Messages must be tuned to the target language: Some implications of crosslinguistic semantic diversity for neurolinguistic research on speech production

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A B S T R A C T

There are nearly 6,500 languages in the world, and they vary greatly with regard to both lexical and grammatical semantics. Hence, an early stage of utterance planning involves "thinking for speaking"—i.e., shaping the thoughts to be expressed so they fit the idiosyncratic meanings of the symbolic units that happen to be available in the target language. This paper has three main sections that cover three distinct types of crosslinguistic semantic diversity. Each type is initially elaborated with examples, and then its implications for the neurobiology of speech production are considered. *Type 1: Semantic field partitions.* These are exemplified by huge crosslinguistic differences in many domains of meaning, including colors, body parts, household containers, events of cutting and breaking, and topological spatial relations. When such differences are viewed from the perspective of contemporary neurocognitive theories which assume that most concrete concepts are subserved by both modal (i.e., sensory, motor, and affective) and transmodal (i.e., integrative) cortical systems, they imply that speakers must access language-specific semantic structures at multiple levels of representation in the brain. *Type 2: Semantic conflation classes.* Some languages have whole sets of words that systematically encode two or more components of meaning. For instance, in the roughly 53 Athabaskan languages there are no generic verbs like *give, carry,* or *throw;* instead, there are entire sets of 9–13 verbs for these kinds of actions, with each set making the same distinctions between the types of objects that are given, carried, or thrown, such as animate objects, round objects, stick-like objects, flat objects, etc. This regular conflation of [action + object] in Athabaskan verb meanings predicts that speakers frequently co-activate both action-related and object-related cortical regions in a functionally integrated fashion. *Type 3: Grammatically obligatory semantic categories.* This kind of crosslinguistic variation involves not only the particular dimensions of experience that speakers are forced to track for grammatical purposes, but also the precise contrasts that they must make along those dimensions, with examples including systems of nominal classification, tense, and evidentiality. It is still not known exactly where or how the meanings of grammatically necessary closed-class morphemes are implemented in the brain, but it is quite clear that whatever the neural substrates of these meanings turn out to be, they are strongly influenced by crosslinguistic differences. In all, by focusing on three separate forms of crosslinguistic semantic diversity, this paper reinforces Levelt's (1989) point that "messages must be *tuned* to the target language," and it also shows that this point continues to have significant consequences for neurolinguistic research on speech production.

1. Introduction

According to the best current estimate, nearly 6,500 mutually unintelligible languages are, or recently were, spoken on our planet (Hammarström, 2016). Although these languages exhibit many similarities regarding the concepts that are represented in their inventories of symbolic units (i.e., in their morphemes, words, and grammatical constructions), they display far more differences (Bohnemeyer, 2019; Evans, 2011; Majid, 2015; Malt & Majid, 2013; Moore, Donelson, Eggleston, & Bohnemeyer, 2015). And these semantic differences have significant consequences for speech production, since they entail that talkers must always organize their thoughts to fit the lexicalized and grammaticalized concepts that happen to be available in the language being used.

This point has been appreciated by prominent researchers in psycholinguistics for a long time. For instance, in his classic book

Speaking, Levelt (1989) raised the question of "whether messages must, to some degree, be *tuned* to the target language. Will a message for an English Formulator have to differ from one that is fed into a Dutch Formulator, merely because of language-specific requirements? The answer … is positive: Using a particular language requires the speaker to think of particular conceptual features" (p. 71, emphasis in original). Likewise, when Slobin (1996) originally presented his influential notion of "thinking for speaking," he observed that different languages "are not neutral coding systems of an objective reality. Rather, each one is a subjective orientation to the world of human experience, and this orientation *affects the ways in which we think while we are speaking*" (p. 91, emphasis in original).

By contrast, the importance of crosslinguistic semantic variation has not received nearly as much attention in neurolinguistics (Kemmerer, 2019a). The aim of this paper is therefore to highlight some of the implications of this diversity for research on the neural substrates of speech production.[1] More specifically, I will describe three general ways in which languages differ in the concepts they encode—(1) semantic field partitions, (2) semantic conflation classes, and (3) grammatically obligatory semantic categories—and for each one I will first give some examples and then discuss their implications.[2] Of course, there are other kinds of crosslinguistic semantic variation, but I have chosen these for two reasons: first, they have been carefully studied in linguistic typology; and second, well-motivated predictions can be made about their cortical underpinnings, at least in some cases.

2. Semantic field partitions

2.1. Examples of crosslinguistic diversity

The languages of the world display numerous similarities and differences in how they symbolically subdivide the same semantic fields, and in recent years an increasing amount of research has been devoted to documenting the extent of this variation, identifying the factors that drive and constrain it, and determining whether it is significantly greater for some fields than others. Comparative studies involving anywhere from a handful of languages to several hundred have already addressed a wide range of domains, including plants and animals (e.g., Berlin, 1992), body parts (e.g., Majid, , Enfield, , & van Staden., 2006), household containers (e.g., Malt, Sloman, Gennari, Shi, & Wang, 1999), landscapes (e.g., Burenhult & Levinson, 2008), colors (e.g., Kay, Berlin, Maffi, Merrifield, & Cook, 2009), temperatures (e.g., Koptjevskaja-Tamm, 2015), odors (e.g., Majid & Burenhult, 2014), spatial relations (e.g., Levinson & Wilkins, 2006), kinship (e.g., Kemp & Regier, 2012), numbers (e.g., Comrie, 2005), emotions (e.g., Wierzbicka, 1999), and quite a few categories of action, such as locomoting (e.g., Slobin, Ibarretxe-Antuñano, Kopecka, & Majid, 2014), giving (e.g., Newman, 1998), reciprocating (e.g., Evans, Gaby, Levinson, & Majid, 2011), cutting and breaking (e.g., Majid et al., 2007), putting and taking (e.g., Kopecka & Narasimhan, 2012), and eating and drinking (e.g., Newman, 2009). All of these studies, and many others as well, demonstrate that languages differ multifariously in their lexical partitioning of the same semantic fields while still tending to exhibit overarching patterns. A few examples are elaborated below.

To begin with the domain of color, Kay et al. (2009) conducted the World Color Survey, which used standardized stimuli and methods to explore the basic color lexicons of 110 geographically and genealogically disparate languages from non-industrialized societies. Among the many intriguing results was the finding that while some languages have separate terms for green, blue, yellow, red, white, and black (e.g., Kamano-Kafe, Trans New Guinea, Papua New Guinea),[3] others have single terms for two or more combinations of these categories. Such composite color categories include green/blue (e.g., Bhili, Indo-European, India), green/yellow (e.g., Cree, Algonquian, Canada), green/blue/yellow (e.g., Karajá, Karajá, Brazil), black/blue (e.g., Martu-Wangka, Pama-Nyungan, Australia), black/green/blue (e.g., Kwerba, Tor-Kwerba, Indonesia), red/yellow (e.g., Múra-Pirahã, unclassified, Brazil), and white/red/yellow (e.g., Dani, Trans New Guinea, Papua New Guinea). It is also well-established that some languages go the other direction, taking a "splitting" rather than a "lumping" approach to categorizing certain sectors of color space. For instance, both Russian (Winawer et al., 2007) and Greek (Thierry, Athanasopoulos, Wiggett, Dering, & Kuipers, 2009) lack a single basic color term for blue and instead have two separate terms—essentially, one for dark blue and another for light blue.

Turning to objects, one interesting subdomain that has been investigated from a crosslinguistic perspective is body parts. Given that the human body is a single object with a continuous surface, the purpose of any mereological nomenclature is to allow speakers to refer to spatially delimited body segments. Hence, the most important semantic component of body-part nouns is probably form—i.e., geometric information about the canonical contours and boundaries of the designated entities. Most languages rely on the visual and motor discontinuities of joints to distinguish between different parts of the limbs—e.g., upper arm, forearm, hand, and finger. But the presence of a salient discontinuity does not ensure that a language will use it as the basis for separate terms, and in fact a substantial amount of crosslinguistic diversity has been found in lexically based body segmentation systems (Brown, 2005a, 2005b; Majid et al., 2006; Majid & van Staden, 2015). For instance, Brown (2005a) found that in a global sample of 617 languages, only 389 (63%) have separate terms for arms and hands. Some other striking examples of variation in the meanings of body-part nouns are as follows. Lavukaleve (Central Solomon, Solomon Islands) lacks distinct terms for arms and legs, employing instead a single term for both, and while it does have a separate term for feet, it lacks a corresponding term for hands (Terrill, 2006). Savosavo (Central

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[1] Naturally, crosslinguistic differences in meaning also have major consequences for research on the neural substrates of speech comprehension, but I will ignore them here, since this paper is for a special issue of the *Journal of Neurolinguistics* devoted to the cognitive neuroscience of speech production.

[2] Throughout this paper, the terms *semantic* and *conceptual* are used interchangeably, in keeping with current practice in cognitive neuroscience.

[3] Hereinafter, for languages that may not be familiar to the reader, the family classification and geographical location are provided after the name.

Solomon, Solomon Islands) devotes different terms to arms and legs, but both of them are semantically general insofar as they cover the entirety of these limbs, including hands and fingers in the first case, and feet and toes in the second; moreover, there are no other words that designate just hands or just feet (Wegener, 2006). In contrast, Jahai (Mon-Khmer, Malaysia) prefers specificity over generality, since it has different terms for the upper arm, forearm, and hand, as well as different terms for the thigh, calf, and foot, but no terms for whole arms or whole legs (Burenhult, 2006). And Tidore (West Papuan, Indonesia) displays yet more peculiarities, since it has one term that covers the foot, calf, and lower part of the thigh, and another term for "groin" that includes the upper part of the thigh, thus drawing a category boundary in the absence of a corporeal discontinuity (van Staden, 2006).

Another subdomain of objects that is carved up differently in different languages is household containers. For instance, Malt et al. (1999, 2003) asked speakers of English, Argentinian Spanish, and Mandarin Chinese to name 60 such objects, and found that while 16 of them were preferentially called *bottle* in English, there was not a matching term in either Spanish or Chinese. Instead, those 16 objects fell into 7 smaller Spanish categories, and 13 of them were subsumed within a larger Chinese category that also included all 19 of the objects called *jar* plus 8 of the 15 objects called *container*. Similarly, Pavlenko and Malt (2011) compared the naming patterns for 60 drinking vessels in English and Russian, and found that although all of them were labeled with just three words in English—*cup, glass,* and *mug*—they elicited no less than 10 terms in Russian. Moreover, the latter categories did not simply subcategorize the former; instead, the two naming patterns crisscrossed in complex ways that reflected variation involving the relative importance of multiple conceptual features, including shape, size, material, and function. More recently, Majid, Jordan, and Dunn (2015) examined how speakers of 12 Germanic languages named 67 dishes, and found that even though the languages have shared histories, their speakers displayed many differences regarding the lexical classification of the very same objects. The average number of separate terms that speakers generated to label the dishes was 39, but the range extended from a low of just 19 in Faroese to a high of 71 in Schwyzerdütsch.

Shifting to the realm of actions, one subdomain that has been carefully studied cross-linguistically is events of cutting and breaking. This was the focus of a project in which speakers of 28 geographically and genealogically disparate languages were asked to name 61 videoclips depicting separations of various kinds (Majid et al., 2007; Majid, Boster, & Bowerman, 2008). Although the researchers did identify some genuine crosslinguistic similarities, they discovered a much richer array of differences. For instance, in naming the 61 videoclips, speakers of Tzeltal (Mayan, Mexico) used over 50 verbs, each with highly specific semantics, such as "cut a round or bulky soft thing across its long axis," "cut/break something so that it falls open in two halves," and "partially separate a long thing so that it is not fully broken" (Brown, 2007). In contrast, speakers of Yélî Dnye (Papuan, Rossel Island) named all of the videoclips with just three verbs that can be glossed loosely as "coherent severance with the grain," "coherent severance against the grain," and "incoherent severance regardless of grain" (Levinson, 2007). Among the many other conceptual distinctions that were revealed by the survey are the following. Lao (Tai Kadai, Laos) has different verbs for cutting into something with a placed blade and cutting into something with a moving blade (Enfield, 2007). Jalonke (Niger-Congo, Guinea) distinguishes between cutting or breaking something that is a whole entity and cutting or breaking something that has already been detached (Lüpke, 2007). And Kuuk Thaayorre (Pama-Nyungan, Australia) has a unique verb for separating a long thing by means of an instantaneous outward pulling force—a category of actions that encompasses not only removing a pen cap and plucking an eyebrow, but also taking a lid off a container (Gaby, 2007).

As a final illustration of crosslinguistic variation in semantic field partitions, it's worth looking briefly at the realm of topological spatial relations. A great deal of comparative work has been done on this topic (Berthele, Whelpton, Næss, & Duijff, 2015; Feist, 2008; Levinson & Meira, 2003; Levinson & Wilkins, 2006; Majid et al., 2015; Regier, Khetarpal, & Majid, 2013), but for present purposes it is sufficient to consider how English, Finnish, Dutch, and Spanish describe the following situations: a cup on a table, an apple in a bowl, and a handle on a door (Bowerman, 1996; Bowerman & Choi, 2001). In English the same preposition, *on,* is used to refer to the "cup on table" and "handle on door" situations because both of them share the features of contact and support, and a different preposition, *in,* is used for the "apple in bowl" situation because it involves containment. Finnish, on the other hand, is sensitive to a different distinction. One case-marker, *-ssa,* specifies what might be called intimate contact, a semantic category that includes both containment and attachment, so it is used for both the "apple in bowl" and "handle on door" situations. A different case-marker, *-lla,* specifies non-intimate contact, which includes horizontal support through gravity, so it is used for the "cup on table" situation. As for Dutch and Spanish, they go in opposite semantic directions. Dutch opts for maximal discrimination, employing three different prepositions—*op, in,* and *aan*—for the three situations, whereas Spanish opts for maximal generalization, using just one preposition, *en,* for the three situations.

2.2. Implications for the neural substrates of speech production

During the past few decades, the branch of cognitive neuroscience that studies how semantic knowledge is implemented in the brain has made significant progress. For one thing, there is mounting evidence that concrete concepts tend to be grounded in anatomically segregated modal systems for perception, action, and emotion, such that a great deal of semantic processing involves the partial reconstruction of sensory, motor, and affective states in different parts of the brain, usually in a rapid, automatic, and unconscious manner, but with sensitivity to task, context, and individual experience (Hauk, 2016; Kemmerer, 2015; Pulvermüller, 2013). It is also becoming increasingly clear that transmodal systems are necessary to integrate the cortically distributed features of multimodal concepts, transcend superficial criteria for categorization, and form unitary, distilled representations that can easily be accessed and combined (Binder, 2016; Fernandino et al., 2016; Patterson & Lambon Ralph, 2016). However, most of this research, including the work that has focused on the retrieval and selection of word meanings during speech production, has failed to consider the particular kind of crosslinguistic diversity described and exemplified above—i.e., diversity in semantic field partitions.

One important implication of this diversity is that it is probably manifested at every cortical level of conceptual representation, from modal to transmodal systems. And if this is indeed the case, it entails that when speakers of different languages talk about the same domain of experience, they often ignite within the same brain regions different patterns of activity that reflect different ways in which that domain is partitioned.

For instance, although there are many unresolved issues regarding the neural substrates of color categorization (Siuda-Krzywicka, Boros, Bartolomeo, & Witzel, in press), an influential fMRI study of color naming in English suggests that the meanings of basic color terms are implemented in two visual areas—ventral V4 (V4v) and VO1 (Brouwer & Heeger, 2013). One would therefore expect that in different cultures around the world, the functional organization of these areas may co-vary with the color term inventory of the local language. For speakers of English and similar languages, V4v and VO1 may capture the simple color categories that we are most familiar with—e.g., green, blue, red, and yellow—but for speakers of some other languages, the same areas may capture the various composite color categories that Kay et al. (2009) discovered in their World Color Survey—e.g., green/blue, green/yellow, green/blue/yellow, and red/yellow.

Continuing with the domain of color, it is also worth discussing an influential event-related potential (ERP) study by Thierry et al. (2009) that focused not on composite color categories, but rather on the fact that, as mentioned earlier, Greek is among those languages that, unlike English, has two separate basic color terms for blue—one for dark blue (*ble*) and another for light blue (*ghalazio*). In this experiment, the researchers recorded the brain potentials of both English speakers and Greek speakers while they performed an oddball detection task that required them to press a button every time they saw a square (probability 20%) within a stream of circles (probability 80%). Crucially, each stimulus was one of four colors—dark green, light green, dark blue, or light blue—and within a given block of trials the most frequent stimuli were circles with either dark or light luminance (standard, probability 70%), and the least frequent stimuli were circles with the contrasting luminance, i.e., light if the standard was dark and vice versa (deviant, probability 10%). There were two main findings. First, the visual mismatch negativity (vMMN), which indexes the unconscious, preattentive detection of rare visual stimuli, was similar for the two groups of speakers when they perceived deviant shades of green, but it was significantly greater for the Greek speakers than the English speakers when they perceived deviant shades of blue. Second, the latencies and amplitudes of the waveforms elicited by dark and light blues were also different for the Greek speakers, but not for the English speakers, during an earlier time window of 100–130 ms post-stimulus-onset, which is when visual stimuli are initially categorized. Importantly, when the participants were debriefed, none of them gave any indication of knowing that the critical stimulus dimension was luminance, nor did any of them report subvocally naming the colors. Hence, the results suggest that even when the color of an object is irrelevant to a person's task, that person's brain still implicitly categorizes the color in a way that is influenced by his or her native language, as if in preparation for potential naming, and it does so very quickly, without the person even realizing what has happened. One might suspect that the observed ERP effects were generated by areas V4v and VO1, but this remains to be seen, since Thierry et al. (2009) did not attempt to identify the sources of the effects. (For a closely related ERP study see Athanasopoulos et al., 2010; and for similar ERP results reflecting crosslinguistic semantic variation in the shapes of drinking vessels, see Boutonnet, Dering, Viñas-Guasch, & Thierry, 2013).

Turning to body-part nouns, although the neural substrates of their meanings are still being elucidated, some studies suggest that the shape features of these meanings rely, to some degree, on the left lateral occipitotemporal territory in, or just anterior to, the extrastriate body area (Bracci, Caramazza, & Peelen, 2015; Goldberg, Perfetti, & Schneider, 2006; Gorno-Tempini, Cipolotti, & Price, 2000; Kemmerer & Tranel, 2008; Lacey et al., 2017). If we assume, for the sake of argument, that this is true, then the representational topography of that territory must co-vary with the sorts of semantic differences in body-part lexicons that we encountered earlier. As a result, when speakers of languages like Lavukaleve, Savosavo, Jahai, and Tidore talk about the structure of the human body, they may often trigger in that cortical territory different activity patterns that represent different lexicalized shape categories of body parts.

Moving on to another example, although the neural substrates of the meanings of verbs for cutting and breaking events have only recently begun to be delineated, some studies suggest the following functional-anatomical associations: (1) the motor features of these meanings depend on left arm/hand-related (and tool-related) parietal and frontal regions; (2) the visual motion features depend on the left posterior middle temporal gyrus and superior temporal sulcus; and (3) the object separation features depend on the left posterior fusiform gyrus (e.g., Lewis, 2006; Kemmerer, Gonzalez-Castillo, Talavage, Patterson, & Wiley, 2008; Kemmerer, Rudrauf, Manzel, & Tranel, 2012; Watson, Cardillo, Ianni, & Chatterjee, 2013; Desai, Herter, Riccardi, Rorden, & Fridriksson, 2015; Tarhan, Watson, & Buxbaum, 2015; for further information see Kemmerer, 2019a). If these proposals are on the right track, it follows that when people talk about cutting and breaking events, the specific ways in which they neurally represent the concrete features of these events in the cortical areas just mentioned vary as a function of the specific ways in which the events are categorized by the verbs in the language being used. After all, the crosslinguistic project summarized above (Majid et al., 2007; Majid et al., 2008) revealed tremendous diversity in how speakers of different languages name cutting and breaking events, and it is likely that these richly contrasting lexical partitions of the same semantic field are neurally implemented as richly contrasting population codes in the cortical areas that underlie the major representational parameters of that field. Another notable point is that the cortically distributed features of verb meanings may be conjoined in transmodal areas such as the anterior temporal lobes (Bird, Lambon Ralph, Patterson, & Hodges, 2000; Cotelli et al., 2006; Hillis et al., 2006; Meteyard & Patterson, 2009; Pulvermüller et al., 2009) and certain posterior parietal regions such as the angular gyri and precuneus/retrosplenial cortex (Lin et al., 2018; see also Binder, 2016). Hence, these higher-order areas may also capture, but in a more integrated fashion, the idiosyncratic ways in which different languages subdivide the semantic field of cutting and breaking events.

Stepping back from the details of specific examples, it is important to realize that the sorts of crosslinguistically variable cortical activity patterns that we have been considering from a purely theoretical perspective could potentially be explored in an empirical

manner with the functional magnetic resonance imaging (fMRI) technique known as representational similarity analysis (Kriegeskorte & Kievit, 2013). This approach is based on the well-established assumption that any given brain region can be regarded as a high-dimensional representational space in which each neuron (or, in the case of fMRI, each voxel) is a single dimension with a certain range of values, and a particular pattern of activity across the entire region corresponds to a point in the multidimensional space. If two different word meanings evoke two different activity patterns in that region, the degree to which they are similar can be plotted as the distance between their corresponding points. Thus, the manner in which the region implements a whole set of word meanings—such as the color terms, body-part nouns, or cutting/breaking verbs in a given language—can be portrayed as a representational geometry that indicates how the neural correlates of those meanings are related to each other at multiple scales (Borghesani & Piazza, 2017). With enough ingenuity, such an approach could be used to compare the cortical mapping of certain semantic fields across languages. And this would allow researchers to begin to delineate the fine-grained neural substrates of several types of language-specific concepts that different cultural groups access during speech production.

Another noteworthy implication of crosslinguistic diversity in semantic field partitions has to do with one of the most frequently studied aspects of lexical processing during speech production—specifically, the tendency for several closely related word meanings (and, according to some researchers, their corresponding lemmas) to be co-activated to different degrees, forcing the speaker to select the most appropriate one. Some of the most commonly used experimental paradigms for investigating these processes are as follows: (1) participants generate verbs that are semantically related to certain nouns, with one condition involving nouns with many associated verbs (e.g., *cat → purr, pet, meow, play*) and another condition involving nouns with few of them (e.g., *scissors → cut*); (2) participants name pictures of objects, with one condition involving objects with low name agreement (e.g., *stove/oven/range*) and another condition involving objects with high name agreement (e.g., *book*); and (3) participants name pictures of objects in a blocked cyclic design, with one condition (i.e., alternating block) involving objects that belong to the same category (e.g., *apple, mango, peach, lemon,* etc.) and another condition (i.e., alternating block) involving objects that belong to different categories (e.g., *apple, chair, duck, bus,* etc.). In each of these paradigms, the first condition reliably elicits longer response times and error rates than the second because it requires the speaker to select from a larger pool of competing representations. Moreover, across all of the paradigms, the first condition reliably recruits one particular cortical region—the left inferior frontal gyrus (IFG)—significantly more than the second, which suggests that the selection process depends on this region. Indeed, this has been found in numerous studies using diverse brain mapping methods, including fMRI (Badre, Poldrack, Paré-Blagoev, Insler, & Wagner, 2005; Kan & Thompson-Schill, 2004; Moss et al., 2005; Schnur et al., 2009; Thompson-Schill, D'Esposito, & Kan, 1999, 1997), lesion-symptom mapping (Jefferies, Baker, Doran, & Lambon Ralph, 2007; Ries, Greenhouse, Dronkers, Haaland, & Knight, 2014; Schnur et al., 2009; Thompson-Schill et al., 1998), and transcranial direct current stimulation (Pisoni, Papagno, & Cattaneo, 2013).

Crosslinguistic diversity in semantic field partitions bears on this topic because the more finely a language subdivides a given domain with distinct terms, the more competition there should be among those terms during speech production. This point can be elaborated by returning, once again, to some of the domains discussed earlier. In the case of color, we saw that while some languages have separate terms for green, blue, yellow, red, white, and black, others have terms that lump together various combinations of these categories (Kay et al., 2009). In light of these crosslinguistic differences in how narrowly the color spectrum in carved up, it seems to follow that when referring to colors, speakers of a language that has distinct terms for, say, green, blue, and black should experience more lexical competition than speakers of a language that has just one term for all three hues. Similarly, it is likely that in communicative situations involving household containers, speakers of a language that has a relatively large inventory of nouns for such objects should experience more lexical competition than speakers of a language that has a relatively small inventory of them. And in the same vein, it is reasonable to suppose that when talking about cutting and breaking events, speakers of a language with a relatively large inventory of verbs for such events should experience more lexical competition than speakers of a language with a relatively small inventory of them. These predictions, and their consequences for left IFG engagement, could be tested in future research.

3. Semantic conflation classes

3.1. Examples of crosslinguistic diversity

The second kind of crosslinguistic variation to be considered here involves semantic conflation classes, which are systematic combinations of conceptual elements encoded by certain categories of words. Several different types of conflation classes have been described (Talmy, 1997), but we will focus here on the one exhibited by many groups of verbs in the large family of roughly 53 Athabaskan (a.k.a. Athapaskan or Na-Dene) languages distributed across western North America. What is interesting about these verbs, and what distinguishes them quite sharply from verbs in English and other familiar Indo-European languages, is that they are organized in parallel sets of about 9–13 items, such that each set denotes a different kind of event (e.g., giving, lowering, tossing, etc.) while simultaneously specifying the same crosscutting taxonomy of 9–13 kinds of objects that are involved in the event (e.g., round things, stick-like things, flat things, etc.). Although the critical semantic features vary somewhat across the Athabaskan languages and have been analyzed in somewhat different ways, the basic principles of how this complex semantic system works are fairly clear-cut (Carter, 1976; Davidson, Elford, & Hoijer, 1963; Hoijer, 1945; Krauss, 1968; Landar, 1967; Mithun, 1999; Rice, 1998; Rushforth, 1991).

To flesh this out more fully, numerous sets of verbs in Athabaskan languages encode numerous types of events, including those that would be expressed in English as *give, take, put, handle, lower, pick up, bring, carry, misplace, toss, throw, throw out/dispose of, hang up, set down, drop, lose, push over, fall,* and *tip over.* The key point, however, is that there are not really any translation equivalents for

these English verbs in Athabaskan languages. This is because all of the English verbs are completely neutral with regard to the type of object that is involved in the given type of event, whereas none of Athabaskan ones are. On the contrary, each English verb maps loosely onto an entire set of 9–13 Athabaskan verbs, with each of those sets making parallel distinctions between 9 and 13 types of objects. The ten most commonly encoded object types are as follows (Rice, 1998, p. 106):

- Animate objects (e.g., a baby, a person, a fish, a dog)
- Round or hard/compact objects (e.g., a ball, a radio, a coin, a pen-knife, a berry, a shoe, a ring)
- Stick-like objects/empty containers (e.g., a pen, scissors, a table, a chair, a key, a canoe, a car)
- Flat or flexible objects (e.g., a blanket, an article of clothing, a leaf, a pillow, a dollar bill)
- Object in closed container/bundled objects (e.g., a single large box and its contents, a sack of flour, a pack of cigarettes, berries in a jar, a train at a station)
- Plural objects (e.g., a plurality of any of the above objects; eyeglasses, keys, antlers, firewood)
- Object in open container (e.g., a pail of water, a plate of berries, tea in a cup, any food on a platter)
- Mushy matter (e.g., porridge, butter, mud)
- Granular object/object in heap (e.g., an amorphous mass of hay, grain, sugar, gravel)
- Unspecified or generic object

Thus, unlike speakers of English and similar languages, whenever speakers of Athabaskan languages select a monomorphemic verb stem to describe any of several different domains of action, they must take into account not only the particular type of event that they are referring to, but also the particular type of object that happens to be involved in that event, based on a highly consistent, and hence habitually accessed, inventory of 9–13 schematic categories of objects. In short, event types and object types are systematically conflated in the concepts encoded by many Athabaskan verbs.

3.2. Implications for the neural substrates of speech production

These lexical-semantic differences between, on the one hand, English and similar languages, and on the other, Athabaskan languages, predict corresponding neural differences with respect to which combinations of cortical areas tend to be simultaneously engaged and functionally integrated during the retrieval of verbs for speech production.

There is abundant evidence that object properties like animacy, shape, and material constitution are represented largely in the ventral temporal cortex (Bracci & Op de Beeck, 2016; Cant et al., 2011; Cavina-Pratesi, Kentridge, Heywood, & Milner, 2010b, 2010a; Hiramatsu, Goda, & Komatsu, 2011; Jacobs, Baumgartner, & Gegenfurtner, 2014; Martin, 2007; Proklova, Kaiser, & Peelen, 2016). To be sure, in English and similar languages these sorts of object properties do appear in the meanings of some verbs—for instance, in a handful of verbs that denote events of putting things in places (e.g., *coil* applies to long flexible objects, *smear* applies to semisolid substances, and *sprinkle* applies to granular things). For the most part, however, in these familiar languages object properties are preferentially encoded by nouns, not verbs. Indeed, this is generally taken to be the main reason why the ventral temporal cortex has historically been associated much more with the processing of prototypical nouns than prototypical verbs, whereas several action-related brain regions—most notably, the posterolateral temporal cortex, the supramarginal gyrus, and the premotor cortex—have been linked much more with the processing of prototypical verbs than prototypical nouns, as mentioned above in connection with verbs of cutting and breaking (Gleichgerrcht et al., 2016; Kemmerer, 2014, 2019b; Vigliocco, Vinson, Druks, Barber, & Cappa, 2011).

Our expectations change significantly, however, when we consider the most probable neural substrates of the many parallel sets of verbs that are found in Athabaskan languages. As described above, these sets of verbs are semantically parallel because even though they denote different types of events, they sort those events according to the same crosscutting rubric of 9–13 different types of objects. For example, there are no generic verbs like *give, carry,* or *throw;* instead, there are entire sets of verbs for these kinds of actions, with each set making the same distinctions between the types of objects that are given, carried, or thrown, such as animate objects, round objects, stick-like objects, flat objects, etc. It therefore seems likely that while the action-related components of these Athabaskan verb meanings depend on the same action-related brain regions that underlie prototypical verb meanings in English and similar languages, the object-related components depend primarily on certain sectors of the ventral temporal cortex—sectors that are more often associated with prototypical noun meanings in English and similar languages. Moreover, because speakers of Athabaskan languages routinely access the 9 to 13 schematic object representations that recur across multiple sets of verbs, these representations are presumably entrenched quite deeply in the relevant ventral temporal regions of their brains. One could also hypothesize that the anatomically distributed action-related and object-related components of Athabaskan verb meanings are integrated into coherent, unified concepts by transmodal cortical areas such as the anterior temporal lobes, angular gyri, and precuneus/retrosplenial cortex (see the earlier discussion of verbs of cutting and breaking). Finally, it is worth noting that all of these proposals could be tested, since the most widely used language in the Athabaskan family, Navajo, has approximately 170,000 speakers.

4. Grammatically obligatory semantic categories

4.1. Examples of crosslinguistic diversity

Finally, it is important to realize that languages differ greatly regarding the conceptual parameters, and the distinctions along those parameters, that they require speakers to encode grammatically, and that they therefore force speakers to monitor on a regular

basis. In the early 20th century, Boas (1911/1966) demonstrated this in a compelling manner by comparing the English sentence *The man is sick* with the corresponding sentences in a variety of North American Indian languages. He noted that in several Siouan languages distributed across the Great Plains, one would have to indicate whether the man is moving or at rest; that in a Wakashan language of Southwestern Canada called Kwakiutl, one would have to specify whether he is visible or nonvisible to the speaker, and also whether he is near the speaker, hearer, or a third person; and that in a language of the Eskimo-Aleut family spoken way up on Baffin Island in Northern Canada, one would just say "man sick" without having to encode definiteness, tense, visibility, or location. Boas remarked that "when we consider for a moment what this implies, it will be recognised that in each language only a part of the complete concept that we have in mind is expressed, and that each language has a peculiar tendency to select this or that aspect of the mental image which is conveyed by the expression of the thought" (Boas, 1911/1966, pp. 38–39; for further discussion see Jakobson, 1959, and Slobin, 1996).

More recent research has documented extensive crosslinguistic diversity involving not only which dimensions of experience speakers are forced to track for grammatical-semantic purposes, but also which contrasts they are forced to make along those dimensions. Here are just three representative examples from the vast literature on this complex topic (for a broad overview see Dixon, 2010, 2012).

First, in many languages whenever a speaker produces a noun for a basic-level object, he or she must also produce another element, typically called a classifer, that provides a more general level of categorization according to one of several semantic parameters (Aikhenvald, 2000, 2006; Grinevald, 2007; Seifart, 2010). For instance, as Dixon (1982, p. 185) points out, in Yidiny (Pama-Nyungan, Australia) "one would not generally say … 'the girl dug up the yam,' or 'the wallaby is standing by the black pine'; it is more felicitous to include generics and say 'the person girl dug up the vegetable yam', or 'the animal wallaby is standing by the tree black pine'." There is a great deal of diversity in the size of classifier inventories, with some languages having only a handful of elements and others having as many as several hundred. The most relevant semantic parameters, however, tend to be animacy and related properties, shape and related properties, size, constitution, and interaction/function. For each of these parameters, some semantic distinctions are crosslinguistically common, but many others appear to reflect culture-specific concerns. For instance, regarding the parameter of shape and related properties, numerous languages have classifiers that distinguish between saliently 1D objects (e.g., vines and spears), 2D objects (e.g., plates and blankets), and 3D objects (e.g., eggs and boxes). Some languages, though, have classifiers for more precisely defined geometric categories, as illustrated by the following examples, all of which come from the references cited above. Southern Haida (Haida, British Columbia) not only has three different 1D classifiers—one for long, narrow, rigid objects (e.g., canes and needles), another for long cylindrical objects (e.g., bottles and pipes), and a third for long flexible objects (e.g., ropes and belts)—but also has two different 3D classifiers—one for fairly spherical objects (e.g., clams and stones) and another for objects that are roundish but flat on one side (e.g., hats and masks). Similarly, Burmese (Tibeto-Burman, Myanmar) has two different 2D classifiers—one for thin flat objects (e.g., carpets and slices of bread) and another for very thin flat objects (e.g., leaves and sheets of paper). Furthermore, Minangkabau (Austronesian, Sumatra) has a classifier for rolled objects, Akatek (Mayan, Mexico) has a classifier for bent or half-circle-shaped objects, and Palikur (North Arawak, Brazil) has a classifier for objects that split and branch out from a central axis.

Second, although English speakers are accustomed to a simple tense system that only distinguishes between past, present, and future, some languages have more highly developed systems that obligate speakers to provide further information about when an event occurred relative to the time of utterance (Dahl & Velupillai, 2005). For instance, whenever a speaker of Yagua (Peba-Yaguan, Peru) wants to refer to an event in the past, he or she must specify one of five different degrees of remoteness from the present: proximate 1 (i.e., a few hours before the time of utterance); proximate 2 (i.e., one day before the time of utterance); past 1 (i.e., roughly one week ago to one month ago); past 2 (i.e., roughly one to two months ago up to one to two years ago); and past 3 (i.e., distant or legendary past).

Third, in many languages speakers must use evidential markers to indicate the source of information for *all* statements expressed in the past tense and declarative mood (Aikhenvald, 2018). Some evidential systems make just a two-way contrast between eyewitness and non-eyewitness, but others make up to five distinctions. For instance, in a number of languages of the Tucanoan family (Columbia/Brazil), if a speaker wants to say that the dog ate the fish, he or she must specify one of the following types of evidentiality (Dixon, 1997, p. 120): visual (e.g., the speaker saw the dog eat the fish); non-visual (e.g., the speaker heard the dog in the kitchen but did not see it, or the speaker smelled fish on the dog's breath); apparent (e.g., there are fish bones spread on the floor around the dog, which looks satisfied, as if after a good meal); reported (e.g., someone told the speaker that the dog ate the fish); or assumed (e.g., the fish was raw, and people do not eat raw fish, so it must have been the dog that took it).

Many more examples could easily be adduced, but the main point should be clear, and it was actually captured quite nicely three decades ago in the following passage from Levelt (1989, p. 106): "Languages differ in the kinds of semantic features that are grammatically acknowledged. As a consequence, the encoding of messages is not the same for speakers of different languages. The message-encoding procedures must take into account that certain semantic components are obligatory in a message."

4.2. Implications for the neural substrates of speech production

As with the other two types of crosslinguistic diversity discussed earlier, this one has serious ramifications for the cortical representation and processing of concepts during the generation of spoken sentences. In this case, however, less is currently known about the underlying neural substrates.

Now, it does appear that the left posterior IFG is essential for the mental manipulation of obligatory closed-class morphemes during speech production. This cortical region is activated significantly more when healthy subjects generate inflected versus

uninflected forms of nouns and verbs (Sahin, Pinker, Cash, & Halgren, 2009, 2006; Siri et al., 2008) and also when they generate full-blown sentences that include both open-class items and obligatory closed-class morphemes, relative to when they generate mere word lists that consist solely of the same (uninflected) open-class items as in the sentences (Haller, Radue, Erb, Grodd, & Kircher, 2005; Indefrey, Hellwig, Herzog, Seitz, & Hagoort, 2004, 2001). In addition, agrammatism—a disorder of sentence production that usually involves impaired use of obligatory closed-class morphemes (Menn & Obler, 1990)—is reliably linked with damage to the left posterior IFG in patients with the nonfluent variant of primary progressive aphasia (Mesulam et al., 2009; Sapolsky et al., 2010; Wilson et al., 2010), and it is often, but not always, linked with such damage in patients with stroke-induced aphasia (Vanier & Caplan, 1990; den Ouden et al., 2019). These findings, however, may simply reflect the involvement of the left posterior IFG in the retrieval and/or selection of obligatory closed-class morphemes during speech production. After all, while there is abundant evidence that this region is necessary for such executive functions (Novick, Trueswell, & Thompson-Schill, 2010), so far very little if any research has convincingly shown that the same region actually represents the *meanings* of particular types of closed-class morphemes.

One interesting possibility that dovetails with recent advances in neurolinguistics, and that therefore warrants some consideration, is that the neural localization of grammatically required semantic categories may vary according to their content. Let's return briefly to the three examples of crosslinguistic diversity described above. In a previous paper I laid out a number of testable hypotheses regarding the cortical underpinnings of classifier meanings (Kemmerer, 2017; see also the commentaries on that article and my response). For instance, I proposed that the concepts encoded by shape-related classifiers may be implemented partly in sectors of the left ventral temporal cortex that are already believed to store conceptual knowledge about the shapes of things. Along similar lines, although it is still completely unclear how the meanings of tense markers are represented in the brain, this topic has begun to receive some attention in aphasiology (Bastiaanse, 2013), and additional hints come from recent work on the temporal uses of both prepositions (Kemmerer, 2005) and motion verbs (Lai & Desai, 2016). Finally, although we know next to nothing about the neural substrates of the meanings of evidential markers, it would not be unreasonable to suppose that these epistemological concepts rely to some extent on the mentalizing (a.k.a. theory of mind) network, since it provides the foundation for representing one's own and other's beliefs (Schurz, Radua, Aichhorn, Richlan, & Perner, 2014).

Due largely to methodological challenges, progress in understanding the neurobiology of spoken sentence production has been extremely slow (Wise & Geranmayeh, 2016). And it seems that virtually no headway has been made in elucidating the cortical bases of those kinds of concepts that speakers must express in closed-class morphemes whenever they formulate utterances. Hopefully, though, some breakthroughs will occur in the near future. As Talmy (1988, p. 173) observed, the relevant concepts help to frame the messages conveyed by sentences, since they "establish the main delineations of the scene organization and communicative setting." And as we have seen, these concepts also vary greatly across languages, leading to striking cultural differences in precisely those aspects of meaning that speakers access most frequently.

5. Conclusion

There are nearly 6,500 languages scattered around the world, and they display tremendous diversity in the inventories of lexically and grammatically encoded concepts that they provide for their speakers. Because of this huge semantic variation, whenever the speakers of a given language formulate utterances, they must mold their thoughts to fit the prepackaged concepts that are available in, and sometimes required by, that language. As Levelt (1989) put it, "messages must be *tuned* to the target language" (p. 71, emphasis in original). In this paper I have focused on three general types of crosslinguistic differences in meaning: semantic field partitions; semantic conflation classes; and grammatically obligatory semantic categories. For each type I have first given examples and then discussed their implications for neurolinguistic research on speech production. I have argued that well-motivated and testable predictions can be made about the cortical underpinnings of several forms of language-specific conceptual knowledge. My main goal, however, has simply been to raise awareness about the extent to which crosslinguistic differences in meaning must be taken into account when studying the neural representations and computations that are engaged during the initial stages of speech production.

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