Hi Reddit, my name is Dr. Nina Kraus and I am professor and neuroscientist at Northwestern University. My research focuses on how the brain learns to make sense of sound, and the impact of this learning on our ability to communicate with one another.

I recently published a study titled "Auditory processing in noise: A preschooler biomarker for literacy" in PLOS Biology. In this study, we measured how a preschooler’s brain responds to sound, using an objective biological approach my lab has developed. We found that the integrity with which preschoolers’ brains processed consonants in noise paralleled their early language development, and could predict the development of their literacy skills one year out. This suggests we have an approach to identify which preschoolers will struggle learning to read long before they begin formal instruction. This is important because it would allow us to provide interventions for language disorders such as dyslexia to children before they experience prolonged challenges in school.

To learn more about my work and our biological approach, please check out our website, brainvolts. The website is a labor of love; we update it almost daily. By viewing lab projects, you can gain a sense of the scope of our work. Choose the individual lab project pages that interest you most to see relevant videos, publications, and more -- do be sure to check out the friendly overview slideshow offered for each project. And be sure to check out the demonstration of our biological approach to auditory processing on the homepage, and all papers are available for download from publications.

I will be answering your questions at 1pm ET -- Ask Me Anything!

Don’t forget to follow us on Twitter @brainvolts.

Edit: Thanks all for the questions and interest. We invite you to visit our [website](www.brainvolts.northwestern.edu) to keep up-to-date with our work, and please explore all the resources we have there!

Are speech delays indicative of dyslexia or are there other developmental delays that eventually correct themselves? Is your technique an objective test for dyslexia?

Also, speech delays are recognized quite early, and often addressed through speech therapy, does treatment for literacy early on differ substantially from existing speech therapy?

nate

Thanks for your questions! Speech/language delays are definite risk factors for dyslexia. Estimates vary, but probably about 30% of children with a speech/language delay will eventually receive a dyslexia diagnosis, and more are likely to be on the low end of reading achievement (just not low enough to be diagnosed). However, there are many children with speech/language delays who do not struggle in reading, and there are many children with excellent speech development who do struggle in
reading. We think our technique has potential as an objective test for dyslexia. In the PLOS Biology paper, we found that in school-aged kids our consonants-in-noise score reliably identified which had a reading impairment (see Experiment 4). We are following the preschoolers from that paper and are optimistic we’ll be able to use this technique to test for future reading impairment. We’re also working to replicate these findings in a larger group of children. And, our previous work using this objective biological approach in older children suggests it can distinguish between those with and without reading impairment.

Check out our reading webpage, which includes an overview slideshow on this work.

Does your research indicate any types of treatment that are particularly helpful for these children?

I work with preschoolers but am not an SLP, are there any indicators in typical interactions that would suggest they may have difficulty identifying consonants?

Thank you so much! We do not get tons of researchers who do clinical work.

vespertine124

Thank you for your questions. We should emphasize that we are only researchers, not clinicians, so cannot make any formal recommendations.

That said, we think that effective auditory learning integrates how we think about sound, how we hear sound, and how we feel about sound. So, we think that the most effective treatments will integrate these cognitive, sensory, and reward domains. For example, there are computer-based programs that direct attention to fine-grained details in sound and provide instant feedback on performance. These ideas can also apply to effective one-on-one speech therapy. Moreover, since we believe that communication challenges are rooted in poor sound processing in the brain, we think that interventions to promote meaningful interactions with sound—music, speaking a second language, assistive listening devices, and more—may be a good avenue. We’re talking about these topics in depth in response to other questions on this thread, including links to project pages on our [website](www.brainvolts.northwestern.edu).

Unfortunately, we do not think that there are indicators in everyday interactions that are sensitive enough to suggest a child is at risk for a reading problem. Many kids seem to be doing well but then struggle when they start to read. It was this conundrum that motivated us to conduct this study, and look for an objective, biological approach.

I understand that children in bi-lingual households typically develop verbal and auditory skills at a slower rate than children in a home wherein a single language is spoken. Does your approach account for, or further help us understand, this phenomenon? Do you think that this specific [bilingual] neural coding process is related to or interactive with the process(es) you are investigating?

moemoe111

This is a fascinating question, and one that we are working on. Most of the world speaks more than one language, and the US is heading that way as well.

Verbal and auditory skills may take a bit longer to emerge in some children who grow up bilingual, but those kids are likely to soon outpace their peers developmentally. For example, bilingual children tend to have stronger attention and executive skills (such as focusing in on one target and ignoring distractions). Not to mention that being conversant in more than one language opens up children to more diverse cultures, perspectives, and opportunities to engage with communities.
We have investigated the consequences of bilingualism for sound processing, and have found that bilinguals have stronger neural coding of the pitch of a talker's voice, and also more stable neural responses to speech. These brain enhancements are associated with their cognitive advantages. What is very interesting to us is that this neural signature is somewhat distinct from the neural signature for poor reading—we're optimistic that we might therefore be able to design a uniform, objective biological test for language development in both monolingual and bilingual preschoolers, but this remains a future direction for our work.

Please check out our lab’s work on bilingualism; be sure to go through the slideshow that provides an overview of our work.

And here's the paper where we showed that bilingualism shapes sound processing in the brain:

Any tips for a librarian conducting storytimes (3 months-5 years)?

Sweet1014

Great question! First, as auditory neuroscientists, we need to mention hearing. One of the themes of this paper/AMA is background noise, so think about what you can do to conduct storytime in an acoustically-favorable environment. Make sure it’s in a quiet room that will facilitate learning. Reduce distractions and background noise. Simple measures such as pillows, carpets, and blankets will help reduce reverberation.

Second, think about what neuroscience teaches us are the important ingredients for learning. Do what you can to actively engage the kids in the stories—active learners are successful learners. Engage cognition (thinking, memory, and attention), perception (seeing and hearing), and the reward system (make it fun and entertaining). Make the kids active readers even if they’re listening, especially the older ones. For example, if you’re going to read a book about penguins start by going around the room and ask kids what they know about penguins, or what penguins remind them of. Pause midway through a book and ask questions about the topic, or encourage the kids to make predictions about what might happen next. Getting them thinking about the topic will help them soak up the story and its content. Additionally, one of the most important uses for storytelling for young children is to teach the mechanics of reading: here’s how we hold a book, here’s the order in which we read the pages, here’s how we take a book off a shelf then put it back on, etc. So don’t forget that these simple things are worthwhile.

Finally, remember that library storytimes should be as much about teaching the parents as about teaching the kids. If possible, encourage parents to stick around for storytime and participate. Keep parents engaged in the stories, and given them tips on doing effective storytimes at home. If it’s a weekly event, tell parents what you’ll be reading next week so they can discuss the topic of the book with their children ahead of time. Parents will be grateful for your expertise on topics including good books for different ages, pacing a story to keep kids engaged, doing voices that emphasizes prosody, stress, and different characters, and recommendations for books that speak to their kids' passions.

My 9 year old has capd. (central auditory processing disorder). He's very smart but complains he “can't hear” during school classroom lectures. The school has diagnosed him and he has programs which don't seem to help. We spend every day after school until he sleeps reteaching him until his homework is done. I myself have recognized a LOT of his symptoms as ones I went through without the support.

What can we do?

OaklandHellBent

APD/CAPD is a topic that is near and dear to our hearts. This is exactly what this paper is about—we’re driven to understand the biology of auditory processing precisely because of kids like your son. If we can understand the biology better, then we can identify better treatments to boost auditory skills.

We think that the brain measures we report in this paper are, in fact, a direct measure of auditory processing, especially because one of the hallmarks is difficulty hearing in noisy, real world environments.

We should emphasize that we are not clinicians, but:

First, accommodations that you’ve probably already done. Make sure he has good seating in the classroom, at the front to help hear the teacher’s voice. Talk with the teachers so they understand your son will likely benefit from hearing instructions more than once (for example, if the teacher instructs the classroom on an activity your son should then get the same instructions one-on-one). Coach your son to self-advocate graciously, such as asking people to repeat themselves or speak more slowly and clearly.

Second, the research. We recently conducted a school-based study where children with dyslexia and/or APD wore assistive listening devices (FM systems) for one year. After the year of classroom use, we found that their reading skills were boosted and their brain responses to sound were more stable—in fact, their neural response stability was in the range of typically-developing children. We think that these assistive listening devices have a lot of potential by directing the teacher’s voice right into the kids’ ears and helping them learn what to pay attention to. Here is a link to the study: Hornickel J, Zecker S, Bradlow A, Kraus N (2012) Assistive listening devices drive neuroplasticity in children with dyslexia. Proceedings of the National Academy of Sciences. 109(41): 16731–16736.

You may find it helpful to discuss one of these systems with your audiologist and school. We have also heard anecdotal reports that low-gain hearing aids are extremely effective in APD, and that kids love them because they provide just a little bit of a boost for signal clarity, especially in noisy classrooms.

Again, we think what’s important is that they clue kids in on what auditory signals are important to focus on.

It sounds as if you’re also having trouble one-on-one at home. Think about what you can do to make your home environment as acoustically-friendly as possible. Make sure he works free from distractions such as the TV, music, siblings, appliances, etc. Simple things such as curtains, blankets, pillows, and carpets will help cut down on reverberation. If we can tell that you’re saying something, but can’t understand the message, try to speak more slowly and clearly (overarticulate).

Finally, we have a good bit of evidence that active music training can help boost hearing in noise and its brain mechanisms. Instrumental music lessons may be challenging (see responses to other questions on this AMA), and it may take a while to notice a difference, but they may help engage him in sound. We invite you to view our webpage on our music work. Be sure to check out the slideshows that walk through details on each of our studies on music and brain plasticity.

You have a slide show about the positive effects of music on the brain. Your results are pretty clear about the cognitive, emotional, and memory benefits of musicianship. But your definition of “musician”
is quite loose. Can you prescribe a recommendation for music exposure in preschool? There is quite a vast world of music between Suzuki method violin and singing nursery rhymes while doing laundry. Relatedly, is there a specific type of music that works best? For example, preschoolers love to dance. Is it more effective to expose them to, say, Uptown Funk, which they can dance to, or Mozart? Or is it actually the act of musical production that makes the difference and therefore the point is moot?

Thank you for your work and taking the time to talk to Reddit!

AngelinaBallerina

Thanks for this question, and for checking out our website!. In our studies, “musicians” are individuals who actively make music for 30+ minutes 2 or 3 times a week. We think what’s most important is that the kids actively make music on a regular basis. The genre, instrument, or approach probably doesn’t matter as much.

One element of music making we think is especially important for speech and language development is rhythm. There is now a good deal of evidence that children with dyslexia struggle to keep a beat, and we have shown that prereaders with more precocious early rhythm skills outperform their peers on tests of reading readiness and have stronger brain encoding of sound:


Also, check out a Scientific American 60-second science podcast about this paper.

So, we think it’s important that music training incorporate rhythmic awareness and training, especially for preschoolers. My former student Gabriella Musacchia, in fact, has developed a drumming-focused music training program for toddlers.

Is a language delay equally likely in subsequent siblings?

yogamama2016

Biologically, we know that auditory processing is similar between siblings. We have found that siblings have very similar (but not identical!) brain responses to speech:


Language development is such a crucial skill in childhood that for in some cases, deficits in the area may correlated with other forms of development, including certain areas of cognitive development, as well as social skills and adjustment. Have you found that early deficits in ability to process consonants was associated with any other outcomes? Do you predict that earlier intervention for such deficits would affect any of these other outcomes? I imagine your research would have implications for determining whether the correlation between language disorders and other areas of development is because language deficits simply make it difficult to participate in the social interactions that are necessary for development, or whether they’re correlated because of some underlying neural or cognitive differences that simply affect these outcomes simultaneously.

Thank you!

fsmpastafarian
Thanks for your question. We think that these skills all need to work together. This paper is an illustration of how we hear with our brains, and that means that our ability to understand speech is tightly linked to cognitive outcomes, probably in a highly-interactive circuit.

We have done some research on the biological benefits of auditory enrichment in children from low-SES backgrounds. Engaging with sound is important for language development, and we think that boosting engagement with sound is a promising avenue for these populations.

In one line of work, we have shown that making music speeds up auditory development, and improves hearing in noise and language skills, in children from low-SES backgrounds. In another line of work, we have shown that speaking two languages partially counteracts the brain signature of low-SES; we think that the linguistic enrichment specifically deals with the linguistic impoverishment that is part of low SES.

Please check out our neuroeducation project page, which covers all this work and has a slide show with an overview of each paper. Additionally, we have a one-page summary of five years of research on music and the brain in at-risk populations.

What sort of yardstick did you use to measure preschoolers’ literacy skills? There’s been a body of research lately suggesting that early reading (before age 7) does not correlate with test scores when children are older, so it makes me wonder how important these early literacy skills really are.

Which consonants do you generally find preschoolers struggling to process most often?

I’m looking forward to reading your answers to everyone’s questions today, thank you!

littlebugs

Thanks for your question - it encapsulates one of the chief goals of our PLOS Biology paper. Classic behavioral tests of early language are effective, but preschoolers perform variably on them. Imagine giving a test when it’s nap time!

This is why we sought to develop an objective, biological test of the sound processing mechanisms that underlie language development. We hope to keep following the children over the next several years to keep working on this question.

Thanks for your question -- this is exactly the spirit of our paper. We want to make it possible for clinicians and educators to objectively evaluate sound processing on the brain because of its importance for language development.

In the PLOS Biology paper we discovered a biological test that predicts language development, and we think it could be an avenue to facilitate early screening to identify which kids might benefit from early interventions to boost development.
Dr. Kraus, thank you so much for participating in this AMA!

In your research have you found any class-wise differences in terms of the effectiveness of intervention?

Some research indicates that children from low SES backgrounds have poorer functioning in certain areas of the brain and even less mass in certain structures (primarily the amygdala and hippocampus if I recall correctly).

I am a grad student studying experimental psychology and I deal in class differences, disgust, and aggression. So I'm curious here if these differences may prevent unique challenges in language acquisition that might contribute to poor social interaction skills.

Drathrul

This is an intense topic of study in our lab. In fact, we have found that children from low SES backgrounds have dampened neural responses to speech sounds—they are noisier, less stable, and represent fine-grained speech cues less accurately. As you say, this work is in the context of lots of important research showing that low SES negatively influences neurological, cognitive, and emotional development. One interesting note is that this “neural signature” partially overlaps what we see for language impairment.

We think that one of the most insidious facets of low-SES backgrounds is the linguistic deprivation, namely, the well-known “30 million word gap.” We have shown that bilingualism, a form of linguistic enrichment, partially counteracts this effect. We have also shown that music training sparks brain plasticity in children from low-SES backgrounds in a very similar way as children from higher-SES backgrounds.

So while we think that low-SES backgrounds are a definite risk factor, many of the same interventions are promising. That said, it is an open question whether identical interventions for language disorders will work in children from lower- and higher-SES backgrounds, and one we hope to pursue in the future.


Be sure to check out our neuroeducation project page, including the overview slideshow covering our work.

Prof Kraus, first of all thank you for doing this AMA. I am currently studying the circuits that we think underlie the processing of auditory inputs in noisy environments, namely the descending projections from the cortex. These projections allow for a more "conscious" control (control from higher order processing centers) of the lower structures ranging from the cochlea to the thalamus. In some previous studies looking at the role of interneurons (as well as the excitatory/inhibitory balance in the aging literature) in the cortex there were some indications that dysfunction in this system could lead to problems in both cortical processing and therefore the processing and filtration that the descending system provides.

Do you think that this (the corticofugal) system is disrupted or underdeveloped in these children, and do you think there would be a good way to test this?

mei9ji

We are deeply interested in this question and the role of the corticofugal system in shaping automatic
auditory response properties. We have argued that the auditory system needs to be thought of as a distributed, but integrated, processing circuit, and hypothesized that many cases of poor auditory function are due to a failure of corticofugal input to shape basic auditory response properties.

You may be interested in our recent TiCS paper where we spelled out this framework and where we encourage the field to move past thinking about “higher vs lower” towards more of a network view:


Obviously it’s difficult to look at corticofugal modulation in humans, although there is some evidence that children with poor auditory processing have a reduced medial olivocochlear reflex. There is exciting work in animal models that knockdown expression of dyslexia candidate genes and we’d be interested to look both at the corticofugal system and excitatory/inhibitory balance which, as you point out, we know is a factor in poor auditory processing at least with aging.

Hello Dr. Kraus! As an educational audiologist, I’ve been very interested in your work since I saw your Marion Downs lecture at the AAA convention a few years ago. I regularly quote your research on the cortical changes seen in children with APD after using remote microphone technology when explaining to case managers and school districts why purchasing this equipment is so important to the child’s treatment and education.

I believe that your original research on this topic was performed with traditional FM equipment. Do you have any plans to replicate that study with the lastest DM technology that had been released (since the audio quality is much more refined when compared to FM) or do you assume that the outcomes would be identical, if not better, with the DM equipment?

Thank you!

audiodoc

Thanks for your question, and your ongoing interest. I was honored to deliver that lecture.

We think that the conceptual advance in the study you’re talking about is the idea that facilitating access to sound in children with poor auditory processing boosts sound processing in the brain and language skills. We hypothesize that these devices teach children what to pay attention to, transforming their everyday listening experiences into learning. This was the conceptual advance in that paper, and we look forward to seeing future work exploring variants with other technology.

Here’s a link to the paper, which discusses these ideas more thoroughly:


We’ve also written elsewhere on this AMA about how other forms of auditory enrichment, such as music training or bilingualism, enhance sound processing. We think these are all avenues to explore, especially with regards to the objective, biological test we discovered in the PLOS Biology paper. We review these ideas in a recent paper in TiCS: