Who's Talking?

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experiments with bats involving a microphone that was sensitive to sounds above the range of human hearing. In 1944, this American zoologist coined the term "echolocation" based on the work he and colleagues did with bats (*14*), and this remains a milestone discovery about animal behavior. Simon *et al*. and Bates *et al*. have demonstrated that echolocation is a gift in research that keeps on giving, whether the study organisms are bats, birds, shrews, toothed whales, or even people (*15*).

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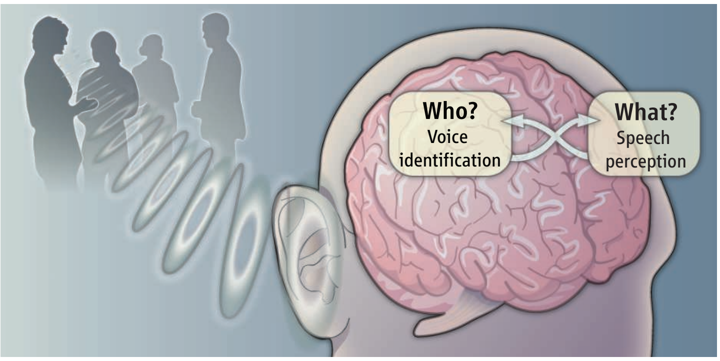
NEUROSCIENCE

Who's Talking?

Neural systems in the human brain that process auditory information about who spoke and what they said are functionally integrated.

Patricia K. Kuhl

You pick up your smartphone and hear someone speak. Without visual contact, you immediately try to discern whether the caller is male or female, young or old, happy or sad, mom or a stranger. You want to know who is speaking and what they are saying. How do you derive two distinct impressions from that single auditory event? Voice recognition (the Who) and speech perception (the What) involve primarily the right and left hemisphere of the brain, respectively. But the tidy notion that two neural modules are independently working to decipher Who and What is challenged by Perrachione *et al*. (*1*). On page 595 of this issue, the authors propose that the brain regions underpinning Who and What are functionally integrated.



Who? What? A unified sound wave coming from an unseen talker is analyzed to produce two distinct percepts—Who spoke and What was said. The two processes appear to be intertwined, even though they use different aspects of the auditory signal and distinct brain regions.

Perrachione *et al*. show that people with dyslexia have difficulty learning to recognize new voices, demonstrating that voice recognition and speech perception are intertwined. Dyslexia was historically considered a deficit in sensory or cognitive processing (*2*), but phonological processing impairments are now considered more fundamental (*3*). The authors reasoned that voice recognition should be impaired in people with dyslexia because of this phonological deficit. They tested people with a life-long history of dyslexia and controls (nondyslexics) matched in age, education, and IQ. Participants had to learn to identify five new voices they had never heard before. When the new voices spoke the participants' native language (English), people with dyslexia performed 40% lower than controls. This difficulty in recognizing voices is a new finding on dyslexia. When the participants attempted to identify new voices speaking Mandarin Chinese, the control and dyslexic groups performed equally well. Controls were far more accurate at voice recognition when listening to their native language compared to a non-native language, but people with dyslexia showed no native-language advantage—they were equivalent at English and Mandarin voice identification. Thus, impaired native-language voice recognition was not due to general auditory difficulties or learning problems in people with dyslexia.

Why do our brains work this way? The complexity of the evolving social world likely produced a selective pressure on brain mechanisms to integrate, rather than isolate, information about the world. Functional integration of information about a speaker's identity—a social goal—and the content of the message being conveyed—a linguistic goal—would provide maximum detail about the social scene. Selection for a seamless connection would forge a neural basis for sharing social information and linguistic content in real time.

If this account is correct, might the novice mind of the infant also work in this way? Evidence suggests so: At 7 months of age, human infants recognize a shift in the identity of a speaker only when listening to native-language speech; they fail to detect a change in the speaker's identity when they are listening to foreign-language speech (*4*, *5*). At this age, infants cannot understand words, so the voice-change deficit for foreign speech cannot be attributed to a lack of speech understanding. Rather, the findings suggest that the infant brain stores detailed information about the statistical patterns contained in the auditory signals they hear speakers use. These stored patterns help them learn the phonetic characteristics of their native language (*6*), and words (*7*), as well as the idiosyncratic patterns of speech used by individual speakers (*4*). In the absence of stored memories of foreign speech, infants have difficulty recognizing a change in the identity of the speaker of the novel language. Infants listening to foreign speech somewhat resemble adults with dyslexia listening to native speech—in both

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cases, the absence of (or poorly rendered) phonological representations of speech make voice analysis more difficult.

Social and linguistic realms are biologically intertwined even more broadly in early development. Social processing affects language processing by infants: At 9 months of age, infants learn the sound units and words of a foreign language only through interaction with a live person, not via television (*8*); infants' learning of vocabulary can be predicted by their ability to utilize social information (such as eye gaze) from others (*9*); infants' vocalizations in speech advance more rapidly when social information is provided contingently on their utterances (*10*); infants prefer to look at a person who previously spoke their native language as opposed to a foreign language (*11*); and brain responses to speech in children with autism are predicted by their social interest in speech (*12*).

Speech provides a canonical example in which linking the source of the information (Who) and the content of the information (What) adds value. It yields optimal information about the world, its inhabitants, and what they might do next. Infants appear predisposed to learn through the integration of social and linguistic information (*13*).

The grand challenge is to understand how information in one area of the brain connects to, coheres with, and causes activity in another brain area. Whole-brain imaging technology in the form of functional magnetic resonance imaging, magnetoencephalography, and electroencephalography are allowing us to pose specific questions about brain function in people of all ages, including preverbal infants (*14*). Studies on people with varying capacities and disabilities will help us understand how brains evolved to link Who and What in an increasingly complex social world.

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CHEMISTRY

Building a Lewis Base with Boron

Boron compounds are normally acids, but stable boron bases have been synthesized that may have applications in chemistry involving transition metals.

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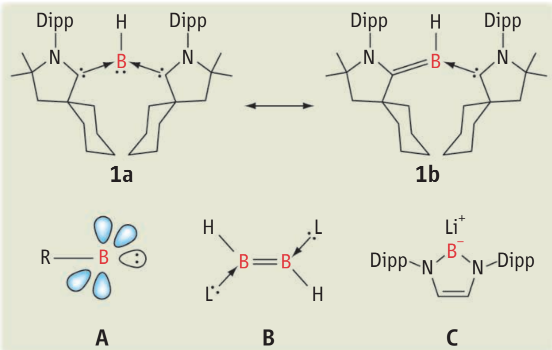
In introductory chemistry courses, acids are defined as substances that increase the concentration of H^+ (or H_3O^+) in solutions (the Arrhenius concept) or act as proton donors (the Brønsted-Lowry concept). The more general Lewis concept defines an acid as a substance that can accept an electron pair and a base as a substance that can donate an electron pair. Compounds with atom centers that are inherently electron-deficient, such as boron or aluminum, readily accept electron pairs. Thus, simple compounds of these elements, such as borane (BH_3) and aluminum chloride ($AlCl_3$), are typically strong Lewis acids. If a monovalent boron center is to bear an electron pair that could be donated as a Lewis base, it would exhaust its own supply of valence electrons and end up with empty orbitals. For example, borylene compounds (such as compound **A** in the figure) (*1*) would be bases, but they are so reactive that they have only been observed as transient intermediates (*2*, *3*). On page 610 of this issue, Kinjo *et al.* (*4*) used carbenes to stabilize a borylene (see compound **1** in the figure). This unusual type of base (and analogs yet to be prepared) may open up new avenues in synthesis and catalysis.

Previous strategies for stabilizing highly reactive borylenes have used transition metals (*5*), which may provide facile routes to diverse borylenes. The exploration of photochemically or thermally induced borylene transfer reactions represents a remarkable endeavor in this regard (*6*). The strategy of Kinjo *et al.* for the synthesis of **1** extends the use of carbenes for stabilizing highly reactive main-group species with unusually low oxidation states, such as H-B=B-H (*7*, *8*). Carbene ligands have a lone pair of electrons that can be donated into empty boron orbitals (they are σ-donors), and have empty p orbitals that can help stabilize a lone pair on boron in a p orbital (they are π-acceptors). In this regard, cyclic (alkyl)(amino)carbenes possess stronger σ-donating and π-accepting capabilities than N-heterocyclic carbenes (*9*). Thus, the potassium graphite reduction of L:BBr_3 (where L: denotes N-heterocyclic carbenes) yields carbene-stabilized neutral diborenes (see compound **B** in the figure) (*10*). Kinjo *et al.* showed that potassium graphite reduction of L′:BBr_3 [where L′: denotes cyclic (alkyl)(amino)carbenes] yields **1**.



Boron as a base. Boron compounds normally are acids that accept electron pairs, but Kinjo *et al.* show how to stabilize an electron pair on a boron center so that it forms a base—a borylene compound. The parent borylene **A** (R = H) is linear and sp-hybridized, and the lone pair is in an sp orbital. It accepts two electron pairs from two carbenes, yielding a neutral, three-coordinate boron Lewis base **1** (now trigonal planar and sp^2-hybridized, with the lone pair now in a p orbital). The favored resonance structure **1a** bears a lone pair of electrons at boron. In **1b**, the two valence electrons of boron involves a B=C double bond. Related to **1**, carbene-stabilized neutral diborenes **B** and boryllithium **C** represent other important three-coordinate boron(I) compounds. Dipp, 2,6-diisopropylphenyl; L:, N-heterocyclic carbenes; R denotes hydrogen, alkyl, aryl, or halides; boron, red.

Protonation of **1** with trifluoromethane sulfonic acid formed $[1H]^+[CF_3SO_3]^-$ and demonstrated its basicity. Reaction of **1** with gallium trichloride yielded the radi-

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