Glean Education's Research to Practice Podcast Episode #13 - James Booth and Marisa Lytle (Vanderbilt University)

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Jessica Hamman: I'm Jessica Hamman, founder of Glean Education. And today, we're thrilled to be talking with Marisa Lytle and James Booth from Vanderbilt University. Marisa Lytle is a research assistant at the Brain Development lab, with a research interest in studying neural development of peer interactions and their impact on academic success. James Booth is the Patricia and Rodes Hart Professor of Educational Neuroscience in the Department of Psychology and Human Development at Vanderbilt University. Today, we'll be chatting about their research and mission to make over 3000 MRI scans that explore brain structure and function in school-aged children available through the open source digital repository, OpenNeuro. Marisa and James, welcome to the podcast.

James Booth: Thank you for having us.

Marisa Lytle: Thank you.

Jessica Hamman: Three recent research papers that you guys have published include neuroimaging data sets on school-aged children, and they investigate three different areas of learning. One is lexical processing. The next is orthographic, phonological, and semantic word processing. And the third was arithmetic processing. Tell us a little

bit about the background behind this research and how you came to focus on these areas.

James Booth: So the projects that you mentioned deal with reading and math, and the reading projects are our oldest projects. We started those around 2002, and they're actually two distinct projects, one focused more on spelling, meaning, and rhyming judgements, and the other one focused on different modalities of processing, looking at visual, versus auditory visual, versus auditory only. So they were really distinct projects that were different grants. In terms of the math project, that started a bit later, I guess, around 2008. And the goal there was to look at the role of spatial and verbal mechanisms in arithmetic processing.

Jessica Hamman: And was there a lot of crossover in what you found?

James Booth: Our lab has been investigating language and reading since its existence, and we've extended out from there to look at different aspects of processing. So our take on the arithmetic processing was to look at the verbal mechanisms, It turns out that as you older and older, between the 2nd and the 8th grade, there's greater and greater engagement of these verbal mechanisms over that time. But there's also a decrease, actually, in the engagement of spatial mechanisms. So what happens is you engage the verbal more and then you engage the spatial less when you're doing multiplication problems.

Jessica Hamman: Mm-hmm (affirmative). And in terms of the brain scans that you are viewing, what did this look like on the MRIs?

James Booth: The two major areas that we've been looking at are the parietal cortex, which is involved in visuals, spatial processing, and the temporal cortex, which is involved in verbal processing. One relatively unique aspect of that project is that we use what we call localizers. So arithmetic is really complicated. And maybe it seems pretty straightforward, but it involves lots of different processes, all the way from when coding, to attention, to decision processes and everything in between.

James Booth: And so we use these localizers to identify areas independently. So we'll use a dot task where they have to make a judgment about whether two arrays of dots are the same or different to localize visual spatial mechanisms. And then we use a rhyming task. So they get two words, lake and cake, and they have to determine whether they rhyme or not. And that identifies these verbal mechanisms. So we independently identify those mechanisms in the parietal and the temporal cortex. And then we can see when we give them an arithmetic task, like a multiplication, or we also study subtraction, how these mechanisms are engaged in these seemingly simple tasks that require lots of different processes.

Jessica Hamman: And can you tell me a bit about the methods for creating these data sets?

James Booth: I'm going to turn that over to Marisa.

Marisa Lytle: Sure. Yeah. So how we usually go about creating these giant data sets on math and reading processing in all these kids is we recruit them from the community and then they'll come into our lab. And we actually have a wide swath of standardized testing measures that we provide to these kids. So those are measures of reading skill and cognitive skill that will help us ask really interesting questions when we look at both those measures of reading skill in comparison to the different brain regions they're using in the scanner. And then we get our kids in the scanner. So we train them up, teach them how to do these reading tasks, these rhyming judgements, semantic judgements, the math games.

Marisa Lytle: And then we have them go into the scanner and do all these tasks in the scanner while they're watching the games or tasks, as you might call them. We like to frame them as games to our kids, because then they get more excited about it. And especially because these kids are anywhere between 7 and 16 years old. So we get this large developmental range, which is really interesting because you can ask those cross sectional questions. We also will follow them up two years later. So in both our math data set, as well as the multi-sensory data set, we follow these kids up two years after so that we could see these changes happening, ask all those questions that James was mentioning.

Jessica Hamman: And were the methods different for each of these three research studies or they were relatively similar. And was there a reason for one or the other?

James Booth: So the math study is a study that we implemented this novel technique of independently localizing areas and then looking to see how those areas were engaged during the arithmetic. So that was a novel addition. Our earlier studies didn't use those localizers. Rather, we just had a variety of tasks. So for example, in the first study where we looked at the spelling, the rhyming, and the meaning judgements, we could still look for specific activation during certain tasks or overlapping activation between the tasks to ask questions about, yeah, specialization versus domain general processing, but we didn't use those localizers. Our earliest reading study also used a lower strength magnet in terms of the MRI, so the signal wasn't quite as strong as our second major reading study and our math study. So in terms of the hardware, there was some differences as well.

Jessica Hamman: So tell me a little bit about the findings from these studies.

James Booth: Maybe we'd focus a little bit on the reading studies. For me, one of the major discoveries of the project is the engagement of the inferior parietal and the superior temporal cortex being involved in mapping between representation. So if you think about reading, you see the words and then you have to access how they sound. So you have to map from the orthography to the phonology. What we showed is that there's an area in the brain that seems to be really

important in this mapping process. I think more importantly, is we've seen that there are individual differences. So those who are higher skill tend to engage this area of the brain involved in mapping to a larger degree than those who are lower skill. And that suggests that this multi-sensory, or this mapping process, is an absolutely critical component to being a proficient reader.

James Booth: So the idea is that a fundamental aspect of skilled reading is this multi-sensory integration. So that has educational implications in terms of the importance of teaching the mapping between letters and sounds and the importance of directly teaching the alphabetic principle. Evidence is very convincing that when you're a skilled reader, you always robustly activate those smaller units of sound, regardless of how automatic you are at recognizing visual word forms. So the process of mapping between letters and sounds is absolutely critical for skilled reading.

James Booth: We talked about the educational implications in terms of instruction, but there are also implication in terms of early identification. We've done some studies, and other people have done studies in the field to try to use neuro imaging, to predict who is going to end up struggling with reading, or math, or more generally, to predict who will show greater gains versus lesser gains in reading and math. Earlier on, we talked about the importance of the temporal cortex, for example, in reading. And we've done some studies showing that the amount of activation in the temporal cortex predicts reading gains three to six years later over and above behavioral measures.

James Booth: So we're not going to argue that we shouldn't use well-defined standardized measures of reading and other academic tasks, but perhaps we could use neuroimaging in addition to those behavioral tasks to identify, early on, those who are likely to struggle. We haven't done this work, but other people have done work looking at preschoolers before they even start to learn to read. Can we peer into their brain with neuro imaging to try to predict who's going to struggle with reading before they even start to read? I think that's a really important implication of this neuroscience work.

Jessica Hamman: And I've heard it spoken of by Nadine Gaab, out of Harvard, the Gaab Lab, who talked about it as the paradox between having a brain that's just less optimal for reading the day you enter kindergarten. And yet, we wait till 1st or 2nd grade to decide that they will struggle with reading. So there's this time lapse in that identification that can be really harmful academically and emotionally. So if we can identify early, that would be a huge boon for students, because we could then intensify instruction and make sure that we are applying the right instruction to support these students.

James Booth: Sure. We have a new study looking at language processing in five to six year olds. So these folks are in kindergarten, but are just starting to read. And we looked at semantic and phonological processing. So meaning-based versus sound-based processing. And we're really interested in whether early specialization in the brain is related to later reading at acquisition. We have some promising results to suggest that this specialization measure is predictive of later reading.

That work is still in development and we're hoping to get that disseminated soon.

Jessica Hamman: I also think it's really interesting that you cover such a wide range of academic areas that really give us a really well rounded idea of what the brain is doing during these processes and development. Because really, all the academic work is interconnected. So it makes a lot of sense.

James Booth: Yeah, I agree. That's been the fun part about the lab, I think, is not necessarily going super deep into one area, but rather, going broader to look at the interconnection between different areas. So I think that's one way our lab is a little bit unique looking at arithmetic, and language, and reading. We've done a little bit of work in ADHD, scientific reasoning, and we have some ideas how these are related in terms of different underlying mechanisms. But for us, that's given us a broader view of how the brain does academically relevant processing.

Jessica Hamman: And just out of curiosity, do you find that where there are weaknesses in one area, perhaps in the lexical processing or orthographic processing, sometimes you can find strengths or greater activity in arithmetic processing? Are you comparing students' images in these separate areas to find the differences too, that there's some weaknesses, but strengths on the other side?

James Booth: It turns out that there is a pretty high correlation between a learning disability in reading versus a learning disability in math. I'm not sure what the comorbidity rate is, but I think it is on the order of around 50% or so. Yeah. I mean, that makes sense if you think about some of the same underlying mechanisms that are involved. If you think about like arithmetic, for example, you're wanting to map from a symbol to its meaning, or a symbol to its sound. If you think about reading, you're doing the same thing, but instead of an Arabic numeral, it's a letter. And you're still wanting to map from the letter to its meaning, or its sound. So-

Jessica Hamman: Interesting.

James Booth: ... At a fundamental level, it's a similar process.

Jessica Hamman: What out curriculum implications? It speaks toward the power of multisensory, systematic phonics learning and creates that orthographic map.

James Booth: Sure. Yeah, that's a direct implication of the work, is that we have to be deliberate and explicit in terms of instructing kids about the alphabetic principle, which is essentially phonics. Another interesting discovery that we made a while back was that those who struggle with reading also tend to show alterations in different parts of the brain. So not just areas of the brain involved in this mapping, but between orthography and phonology, but rather, they seem to

show differential patterns of activation in brain areas associated with vocabulary.

James Booth: So at the time, this was relatively unique because a lot of the brain work, a lot of the neuro imaging work, for good reason, was focusing on mapping between orthographic and phonological representations. But we additionally showed that there seemed to be changes in areas involved in representing vocabulary. So I guess the implication of that is that you can't solely focus, I suppose, on instruction of the alphabetic principle or phonics, but you also have to supplement that with vocabulary instruction or instruction in the more meaning-based aspects of-

Jessica Hamman: Comprehension.

James Booth: ... Reading. And comprehension. It turns out that those who are struggling with reading their brain is not as sensitive to the magnitude of association between words.

Jessica Hamman: When spoken or when read?

James Booth: Both, actually, okay. So the kids who struggle with this decoding process also have alterations in the precision of their vocabulary representations. And we know that vocabulary representations are really important, particularly as children get older and

comprehension becomes more and more important. So around the 3rd, 4th, and 5th grade, where the demands switch from decoding and fluency more to understanding the meaning of the text.

Jessica Hamman: Really interesting. Let's switch topics a bit to talk about out the efforts that Marisa and you are doing in order to make these data sets, which include nearly 3000 scans available via an open source platform called OpenNeuro. Tell us a little more about that effort and what can come of it.

Marisa Lytle: Yeah. So there are a lot of great benefits to data sharing and we're just really trying to get in on it and share our data so that other people can use that data for further analyses. These data sets that we've been talking about are massive when we compare them to your typical developmental imaging data set. And there's so many additional questions that can be at asked using them, especially for people who don't have access possibly, to these type of resources that you might need to collect such big data sets. Booth is really fortunate to have the funding to collect these big data sets and some people aren't, but making it public allows anyone to be able to use these data sets to answer questions that they're interested in. So that's one really exciting part of making this data public.

Marisa Lytle: One other thing that we think about is the field of psychology is really an educational psychology too. It's really shifting towards this increased transparency and reproducibility in research, because often, we see that as many as even 50% of publications of high impact journals will have some sort of small statistical error or

maybe a problem with p-value reporting. And so making your data public really increases the transparency and the reproducibility of research so that peer reviewers can catch those small errors and we can correct them and improve science in general.

James Booth: There's increasing emphasis for sure on sharing data. So the national Institute of Child Health and Human Development really took the idea of data sharing seriously. About three years ago, they introduced this RFA, which is a request for applications and made a special mechanism that you could apply for that was specifically targeting those investigators who had high impact data that they wanted to share. So we applied for that funding and we got it. It's a small amount of money, but we devoted it entirely to our sharing efforts. And that's what Marisa has been working on for the last, almost three years. That RO3 was used to then allow us to share the other projects that we've been talking about in terms of the reading, and the language, and the math. So we're really taking this idea of data sharing early on seriously, getting the data out there so that people can start to answer their own questions.

Jessica Hamman: That is very exciting and a very selfless approach to your research gathering and one that benefits all.

James Booth: Hopefully, people will access the data and try to answer new questions with it.

Jessica Hamman: Excellent. Well, thank you both for the work that you've done to make these data sets available and for the work you continue to do in the field.

James Booth: Thank you.

Marisa Lytle: Thank you.

Jessica Hamman: To learn more about Marisa Lytle's work, you can find her on Twitter @Lytle_Marisa. To find Booth's work, visit his lab at braindevelopmentlaboratory.com, or follow him on Twitter @DrJamesBooth. To find links to the articles and resources mentioned in this podcast, go to GleanEducation.com/podcast and access them in the show notes. Thanks for listening to Glean's Research to Practice podcast. If you're interested in learning more, head over to gleaneducation.com to listen to more episodes, access teacher resources, and join the movement to make in-service teacher education more dynamic and accessible. Bye for now.