later and give the monkey 10 more peanuts. Monkeys rapidly reversed their natural preference and now chose two peanuts on about 70% of the trials. They apparently anticipated the replenishment of peanuts dependent upon initial choice of the smaller quantity.

In a similar experiment, Naqshbandi and Roberts [12] controlled monkeys' motivational state as a test of the Bischof–Kohler hypothesis. When given a choice between one and four dates, squirrel monkeys chose four dates on 80–90% of trials. Eating dates makes monkeys thirsty. In an experimental phase, monkeys that were not thirsty when they chose between one and four dates had their water bottles taken away just before they made the choice. If a monkey chose one date, its water was returned 30 minutes later, but, if it chose four dates, its water was returned three hours later. Monkeys choice of four dates now dwindled rapidly, and they came to choose one date on 80% or more of the trials. Monkeys made the appropriate choice to reduce an anticipated future state of thirst that they did not experience at the time of choice.

Mental time travel is bi-directional: People can remember a sequence of events that extends from the present moment into the past and defines their personal history (episodic memory) and can anticipate a series of events extending from the current moment into the future. As a consequence of our ability to anticipate future occurrences, we may take actions now that will allow us to cope with future events. Recent articles in *Current Biology* [13–15] reported evidence that rats and scrub jays show episodic-like memory. Episodic memory is defined as memory for personal past episodes that contains information about what happened, where it happened, and when it happened. The episodic memory findings combined with these new studies that now challenge the Bischof-Kohler hypothesis clearly promote the idea that humans are not the only species capable of bi-directional mental time travel [7–9].

Behavioral experiments in the field of animal cognition are revealing a capacity for mental time travel in animals long thought to be found only in humans. Episodic-like memory for what, where and when past events occurred has been revealed in scrub jays and rats [13–17]. New experiments now suggest that scrub jays and nonhuman primates can peer into the future and respond intelligently to anticipated future happenings. Remarkably, animals are able to anticipate future needs they do not currently experience. Scrub jays, in particular, cache foods in the evening that will provide an optimal selection of foods at breakfast and cache food for which they are currently satiated in anticipation of an expected future need for that food [1,2]. The clever procedures used in these studies will undoubtedly be used to search for behavioral examples of foresight in other species of animals.

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Speech Perception: Linking Comprehension across a Cortical Network

Listening to speech amidst noise is facilitated by a variety of cues, including the predictable use of certain words in certain contexts. A recent fMRI study of the interaction between noise and semantic predictability has identified a cortical network involved in speech comprehension.

Asif A. Ghazanfar and Mark A. Pinsk

During a live New Year's Eve television broadcast of the "*The Tonight Show*", Vince Neil, the lead singer of the heavy metal band, Mötley Crüe, wished his drummer a "Happy f—ing New Year". The expletive went out uncensored to a large swath of the United States, but in some regions a delay was introduced, during which the expletive was replaced with a beep. Similarly, U2's Bono let slip "f—ing brilliant" during the 2003 Golden Globes broadcast, and a beep was introduced to replace the offending word in subsequent rebroadcasts. Whether you've seen these particular TV incidents or not, we all know that 'beeping' has almost zero effect in masking the cuss — we know exactly what was said in spite of the beep. We can accurately predict what was said, not because the beep was not loud enough or long enough, but because the auditory system can use many alternative experience-based cues (much in the same way that, despite our use of dashes for the letters 'u', 'c' and 'k', your past experience allows you to easily infer what the censored word above is).

One prominent predictive cue for deciphering noisy or degraded speech signals while watching TV is the visual information gleaned from the face. Numerous studies have demonstrated the benefits of audiovisual speech perception over listening alone or listening in the presence of noise, like at a New Year's Eve party (for example [1,2]). Indeed, the addition of visual cues to audition can be effectively equivalent to turning up the volume by as much as 15 decibels [2]. However, another predictive cue that we can use solely in the auditory domain is the context in which the word is produced — or semantic predictability [3]. That is, in some sentences, it is easy to predict words by their strong association with other words. For example, "He caught a fish in his net" has a high semantic predictability ('caught', 'fish' and 'net' have strong associations). In contrast, "She discussed the bruise" has low semantic predictability because 'discussed' has no strong association with the word 'bruise'. Like visual information, semantic context can strongly influence speech comprehension in noise. Spoken words embedded in sentences are usually better understood than isolated words [4], and in noisy environments, listeners can understand words better when they know the topic of conversation.

How the brain manages to integrate the noisy auditory signal with the semantic predictability to produce comprehension is, naturally, a question of great interest. It evokes the intuitive notion that 'bottom-up' processes, which analyze the acoustic properties of the speech signal, interact with 'top-down' processes encoding the *a priori* probability of a particular stimulus. A previous functional imaging study [5] revealed that, as the speech signal is degraded, there is greater activation along the left superior and middle temporal gyri (but not primary auditory cortex) and in areas well-beyond the classic auditory cortical regions of the belt and parabelt. This would constitute the 'bottom-up' network. On the 'top-down' side, there are many studies demonstrating a role for frontal and parietal areas in verbal working memory tasks and semantic decision tasks (for example [6,7]). But, until now, how these two networks interact during speech comprehension remained unexplored.

In a recent event-related fMRI study, Obleser *et al.* [8] had subjects listen to a set of sentences that varied on three levels of intelligibility and two levels (high and low) of semantic predictability. Intelligibility was varied using 'noise-vocoding', which manipulates the spectral details of speech in order to make it more or less intelligible in a graded fashion [9]. In this study, the levels of increasing intelligibility were: 2-, 8- and 32-filter bands of vocoding. Critically, the authors identified *a priori* which level of noise produced the strongest benefit of semantic predictability in speech comprehension by listeners: with 8-filter bands of noise-vocoding (an intermediate level of noise), high semantic predictability improved comprehension by up to 90% relative to low semantic predictability.

Obleser *et al.* [8] found that, regardless of semantic predictability, cortical regions that showed increases in activity with increasing intelligibility included the superior temporal sulcus and inferior frontal gyrus. Conversely, different regions of the parietal cortex showed decreases in activity with increasing intelligibility. The effects of semantic predictability at the intermediate level of noise revealed that the superior temporal sulcus was not all influenced, but high predictability (compared to low predictability) activated five other cortical areas distributed across the frontal, parietal and temporal lobe. A subset of these five regions — angular gyrus, dorsolateral prefrontal cortex and the posterior cingulate — were active only under the effortful speech comprehension condition; that is, when highly predictable sentences were presented with minimal noise, and thus, minimal effort on the part of the listener, these brain areas returned to their baseline level of activity [8].

The centerpiece of this study was to investigate how the five cortical nodes interact. Correlations between their activation time-courses were measured and, surprisingly, those correlations increased for sentences of high predictability relative to low predictability, and only when intelligibility was compromised by noise. This increase in functional connectivity across these disparate regions supports the idea that they form a network that uses semantic predictability to compensate for decreased intelligibility in speech signals. The co-activation of areas, unfortunately, does not provide any information about the direction of information flow or whether the areas are even anatomically connected to form a network. There is, however, anatomical evidence from monkeys for connections of the angular gyrus with the temporal pole and prefrontal cortex [10], but whether this is true for human neocortex cannot be assumed. Other statistical approaches may be worth exploring in studies of this nature. For example, independent component analysis offers the advantage of being 'blind' in the sense that functional systems are revealed without the investigator having to select a seed region of interest [11]. This method could also be used to investigate cortical responses to dynamic, on-going speech.

Obleser *et al.*'s [8] unique approach of pitting intelligibility against semantic predictability to investigate cortical networks is revealing in many ways. First, the data show that speech perception involves a diverse and disparate array of cortical regions beyond the auditory cortex. Second, the structure of the network is revealed to be highly dynamic and dependent on the nature of the interacting signals (intelligibility and predictability). Third, the fronto-parietal system is involved in the monitoring and selection of auditory information, particularly in directing attention to auditory features to both guide short-term memory and access long-term memory representations [12]. Fourth, and finally, it reveals that a greater understanding of brain function will be achieved by not only thinking in terms of 'networks' but also by incorporating more realism into our experimental paradigms. More generally, one hopes that such an approach will take us beyond a search for unitary brain areas that do this or that specific function.

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Behavioural Ecology: Niche Construction via Grooming and Extortion?

A recent study shows that brood parasitic cowbirds employ Mafia-like tactics to discourage rejection of their broods by a common host. This may be a new example of animals adaptively 'constructing' key features of their ecological niches.

Sasha R.X. Dall

Everything an organism does affects its environment. This must be true in a universe unfolding under the laws of thermodynamics — with the inexorable erosion of order prophesied by the second law, the origin and maintenance of the highly ordered arrangements of matter and energy associated with life require it [1]. For this reason, living systems harvest high-grade energy from the environment, usually via sunlight or biomass, to metabolise and reproduce to combat entropic erosion, discarding low grade energy — heat — in their wake [2]. Nevertheless, traditional evolutionary accounts of life's complexity have it that the direction of influence is reversed: "organisms adapt to their environment, never *vice versa*" [3]. With this apparent paradox as a backdrop, some biologists suggest that evolutionary relationships between organisms and their environments are likely to be more complex and dynamic in nature: organisms can often change their environments profoundly enough to influence the evolutionary dynamics of their own reproductive lineages, the argument goes. In this way, some organisms may actively 'construct' features of their own ecological niches, which can range from the engineering of sophisticated climate-controlled termite 'fortresses' to altering soil chemistry via earthworm composting [4,5]. A recent study [6] of the behaviour of brood parasitic brown-headed cow birds, *Molothrus ater*, towards a common host species, the prothonotary warbler *Protonotaria citrea*, suggests a quality to some potential niche construction activities that is reminiscent of the darker side of human nature — it seems female cow birds 'groom' future victims and 'extort' care for their parasitic brood from some of their reluctant hosts.

Adaptive alterations by organisms to their physical environments are often cited as the most compelling examples of niche construction as an evolutionary force [5]. For example, naturalists, including Darwin, have long been fascinated by the soil processing activities of the lowly earthworm [7]. It seems that earthworms actively co-opt the soils they live in and the tunnels they excavate to serve as accessory kidneys, which