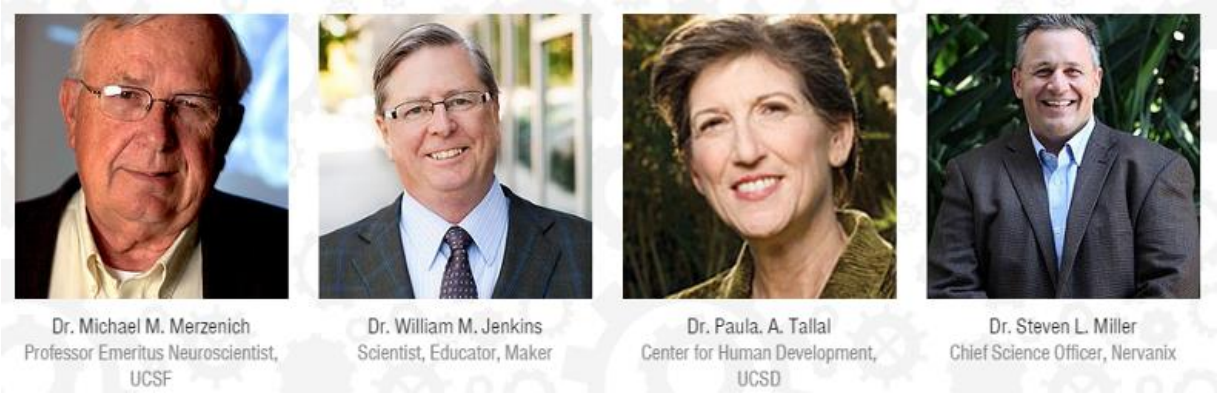
4 Eminent Neuroscientists Discuss the Last 20 Years of Educational Neuroscience

2016 VISIONARY CONFERENCE
CELEBRATING 20 years of Fast ForWord

This is an edited transcript of a panel discussion with the four neuroscientists who developed Fast ForWord and founded the Scientific Learning Corporation.

This panel discussion took place at the Scientific Learning 20th Anniversary Visionary Conference in San Diego, March 2016.



Dr. Michael M. Merzenich
Professor Emeritus Neuroscientist, UCSF

Dr. William M. Jenkins
Scientist, Educator, Maker

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Center for Human Development, UCSD

Dr. Steven L. Miller
Chief Science Officer, Nervanix

The discussion covered the history of the science that underlies the Fast ForWord programs, starting with Dr Paula Tallal's research in 1973.

It was a wide-ranging discussion that looked both back to the past and also the future of educational neuroscience.

Topics mentioned included:

- Language disorders
- Acoustically modified speech
- Language based learning problems
- Phonological awareness
- Translating scientific knowledge into action in classrooms and clinics
- Cochlear implant research
- Brain plasticity
- Scientific Learning Corporation
- Fast ForWord
- Dyslexia
- Autism

Dr Paula Tallal's paper on the temporal processing of language was published in 1973. It revolutionised the way we think about language problems as having an auditory perceptual component to them. But what led from that research to actually thinking about developing an intervention?

Dr Paula Tallal: When I went to Cambridge, and I got started doing research, I was interested in language, and I was fortunate enough to just pick up a journal that had an article by Arthur Benson, and he was talking about this group of children that seemed to have a developmental form of aphasia.

His clinical observation was that they might have something wrong with their higher-level auditory processing. So having done only animal research prior to that, I thought it would be interesting to just look at higher-level auditory processing. I had no idea what a maelstrom it was going to create over time.

I basically went to the animal literature and looked at what was known at that time about higher-level auditory processing in cats and monkeys, et cetera, and created what I could .....in terms of something that I thought children who might have language problems could do.

It turned out to be this two-toned processing task which looked at detection, association, discrimination, sequencing, rates, processing, and I was really surprised to find that these kids had difficulty just with the rate of processing part of and sequencing part of the test.

So I thought I'd probably done something wrong at that point and hadn't asked the question right. So I began to ask in lots of other ways. It turned out that that was just very fortuitous to have taken that approach.

So over the years, when I gave talks on this, there was a lot of interest. Almost every talk, though, that had anything that was presented to any practitioners, be they clinicians or educators or whatever, was, “That is so interesting. That matches so much my personal experience with children with language disorders. What can I do in my clinic to address these problems? “

For a long, long time, I basically said, “I don't know. This is what we do in the lab, but that's not something that you could do in the clinic. “Then when I came across Dr Mike Merzenich's work with Dr Bill Jenkins, and then, of course, Dr Steve Miller came to my lab and was interested in intervention.

I basically began to get interested in whether or not we could use neuroplasticity-based approaches to address the problems that we had discovered over the years. The other major component was that I had used acoustically modified speech, very early on, even in my dissertation, and showed that when you change the acoustic parameters of the sounds themselves, the speech sounds, and made the most rapidly changing components longer, these children did remarkably better.

So we took the two approaches together. I thought that we wouldn't be able to fix these children's speed of processing, but we might be able to give them some sort of a prosthesis that was something that was going to change the temporal components of the speech sounds.

We basically decided to disagree. Dr Bill Jenkins said, “Oh, no. Of course you're going to be able to fix it and very quickly. You're going to be able to speed them up. “I wasn't sure, and certainly not that quickly. So we decided we would do both together, and that turned out to be, again, very fortuitous. It was really in response to people like you, saying to us, “What can we do with this really valuable information? “

An action gap, not a knowledge gap

What's so interesting is, to this day, and you'll hear in my presentation, **the issue is not that we don't have the knowledge to know what to do, that will really significantly improve the outcomes for these children**.

We don't have a knowledge gap. **We have an action gap**.

So our goal in Scientific Learning Corporation, I would say, for 20 years, we've been trying to address the action gap. That is, how do you translate the knowledge that we actually have, that we know has such incredible impact in the lives of so many?

How do we get the people who are responsible for improving those outcomes to use what we have developed? Not just us, but all of science. How do we translate the scientific knowledge into action for use in classrooms and clinics? That's where we are today.

What's so interesting is Dr Mike Merzenich published the exact same year. It was almost the same month, I think. On cochlear implants - on what Mike was doing with monkeys.

Dr Mike Merzenich: Well, Dr Bill Jenkins and I were working together and we were publishing continuously because we realised that the brain was plastic, and we realised that we could change the temporal response characteristics in the brain of an adult monkey. Presumably, it would be easy to do in a young monkey or a young kid.

We heard Dr Paula Tallal describe these steps. Well, hell, if this was a monkey, we could change that range relatively easily, we thought. The only question was whether the genetic faults or some other problem, unknown problem, would be in the way. But certainly, we thought the brain would be plastic, and we ought to be able to drive it in an improving direction.

It turned out that, in the great majority of these children, that is, in fact, the case. So Paula basically had done all the groundwork. We were looking for a practical thing to do, to apply brain plasticity to. Bill and I had already sorted out that we can make training programs that would be game-like.

We were just looking for an opportunity, and Paula provided us with the opportunity. We could see she had a big population of individual kids. Who wouldn't want to help them? So it was exciting for us to come to the realization that this could be the big demonstration, brain plasticity-based training; delivered by computers, to be transformative.

Cochlear implant research a prime example of neuroplasticity at work

Dr Martha Burns: How did the cochlear implant research inform the development of the acoustically modified speech? Talk about your understanding of how the brain is organised tonatopically and what acoustically modified speech actually is and the power of it.

Dr Bill Jenkins: Well, actually, there are a couple things. Mike recognised, from the very earliest of cochlear implants. The earliest ones were single electrodes. And yet, ultimately, these early patients had very high-quality speech recognition, but not instantly. That suggested that, over time, their brains and their auditory systems were changing in response to these new inputs that allowed them to pull information out of the poor signal that they were getting, but better than none at all, obviously.

So I think the cochlear implant research, at least to me, is a prime example of neuroplasticity at work.

There was, at the time, quite a nice group of collaborative scientists working in Mike's lab. It was a great lab to be in. Lots of different things going on simultaneously, from work on auditory science, auditory physiology, cochlear implants, chronic recording from cortex, sensory research, motor research, particularly once we got into the brain plasticity area.

We were looking for all kinds of ways that we could exploit and demonstrate the connection between brain changes and behavioural changes and how to leverage that for practical applications, like recovery from stroke.

As far as what we did to the speech sounds, a group of us went to New York and met Dr Steve Miller and Dr Paula Tallal and the rest of her research team, in a hotel near Central Park. For several days we basically reviewed every study that had been done that related to the problems that were seen in kids. Us, neuro-physiologists, behaviourists, et cetera, kind of noodled on that, went back, and said: "Well, looks like stretching speech would be a good thing. How do you do it on continuous speech?"

Because the research that Paula had done was isolated. We wanted to figure out a way to do that on continuous speech, which was part of the emphasis algorithm that was developed and the stretching algorithm. The emphasis algorithm . . . I have to give credit to Mike and Christoph

Shriner who was a crackerjack auditory neuro-physiologist/neuroscientist that was in Mike's lab as a researcher at the time.

He said, "Well, we could go in there and amplify those parts of speech that are of short duration and make it more impactful for the brain." It clicked with all of us. Then it was a matter of coming up with the digital signal-processing algorithm to do that, without creating too many unwanted effects. That took us a while to figure out, but that's really the basis for Fast ForWord: understanding the basic research on the kinds of auditory-processing problems that these kids had and evidence of what would have an impact. That's what led to the speech processing algorithms that we employed.

Dr Martha Burns: Dr Steve Miller came in with a clinical focus with Paula.

Dr Steve Miller: So I had been on a project, where we were doing brain imaging, EEG, before kids entered school in North Carolina, to look for information processing deficits that might predict what was heritable among dyslexics. As well as co-teaching, doing what, for most people, would be called kind of a Phonics-based kind of approach, in a classroom.

So I was, in part, recruited to come and do the family genetics project because I was one of the few people who had been testing adults with dyslexia, who had diagnosed - not hindsight dyslexia but where we had childhood records. Usually, you meet somebody who's 50 years old, and they say, "I had dyslexia. " It's just their word. Right? North Carolina had rare access to a project where we actually could assess them.

So Paula's idea was to come and help bring the psychometric battery, because I was a clinical neuro-psychologist in North Carolina. So I came to Rutgers University and the idea was that we would focus on the family genetics study, which has been ongoing. I was told, initially, there would be no intervention studies at Rutgers, for a variety of reasons. Again, I think . . . As Paula knows, when I was out looking for kind of a mentor research relationship, one of the first things I told her was I really appreciated that I thought she was, first of all, open-minded and wanting to approach things very data-driven.

Not everybody, as you know, in science is. But Paula came in with a project and said, "We have an opportunity to do an intervention study, and I think that you could really contribute on that. You know the current versions of the products, like what we would call the auditory processing tests that kids have to go through, and how challenging they are."

Well, you can imagine what version one was like. Providing video evidence back to Bill and the team in San Francisco, that, no, kids really weren't enjoying themselves, and Paula freaking out because the stretched speech sounded so challenging for some kids. We didn't know how to reward them.

Token economy

So everything that Paula had at home, that she thought kids would like, became part of our token economy, and things that we can ask people for. So if you hear some of the toys we had, they weren't Paula's toys. So that was really it. It was to look at what tasks had good psychometric properties that would, in my opinion, generalise better.

So there was a token test that Paula worked on modifying, but we knew the token test could be made more difficult and that you could have enough items to give to people, so that we thought

generalisation would go well. So in that sense, there was back-and-forth iterations with everything from Bill's daughter being one of the test subjects, I think, to some of the kids that we had in the early Rutgers projects, to come in, put headphones on, and try some stuff. You know?

We had twisted clown faces, I think was the first version of the reward, but not everybody likes clowns. Right? So there was that element of what I would call compliance. You all know that there's only so much leverage you can apply to kids to get them to do things multiple days, and that does play, in my mind, a key role.

There was a huge team in New York, and I think it was probably around 20 people. We had a pretty large team working on a variety of elements, some that didn't make it through to Fast ForWord because of implementation challenges. We really had a phenomenally collaborative group.

To be clear, a lot of academic labs are famous for not being good collaborative groups, so even in the same universities, in the same building. So to have a relationship between greater New York City and greater San Francisco was challenging in its own right, trying to send data to Bill or back and forth, overnighting things. We overcame those challenges.

Early (dial-up) days of internet, used to send data daily from New York to San Francisco

Dr Bill Jenkins: Actually, in the second year of the study, we did, in fact, use the Internet to transfer data. So Steve used a program called Timbuktu and wrote a little script and went around and collected data off every one of the student machines every day, at the end of the day, and would upload it to my computer at UCSF. So I'd have a big pile of text data, in text format, for every trial. It was an enormous amount of data.

Dr Mike Merzenich: Probably the first time that strategy was used to ship data from a population of people being trained in anything, back to a research laboratory. It was the basis of the patent, actually.

Dr Steve Miller: What was really funny for me was we had this thing going back and forth, where I'm in greater New York City, and we would have a snow day, and Bill would never understand why our Internet kept going down. I'm thinking there's 10 million people trying to dial-in right now to do something with their computer. These were all dial-up.

Dr Bill Jenkins: Steve also needs to get credit for being one of the primary rewards systems during those initial studies. To keep kids engaged, one of the favourite things was Dr Steve Miller standing on his head, for the students.

Dr Mike Merzenich: That's one of his main talents, by the way.

Dr Bill Jenkins: I had pictures of him in his Hawaiian shirt. He was definitely part of the reward token economy.

Dr Steve Miller: Yes, as they got better, I got a headache. But just to point out, as I said, our biggest issue was with any token economy or behaviour-modification program, you have to be adaptive, be flexible, and you have to deliver. So we had to do whatever it took to get kids through, and we really, really did. That doesn't necessarily bode well though for your first commercial launch.

There's some steps in between there. I won't say we forget, but even today, we still have those challenges. Right? So we're probably . . . I don't want to say what version we're in, compared to

what we were in '93, but it's a lot of versions of re-enforcements, of modifications, of various algorithms, to enforce learning and to keep kids on task.

I never thought I could teach in an elementary school classroom, because I tried, and I found that the numbers didn't bode well for me, too many kids per me. But smaller groups were fine. I think that we did an exceptional job, bringing in, as you can imagine, young undergrads to run a token economy. To give thumbs up and thumbs down, while we monitor from a two-way mirror, while we videotaped, while we did a variety of different things, to ensure that we were both complying with the ethical treatment of young children, as well as the tiger mums who wanted their kids in the experimental group, not the control group.

But those are the challenges that you have to overcome. I think that the beauty, for me, of working with this group was that we had lots, and a "LOT" in capitals, we had a lot of disagreements on a variety of topics. But we always found a way to empirically test the answer that we would choose in the end.

Again, there's a lot of people today, in a lot of domains in the world, where getting input, scientific input, et cetera, doesn't change any element of their opinion. So it's really unique to say . . . again, I know Mike was the first CEO of Scientific Learning Principles Corporation, which is our original first name. But we had a disagreement on something, and Mike was like, "How are we going to study this? " Paula was like, "Yeah, how are we going to study this? " We did a field study to demonstrate that we could generalise, but the format of that field study allowed us to frame what our claims would be.

I think where Scientific Learning was/is really different was we had a claims analysis. I think even today, compared to all the companies out there, all of them, we are still extremely conservative in what we say Fast ForWord does, compared to other companies.

Now some companies have gotten in trouble for what they say, but I looked at it the other day, in part, looking at the history of the company and the companies that are out there. We are absolutely, arguably, the most conservative company when it comes to claiming what we do, in part because we got so beaten up for being first.

There are a lot of companies out there with brain-training products that make statements that we wouldn't find acceptable. I don't know if that means we're overly conservative, wherever Bob Bowen (Scilearn CEO) is, or whether that means, right, that we're holding a good line. But to have a formal team to evaluate claims is something that Scientific Learning does.

Team science

Dr Mike Merzenich: I'd like to make one other acknowledgement. First of all, you should know by now that this is team science. I mean we were surrounded by smart people. We had a wonderful group of smart people; Dr Paula Tallal and Dr Steve Miller, Dr Bill Jenkins and I. It's team science. We were in an environment in which many, many people contributed.

Now as soon as we begin to apply this, we had wonderful outside help and collaboration. We couldn't have done it without them. Everyone in here . . . All of the older people here were a part of this.

Dr Bill Jenkins: More experience.

Dr Mike Merzenich: I want to say something else about its origin. We were neuroscientists. We were studying the plastic brain. No one had done what we tested before. We were training monkeys, primarily, and we were driving improvements to their performance abilities. We were looking in their auditory cortex, and we were driving them to go from something, some basic ability that we were measuring, using adaptive training.

Guess where all of that skill and ability came from? It came from him [*pointing to Dr Bill Jenkins*]. This man was trained as an expert in progressive and adaptive training in animal models. So he was a key. He was a key in our early experiments, in this respect. Bill knew this science.

Bill knew, basically, what progressive training was all about in humans and animals. So he was the resource. Without him, this would not have happened. So now when we look at this from the point of view of what we need to do, we understand how the brain responds to complex sound. So we immediately understand what we would need to do if an animal or a human had primitive listening or brain . . . you could say analysis capabilities.

How we'd have to distort or exaggerate the sound so that they could get the answer right. That's what the algorithm by which we process these stimuli was all about, was to make it . . . put it in a form in which the brain now can respond and detail all of the component parts of this sound, relevant to speech understanding, relative audio reception.

An invention of the first order

So we had Paula's platform. Bill knew how, once we had that starting position, we could drive the brain in a progressively advancing direction. Those were the critical elements. This is the first time in the history of all of this science and clinical practice that someone actually started with an understanding of neurological coding in the fore-brain, the first time.

This was an invention of the first order, and it took all of us to do it. It's absolutely teamwork. Could not have been done without all of us working together on it. Could not have been done without you [*Bill*].

Dr Paula Tallal: So the step from that point to this point was how do you then go about translating it into your hands, and that's where your collaboration came back to us. I'm going to give credit now to Steve, because he really was the next step of getting out there and figuring out how do we create a model that uses what we had done. It's one thing to do things in a laboratory, where you have a tremendous amount of control, a lot of expertise. Everyone can do things exactly how you asked them to do it.

The next step is much more difficult and has continued to be much more difficult. That is how do you translate this into something that the diversity of people, and much more diversity than you, can actually make work? It's taken 20 years to get to the point that we're at now. Well, technology had to catch up with us, but also our ability to learn from what Steve and his team and the other part of the team put into place, in terms of getting feedback from the actual use in the real world.

Dr Martha Burns was one of the first practitioners to use Fast ForWord

Dr Martha Burns was one of the first users in the real world. So it's really wonderful that we're all here together. I said to Mike this morning. “One of the most unique things, I think, about this teamwork . . . first of all, it's not that typical in science to be collaborative rather than competitive.” After this many years together, of the four of us, I do not recall a single time that any one of us has ever said a bad or unkind word to each other.

Dr Martha Burns: So I guess that takes us to the question of . . . When I first started using this, and many of you in the room were in that same stage, I thought, “ This is just going to take over everything. “ My interest in those days, to a certain extent, were a lot of the children in the inner city of Chicago that I tried to work with years before, as a speech language pathologist, correcting a lisp. That was the least of their problems. But how do we get to all these children that really, really need this? I thought this is just going to take off.

Dr Paula Tallal: So did we.

The future of Fast ForWord & neuroscience based interventions

Dr Martha Burns: But obviously, it's taken time. The research is now, in a way, catching up to the foresight that the four of you had, which was incredible. But maybe we'll start with Mike and just go down the row. Where do you . . . Do you see now an explosion actually occurring, where this becomes just widely adopted, which it should?

Dr Mike Merzenich: Well, I'm excited that millions of children have used this technology. This strategy has helped them. All of you have individual children that you know their lives have been changed by it.

So you say, “Well, why doesn't every kid that could make use of this, get it? Why is there so much resistance? Why is it so painful? “

When we first began this, we thought, “Well, everybody will see this, these outstanding results that we were seeing in children in front of us, and they'll fall over one another, trying to use and apply it.”

It didn't work that way. It's still not working that way. There's still strong resistance to it. I think what I've learned through this process is it's really a painful process, because so many people struggle, unnecessarily, that could be helped. I've learned a lot about human nature and civilization and culture.

In fact, I started to write a book about this, not too long ago, and I got about a third of the way through. It's about how the brain limits us in important things, in dealing with complexity and making complex correct decisions about things.

I gave it to my wife, and she read it, and she said, “Mike, you can't write this book.” She said, “In the first place, nobody really wants to know how their brain works like this. It's too discouraging. The second thing is that everyone will just think you're an old crank. The third thing is you'll be dead for 20 years before anybody really understands that this is true.” That's sort of the way it is with this.

You could say, “Will there ever be a clear awakening? Or will we continue to add to the confusion of what people think, about brain training, and how children could be advantaged by working on the computer and doing this or that?” Because, in a sense, that's what's happened.

Rather than clarifying this and crystallising on the solutions that really come from a deep science understanding, we create all of this noise on the surface, all of these alternative strategies.

Every damn fool thinks that can make a brain training program

Every damn fool, just about, in the scientific universe or clinical universe, thinks they can make a brain training program now, and most of them are damn fools because most of them don't understand very much about the underlying brain and how it operates. Most of them actually don't understand very much about the real neurology that relates to the limitations that children and adults have in life.

So we continue to fight against this noise. People are continuing to muddy the water. I hope that, at some point, there is a kind of crystallisation.

I keep thinking that there could be authorities that look at this, at some point, and say, “Look. Every kid in this place, in this city . . . “Actually I asked the Foundation, about a year ago, to support the transformation of the child populations for children that struggle in a place. I said, “ Let's pick a city or a county that has 150,000, 200,000 people in it, and let's see if we can find every kid in this county that struggles, and let's try to get them past their struggle, so that they can have a good life.

What we are doing is transformative

Then let's try to set up this place, as a transformative example, for the wider region and the state and across the state, across the country, across the world. “Because I do think that what we are doing is transformative. I think we now know enough so that we can go to almost any place and, with a relatively modest investment, find every kid that needs help.

Help them and give them a chance to a better life and have them be part of this, as opposed to a member of an outcast society, which so many children are doomed to be.

What an incredibly stupid, costly, ridiculous thing we do now with children that struggle. And how haphazard and casual and ineffective we are so often. Actually, what we do is even worse than that. We blame them. We blame them. We blame them for their entire life for having a shitty life. That was a cuss word. I'm sorry about that.

So the other side of this is I'm an optimist. I keep thinking that people will wake up and that Paula will give a lecture somewhere, and people will say, “ Damn. “

So it's a struggle, but it's a great, great sight. I see this as kind of a holy war.

Dr Bill Jenkins: Yeah. Well, I agree with much of what Mike said. I do hold hope out for the future. I know there are lots of young neuroscientists that understand the importance of neuro-plasticity. They understand how to apply it. They're studying the neurology, and they have ideas of applications. They see us as really a solid model to go after.

So the other thing is that the federal government has research dollars, not enough, but there is investment in this type of research and these kinds of applications.

So I have to believe, over time, it's not as fast as we had hoped, but over time, I think you'll see new applications coming online that impact the lives of children and adults with neurological

problems. It's just taking a hell of a lot longer than any of us would have hoped for, given what we know about the science and what the possibilities are.

Dr Martha Burns: But do you think in all the new neuroscience related to poverty and stress will help people start to understand this isn't the child's fault? But the brain is changeable, and we can fix this. There is a path out of poverty. There is a path out of being neglected. Steve, how about you?

Dr Steve Miller: You know what? I always think of myself as being more pragmatic, but I'm also more pessimistic about these elements than my friends up here. I remember about 38 states going and talking about early brain development to state legislative bodies. I forget who it was, who the agency was but they about birth-to-five brain development and the role of poverty that we did or didn't know about.

I was at a meeting that was held in California recently with some of the large Foundations. It is surprising to me how similar the same conversations are from 25 years ago, as if none of this other stuff happens. I think we have institutionalised various approaches that are not data-driven, are not outcomes-driven. So convincing them to review their outcomes as being a method for change analysis just doesn't work. Right?

Schools don't have innovative approaches

For me, that's the pessimistic element. It's that schools don't look at outcomes as a defining feature as to whether they should innovate. They don't have innovative approaches.

Many of the critics, 20 years ago, that talked about scientific learning. I would always ask them the same open-ended question. Pick your program. Any program you want. How do you evaluate evidence to improve your program? A third of the time, I would get a chuckle and, "We really don't have a way." These are people at universities that sell programs. They just believe that their model is to get their model out there, and they're not innovating. They're not trying to improve.

Again, it's hard to keep my colleagues up here from not wanting to change things too fast. Because they want to innovate, and they want to improve. If it's good, why can't we make it better? So I'm just saying to you I think that part of the challenge is we have an institution that is not data-driven around outcomes. So having an outcomes pitch to them is a difficult one to communicate.

I agree 100% with Bill's statement that the neuroscience community funding is driving approaches and change. I think there's a lot of noise out there with people having brain-training programs, which means they took a psychology experiment and computerised it. It doesn't mean it's bad, but it doesn't necessarily mean it's brain training or that it's going to be effective.

But I think those are the challenges. I think the battle is going to continue, as long as we're willing to put the gear on. It doesn't ever change on its own.

I cold-called people in Chicago and said, "If there was somebody who you would go listen to, who said something worked, who would you go see?" I thought it was the most reasonable question in the world. Dr Martha Burns was one of those individuals. Then Marty was silly enough to say she would actually buy computers to test this new thing and help us along that line.

But given that, it's now 20 years, Marty. So I think Marty is, in action and in her duties, demonstrating that. I think people know about Fast ForWord and Scientific Learning in that area,

but there's a lot of areas where I go, where they don't know Dr Martha Burns, where we don't have evangelists, and they have no idea we even exist. That's the challenge.

So I think in the areas where we talk about the kids who need it the most, where they have the impact of poverty, which will be, in some ways, trans-generational, we have a big fight in front of us. We really do. That challenge is one that the data will just make it sound worse than we thought it was.

I think everybody . . . I mean everybody . . . Anybody who didn't think poverty was one of our biggest issues, if not the biggest issue, can see me afterwards. I can't imagine how . . . If it's not number one, it should be in your top three. I think it's been there for a long time, and it's gotten worse.

Dr Martha Burns: Now, one of the advantages all of us have in this room is that we have our own world, and we have control over our own world. So we can offer Fast ForWord to every single child that we think needs it. Sometimes we might be a little bit shy about recommending it to a family. I think sometimes that happens, your fear that, "Well, if I recommend this, maybe they'll think I'm just trying to add on more something else. "

But we have control. We're lucky that way. What I'll tell you is when I present in the public schools, it's really tough because you have an advocate who's fighting, many times, against philosophies and belief systems that are anti-computer, anti-technology, anti-neuroscience, if not anti-science.

Dr Bill Jenkins: Anti-change.

Dr Paula Tallal: Well, I think what we're hearing, at some level, is everyone's individual personality. I'm an extremely optimistic person. I feel so confident because of the management team of Scientific Learning and the dedication of the people who actually run this company at this point. Their ability from the level of the board, to every level within the company.

There is such optimism for the future and such incredible hard work on the part of every single person about how we are going to achieve our ultimate goal, which is to get these innovations to the children that need them.

Such ability, such flexibility within the company to try new things and to just keep on slugging away and working like dogs, frankly. I cannot say enough about what Bob Bowen has done for this company over the years. Oh, my god. He understands and supports and never takes credit. If it goes wrong, he takes credit. If it doesn't, if it goes right, he gives credit. I mean, what a great leader. And Steve Gardener who's running the group in Tucson, Peter Carabi who runs our international network. . . talk about having to fly around the world. . . .

55 countries are using Fast ForWord

We have 55 countries using these products. Is it enough? No, it's not enough. Was it 11 million children? I saw the slide the other day. It's been 20 years. We were way ahead of our time, but I do believe in the future, and I do believe that we have achieved a lot.

The fact that we have so many of you who have been with us the whole time and continue to do your part. I mean this is an enormous family, enormous team effort. You know? It just keeps on keeping on. That's what I think will happen. So I am optimistic. I don't think I'm a Pollyanna. I

understand how difficult it's been. It's been a tremendous personal toll to both me and Mike, and of course Steve and Bill changed their entire career for this. They left the scientific world and joined Scientific Learning to help bring this into the world.

I'm very emotional about this meeting. I am so proud of everything that has happened, every one of you who's been with us. I'm very excited about all the new people. Please, keep bringing in additional new providers. That is our future, is to have more and more providers. So I thank Heather and her team, who have really gone out there getting new providers.

How many did we have this past year? 200-something? Yay. Unbelievable. So the other thing that I think is really important Dr Martha Burns touched on it a little bit in terms of some of the naysayers and some of the earlier studies. I think it's really important to understand that, from the point of view of a scientist . . . from the point of view of what our products do, they are . . . the products themselves are smart.

Constantly learning from the data to improve.....Fast ForWord is very different now to 20 years ago

We're constantly learning from the data and driving the data to make ever-increasingly better and easier-to-use and more efficient products. So what do we call that is something that is "not evergreen". Evergreen means you've got something. You put it in a box. It's a pill or something, and it stays in that configuration. We have the opposite of that.

Fast ForWord of 20 years ago is extremely different than Fast ForWord of today. So that's a wonderful thing. It's better. It's easier to implement. It's faster. It's more efficient for the individual, et cetera.

We have to understand, from the point of view of a scientist, a good scientist, that's about the worst thing you could ever do, because it's a moving target. For scientists, if you change a single variable, you have to start over and do a new study. Our colleagues, unfortunately, don't realise and don't understand that the Fast ForWord that was tested or assessed in I guess 1995, 1998, 2003 . . . is not the Fast ForWord of today.

So if you need to address anyone who's talking about a previous, an old study, a meta analysis whatever, it's not the same product. It's just different. We call it the same because we have a brand name, but the wonderful thing is that our products keep improving because of feedback from you, feedback from the user, and the actual data itself and driving these new versions.

So software is not evergreen, and that's a tremendous advantage of having this kind of intervention. So that's where I am. I'm much more optimistic, and I know that our products are improving. With the team we have that runs this company . . . We have such high evaluations from customer service and from the implementation specialists and from just all of you, back to us. I'm very proud of this company.

Questions from the audience

Dr Martha Burns: I'd like to open it up for questions from the audience now.

Female: I'm one of the . . . I wouldn't say old, but seasoned providers. Experienced. I think that we've had a history of under-promising and over-delivering, in comparison to other companies that offer different products that do the opposite of that. So I think that that's a good way to be, because a

happy customer is going to tell more people and give us more benefit from that than if we just try to say it ourselves.

The other thing I had a question about is, in the early days, we talked a lot about the research on specific language impairment. Then there was a shift to the dyslexia. I'm just wondering if you could speak a little bit to that, explaining that, especially for new people, to potential parents of Fast ForWord kids, how we could better explain that.

Dr Paula Tallal: Okay. Well, I can speak to that because I was very much a part of that entire process. When I started doing my research, there were these silos of individual clinical populations. There was a lot of work even within the scientific community for dividing language-based learning problems into this type and that type or whatever it's called.

Then I started doing longitudinal research. In the longitudinal research, what we found, and I didn't expect to find this - my scientific career has often been one in which I find things I didn't expect to find - the same children who fit certain kinds of criteria when they were five years old, as a language-impaired child, let's say they had receptive and expressive language problems, versus a group of kids who just had expressive language problems or whatever.

If you tested them again when they were six or when they were seven or when they were eight, they'd go into a different category.

Then it looked like it may be that the tests themselves were different at these different ages and more sensitive at certain ages or others, or that as a child developed, they started having difficulties with other kinds of things. The longitudinal studies themselves began to show the children who initially had spoken language or oral language deficits, as they developed, often became the children who would be classified as dyslexic.

So I was one of the first people, maybe the first person, to start calling these children “language-learning impaired” or “language-based-learning problems”, to encompass the breadth of what language learning is about and what it is you're expected to be learning at different ages.

So when you're a two-year-old or a three-year-old, you're learning different aspects of the linguistic system than when you're a five-year-old or a six-year-old. When you get into school, you're needing to use that information to map on top of the language system, the reading system.

Phonological awareness is the core deficit in children with dyslexia

So I think the history within this whole field of speech pathology has changed as well. Initially, these pathologists did not treat children with reading problems. Now you treat them all the time. The understanding that phonological awareness is the key, is the core deficit in children with dyslexia.

When does phonology leave the language system? It's what I often say. It's part of language. I mean phonology. The main test for phonological awareness deficits doesn't involve a letter at all. It's how do you say the word “plate” without the “P“. That's a language skill.

Dr Steve Miller: The other part is . . . Again, you have to remember the timing. So in the early '90s, twin studies of dyslexia didn't assess language. When they did, they found kids with language problems. George Hine at University of Georgia, had a diagnostic group on dyslexia. He wrote a paper and said how shocked he was that the kids didn't do well.

Why? He wasn't a speech pathologist. He wasn't supposed to give those tests. Right? So the definition in states that had a definition for dyslexia changed. It became a language-based learning disability. Before that, it wasn't. Speech pathologists at the time, appropriately, professionally, were offended by that definition. So then . . . I forget what year they put out a consensus position on the role of a speech pathologist with reading.

So in the '90s, they were different, classified as different disorders. By 2000, early 2000s, the definition becomes an overlap. We find, from the genetic studies, the early childhood studies, found three-year-olds who became dyslexic talked funny. Right?

But you didn't want to call it a language impairment. So what you had was a complete nosology. Right? You had the DSM and others started to make changes in how they classified kids. So the kid from 1985, who was called something, today would have a different label.

Dr Paula Tallal: Autism.

Dr Steve Miller: Right. Autism is another one. I'll let Mike comment, but I think part of it was, if you look at the history, the labelling system changed.

Dr Paula Tallal: So our products also, fortunately, were able to change as we began to recognise that it's the same issue with the auditory processing leading to language.

Dr Steve Miller: The kids never change.

The language-literacy continuum

Dr Paula Tallal: The kids didn't change. So it's auditory processing to phonological analysis to phonological awareness, language, into reading. If you look at the history of the development of our products and the product line we have now, it follows this understanding from the research literature of the continuum, the language-literacy continuum.

Dr Steve Miller: Some of the good news is that kids that used to be moderately mentally retarded, a small percentage of them now are called communication disorder. Why? Because we've raised their abilities. In theory, now they're discrepant. Before, they were just low.

So that's part of the autism spectrum disorder kids now. That kind of grew, small percentage, but it's a real one. So I think that the good news is we're changing some of these classifications. The kids aren't different, but we have better identification systems, better cross-functional teams accepting them, and better intervention, helping them. So they now are higher functioning. Now they get a new label.

Dr Mike Merzenich: I wanted to comment about about what Steve just said. When we founded Scientific Learning, we needed help from clinicians. We got about 35 or 36 volunteer clinicians, mostly speech pathologists and audiologists, to help us train and evaluate children.

They agreed to give all children the same standardised assessments and look at those children. It took about a week before they started to tell us, “We want to look at children that have different labels.”

So we said, “Okay. You can do that. But if the label is neurological, try to get a neurologist or a child psychiatrist, somebody to confirm that label.” So ultimately, we collected data from roughly 3000 children that were trained, longitudinally. Those children had about 20 labels, in which we

had enough children to make a statistical argument about whether or not the training was effective and whether the training was different.

Some children, we imagined would respond very strongly, and we'd see very good effects, and other children we thought less so. Well, it turned out that every category, every child, every label put on a child was indistinguishable from one another, except for two. Two labels were discrepant. The other 17 or 18 were all the same. That is to say in all of those cases, all children were language-impaired, and we trained them, and they got better.

The magnitude of the differences was not distinguishable. That's rather amazing. Who was different? Who were discrepant? About half of them got better, much better. About half of them, there was no response. Children that had brain injuries, that was a little bit spottier. Some of those children improved a lot. Some of those children didn't improve.

So one of the things that's happened in the last 65, 70 years, in science and clinical science, is the elaboration of the definition of the child or the adult in front of us. So we've gone through this sort of fanatic progression in trying to identify, characterise individual children, so that they fit in the population. Then we give them the label, and then we pull the treatment out of the bag that fits a label. That's largely bullshit.

To put it another way, nobody really told the brain about that. What we're going to evolve to and one of the things that technology provides us a basis of evolving to is a strategy in which we basically can look at each individual as an individual and say, “What are the weaknesses that apply to this child in front of me? And how can I understand them in relation to their neurology and given my understanding of neurology?

And on that basis, how can I treat them as an individual? “That's where things are going to go”.