QnAs with Richard N. Aslin

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Imagine seeing the world from the perspective of an infant: surrounded by novel sights, sounds, and smells but not knowing the significance of any of it. How does an infant begin to make sense of such stimuli without instructions? Richard N. Aslin, a developmental psychologist at Haskins Laboratories in Connecticut, has made landmark contributions to our understanding of how infants learn about their environment, especially with regard to language. In honor of his achievements, Aslin was awarded a share of the 2020 Atkinson Prize in Psychological and Cognitive Sciences from the National Academy of Sciences. PNAS spoke with Aslin about one of his major discoveries—statistical learning—and his use of neuroimaging techniques to study the neurological bases of infant learning.

PNAS: What is statistical learning, and what led you to examine its role in early language acquisition?

Aslin: My colleagues, Elissa Newport and Jenny Saffran, and I were interested in how it is that babies can pull out words from a stream of speech. The learning that I studied as an undergrad was reinforcement learning—that is, you're getting a reward for responding to certain kinds of input—but it seemed that that kind of learning, in language acquisition, didn't make any sense. The mother is not saying, "listen to this word. . .no, that's the wrong word, listen to this word," and giving them feedback. It's all done just by being exposed to the language without any obvious reward. The idea that we had was that perhaps there are statistical relations—probabilities that one sound will follow another—that allow the baby, when hearing speech, to organize those sound units into a structure. Because, of course, there really is a structure in language, we asked whether they could discover that structure simply by listening to the input and keeping track of the probabilities that one sound follows another sound.

Richard N. Aslin. Image credit: Patricia Aslin (photographer).

PNAS: How did you demonstrate that statistical learning actually occurs?

Aslin: Initially with adults (1), and then babies (2), we created a sequence of speech sounds that had an underlying structure. It was not the kind of structure that they were exposed to in English; it was a novel structure we created. Would they be able, by merely listening to this string of sounds, to learn implicitly that certain sounds went together because they were more likely to follow each other than other sounds? We did this by familiarizing them for just a few minutes with this structured sequence of sounds and then measured their attention to familiar and novel versions of these sequences. And they could discriminate between these test sequences, which was quite surprising. If I told you that I'll just let you listen to something and then, without any instructions, you could access the underlying information, which is being presented at four events per second, and keep track of the probabilities that each one of those events follows another event or not, and that you would do that over the course of about 2 minutes of exposure, I think most people would say that seems kind of implausible.

PNAS: Subconsciously and automatically, no less.

Aslin: Exactly. Demonstrating that ability even in adults was interesting; demonstrating it in 8-month-old babies seemed shocking. Most people believed that it takes months and months to extract a lot of the structural information that's present in language. To be clear, our experiment in the laboratory was extremely simplified, but nevertheless the baby had to keep track of 540 syllables that were presented in 2 minutes, and the likelihood that one syllable followed the other, in order to show the effect that we demonstrated in the [laboratory].

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PNAS: Do species other than humans exhibit statistical learning capabilities?

Aslin: Yes, they do. It's been shown in birds (3), in rats (4), in nonhuman primates (5). However, the complexity of the structure that appears to be learnable by these other species apparently has considerable limits to it, whereas in the case of humans, not only do they have the rudimentary form of statistical learning that's shared across many other species, but there seems to be something extra. For example, languages are organized in terms of hierarchies of structure. And it seems as though these other species are not as good at extracting the multilayered levels of structure that are present in human languages (6).

PNAS: More recently, you have used neuroimaging techniques, particularly functional near-infrared spectroscopy (fNIRS) to study the neurological bases of learning. Could you explain what fNIRS is and how you use it?

Aslin: One of the difficulties with fMRI in studying early development, particularly in infancy, is that the constraints of the apparatus itself are rather stringent. You're lying down, you're inside of a tube, you can't move your head, you're not supposed to vocalize, and that's challenging for babies. fNIRS is an optical technique, so instead of using magnetic signals, as in MRI, to study the properties of the brain, it's doing it with light. The light is in the infrared range, so it's invisible to us but can penetrate biological tissue: not just the skin but also the skull. When the brain is highly active, it is using oxygen to energize itself and you can detect optically how much the oxygenation of the brain has changed from moment to moment. But the real advantage of it, for babies in particular, is that the subject does not need to hold still during the measurements, and that allows you to present naturalistic stimuli while the baby is awake and record the correlates of their neural activity in the brain.

PNAS: What have you learned from fNIRS studies?

Aslin: In a recent publication with Lauren Emberson and John Richards (7), we created a situation in which 6-month-old babies are able to predict what stimulus comes next. The experiment was quite simple: You hear a sound and it's followed by a visual stimulus. And the question is, does the brain create a "prediction signal" that there is going to be a visual stimulus even on trials in which there is no visual stimulus presented? And interestingly enough—this had already been shown in adults with fMRI (8)—when the brain is expecting a stimulus to occur, the part of the brain that normally represents that stimulus—in this particular case, the visual part of the brain—shows an activation, even though there's no visual stimulus present. And we showed that very same phenomenon in 6-month-old babies using fNIRS. It suggested that the fundamental architecture of the brain that we know is present in adults for making efficient predictions, and which fulfills the predictions by having the brain activated even in the absence of a stimulus, is also present in 6-month-old babies.

1 J. R. Saffran, E. L. Newport, R. N. Aslin, Word segmentation: The role of distributional cues. *J. Mem. Lang.* **35**, 606–621 (1996).
2 J. R. Saffran, R. N. Aslin, E. L. Newport, Statistical learning by 8-month-old infants. *Science* **274**, 1926–1928 (1996).
3 K. Abe, D. Watanabe, Songbirds possess the spontaneous ability to discriminate syntactic rules. *Nat. Neurosci.* **14**, 1067–1074 (2011).
4 J. M. Toro, J. B. Trobalón, Statistical computations over a speech stream in a rodent. *Percept. Psychophys.* **67**, 867–875 (2005).
5 M. D. Hauser, E. L. Newport, R. N. Aslin, Segmentation of the speech stream in a non-human primate: Statistical learning in cotton-top tamarins. *Cognition* **78**, B53–B64 (2001).
6 C. Santolin, J. R. Saffran, Constraints on statistical learning across species. *Trends Cogn. Sci.* **22**, 52–63 (2018).
7 L. L. Emberson, J. E. Richards, R. N. Aslin, Top-down modulation in the infant brain: Learning-induced expectations rapidly affect the sensory cortex at 6 months. *Proc. Natl. Acad. Sci. U.S.A.* **112**, 9585–9590 (2015).
8 P. Kok, M. F. Failing, F. P. de Lange, Prior expectations evoke stimulus templates in the primary visual cortex. *J. Cogn. Neurosci.* **26**, 1546–1554 (2014).

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