frequency. To study this directly, Fuchs and Toda (2010) obtained both acoustic and articulatory measures (using electropalatographic [EPG] recordings) from 12 speakers of English and 12 speakers of German (6 male and 6 female for each language). The EPG measures provided an indication of palate length as well as place of sibilant constriction. Interestingly, Fuchs and Toda found that there was no effect of sex overall for palate length, but there was an "effect of language" with English speakers having, on average, a longer and narrower palate than German speakers. A further difference was found across languages, namely that place of articulation (as measured by calculating the center of gravity of points of contact with the artificial palate) correlated with palate length for the English speakers, but not for the German speakers. This is interesting for two reasons: 1) two of the male English speakers had palates as short as the female English speakers and their place of articulation for /s/ was the same as that of the female speakers, and 2) the female German speakers all had fronter places of articulation for /s/ than the male German speakers, despite the fact that palate length was even more similar across sex for the German speakers. While the finding for the English speakers supports the previous interpretation that place of articulation is simply a function of vocal tract physiology (with a short palate leading to a fronter place of articulation), the finding for the German speakers unequivocally supports an interpretation that the more front place of articulation observed for female speakers is a learned behavior rather than a direct consequence of anatomy.

Fuchs and Toda's (2010) findings support other studies that also provide evidence for the notion that observed differences in sibilant acoustics between men and women may be due to something more than simple anatomy. In her study of /s/ production in Glaswegian English, Stuart–Smith (2007) found that young working-class girls differed from all other girls in the sample by virtue of their having spectral centers of gravity and peak frequencies that were similar (and sometimes identical) to older working-class males. This pattern cannot be reasonably interpreted as an indication of anatomical differences between the girls, but rather indicates that articulation is a learned behavior that is open to strategic variability, allowing the working-class girls to recruit /s/ variation as a way to diverge from their peers. Similarly, Munson et al. (2006) also found a

difference in the acoustics of /s/ among male speakers of American English. In that study, self-identified gay male speakers differed from self-identified heterosexual male speakers with respect to the skewness of the sibilant spectrum (i.e., the third spectral moment). Interestingly, Munson et al. (2006) also showed that listeners use this difference when guessing the sexual orientation of speakers. This supports the finding in Linville (1998), who demonstrated that listener identification of male speakers' sexual orientation correlated with the peak frequency of their productions of /s/ (as well as with /s/ duration). Strand (1999) has shown that expectations about who the listener believes the speaker to be based on visual presentation of gender may affect how listeners perceive their sibilants on a continuum from /s/ to /ʃ/, since listeners require a higher peak frequency in the sibilant to classify it as an instance of /s/ when the sibilant is presented in a word together with a female face, rather than when presented together with a male face.

Taken together, these studies show that speakers may break away from the expected patterns of /s/ production on the basis of their gender, but also that when male speakers do so, listeners are likely to interpret this as a sign that they belong to a category of males that are stereotypically associated with femininity. This tendency to associate /s/-fronting and gayness has been further supported in a number of studies where variation in the peak frequency of the /s/ was manipulated, but where listeners were not asked to identify the sexual orientation of the speaker, but rather indicate their beliefs about the speaker. Campbell-Kibler (2011), in a study where 175 listeners were asked to rate male speakers of American English on a number of scales of personality traits including "gay" and "masculine", found that listeners were more likely to rate a speaker as "more gay" and "less masculine" when the stimuli used contained tokens of /s/ with a higher center of gravity. Levon (2014) found a similar result when listeners were asked to rate male speakers of British English. Finally, Pharao et al. (2014), in a study of the social meanings associated with different registers of contemporary Copenhagen-based Danish, found that for some male speakers of Danish, listeners rated them as more "gay" and more "feminine" sounding when they were heard producing tokens of /s/ with a higher center of gravity. While a number of additional linguistic and social factors affect the responses in these studies, the general pattern emerging from both acoustic studies, perceptual experiments and speaker evaluation experiments indicate that while it may be a learned behavior, female speakers tend to produce /s/ with spectral characteristics that are indicative of a smaller front cavity, and that listeners in turn use this expectation both in the identification of speech sounds and in forming beliefs about speakers.

3 Shared social meanings of /s/

As the review above demonstrates, there are striking similarities in the perceived meanings of fine-grained phonetic variation in /s/ production across a range of linguistic and cultural contexts. This similarity is interesting from a theoretical perspective since it challenges standard assumptions about the relationship between linguistic form and perceived meaning. At least as far back as de Saussure (1916), modern linguistics has assumed that the link between a signified and its signifier (be it lexical, morphological, or phonetic) is arbitrary, governed by language-specific convention rather than some more general principle of form-meaning correspondence. The discovery of sustained cross-linguistic similarity among a diverse group of languages calls this assumption of arbitrariness into question, and requires us to consider alternative explanations for the source of convergent perceived meaning.

In their comprehensive review of cross-linguistic exceptions to arbitrary form-meaning pairs, Hinton et al. (1994) identify four types of *sound symbolic* relations, or situations in which there is an iconic correspondence between phonetic form and the meaning conveyed. Corporeal sound symbolism involves both segmental and intonational patterns that express the physical and emotional states of speakers, including so-called "symptomatic" sounds, like *achoo*, and expressive elements of prosody and voice quality. Imitative sound symbolism, more commonly termed onomatopoeia, refers to approximations of sounds that exist in the exterior world, whether animate (e.g., 'moo') or inanimate (e.g., 'swoosh'). Conventional sound symbolism, in contrast, is not based on an inherent iconicity of phonetic form, but rather one that has developed in specific languages over time. A canonical example of conventional sound symbolism is words in English beginning with [gl] clusters and a set of meanings referring to luminosity (e.g., glow, glisten, glimmer) (Bloomfield 1895; Hinton et al. 1994; Bergen 2004). The argument is that by historical accident, clusters like [gl] in particular words become phonesthemic – sounds associated with specific conventionalized meanings – and then "irradiate out" (Bloomfield 1895) to congeneric terms in the same semantic domain.

The final type of sound symbolism, and that which is most relevant to us in this issue, is synesthetic sound symbolism, or the association of (classes of) sounds with properties in the world. The most common form of synesthetic sound symbolism is magnitude symbolism, that is the perception that certain sounds are naturally expressive of size distinctions (i.e., large versus small). According to Ohala (1984, 1994), the principle, and perhaps primary, phonetic correlate of magnitude symbolism is acoustic frequency, including the formant

frequencies of vowels (normally F2) and the fundamental frequency of pitch (F0). Described by Ohala in terms of the Frequency Code, research has shown a general tendency for higher frequency items (e.g., elevated pitch, front vowels) to perceptually map to "smallness" while lower frequency items (e.g., low pitch, back vowels) map to "bigness". This correlation has been demonstrated in a variety of ways, including in novel object-naming tasks (i.e., the famous *babou/kiki* effect) (Jespersen 1933; Newman 1933; Thompson and Estes 2011; Shinohara and Kawahara 2012), and surveys of the lexicons of genetically, areally and typologically distinct languages (Ultan 1978; Woodworth 1991; Haynie et al. 2014).

In analogy to Ohala's Frequency Code, Gussenhoven (2002) proposes two further sound symbolic codes that govern the non-arbitrary association between phonetic form and linguistic meaning. The first of these is the Effort Code, or the regular correspondence between sounds requiring greater articulatory effort in speech production and meanings such as "emphasis", "prominence" and other derived affective characteristics (e.g., "surprise", "helpfulness"). As examples of the Effort Code, Gussenhoven (2002) cites the fact that stimuli with wider pitch ranges and higher pitch peaks are judged as sounding more "emphatic" and salient in laboratory testing. Gussenhoven also argues that the phonologization of intonation focus is often derived from the Effort Code. In Dutch, for example, focused information is often marked in discourse via a wider pitch excursion (i.e., a great amount of effort), a pattern that also distinguishes contrastive from neutral focus in Bengali (Haan 2002). In addition to the Effort Code, Gussenhoven (2002) also proposes the existence of what he terms the Production Code, which associates high pitch with utterance beginnings and low pitch with utterance endings. According to Gussenhoven, this association is due to the gradual decline in sub-glottal pressure towards the end of breath groups, leading to an iconic link between decreased pitch and/or decreased vocal intensity and a perception of utterance finality. In support of this claim, Gussenhoven (2002) cites the common pattern of phrase-final high boundary tones (H%) cross-linguistically for signaling continuation (i.e., reversing the more expected decrease in pitch at the end of an utterance as a marker of non-finality) while phrase-initial high tones signal topic refreshment.

Central to Gussenhoven's (2002) framework is the notion that sound symbols can carry both "informational" and "affective" meanings, where informational meanings signal attributes of the message being communicated (e.g., emphasis, non-finality) and affective meanings signal perceived attributes of the speaker (e.g., helpfulness, friendliness). The idea that sound symbolism necessarily involves affective meaning is also central to Silverstein's (1994) analysis of the sound symbolic augmentative/diminutive system of Wasco, a Chinookan language spoken in present-day Oregon. In Wasco, the augmentative/diminutive system is

highly developed, correlating with contrasts such as voiced (augmentative) versus glottalized (diminutive) versus voiceless non-glottalized (neutral) consonants, as well as with patterns of sub-phonemic fronting (diminutive) versus backing (augmentative) of certain vowels. In his work, Silverstein demonstrates how the sound symbolic denotations of augmentation and diminution serve as affordances for a complex indexical system of culturally relevant contrasts in Wasco. Rather than simply signaling "bigness" versus "smallness", the augmentative/diminutive system is recruited to instantiate contrasts such as "distanced" versus "intimate", "repugnant" versus "desirable", "impersonal" versus "personal", and "disgusting" versus "pleasing". Silverstein describes these culturally derived meanings as resulting from an *affective engagement* with sound symbolism, i.e., a process through which the concepts "bigness" and "smallness" are evaluated and, ultimately, ideologically elaborated (Peirce 1932; Silverstein 2003) through a particular cultural lens. Thus, while they approach the issue from distinct theoretical perspectives, Gussenhoven and Silverstein agree that iconic sound-meaning correspondences (such as the Frequency Code) provide the essential building blocks for sound symbolism, but they do not tell the whole story. In order for a sound symbolic system to be realized in a language, it must first be taken up and interpreted in language- and culture-specific ways.

This theoretical clarification is important because it allows us to expand the empirical breadth of our investigations, and to uncover how a diverse range of linguistic meanings may in fact be sound symbolic in nature. Joseph (1994), for example, describes how the coronal affricate [ts] and [dz] in Modern Greek predominate in three related semantic domains: 1) words for "small" things (e.g., *tsíros* 'thin person', *korítsi* 'little girl'), 2) words for "deformed" things (e.g., *kútsa* 'limp', *katsíða* 'balding'), and 3) words for things that "sting" or "burn" (e.g., *tsukníða* 'nettle', *tsimbó* 'pinch'). In addition, Joseph notes that expressives, slang terms, and foreign borrowings are often iconically marked in Greek by the presence of the [ts] affricate. Joseph argues that all of these meanings exist in a "relatedness network" that is itself derived from a broader sound symbolic association between affrication and (social) markedness. In a similar vein, Hamano (1994) demonstrates how palatalization of alveolar consonants in Japanese links to meanings like "childishness" and "immaturity", and then by extension to meanings such as "instability", "unreliability" and "lack of elegance". Finally, Diffloth (1994) discusses how an understanding of sound symbolism as necessarily instantiated at the culture-specific level can help us to account for apparent counter-examples to predicted sound symbolic associations. Diffloth shows how in Bahnar, a Mon-Khmer language of Vietnam, "bigness" is signaled by high vowels and "smallness" is signaled by low vowels, in a seeming contradiction of the expected pattern. Diffloth argues, however, that the facts of Bahnar can be

reconciled with an iconic understanding of the high-low vowel distinction if we consider the fact that the tongue occupies a larger volume of the oral cavity when producing high vowels than it does when producing low ones. As a result, we could hypothesize that in Bahnar the iconic meanings of vowels are based on a phonic symbolism derived from tongue mass and position (where higher = bigger), as opposed to a symbolism derived from the size of the resonating cavity (where higher = smaller), as has been argued to be the case for languages like English. It is thus not only the network of sound symbolically linked meanings that are potentially language- and culture-specific, but also the interpretation of the iconicity of form itself.

In recent work, Eckert (2010) has built upon these semiotically informed understandings of sound symbolism to investigate potential iconic motivations for observed patterns of sociophonetic variation in speech. Eckert focuses on the backing (and raising) of the LOT and PRICE vowels (in words like *gosh* and *ride*) in the speech of a group of preadolescent girls in Northern California. She demonstrates that the girls systematically vary their production of LOT and PRICE depending on the kind of social personae they are enacting in a particular interaction. When presenting themselves as "nice", "friendly" and "positive", their productions of LOT and PRICE are significantly fronter (and lower) than when they are presenting themselves as "cynical", "negative", or "having an attitude". Eckert argues that this stylistic pattern can be seen as sound symbolic in nature. According to this interpretation, the girls affectively engage with the magnitude symbolic meaning of differences in F2 so as to interpret backing as being linked to things like "adulthood" and "maturity". In contrast, front vowels (and hence higher F2) seem to symbolize "childhood" and "innocence". The "big" versus "small" contrast has thus been reoperationalized by the girls in question to refer to a locally salient difference between things that are big (i.e., adults) versus things that are small (i.e., kids). Eckert's (2010) argument is reminiscent of one of her earlier studies (Eckert 1996), where she found a similar pattern of backing of the TRAP vowel among a subset of the same girls. In that work, Eckert shows how backed tokens of TRAP correlated with the girls' discussions of "boyfriends", "love", and "dating" – topics that for most preadolescents are the quintessential representatives of what it means to grow up and "get big".

4 This issue

In this issue, we follow in the tradition of scholars like Eckert and Silverstein to examine how sound symbolic considerations may also be implicated in variation in the production and perception of /s/ crosslinguistically. The issue includes

papers based in analyses of production, perception and discourse. Among the papers looking at production, Lal Zimman's contribution focuses on spectral qualities of /s/ among English-speaking transgender men. The focus on trans-men makes it possible to examine to the ways in which physiology and gender identity interact in the production of /s/. Zimman's analyses show that sex category does not determine the gender-linked acoustic characteristics of /s/, and that a much more complex framework for the conceptualization of sex/gender is necessary to account for the individual variation in /s/ observed. In her production-based study of /s/ and /ɕ/ in Mandarin, Fangfang Li focuses on the development of gender-specific speech patterns in Mandarin children's produc-tion of voiceless sibilant fricatives. Variation in 94 children aged from 2 to 5 is analyzed (together with a smaller comparable group of adult speakers). Li's results show that there is gender difference in the production of both /s/ and /ɕ/ in Mandarin-speaking children, but that in the parent generation gender differences only exist for /ɕ/. As a result, Li suggests that gendered variation in /s/ is potentially the result of a chain shift initiated by gender-linked variation of /ɕ/, one that emerges around the age of 4. Li's study is important because it demonstrates the potential for the social meaning of one phoneme to be trans-ferred to other "neighboring" phonemes. The final production based contribution is by Sophie Holmes-Elliott and Erez Levon, who present an empirical method for correlating variation in /s/ production with the different interactional stances speakers adopt in interaction. Focusing on stance and /s/ variation in two British reality-television shows, the authors demonstrate how high frequency variants of /s/ are used in less threatening social interactions whereas low peak frequency variants are used in more threatening ones. Holmes-Elliott and Levon argue that this type of interactionally based account provides a more detailed and robust analysis of the data than an account based solely on speaker sex would.

While studies of production offer us one way to gain insight into the relationship between variation and indexicality, studies of perception provide us with a complementary vantage point. In their article, Benjamin Munson, Kayleigh Ryherd and Sara Kemper examine how listeners perceive variation in sibilant fricatives depending on whether they are primed to believe that the talker is a woman or a man. Two types of experiments are conducted, one in which the gender of the speaker is implied more explicitly than the other. Through sophisticated statistical analysis of their findings, Munson and collea-gues demonstrate how beliefs about a speaker – in this case their gender – are important in their perception of linguistic variation. Ian Bekker and Erez Levon make a similar point in their study of listeners' perceptions of /s/-fronting in White Afrikaans and in White South African English. Their results indicate that /s/-fronting in both languages is fundamentally an index of femininity, though

different sociohistorical circumstances have led to somewhat different indexical meanings in the two speech communities. Bekker and Levon also discuss whether the presence of a socially meaningful pattern of /s/-fronting in White Afrikaans should be seen as a transfer from White South African English, or as the result of an independent language-internal development. The final perception-based contribution is by Nicolai Pharao and Marie Maegaard, who investigate the indexical meaning of fronted /s/ in Copenhagen Danish when it is combined with different variants of /t/. Pharao and Maegaard's results show that the presence of palatalized variants of /t/ affects the perceived meaning of fronted /s/ in one Danish register, but has a different and much weaker effect in the other register. This means that the indexical value of fronted /s/, even within the same language, can be quite different depending on what other features also occur in the speech signal.

Finally, Mia Halonen and Johanna Vaattovaara's contribution describes how the ideological link between the city of Helsinki and a certain pronunciation of /s/ emerged in Finnish. While there is no evidence from production that Helsinki is in fact home to a different realization of /s/ than the rest of Finland, the belief that there is such a thing as a" Helsinki /s/" is a dominant theme in Finnish popular discourse. Halonen and Vaatovaara investigate the development of this perceived connection between Helsinki and a certain type of /s/ production, and show how it involves historical processes of mediatization, the development of the entertainment industry, and a cultural opposition to Swedish.

The special issue concludes with a brief commentary by Penelope Eckert. Situating her discussion in relation to Charles Saunders Peirce's (1932) triadic theory of signs, Eckert reminds us that even the most seemingly iconic sound-meaning correspondences are not "natural" or "universal", but are instead always a product of convention: "conventions about the relation between language and sounds in nature ... [and] conventions about the natural characteristics taken to be represented by sounds" (Eckert, this issue). Eckert's point serves as a useful caution against drawing too direct a line between sound symbolic origins and the culturally specific indexical meanings that ultimately obtain. As the contributions to this issue all demonstrate, the meanings of /s/ variation cross-linguistically can, for the most part, all be traced back to a salient association between sibilant frequency and perception of magnitude (i.e., "bigness" versus "smallness"). Yet what we hope to demonstrate is that this form-meaning association is only the first step. The truly interesting findings are located in the details of how an underlying meaning of "smallness", for example, comes to be interpreted as related to traits like "femininity", "gayness", "urbanness", "whiteness", and "middle-class-ness". This is the question that the contributions to this issue collectively seek to address, with the aim of

understanding not only where socially meaningful variation comes from, but also the path this variation ultimately takes.

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