Stroke Rehabilitation: Maximizing Recovery in Acute and Chronic Cases

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- [Moderator] Again, today's course is titled: Stroke Rehabilitation and Maximizing Recovery in Acute and Chronic Cases, and it is my pleasure to welcome back to physicaltherapy.com, Mike Studer. Mike is the owner and lead therapist at Northwest Rehabilitation Associates in Salem. He was Salem's first board-certified as a clinical specialist in neurologic physical therapy and has been since 1995. Mike is also the only therapist in the nation to be awarded the Clinician of the Year by two different national academies, the Neurology and Geriatrics Section of the APTA. He has authored over 30 journal articles, six book chapters, and a recognized national and international speaker on topics including aging, stroke, motor learning, motivation and rehabilitation, cognition, balance, dizziness, and Parkinson's disease. So thank you so much, Mike, for returning to physicaltherapy.com and presenting for us tonight and in the next couple days here as well. At this time, I'm gonna turn the microphone over to you.

- [Mike] Great. Calista, thank you so much, and thank you to Kathleen and Josh and everyone at physicaltherapy.com and Continued. This is such a pleasure to work with such a high-quality company and thank you to all the participants in advance out there. I'm very much looking forward to interacting with you and working with you to give you a very high-quality experience tonight that is going to deliver a very focused effort in just the two hours we've got directed at managing clients with acute and chronic stroke and I really wanna impart on you some very applicable tools that you can use right away in the clinic. We're gonna move at a good pace today, but I'll be certain to be watching for your questions, interacting with you during the course. Feel free to type those in at any point, as was mentioned by the moderators, and I will handle any remaining questions at the end. We will have a decent amount of videotape because I find that to be one of the best ways to exemplify a concept and to be able to apply things back in the clinic. If you need to reach me for any reason after the course, we do provide my direct email address at the very end. And so, please don't hesitate to use that as well. Without further ado in order that you can get two great hours of continuing

education, let's move forward here. So the timeline that we are planning for today, we'll begin talking about neuroplasticity and stroke. We're gonna go straight into motor neuroplasticity, which is the most familiar to us. We'll move into something that won't be quite as familiar to many of you, and sensory neuroplasticity directly as related to stroke, and then we're gonna talk about how to improve especially that chronically involved stroke patient, going beyond the resources that are available in the brain. As I mentioned, we'll go into videotape thereafter. Again in order that you are able to receive credits appropriately in the state that you practice in, we need to go over the learning outcomes.

Once we've done that, please understand I'm not a presenter that typically would read slides to you, but this is a mandatory function that we do carry out. So at the end of this course, we would expect: that participants would be able to list at least four critical elements necessary for neuroplasticity in stroke recovery, additionally that you would be able to identify at least three variables that can increase task intensity, one of the most critical factors in clinical practice, and additionally that you would identify at least three critical measurement techniques in stroke rehabilitation to maximize outcome, intensity, and attention, as well as participation.

With that said we will move forward then and we're gonna talk as I mentioned about neuroplasticity. I mean to make this somewhat related to a concept that you might have thought to be a financial idiom if you will and that be to be pushing along in the world of finance, we talk about supply and demand in a capitalistic world. However, in neuroplasticity, I like to phrase things in terms of demand and supply. If you are sufficiently demanding your patient, client, consumer, customer, then they will have the opportunity to supply that change in the form of neuroplasticity in their brain. We now know, you might wanna pay attention to this part too 'cause I know that you need to take a test at the end of this course, that persons greater than five years post stroke can actually make neuroplastic changes in their brain. That's been evidenced through

fMRI data of patients that are more than five years post stroke undergo rehabilitation re-map their brain through that effort and the evidence of those changes are clear in fMRI changes after the intense rehabilitation. That's very shocking and also extremely important, and we actually don't know what the end timeframe really is. So what we do know is that we can't ascribe any limits to the brain and we additionally know that it takes as little as 10 minutes time to make some of the neuroplastic changes that we rely on in the brain that we call learning. Now some of the mechanisms of neuroplasticity, which is where this course has really evolved a lot in the techniques that we use, I started teaching a course similar to this in about 1998. And for physicaltherapy.com, I've taught this very course in different iterations across the course of nearly 10 years now and each time we have evolved the course in terms of the techniques and the interventions, but also our understanding of what happens in neuroplasticity.

So we are very clear that the mechanisms, physically, that happen in the brain include those four in the left-hand column. I'll take them point-by-point to give you an understanding that synaptogenesis is really the genesis or new creation of new synapses or connections. Not to make the word any more difficult than it is, with enough repetitions that have enough intensity and enough demand that forces a new supply, we know that the brain can actually make new physical connections between two neurons or more that formerly had not been connected.

Now that can be to the learner's favor when we have synaptogenesis that creates function, that creates an opportunity that previously wasn't there or really paves the road where there's some road construction due, where due to a stroke, we actually have a road or a bridge that's out and we create synaptogenesis and start to pave that road over again if there's enough repetitions to reinforce the stability of that road or bridge, and it is the repetitions that can help us lay down more pavement and allow more cars to travel through the repair of that road. It's a brand-new pathway if you've

had a stroke. We know that there are some cells and neurons that are actually dead and gone forever, so we don't lay necessarily that road down in the same exact spot. We don't connect the same two points over and again, but if we can restore the function, then we have allowed that individual to be as independent and efficient as possible as they were before. Now dendritic arborization is actually part of the growth that occurs with that. We won't need to spend more time on that. Synaptic efficacy really does take into consideration the improved use of the connections that are viable, and then angiogenesis is really that infrastructure, the blood flow that changes because of the demand and supply and the increased utilization of a specific region of the brain and so we actually get increased vascularization. Now how does this happen, the method? So here we have the physical mechanisms over here, that's the physiology, and then the methods of what we do in rehabilitation to cause that are all occurring over here.

Repetitions used to be probably the strongest thing that we would think of. Back in 2005, 2006, we were all questioning ourselves as to, really, how many repetitions does it actually take to get someone's arm back? We certainly learned in pop culture and in the world of Psychology, Malcolm Gladwell was talking about 10,000 hours and the need for more experience and practice and exposure. What we've come to understand as this has evolved even more is that it does take repetitions, but repetitions by themselves are insufficient.

We need actually some demand and some intensity. We need some error. We need also, if we have constancy of error, there's not going to be any supply because the demand is gonna be overwhelming and the brain doesn't see the possibility or the hope to make a change. So we need occasional success, and to have the greatest amount of attention and intensity, we need salience. We need something that's meaningful for the individual. In order to take advantage of the human spirit of gamification, we better make things measurable. A lot of times where we make

mistakes as therapists is we think we're actually taking measures for the purpose of documentation and reimbursement and marketing and authorization. I would actually tell you that the most important reason we take any measure is to motivate that patient to see that they are making improvements. Observable improvements are helpful as well, but quantification is really hard to beat, and that's where measure comes in. We can additionally use and we'll be talking today about vicarious experiences. If some of you are familiar with the OPTIMAL Motor Learning Theory, you're becoming very familiar with the notion of vicarious experiences, and that is to say the therapist explains their past experiences of success with similar patients and so the patient can improve and expect some improvements based on the life that this therapist has had, the career of this therapist and what I like to call in a cheeky way to create a term, the vi-curiosity.

So that is to say, I can expect greater things because you have experienced those greater things, and then finally we have to go over some overload principles. I have a lot of fun with overload principles in the clinic where we place weights on, we increase speeds of, we change directions, we add secondary and multi-task demands. When we have overload principles applied throughout the methodology of stroke rehabilitation, we know that we have created a learner that expects themselves to be able to function at a higher level in a world that is actually easier than what the clinic demands.

So some of those overload principles we'll cover. Now these are not my principles. You all should probably recognize the Neuroplasticity Principles, we're gonna share 10 of them, originally published by Kleim and Jones in a revised article in 2008, but the original article in a speech language pathology journal in 2006. I'm not going to waste your time going through these point-by-point and reading them to you. You're already aware. Many of you have taken classes of mine in the past and hopefully that's something that you find beneficial, but we'll go over just a couple of them and we put

them in an order that perhaps they are most palatable and important for us. You're all very familiar that if we demand it, the brain will have the opportunity to both improve it, and then also to supply it in the first place, but if we are no longer using that capacity, we're just as likely to prune it or lose it. You know that very well through the language that you have lost that you taught yourself or learned in high school. You've lost some of those capacities. Similarly perhaps you have a musical instrument that you used to play proficiently and now cannot do so quite as well. Doesn't mean there's anything wrong with your brain.

You've just devoted your attention and tissue if you will elsewhere, and so your brain has very functionally decided to rededicate some of that tissue, put it on hold for right now and pruned it away, and if you're not using it, you will in fact lose it. I want you to be mindful that this is one of the greatest reasons why we can make so many gains for a person that's been away from therapy for months and years after chronic stroke in that they have lost some of the function that they don't need to lose. So it's my personal belief, and I've looked through literature on this and found a few supporting pieces of evidence, that when individuals stop rehabilitation after a stroke, one year later they are actually worse than they were when they stopped rehabilitation.

That is to say without that sufficient demand and challenge on a regular basis of the stimulation of rehabilitation they actually begin to slow down their walking, perhaps become a little bit more asymmetrical, pick up some gait deviations, lose their proficient balance reactions, et cetera. It's important that we skip down to number three, talk about salience and specificity. When we're working with someone in a task-specific manner, in a functional context, we have the greatest opportunity to improve that functional context at that time. I'm gonna skip past repetition matters. I think I've already been clear about how important intensity is in my opinion, and we're gonna show that in a thousand or a million words if you will on video, and then we'll go down to number six through 10 where these speak very well for themselves. I think

we're actually learning that some of these neuroplasticity principles need to be reshaped just a little bit because when these were first published, at that time we did not know that it was possible for individuals to improve more than five years post stroke. So time is important for us to rebuild that bridge and the road that has some disrepair in it like we we're talking about, but if the demand is sufficient enough, people can actually improve those roads with motivation, and intensity, and repetition decades later. So how important actually is time was something that was probably most easily represented in individuals having a hemispherectomy early on in life versus later on in life, and those are inarguable. However, what we know now is that, with the appropriate techniques in rehabilitation, especially in the categories that we're talking about today, that stroke patients can continue to improve.

What's required for that? Well if we're putting individuals in a position to thrive, to perform better, to regain independence to protect themselves, we know the brain then has the opportunity when challenged, but given hope, when expecting success, they will very likely then improve. So these are some of those considerations here, and it takes exactly what we talk about in the OPTIMAL Motor Learning Theory, as well as what you are reading here. You've got to be able to connect with your patient, make the tasks meaningful to them and difficult, but you need to give them some success. How much success depends on the person in front of you.

So I'm going to really really emphasize this here tonight to be able to read the individual and the error frequency that is beneficial for one patient and the intensity dosage that's appropriate for one is not the same thing as all, and then finally we talk about relevance. Here we get caught up a little bit too much in rehabilitation with making things so practical and so functional that we think as long as we make it functional, that it must also be relevant, and that's not exactly the case. Keeping something salient doesn't mean that it's task-specific and functional. It means that it's important for this person. Salience is not the same thing as specificity. Salience:

person-specific. Specificity: functionally-specific. So even though we are going to talk about neuroplasticity of motor and sensory control, as well as integrative functions, we need understand, to our benefit and credit, that we still have four more ways to improve a patient beyond just changing the brain. These top three: neuroplasticity, change the brain. These bottom four: changes occurring, A, outside the brain in endurance, muscular and cardiovascular, B, strength, but then also inside the brain, but not directly tied to repairing the road work that's been damaged, psychological and cognitive. We can make improvements in those realms even if the patient does not have improvements in those arenas.

So let's talk about getting to functional. Destination function, that's really what's important for all of us and it may be the road less traveled because oftentimes we think the only way that we can improve someone is by changing them centrally at the brain, but this is really what we can do. These are all available to us, and if we're improving ourselves as therapist, then we are really fully tapping into patient motivation, taking a look at the appropriate person-specific intensity, and then this is going to be really something very tricky for us all to consider, but I actually use measurements as an intervention.

That is to say that when I set a patient up to be tested, I know that I am going to use that score to their advantage to motivate them to be more intense in their clinic-based exercise, as well as their home exercise because there is going to be a measure of accountability that is communicated by me taking the measure and overtly stating, we are going to measure you again with this at some point down the road and I wanna see how much you've improved. That states a reasonable expectation of improvement and causes the patient to be attentive that, A, I'm expecting that they will improve and, B, I'm gonna hold them accountable, and if there's not improvement, it's on one of us. It's either on me because my therapy wasn't good enough, or on them, they didn't try hard enough. So I'm gonna use measurements as an intervention. That'll become even more

clear later on. As I mentioned the dosage of errors is something that I think the most highly skilled therapists used to their advantage, and that is how often and how much can I let this patient struggle before they've gotten to a point that they are frustrated, before they get to a point that they are feeling that they are not going to be able to get this. I need to keep hope, but I need to keep dangling the carrot, and sometimes I need to let them catch the carrot. But if I make the carrot too catch-able, if I make the tasks too menial, if I am pandering to my patient and allowing them or even telling them that every single repetition, good job, good job, nice job, way to go, I can't believe you did that, that becomes really just white noise. It's background noise.

It's not beneficial and it actually causes the patient to feel that when I do give feedback, that it's meaningless. You need to allow errors and you need to allow everybody to struggle at the level that their persona will allow you to let them struggle. So we're gonna talk about these capacities as well in terms of sensory neuroplasticity. I think we'll have that as a destination that is maybe a little bit less traveled to actually try to push changes in the sensation, and we're gonna cover the rest of these too. The other point that I wanna highlight today really are these two: constraint-induced procedural memory training and pressure and distraction training for automaticity.

They are very closely related and I wanna put into your mind the concept right now, that just like constraint-induced movement therapy causes an individual to choose an impaired arm because the intact arm is actually constrained with either a mitten or an arm's-length, I want you to consider that we are going to put patients in a position that they cannot utilize their full attentional resources. We're constraining part of their attention to force them toward greater automaticity, so automaticity, meaning their ability to be able to function at a procedural level, there is a difference here, but nearly at a habit or a skill level so that they're performing like they did before their stroke and they're walking without thinking about it. Too often we try to create patients that are perfect in their walking, and that's important, but we do so at the risk of their attention.

So that is to say, the only way they can walk well is if they have their full concentrated attention on their walking, and doing so creates a patient that is dysfunctionally dependent on that attention that is fleeting in a busy world, gets called away to other things. It can cause the patient to become much more variable in their gait and there is no greater reason that a patient would lose their balance and actually fall in the act of walking than if their walking were to be come variable. Taking an 11-inch step, followed by a 14-inch step, followed by a 9-and-a-half-inch step is most certainly going to happen to a patient that is distracted away from the task of walking and one that can only walk with purely consistent 11-inch steps every stride when they pay attention is no better than the patient that has dense hemiplegia and takes six-and-a-half-inch steps with the left and 12-inch steps with the right. When you can walk the same way without variability, without your attention on it, I will argue that even though you're asymmetrical, you are at lower fall risk.

So a lot to be said there, some exciting things ahead of us and let's take a look at it. So beyond the lesion, over and above training at the central neuroplastic level, there are certainly some ways to improve. I've alluded to a few of them. Let's dive into that a little bit more and let's talk about these that are right here in front of us. So when you look at all of these up here, I want you to take a look at the fact that each one of these can be overtrained and each one of these arenas can never be fully tapped into. Outside of the lesion you can help an individual gain in their capacities toward a contralateral strength, a whole body endurance and expedience and accuracy in terms of balance, a capacity and sensation that even exist beyond the impaired extremities to be that much more accurate and proficient in sense of balance, and then most certainly you can impart, and this is absolutely wholly dependent on the therapist, to be able to impart that this patient has room to improve, potential to improve and we're actualizing their improvement, and that feeds their desire to continue to improve because they see how much they are achieving. So now it's important that we understand the two totally different approaches here, and I shouldn't say approaches,

these two different regions of potential, and that would be capacity and capability. Now exactly what we see here, this is why we swung the pendulum way too far toward task-specific practice, and in my career that's now spanned nearly 30 years, we know that at one point we were so enamored with the Dynamic Systems Theory and so enamored with task-specific practice that we thought we should not do anything at all outside of the context of function, and if we wanted to do strengthening, we must get strengthening done in a functional manner.

I actually do not believe this any longer and recognize that I was one individual across nearly an entire profession that was wholeheartedly wrong and really bemoaning the need for therapeutic exercise. I will tell you now that there are times that we need to be out of the task, in function, working hard to help the patient in a very intense manner just work on resources, and that's what I'm talking about right here, resources such as capacities. The harder it is for this patient to fatigue because I've worked on their muscular endurance or their cardiovascular endurance and the more difficult it is to be able to exceed this patient's power and strength capacities which I can do better in therapeutic exercise but also wanna carryover into function, the more capable this patient is and the more variable and adaptable they are.

Sometimes we just need to get after it and work hard in therex, and I'm talking about working hard. Now there is a translation of capacities into capabilities such that you can't just drag someone on and continue to walk them and walk them and walk them and walk them and expect them to just gain in their capabilities. Sometimes we need to break it down, get them stronger, get them more endurance so they have resources, and then create those resources, convert those resources, those raw materials if you will in the patient that you're working with, and turn those into capabilities. So you can work as hard as you want on the biomechanics of sit to stand. If they don't have enough strength, they're not going to do anything other than to compensate. You can walk as many times as you want and if you haven't work on capacities at the resource

level, the patient's not going to be able to make the type of capability-type changes in walking that you would like to see. So we have to work simultaneously in both. It's okay to work outside the task as long as you're working intensively and you are following the principles of therapeutic exercise that are very well spelled out, but I'll iterate them again for you today. So we have the opportunity to help patients at the level of recovery. Let's restore those connections, and that is in resources and capabilities, and get them back to the point that they look just like function and are as active and as independent and they're making choices about activity for themselves because they've recovered. The contrast is certainly true that some patients are going to need to compensate, but I want you to know that when we get body strength and resources and brain neuroplasticity as well-developed as we can, we're working on recovery. When we're looking at compensation, we feel that we have, sometimes we're wrong, come to the end of the plausible changes for this patient in terms of resources at the level of the body and resources at the level of the brain and so therefore we need to begin to compensate.

When we compensate, we're trying to create a functional capacity in this individual, greater independence, greater walking distance, greater reliability and lower fall risk throughout the day, but we compensate through some of these capacities: so adding an assistive device, a brace, a caregiver, cues coming from another individual, perhaps alternate means of transportation for longer distances. In the case of speech language pathology, maybe word substitution. In the case of ADLs, perhaps we're adaptively using devices or addressing with the use of one upper extremity. These are all compensatory versus recovery. That's important that we're clear on that as we move forward from this point. Compensatory movement, gait deviations, et cetera, those belong in that. Changing to turn your head every time you swallow or to tuck your chin, that's a compensatory movement. Those things are certainly very important and should be clear for you now that I populate those at the bottom of the slide. So if you wanna coax neuroplasticity and you wanna get your patient to make the greatest amount of

changes at the level of the brain, here's where we need to consider. You need to back off your feedback steadily as the individual is improving, and that is the type of feedback. Perhaps that is the verbal cues are coming into play. The manual cues are coming out of play. The frequency of feedback drops down from nothing ever greater than 75%, and then gradually down from there as they improve, and coaxing neuroplasticity asks for more from the learner, and feedback focus. This is extremely important and should be relevant for those of you that are already somewhat familiar with the OPTIMAL Motor Learning Theory, and that is to say that our focus actually needs to be more external, more goal directed, and less body part directed as we advance.

This causes the individual to be goal focused and not so body-part focused. If you wanna get a patient to automaticity and you wanna get them to procedural memory so that they're not dependent on their attention, your feedback should gradually become more external on achieving the goal and less internal, here's what you do with your body. I think I've already been very clear about the interest and practice and specificity on both of those points, but just to catch all of us up to speed, as we progress, these are all intentional in terms of progression of motor learning, we move from a, I'll give you a number of repetitions to work on that, to a random practice where, I'm going to ask you to show it to me, I'm gonna take you away from it, and then bring you back to it again and see if you can regenerate that same movement.

In addition, we look at part practice, only sparingly and only very early, and I would suggest to you we only do this when a task can be broken down because there's no momentum in the movement utilized. So sit to stand, bed mobility, walking can really only be broken down in a part-task practice manner if in fact the individual is moving at such a slow pace that momentum is not used to their benefit. If that's not clear to you, I'm very happy to go over that more, but primarily we use whole practice because momentum is an essential critical variable in the movement and therefore if we try to

break it down into its parts, it's nothing like what it had been. We additionally need to consider, and this is gonna be a novel consideration for a number of you, is that our practice must include variability. It doesn't mean just taking patients outdoors and walking them on uneven surfaces. It means introducing subtypes of challenge across cognition and dual tasking, across introducing pressure to them, moving at different speeds and with different weights and heights and inclines so that the patient does not have an undue expression of tone because it's an unfamiliar environment to them. We'll move forward from there. So also very novel concept for many therapists to consider, and then we'll show you in videotape today sometimes we are actually going to exaggerate and induce errors for patients. We are intentionally going to take their most predictive gait deviations and we're going to exaggerate those very gait deviations so that we can get them to retrain out of them.

Quality of movement is extremely important and the way to get quality movement may not be the way we used to think. We used to think about putting hands on and shaping and showing a patient directly through how to move, and now perhaps it's most successful to have a patient be less focused on what's happening with the body and more capable to be able to perform in different task constraints, in different task demands. So if you're swinging your leg out to the side in circumduction, perhaps I'm going to give you an environment that disallows that all together and that you have to show me that you're capable of walking with your legs in a more narrow base of support. We'll actually be showing some videotape that exemplify that very thing. So sometimes the way to coax neuroplasticity is to get a patient to gamify and to compete against themselves. That's where measurement comes into play, that we're actually going to give them the opportunity to try to beat their own score. Sometimes we're going to get patients that are maybe less than wholly or fully motivated to actually try to work on protecting themselves from a fear standpoint so they don't fall again. Sometimes patients are motivated to actually get better so that they can protect others, and this is actually called Protection Motivation Theory. I'm actually gonna put

that in the chat box for all of you: Protection Motivation Theory. Mari, I do see your question. I'll be certain to answer that a little bit later too, but that Protection Motivation Theory is a consideration for people that don't appear to be quite as well motivated, but they're more likely to actually be willing to get better for the sake of not having to hire caregivers or because their husband or wife can't actually provide the physical assistance that they currently require. So to go home, they wanna get good enough and strong enough that they don't require more than their husband or wife is capable of providing. So rather than being focused on improving myself, I'll improve my lot or my stake for the sake of someone else. So this is a really, really fun slide for us. These are all the motor learning variables that you might wanna consider and exactly why we manipulate them.

So I'll move the arrow up here and just leave it right up there and I'll flash each one of these up on the screen. This is so fun. So the feedback type that we give, be that verbal, visual, demonstration, manual, is very important to be individualized and reducing so as to not create a level of dependence on the therapist. Additionally, we take our feedback frequency, and we reduce it so that we challenge the patient's active participation.

Here's something I'm gonna throw you off with just a little bit sometimes I want your feedback frequency to actually be coming from the patient and not actually from you so that the patient is aware they have to be the ones to give the feedback as soon as this next trial, this next task is done. So they have to monitor and they have to be on the lookout for what they saw in their movement, for how many times they lost their balance, for if they weight shifted to the left or to the right. If you want a patient to be an active participant, then I would suggest to you to say something of the sort of: hey, on this next walk that we're gonna go on, before I say anything when we're done, I want you to tell me how it went. So that would be a very constructive thing to do to force active participation. Feedback focus that we've talked about, it's result and not

process. Less focus on the body. When you focus on the body, you're asking the patient to walk in a manner that they never walked in before their stroke, meaning, concentrate on every single body part. If you want them to re-automatize, get them to focus on the goal, on the total, on the whole, meaning if you're snapping your knee back in as you're walking, I don't wanna call to your attention the body part. I'm gonna tell you, hey, for the next 15 steps in a row, I want you to walk as though you're walking in a very low cave, that you need to reduce your head height. Drop it down a little bit. Additionally, the motor learning variables, task specificity, so that my practice is more likely to carry over to your life. Additionally, practice structure, so creating that variability throughout the entirety of a 45-minute practice structure. Boy and you've heard me already talk about the need for errors and constraint so that patients can deal with, and be stimulated by the presence of errors 'cause that's the only thing that actually pushes demand and supply in that equation.

We know that errors, intensity, and repetition all go together and they are coupled with this constraint of pulling attention away by way of distractions. So now all of these fly in together now. So I'm gonna tell you, we're gonna induce errors through pressure, induce errors through distraction, induce errors through intensity. These are the stimuli for change, for pushing attention, for being able to solidify a motor program, look exactly we've got straight across from here. This is one of my most fun slides to present. Repetition solidify our motor program. They don't create a new program. Intensity creates a new program. Creating pressure causes an individual to be more tolerant of future demands that happen to them in the environment so it reduces their sympathetic interference if they've had exposure to pressure, and yet we move on. So we have our Forced Use Principles and these principles mean that we're going to actually try to force the neuroplastic change in a patient by rearranging what they can use to their advantage. So if your right leg is dominating, then I'm gonna force use out of your left leg by putting your right leg at a disadvantage. I'm in the same manner going to force you to use your procedural memory centers by constraining your

attention. So these principles stand in forced use and we're gonna talk a lot about those today in all of the applications, motor, sensory, and cognitive, and communicative. So we'll have to take a look at the demonstration really of providing patients an opportunity to see how they can improve and we allow them to participate in a task at a higher speed, and then we gauge how well they tolerated that, and then we observe their reaction and response and tolerance so that we can readjust our dosage so that we're not overdoing it with them.

This is one of the greatest uses of high-intensity interval training: to allow a patient to briefly see what they're capable of and to see how they react to that treatment intensity and that error tolerance of how much can I allow my leg to swing out to the side, or do I feel like my ankle's going to turnover in supination, or if I've lost my balance slightly to the left or posterior. How much does that shock each individual and how much can they really tolerate then, and do I need to step in earlier or do I need to continue to allow them to thrive and struggle a little bit? Additionally sensory neuroplasticity requires these really five capacities.

We wanna remove the sensory strengths, meaning sometimes we need to pull the eyes out of the equation, pull that intact left arm out of the equation to help out and force the remapping of an extremity that has been offline for either an acute stroke or for chronicity as well. I'm gonna show you some videotapes on exactly how to do that too. That's one of our first videotapes that actually come up. And, you know me, I really wanna keep it intense, and so we want to be certain that we're tapping into every single possible human attribute that causes someone to be more attentive, and that is keep it interesting, occasionally tell them there's a test coming up to remeasure, to increase the amount of errors, to ask the patient to predict, how well do you think you're gonna do with this? That causes a patient to pay more attention, and then also sometimes ask a patient to estimate how many errors there'll have with this upcoming segment. You want a patient to pay more attention? Use one of these five principles to

your advantage. Now I wanna elaborate on this concept of error dosage and I wanna make it extremely clear for you. So there's four different categories of error dosage that I wanna share with you here. These are the four categories. I can increase the physical demand if we're only talking about gait rehabilitation here, I can increase the physical demand of the error and I can cause more errors, or more frequent errors, or a magnitude of errors can increase by changing the physical demand. Now I could do any one of these things. This is not a comprehensive list. Keep in mind I can change the physical demand by increasing the incline of the treadmill, or a very steep decline. Any one of those would be a physical way to change the demand in gait. Uneven surface isn't even listed up here, and that's another way to change physical demand. Complexity is totally different from physical demand, and these are just five examples of how to change the complexity in gait rehabilitation, and that's all listed here. None of these are dual task.

That's just complexity. Dual task is listed here. Remember, not a comprehensive list, but I can actually draw someone's attention away by dual tasking or distracting them in gait rehabilitation. That's another way to increase the frequency of error dosage, and then finally, but not listed in order, I could utilize pressure to my advantage. This is gonna be a novel consideration for some of you until you realize that if I have never trained my patient to tolerate pressure, then how are they gonna be able to tolerate pressure out in the real world? So when they need to hurry to get to the door, to the restroom, to the phone, how are they going to handle that sympathetic nervous system response if they haven't already managed that here with me in the clinic? So as I alluded to, we're gonna briefly go through optimizing performance through intrinsic motivation, attention and learning, not my theory, but certainly a great theory that I espouse mightily, and that is from my friends and colleagues, Rebecca Lewthwaite and Gabriele Wulf, again, the acronym here, OPTIMAL standing for those attributes, a motor learning theory that actually asks us to not throw out everything else we've learned about Motor Learning Theory in terms of feedback, and repetitions, and

practice, and specificity, but actually asks us to fold in the concept of the psychological resources and the psychological perspectives of human nature. That is to say, we have to encourage our patients to work hard and to see success so they have this first aspect, this first rail of the OPTIMAL Motor Learning Theory completed that they have enhanced expectancies. I just phrased it up here as enhanced expectations to make it clear. So the expectation that I will be able to achieve something even if I can't achieve at every single repetition is this first rail of the OPTIMAL Motor Learning Theory. Because I've had some success in practice but not every single time, I expect maybe this time, maybe the next time, the next repetition I will be successful with this.

Knowing that causes the individual to be primed, and I literally mean motor priming. It causes them to be in a dopaminergic state, that they can expect that there will be some success. That gives them the expectation of all of these six attributes: I see myself improving. I am being challenged, and sometimes I actually achieve it. I have success with surprise, and to me that is absolutely the critical chemistry that's required to force a patient to release dopamine and to force them into neuroplasticity. It is success with surprise, and so that's what you see being exemplified in all six of these.

Sometimes here in the PDPM in group therapy, you can actually use enhanced expectations patients by seeing others around you that have improved, that have been here in this rehabilitation center longer and that perhaps started where I am now and are already looking better than I do now. Perhaps I have hope. Second rail of the OPTIMAL Motor Learning Theory, which I encourage you to look up, is autonomous control. This gives the patient the expectation that they can have some lowered cortisol and some increased dopamine because they get a chance to make some choices in the treatment session, some choices in when you step in to help them. That is the autonomous support of an expert that's next to them that's not helping them constantly, but never lets them struggle to a point of embarrassment or failure, and to

know that they have the capacity to be a teammate and a role player in their outcomes. Their participation with intensity gives them the sense of autonomy. If you don't work hard enough, you won't improve as much, and to have self-efficacy is the bottom line of that, to know that my contribution matters. Additionally we look at the third rail of the OPTIMAL Motor Learning Theory being external feedback, which I've already alluded to quite a bit, and that is to say that our feedback needs to be directed at the level of the goal and we create tasks to be able to reduce inefficiencies: to reduce gait deviations, to reduce compensatory movements in sit to stand, et cetera, and we don't direct our cues around the body parts because that would actually cause the patient to be dysfunctionally connected to and dependent on their attention on those body parts in movements, and I believe these five statements are here for you.

They stand very well and I want you to be able to look back at those and review. Remember, this is two hours worth of intense information. It is intended that you would be able to look back at these slides later to your benefit. So we take a look at untapped resources in terms of capacity and we look outside the nervous system, and this is really, let's start with these very straightforward and let's ask ourselves the tough question: are you being intense enough in the areas of muscular strength and endurance, intense enough in psychological and cognitive? So we created dosage for patients to actually get better.

Our dosage in terms of neuroplasticity at the level of the brain is not perfect, but we're certainly getting there. So the term intensity is important to understand. I'm not gonna read these over to you again here. I think this is a beautiful definition of intensity here and the use of repetitions with intensity here. Again I won't insult you by reading these to you. Now intensity itself, very clearly studied by Dromerick in 2006 and repeated by many others since then to physically show that intensity actually has a difference in terms of outcome. So I have to ask you now: are you being intense enough with your patients when you intervene? You've got several different possibilities here, but I will

tell you by sitting a patient down in a new step or a fit stepper and having them pedal away for five minutes and when you've increased the resistance on that does not mean you're gaining muscular strength. These are the American College of Sports Medicine Guidelines for muscular strength dosage, and these are, notwithstanding the type of diagnosis, or age or gender that you're working with. Intensity in this area is under dosed too often. I tell you that patients need to be told ahead of time, expect some soreness and we're going work hard for something that you probably can't do a 13th or a 15th repetition, but expect soreness. If you do not do them the favor of telling them ahead of time to expect some soreness, they may never come back to you, thinking that you don't know what you're doing, thinking that you don't know how to dose, you don't know how to work with someone of this age or condition. So please, the rest of this is straightforward in front of you, but don't lose those salient points.

Muscular endurance is totally different. Sometimes when we think we're actually improving muscular strength, all we're really doing is improving muscular endurance, and these are the parameters that I follow the ACM Guidelines for that. In addition, we look at cardiovascular endurance, and I'm not going to go point-by-point through these. I'll highlight the fact that we believe that some patients that cannot tolerate 30 can just about as equally improve and benefit from a dosage of 10 minutes three times per , or, sorry, three times per day. Now we wanna take a look at certainly beyond neuroplasticity, reversing the secondary changes. So when we're talking specifically about chronic stroke, remember we have some learned nonuse and we have some dis-use atrophy that happens on a learned nonuse basis in these two and on a dis-use basis here, and then we see patients that are becoming more adaptively shortened because they're not using the full range of motion and they're becoming deconditioned and reduced in their capacity to make rapid and accurate balance changes and strategies and reactions because they're down-trained toward it. They are not regularly stimulating their balance for expedient responses and therefore they've lost those proficient senses. Regular stimulation helps here, and here. Regular conditioning helps

here, here, and here. So what does this look like now? This should be pretty familiar to you. You're ready to put your labels here of capacity at the level of impairment. This is your muscular strength, and endurance, and balance reactions, and capability. This is: I can walk, I can get myself up, I can get myself out of bed. Both of these feed into participation. My choice to actually go to my grandson's birthday party or try to meet with my friends to play bridge, or to go on a vacation a few states away to see my granddaughter, that level of participation is going be affected equally by my capacities and endurance and strength which feed into my capabilities and capacities to walk or the capabilities to walk.

So we must intervene at the level of motor neuroplasticity, and we certainly have a question that we will be addressing about that. You guys have some great questions coming up here, and I will be fielding those as well, but are our interventions restorative or compensatory at the level of the CNS? When we are actually working with someone to improve their capacities in motor neuroplasticity, we wanna be restorative so that they replace the same function, the same control of that tibialis anterior or hip flexor and the pattern of walking and the ability to walk without thinking about it. Those are restorative features.

Motor control neuroplasticity really is summarized now as these things. It does not require me to read those, but now you've heard me several times talk about allowing your patient to see progress through a measurement because measurement is an intervention and so we're going to utilize those to our advantage. Constrained is misspelled right there. That bothers me. Okay, let's move. Lower extremity interventions, now specific interventions to actually allow you to say, what do I do in the clinic right now to be more intense? And this is it, right here. Lower extremity interventions include mass practice. We're gonna get you in body weight supported treadmill or take you on level ground or I'm gonna visit your home and we're going to actually do laps right now of mass practice, and that's completely fine to do, mass

practice. That's one of the things we can do to get the lower extremity going. Additionally we can do what's known as the Systematic Inpatient Rehabilitation Reinforcement of Walking Study. This means, on a regular basis, I'm actually going to take you out of therapy for a moment, not physically out of therapy, but just out of something that appears to be a therapeutic exercise, and I just gonna take you out and just measure you. That can be in walking speed, which is exactly what this study did for us out of UCLA with authors Bruce Dobkin et al. They took these patients out of inpatient rehabilitation and they took a select group, the actual research group, and they tested their walking speed once a day every day. When you compare that against people that did not get the measure of walking speed once a day every day, and that's the only difference the two groups had, when patients saw that they were being tested on a regular basis, their outcome was higher at discharge and higher six months later just because they were measured on a regular basis. Now would that affect a change and how did that actually get them better?

Did they get better by the physical act of testing or just the notion that, I'm gonna be tested again tomorrow, I wanna see what I can do to participate harder in therapy today so that when I'm tested tomorrow, my score of walking speed is actually more sophisticated, more improved, and that's probably what's happening. We additionally, for lower extremity interventions, can use higher intensity training through body weight supported, more repetitions, less fear, less tone through the advent of the support. Again you can use high intensity interval training, both in body weight support or land. That's another great intervention. The others I wanna walk you through just a little bit more in terms of forced use of the impaired lower extremity may mean that I'm going to actually put the less impaired leg on an unstable surface. Put the less impaired leg at a biomechanical disadvantage. Force use out of the impaired leg through higher speeds or inclines, or actually put a weight on the impaired leg, or maybe lift up an assistive device for a couple of steps in a row, or actually put patients through what we call task-specific circuit training. I didn't create that term. You can look that up for

yourselves, but we apply it a great deal. We're gonna move really hard. For the next 90 seconds, I'm gonna have you do sit to stand, and for then the next 90 seconds, I'm gonna have you do bed mobility, and for the next 90 seconds we're gonna try to go climb the stairs, and for the next 90 seconds, I want you to try to close your eyes and work on keeping your balance as you move and reach these objects. Doing task-specific circuit training is stimulating because it uses the principles of random practice. It uses the principles of motor learning and attention and regenerating a new task again and again, but also uses the principles of therapeutic exercise, of high intensity exercise and specificity.

So in neurologic rehabilitation, we know, and I stated this earlier, we can't put limits on any patient's ability to improve at anytime, we must hold ourselves accountable and hold patients accountable by using measurement, and we must be intense and consistent with our repetitions and not waste them. Now I wanna talk to you about sensory rehabilitation 'cause I told you we would get there. Can patients actually improve their capacity to be able to have more sensory control in a extremity and are the mechanisms between sensory recovery and motor recovery the same thing? As a matter fact, when we go through synaptogenesis, and dendritic arborization, and collateral sprouting, and angiogenesis, the mechanism for sensory and motor are exactly the same.

Now many patients actually lose their capacities and sensation because they don't have enough motor to make that extremity meaningful. So that is clearly to say that you begin to lose sensation in an arm that doesn't have enough motor function so you don't use it frequently enough so you get into sensory learned nonuse. There's no timeline that's going to keep a patient from improving. I have a patient that I'm working with right now who's more than four years post stroke who is telling me, "Week after week, "I'm getting more sensation back. "I can actually feel it happening "in my arm and in my leg," and I'm gonna show you a videotape of some of the things that we do

with those patients. Now, I already showed you this slide in a different fashion. If we wanna create sensory neuroplasticity, we have to demand that sensation is important in that extremity, and I wanna show you one way we do that. We can do that by taking vision away, we can do it by giving visual conflict by putting the head in motion. We certainly do that with brain stem stroke, we do that in cerebellar stroke, but when we're working on extremity-based function, we can do that in many other ways. Now just keep in mind that a patient can become visually dependent on a sensation, and that can be one form of it. They can additionally become very dependent on all of their sensation coming from the left side of their body, that they need to have left-hand contact full time. But what we're gonna do now as I show you this is we're gonna systematically remove the strongest sensory modality, and I'm gonna actually show you this video right here now. So, let's see. Why don't we go ahead and pull that video up and I'm gonna give you a good chance for the next 39 seconds to watch this video. The right upper extremity is impaired.

- [Mike] Lower right, and stop, okay. Let's see what kinda percentage you got it down. 9.7%, all right. I told you we were shooting for 10%, didn't I?

- [Patient] Yeah.

- [Mike] Oh, I have to tell you, I love that video so much. Let's go ahead and go back to your slides. What we're seeing there is a patient who is only getting his right hand as the sensory control that he gets an opportunity to utilize in an effort to try to get his balance projected right where he wants to. His eyes are closed. His feet are on a cushion. His left hand is off, and that's the intact upper extremity, and he gets to use his right hand to try to direct his balance and being able to utilize the right upper extremity as the dominant extremity causes him to get that opportunity to put his right arm back on the map. There's so many different ways that we do what's called the Opportunistic Use Therapy. That's one just quick opportunity that I wanted to show

you right there. We can do that will a sit to stand with eyes closed. We can do that where patients are just statically trying to keep themselves steady and trying to reach out for something with the intact upper extremity with their eyes closed, again on cushioned surface, but we want the survivability, not literally, but figuratively your survivability depends on getting information from the intact upper extremity and being able use that to sense where your body position is at this point. That's just one way. We call it Opportunistic Use Therapy. We move on from there. I wanna certainly understand that you when we work with patients, some of what we do, especially in stroke rehabilitation, is understanding the science of neuroplasticity, and understanding kinesiology, and understanding what this person needs from a diagnosis standpoint, but additionally you have to be a psychologist. You have to be a counselor. You have to be someone that can read individuals and know what this person's personality can tolerate right now, and then, additionally, you have to be a motivational coach. You have to know how to use measures, how to use tests, how to use the direction of feedback coming from the patient and incentives through vicarious experiences and accountability that you can impart your role with them as a team member, as a salesperson as well. I'll tell you, to me, a successful clinician takes all three of those things than two. We're gonna move on. Hopefully you are really feeling the energy of what we've got. We've got so much still left to cover in terms of what can be done for the stroke patient, but I wanna let you know we're right on time here and I will be getting to your questions as well. I really appreciate the amount of questions we're getting and your patience for those, additionally. So the psychological principles only some of which that we've covered so far is that we have to use psychology as a tool in terms of not only measurement, but as I've alluded to, group therapy. Let higher-level patients work with lower-level patients and used to your advantage the notion outside of other principles outside of rehabilitation, such as behavioral economics. Patients have loss aversion, just like you do when you're investing in the stock market. They want to try to avoid a loss of balance, a risk at any cost, and we want to try to steadily give them the notion that they can be more successful and take some risks and not

feel like they are going to be literally paying for it. We give them this consideration of confirmation bias so that when they see other patients around them getting better, they realize that everybody is getting better, that there is some confirmation bias and that they actually see their right arm moving better and that this is a wonderful environment for them to continue to improve in, and then we utilize the notion of nudge that an individual can, when they try a little bit harder, can notice they're actually changing at the level of the brain. I think it's a crime for us not to tell our patients that we're not working on their, quote, arm, or on their leg, most of the time, but we're actually trying to repair them at the same level that they feel has been intimately torn away from them. We're changing them at the level of their brain, and that's an important thing to do. Now I've already actually gone through these.

This is what I was talking to you about earlier, Protection Motivation Theory. I was led to understand and I had forgotten, thank you, Kathleen, helping me with moderation here, that when I typed in your comment box, you weren't able to see that, but unfortunately I've got Protection Motivation Theory sitting right there for you to take a look at and look up, especially when you have a patient who has less than full motivation. I want you to study up on that. I relayed exactly how that goes earlier, but there it is written out for you.

We talked about self efficacy and obviously two of the principles of the OPTIMAL Motor Learning Theory earlier about giving patients the opportunity to have a reduced cortisol and enhanced dopamine experience by getting some autonomy, some choice, and allowing them to have some mastery in their ability to actually be their own physical therapist, and these three terms actually come directly from behavioral economics: autonomy, purpose, mastery. Those are the reasons why we go into professions so that we can have some independence and so that we can have enough financial wherewithal so we can contribute and have a purpose, or so we can do something because it's motivating to us because we can master it. These are

principles that we can utilize in stroke rehabilitation as well. So let's do a triple play right now and let's watch in what happens right here. With this patient who was taking his very first steps in over two years post stroke without using an assistive device, I gave him the opportunity to decide when he could lift the cane up and take another step or when he needed to put the cane down. What does that exemplify? That's autonomy. You get to make the choice of when you wanna put the cane back down, then I gave him the opportunity to try to count or have me count how many steps he was actually taking without the cane down. That's enhanced expectancies. He's counting the number of steps and he's actually watching himself improve trial after trial and he's expecting the next time he's gonna beat his own scores. That's enhanced expectancies, and then additionally that forces him to weight shift more symmetrically and less asymmetrically over to a cane, and what does that mean? That's external focus. I'm not talking to him about his body and his weight shift.

I'm just saying, hey, let's see if we can lift the cane off the ground. Let's work on the goal and the task and let's not work on the body. So that's a triple play right there. That's enhanced expectancies, external focus and autonomous support. Hopefully that makes it that much more clear for you too. That's psychological intervention, giving the patients that active role to be right there and to use measurements of how many steps that they took. Measurements doesn't have to be what you can document and what you can justify your care on. Measurements can be, just like I was talking about: How many steps can you take without putting your cane down? How many steps can you take without me having to help you? How much time does it take you to get out of bed on the right side? What's the total time it took you to go from supine to standing up to walking to this point? You can use measurements that are outside of our normal standardized measures to motivate a patient and to let them see their improvements. So this is exactly what we're talking about, using measurements as the psychological principles. So what's in it for me? What's actually in it here when we talk about a patient that is looking for some reason to work harder? And sometimes that reason to

work harder is exactly what we talked about earlier, to answer that question, it's Protection Motivation Theory. It is the reason why you wanna get better so that you can go home, so that you don't have to hire 24-hour caregivers, so that you can have some independence and some autonomy and so that you can get yourself from your bed to your wheelchair, so that your wife's back doesn't hurt because she's helping you more than she physically can. It's external motivations that can sometimes be the difference maker, the nudge, using behavioral economics, that can make the difference between where a patient is and where they can get to. I think that's the remainder of what we can say about that for now, but this slide right here gives you an opportunity to summarize all of those things.

Why do I wanna work on swallowing? So you don't go back to the hospital and have pneumonia. Why do I wanna work on dressing? So that you don't have to lose your privacy and you can keep your modesty to yourself and undress yourself, and this is a great way to summarize that with all of those PMTs that are very stroke-specific now. In addition I want you to look at making changes in that final realm. So we've done motor, sensory, neuroplasticity, muscular strength, muscular endurance, psychological changes and really engaging the patient that much more, and then we've also said, hey, we can also improve patients on a cognitive level.

That's true for PTOT speech as a team working simultaneously together or just working collaboratively together. Is it billable to let them work on this, to let everybody work on this? Absolutely because your context-specific treatment still lives then too. So if you wanna push for more attention of the brain and more capacity for the patient to be able to thrive in a distracting environment and to be present in treatment, sometimes what you wanna do is load them up with some distractions that cause them to be that much more capable and vigilant to perform and see if they can still perform when you load on a distraction. But I wanna warn you: when you do this, you must give the patient the notion that you expect their function to go down when you load them up with

distractions. So when you give the patient that bar that's been lowered because you're gonna load them up with distractions, they don't feel suppressed, depressed, or regressed when they actually perform at a lower capacity after you distracted them. So I'm gonna do a two-minute walk test at some point and they score 221 feet, but now I'm gonna try to do it while they are also trying to engage in a secondary task of maybe pulling a Kleenex out of their pocket, wiping off their glasses, pulling a few different items out of their purse as they do the walk. I say, I expect your distance covered when we're distracting you to go significantly down, but this is very functional for you as you walk down the sidewalk to get to the store, you might be pulling your cellphone out, you might need to be pulling your wallet out, pulling a Kleenex out, and I want you to be able to do those things with your walking not sacrificing and I tell you I think your walking score is gonna go down in this extrapolation of the two-minute walk test.

When I lower the bar, and then that outcome is present and fulfills my expectations, they're not depressed saying, "Shoot, last time I did a two-minute walk test, "I was able to cover 221 feet. "I only got 171 feet this time." If you don't tell them ahead of time that a distraction should cause them to regress in function, then they will, as human nature, most likely actually take this as a demerit, but in fact if you tell 'em that you expect it to go down and it goes down, no one psychology is lost. No one's psyche is hurt, but sometimes they can actually rise above and actually do better and therefore they feel elated and dopaminergic if you will, because they actually performed better under duress. So we challenge attention when patients are ready for it and we challenge attention through dual tasking and through doing interesting tasks and announcing a test and causing challenge not only through dual task, but sometimes by challenging them with error enhancement, with a weight on, or a higher speed, or a change in direction, or we challenge attention by asking them to be the reporter and to tell me, at the end of this, how well did that go for you? I already alluded to that once, and then finally as I mentioned to you but I cannot say too often, sometimes we challenge attention, patients to be more engaged, by telling them, I want you to try to

predict how well you're going to do. They estimate the amount of time it's going to take them. They estimate the number of losses of balance they're going to have when they attempt a certain activity. Having them predict ahead of time is going to cause them to be more engaged and active to see the outcome. You must have attention, otherwise your repetitions are nearly meaningless. You cannot have intensity without attention. That's essentially what we're looking at here is we wanna keep it interesting to facilitate attention, not just keep it functional, but to keep it meaningful for this person. What do you think this word is here? Nothing captures a person's attention like the word test. You lived it in your academic life and your patients also live that. Now we don't use every single one of these strategies to boost attention for every patient because some patients are going to regress when they feel that they're gonna be tested and they're going to feel stressed. I'm giving you an entire arsenal of things that you can use to maximize your patient's attention.

I do not expect you to use every strategy for every person. I've looked through some of the questions already and hopefully that is gonna answer some of your questions, additionally, but I will be certain to address those as well. So sometimes we try to maximize attention through challenging. See if you can score better than you did last time is one way to do that, trying to get them to set a personal best to compete against another individual in group therapy in a competitive, but certainly amicable way, and then remember patient predictions? I wanted to give you three different example sentences that you can use to facilitate patient attention through predictions. These are just three of thousands that you could give, but imagine how engaging that is for your patient to follow through a task when they predicted what the outcome would be. Remember this is human nature. If you say, I bet it's gonna rain tomorrow, I bet he's going to be late, I bet she's the one that gets the promotion, I bet the Cowboys are going to win, anything you predict, whether you lay money on it or not, I'm not encouraging you to gamble here with your patients, I'm just telling you, if you encourage them to predict, they will pay attention. They will try to find out if their

prediction comes to fruition or not. Now additionally we can take patient predictions to another level and we can ask them not only, how do you think you're going to do, but we can also challenge them right afterwards to say: Okay, here's what you learned about yourself. What are you going do differently next time as a function of what you just learned? So error estimation, this is what we ask our patients to do. There are three different outcomes in error estimation. We ask our patients to estimate perhaps how many times they're going to lose their balance between here and the dining room, and they estimate six times. One of these three things can happen and all three are beneficial: The patient underestimates, they say six times, but they lose their balance eight times. You wanna build patient awareness.

If a patient doesn't think they're losing their balance and they estimate zero times, that's a great thing for you to know that they have no awareness of how many times they're losing their balance. They say zero, they lose their balance six times, rather than you arguing with them, or convincing them, or rationalizing with them, you actually let their prediction of zero times shine against their reality of six times, and maybe they only recognize or admit to four of them, it doesn't matter. You don't have to try to use your verbiage and your mental power to try to convince them about awareness. Their prediction is very clear against their actual outcome.

You allow them to gain awareness and you've only done that, only done that because you asked them to predict in the first place. So the patient can underestimate. I should say, in that situation, they would overestimate their abilities. That would be overestimating. "I think I'm gonna lose my balance zero times," but you lost your balance six times, and in that situation, this is what happens: patient gains insight, patient gains awareness, patient works harder to make certain that their estimation of zero is closer to reality next time and the patient gains the awareness that potentially is going to keep them from their next fall. One outcome is that the patient underestimates their abilities. They say they're gonna lose their balance 10 times, but they only lose

their balance six, and your depressed patient, your suppressed patient, your patient with pessimism, your patient with lack of motivation, your patient that doesn't think that they are actually improving, do any of you out there, the 340 of you that are on this webinar right now, do any of you out there actually have any patients that are described as such? You certainly do. Rather than trying to cheer them on and support them and prop them up and wave some pom-poms for them or yell at them, your motivational technique should be asking them to estimate their errors so when they underestimate their abilities and think they're going to lose their balance 10 times but they only lose their balance six, let that prediction speak for itself. Let that patient see what their capabilities are compared to what they stated their capacities would be, and the third outcome is certainly clear and accurate for all of us, that the patient's awareness is perfect. They know exactly what their capabilities are and they stated and predicted it with a degree of accuracy.

So our goals for patients to rehabilitate their attention by actually challenging them as we move now into the realms of dual tasking, we set some goals for them. We want patients to have greater awareness of a dual-task conflict. We additionally want patients to handle more complex and distracting environments through habituation. Now I teach entire eight-hour classes and just did in Virginia two days ago an eight-hour class just on dual tasking, so I'm not gonna be able to go through this in entirety for you, but you guys are getting a great example of what happens here. Distraction training is habituation training. When patients are exposed on a regular basis to distractions at a therapeutic level that's not overwhelming, their tolerance of distractions improves because of repeated exposure and their tolerance of distractions also improves as they gain skill and rigor and habit of the primary task and their ability to function in a distracting environment improves because they change their prioritization. They know where to shift their attention and what to not be distracted away by. It helps them so much. So we have to allow patients on also a cognitive level to struggle a little bit in accordance with whatever level their personality will allow. So

we have to allow them to make an error, give an indirect cue, make another error. Try to actually solve a strategy of where my break is, where do I put my hands on the assistive device, which arm do I put through the shirt first? We allow patients to struggle just within the context that their personality will tolerate in order that they solve the problem, but we always give them that level of autonomy to know the expert is right next to you, ready to help you whenever you need it, and that's what the Systematic Cueing Strategy certainly has us understand.

This is the picture of the Systematic Cueing Strategy. Any problem that a patient has sits right up here: lost my balance, can't find my break, which foot to go up the step with first, how to steer the wheelchair, how to negotiate the assistive device, let a problem occur. If it's a severe problem and you need to give them a direct cue right away, you do it to keep them safe. If it's not, you allow them to make an error, then you allow them to try to solve the problem, and maybe it didn't solve the problem and they have to come back and recognize that it didn't, and then maybe you give them an indirect cue and let them see if they can solve the problem from the indirect cue, and then maybe they generate and correct and select the correct solution and they solve the problem, but maybe they need another indirect cue that they've lost their balance, or that they can't find the break. Now where's that other break? Maybe, I don't know, is it on the left side?

And they try to find it, and now they found it. Rarely do you ever go straight down here and solve the problem for them. Now in this introduction of group therapy in the skilled nursing facility, which we've been using in inpatient rehabilitation, obviously for years as well, sometimes the entire group benefits from watching one individual struggle a little bit, discuss the alternatives, and then another patient in that group doesn't make the same error because they just watched one of their cohorts go through it. So let's take a look at the Systematic Cueing Strategy by videotape. So now to set this up, we're actually gonna watch a patient for the next nearly three minutes go through the

Systematic Cueing Strategy. This is gonna be a painful experience for you to watch this patient and I'll come back on to actually talk you through it when we're done here.

- Oh, boy. I think I had the right idea.

- You did have the right idea.

- Yeah. I just don't have enough strength yet I think in my legs.

- Okay so you need some more help from your arms, don't you?

- Yeah.

- Is this technique up here with your hands up on the walker working for you? Is that allowing you to get some help from your arms?

- Probably not.

- Show me another technique then. What else might work?

- Probably I'll look ahead like this.

- Give that a shot.

- Is that okay to try this?

- It's absolutely okay to try it.

- Oh, it's difficult.

- Okay, what else could you do? If your hands didn't work here--

- Well, wait a minute, wait a minute.

- You're gonna try that?

- Would that be okay to try that?

- That's okay to try that also. Looks like you're getting closer.

- Getting closer now.

- Okay so one hand down and one hand up almost worked for you.

- Yeah.

- What else could you do?

- Well I could scoot my bottom closer to the--

- Let's give that a shot.

- Yeah, that's hard to do in this chair. It's such a soft, soft chair.

- Looks like you're doing it.

- Yes, I know, but I have to fight it to get it... See how you sink into it?

- Mm-hmm.

- Now with your permission, would it be all right to try, wait a minute.

- So far you've tried two hands here.

- Yeah.

- Two hands way back here.

- Yeah.

- And one hand back there.

- Okay. Can I try this?

- Absolutely.

- Oh, I just about got it.

- Almost. So with one hand down, you're almost there. What else could you do to get more help from your arms?

- Well, two down on the--

- Let's try two down.

- But I'm getting tired now.

- I understand that, I understand that, and I appreciate your effort. So you've scooted out to the edge and you've tried to put two hands down and you said you're getting tired. I'll try to help you a little bit. Okay.

- Well.

- So two hands on the arm rest.

- Okay.

- You're gonna lean forward and push up. You might make it this time. There you go.

- Yeah.

- Barely any help from me at all.

- Really?

- Yup, I'm gonna let go. You're all set.

- [Patient] Okay.

- Okay, well, it is actually okay to lie to your patients a little bit. I did give him more than just a little bit of assistance there, but hopefully you got a chance to be able to see this patient not being given direct cues, not to being told exactly where to put his hands right away. He got indirect cues and we actually let him go back and struggle a few different times, always short of agitation, giving him the opportunity to be able to solve the problem on his own, and his likelihood of solving that problem for himself the next time he approached sit to stand would be much more successful since he was given

the opportunity to solve it for himself, patience in the cognitive realm, sometimes minimal assistance in cognition, rather than always providing maximal assistance. So learning after stroke requires the ability to certainly capture attention, but all of these considerations, and now we've been through every single one of these today. I hope that they are very straightforward and meaningful for you in the last 25 minutes of our efforts as we began to look at what it really takes to actually force a patient to get better. I truly mean forced because sometimes, what was exemplified right there, is to say less and actually mean more. Ask for patient feedback. Ask for them to suggest what they think is going to be the best thing. Use motivational interviewing as a part of your intervention and introduce dual tasking when patients are ready for that in terms of their awareness.

So the way to dual task to force a patient to actually get better is to sometimes actually measure to see if they need dual tasking and we compare their performance in a two-minute walk test, in a Berg Balance Scale, in a Four Square Step Test, and in many different considerations with and without a distraction to see how they do, and then we subtract the two differences to create what's called a functional attentional cost or a dual task cost, and then we wanna document their ability to be able to perform in one context, single pass, no distraction, document their ability to be able to perform in a second context, with distraction, dual task, and we wanna shrink the differences between the two of those as we continue to progress them too. If we don't demand their abilities to perform a dual tasking, they're not going to be able to thrive in that outside of rehabilitation, demand and supply. So we need to allow our patients to have some error, not to the point of injuring themselves, psychologically or physically, so we estimate, very, very heavy air quotes estimate, about a 70% success rate, but we allow patients that have more or less competitive spirit to have less error rate when they can't tolerate it, and a greater rate if they need increased demand. So it's very important that we strategize things personally. When we do dual task training for individuals, we do dual task training certainly in many different contexts. I think this is

really a chart I want you to be able to go back to and look at combining mobility with a manual task or perhaps with a cognitive task and we'll talk more about those things. I'm even gonna show you a few more videotapes along the way 'cause we're gonna do one right now that looks at dual-task walking with a patient. This is just a one-minute long video for you to take a look at right here and have with this one as well.

- [Patient] Do what?

- [Mike] Do it again.

- [Patient] Can't get to walk--

- [Mike] Keep your walking.

- [Patient] I'm trying.

- [Woman] Grab a cup.

- [Man] that way.

- [Patient] How am I doing?

- [Mike] You can do it. Take another drink

- [Patient] All right. Good way to recover. Normally you're not gonna have a handrail to right yourself if you get distracted when you're out there walking. So try it again without losing your balance.

- [Patient] Was that ?

- [Mike] Don't lose your balance this time. Focus on the walking. Be very deliberate about the left leg. Okay, take a drink and don't lose your balance. That's okay. You're still safe. She was willing to be challenged. This is an individual who wanted to be able to go back and thrive and live with her friends and go shopping and to be able to take a drink and not lose her walking while she's doing that, and that's a great opportunity to exemplify the need for dual tasking as well. I'm gonna show you a few more videotapes right now and these are gonna be challenging and we're gonna actually go from one right into another and I'm gonna set these up for you. I'm gonna show you a patient first that's gonna be doing some pressure training so that we may see her tone come up a little bit, and then after that I'm gonna show you a patient that is going to be working on walking in a little bit different fashion. I'll tell you what, Kathleen, can we pull back over to the slide for just a second?

I wanna set these up for everybody. So we're going to actually show you first a patient who has to do some pressure training of changing directions while she's on a treadmill, then I'm gonna show you a concept that I want you to just be introduced to called the Method of Amplification of Error. We're gonna actually take a patient's gait deviation and we're gonna ask him to exaggerate his gait deviation, and then we're gonna ask him to minimize his gait deviation. That's gonna be the Method of Amplification of Error, and then we're gonna do some agility training after stroke and we're going to actually take a patient and we're gonna exaggerate his plantarflexion inversion, his tone, and he's gonna have to be able to manage that, that untoward, unexpected, unwanted movement after stroke through habituation. So let's go ahead and show all three of those now. I'm really excited to show you all three of these videos. Thanks so much for your help with that, Kathleen, and again I'll remember to unmute my microphone here at the end, here we go. This is your final turnaround at 0.4 miles an hour, eyes open. Gotta be fast, gotta be responsive. Good, okay, now we're gonna slow the treadmill down to 0.3, here , okay. Now you make one each direction with your

eyes closed. Good, with this pressure training, there's a little bit of a penalty for any hesitancy. So you gotta overcome the tendencies of tone and tension. Now switch back out to exaggerate the opposite direction. What do you think, are you getting a pretty equal amount of turn out, right and left, there you go. Let the right leg mirror the left, that's it. Now just go back to a regular walk, so pull out of the exaggeration for a sec. Good. Switch, good. Good, no hands there, good effort. Place that foot right where you want it.

- [Patient] Yeah.

- [Man] down, down.

- [Mike] Wait for it now, this way. Okay, last lap. So hard. Yeah, that's perfect. You're allowing a patient to habituate and reduce the expression of tone by continually going into and out of the tone by pushing them into the areas of difficulty that are right within the grasp of their abilities. So we're working on agility training, but she's in body weight supported treadmill training. She's got her hands available at any point if she needs to stop herself. So we're giving people the ability to get into and out of tone so that they can habituate and reduce the expression of the tone. So task-specific circuit training, just some quick examples here that I went through earlier that you might use to your advantage. Again, 60 to 90-second bursts of, do this task, and then that task, and really maximizes high intensity interval training, the capacity to use random practice, uses all the principles of motor learning, gotta love that one when you can get that chance to use it, and then finally I really want to get us into obviously your questions, but also just very briefly some concepts about the chronic stroke patient who's also very frail. I want to debunk some of these concepts that patients can't get stronger, can't improve their balance, and realize that a great deal of what these individuals have lost is a straight function of use it or lose it and it's so wonderful to work with a patient that's had a stroke five years ago and hasn't had rehabilitation for four-and-a-half years

because there's so much potential left on the table, table to tap into. So I wanna actually go through a couple things here that are salient for you. I want you to look for ways to measure the frail stroke patient who has psychology, who is a person, who has capacity on the table. If you can just show him a couple of things that they can improve in and that you've measured that they've improved in, they get it, they're engaged, and they go. So how can you use measures? Well, you know what, you don't have to use every perfect measure of a six-minute walk test, or a full Berg Balance Test, or the BESTest. If they can't tolerate all that, you know what you can do is you can actually just measure function. Time their ability to get out of bed. Time them in a five times sit to stand. Measure their unassisted sit to stand type, which we now call a Minimal Chair Height Stand Test. Time them for 10-feet in a wheelchair propulsion using both feet. Just simply time them in how long they can actually stand and endure. Why don't we take the opportunity to share those measures with the patients so they can actually get a dopaminergic taste that they're getting better, and then just get engaged?

So to me, the biggest crime that we have with the frail stroke patient is that we don't give them credit for what they've lost that was not a function of their stroke that's completely right there ready to be grasped again. So again, as I stated earlier, it's important that we are scientists, it's important that we're psychologists, and important that we are salespeople. I'm sorry of how that sounds, but that's what we've gotta be. So you've got to be able to individualize everything because you are a psychologist, and I went through all these things for you, but we understand that that is what has to happen with a frail patient too is to individualize them. We need to look at capacity training. Take them through therex, get 'em stronger, but actually live the science of it. Don't think that putting him on five minutes of a new step is gonna do it. Do five or 10 repetitions of sit to stand from a height that they can't do 12 repetitions from or 15 repetitions from. Actually use the ACSM Guidelines to get them stronger. So let's summarize everything here, and then let's get to your questions. We've gotta use intensity. We've gotta force the brain to improve. We've gotta force sensation out of

patients and make certain it's a meaningful attribute for them. We gotta speak less and let the patients actually give us back more. Let them be the reporters. Let them be the ones that predict, and anticipate, and report back, and be aware. We'll make certain that every point of feedback we give them is something that's beneficial that is hopefully something that's goal directed, not body part-directed. This is my email address, use it. Go ahead and contact me. If you want to see some of the videos, if you want an opportunity to come to our clinic to observe, just use these things. I wanna really get into your questions now too.

We've got another 13 minutes or so to get through these, so I'll do my best, okay. Hank said, "Active participation and patient feedback "is also asking the patient, 'What is your goal?'" Absolutely, that's true too, but that's something that we've known for 10 to 15 years now, what is your goal. I wanna go beyond that and I wanna say: How do you think you did? What are you gonna do differently next time? But it's a great point, well taken and spoken. Okay, Chelsea, "Suggestions for when group therapy isn't available?" Use the patient to be able to, let's say, put 'em in a testing situation. I'm gonna show you this information, and tomorrow I'm gonna test you on this very information, and if you do well on it, we're actually never gonna cover it again. Compete against yourself.

Show them that they have the opportunity to retain. Show them their numbers, and then show them the opportunity to actually beat their own numbers so that they're competing against themselves. The first time you did the 30-seconds sit to stand, you got eight repetitions. Today, you got 12. How many do you think you're gonna get next time? Give yourself some feedback so when we go into this task next, I want you to remind yourself of how you did last time so that you even improve that the next time. So now they're giving themselves their own education and I'd rather the feedback comes from them if they don't have another group cohort. Misty, "At what point would you reduce goals "if no improvement has been attained, "timeframe for their

confidence?" Sometimes I actually, rather than discontinue therapy, there are a couple different ways to answer your question here. I will actually shift my emphasis away from balance and onto strength. Sometimes I'll change my techniques and understand I have not been intense enough. Sometimes we'll stop therapy for the course of a month, send somebody home with a home exercise program so that they can just get themselves stronger with a scheduled time to come back into therapy in a month. If they can prove they've gotten stronger, then we restart therapy. That's my best and quickest way to answer your question there. "I certainly feel you've covered several valid methods "to facilitate recovery via increased neuroplasticity, "but one topic I would like to speak to is post stroke pain, "especially upper extremity pain, "how it possibly impacts recovery in neuroplasticity.

"How do you address the patient with very low pain tolerance "in order to maximize neuroplasticity?" Tough question to answer, not really a big part of what we were doing here. I would like to address this a little bit more offline, but I'm gonna try to tell you, the best way to do this with consideration of neuroscience of pain right now is to do successive approximations, to actually give them some small movements that are successful that are not painful, then move them away from it and I wanna drop their focus on pain and increase their focus on the goal.

So not big movements, not heavy movements, not painful movements, but have a little successful experience, then move out of the arm. Come back, have another small successful experience, and move it away. What we talk about there is we talk about desensitization and we reduce the association of every single thing being done with this extremity as being painful because otherwise we get into either chronic regional pain syndrome, thalamic pain syndrome. We get into a huge sensory homunculus problem of everything that's being represented from this extremity as being painful. I could go on and on about this, but that's my shortest answer for you and I'm happy to address that more offline. Nancy, "I like autonomy because you "can't treat every

patient the same. "What works for one might not work for the other." Great comments, yeah, perfect, and thank you so much for reinforcing the statement there. Nika, , "How would you apply these same "principles and concepts to a patient "in the SNF setting or is that possible?" All these concepts are SNF appropriate, intensity, chronicity, frailty, need for measurement, psychology, dual tasking, the long-term patient, the short-term patient, the heavily impaired patient. How can you get up from a low surface? Make it a high surface to start off with. Give them a little bit of success. If you can only walk 10 feet, time the 10 feet, and then see if tomorrow they can actually beat their own score and take 'em to the same place in the same hallway in the same skilled nursing facility and apply the SIRROWS, the Systematic Inpatient Rehabilitation Reinforcement of Walking Study. It just named that.

It doesn't mean you can't do that in the SNF setting. Use all of these principles in the SNF. "Really love the strategy "of circuit training to achieve greater recovery." Susan, thank you. "Please give a few more ideas "for circuit training in stroke rehab," and I think we actually did that at the end so you probably asked this question before I got to that summary slide of that. So we got to that, oh, good, and I see that's the case. Sonia, "When applying this "approach strategy in rehabilitation, "is right or left side neglect "a limiting factor for success? "Does it also improve?" Great question, Sonia. I can tell you that we use the Systematic Cueing Strategy as a main strategy for persons with right or left neglect, but I can tell you that the ability to be able to compensate and remember to look to the left is not a function of how frequently the therapist says it but how proficiently the patient actually gets the understanding from successive errors, but not overwhelming errors, that, "Oh, that's right. "The strategy was right there in front of me. "All I had to do was remember to the left," and use indirect cues and indirect cues and indirect cues rather than directly solving it for them. Lisa, "Do you find these specific rehab strategies "for hemiplegic motor and sensory recovery "also work well for other neurologic populations "with hemiplegic loss, i.e. MS?" Let me tell you at least this, Lisa. I am planning on a full multiple sclerosis course upcoming and we're

gonna talk with physicaltherapy.com about this and I can tell you that neuroplasticity is a viable opportunity for persons with MS and I can also tell you that intensity is much more applicable in MS that what we used to think, but I can't tell you these are wholeheartedly actually the same principles. I can tell you the importance of having the upper extremity available to be able to keep me from losing my balance, is a human attribute that rains throughout.

Whenever you have an individual with neuropathy, or spinal cord injury, or stroke, or MS, they have upper extremity contact, the brain is going to wanna try to use that upper extremity to give the person a sense of where they are positionally so I would encourage you to try that and keep me posted. We've got a lot more questions to get through. Bhagat, "Stroke patients usually are "frustrated when they try and fail. "Do you need to do outline your anticipated plan "to gain their cooperation or do you do as you go?" I find that actually understanding the person as soon as I start rehabilitation with them and actually looking at their first response the first time I let them have a foot that drags or not keeping up with the treadmill, or a slight loss of balance as they go sit to stand begins to tell me everything I need to know about their persona.

If they feel angered or agitated that I should've stepped in sooner or if they feel like they wanna go for it and try a little bit harder and get right back at it, that's what tells me everything. "Can I get the four critical elements "of stimulating neuroplasticity? "Is concentration a component?" So the critical elements of stimulating neuroplasticity: we need attention, we need intensity, we need repetitions, and we need challenge or difficulty, and that was way back, I believe probably maybe the 13th or 14th slide, but you can look back at that as well. "For Method of Amplification of Error," Arlene's question, "you exaggerate the abnormal, "then you try to minimize the abnormal?" Yes you immediately go from maximizing and exaggerating and swiping those cups off the side of the treadmill, or leaning way over to the left, or hiking up that shoulder blade like it's not supposed to, and then you immediately follow that very temporally and very

quickly thereafter with their efforts to try to reduce the untoward movement. Nika, "I can somewhat see how to apply them. "Just need to know how to adapt them for those "with other altered mental status, such as dementia," and I think, I don't remember your first question, maybe you were talking about task-specific circuit training. So if that's the case, then I would say, maybe even use a smaller dosage. I use a 30-second bout of moving from task to task to task, and that will be totally fine to do as well. So Rose, "So if we are impairing the strong side, "would it also still be appropriate "to challenge the affected side?" Absolutely, that's why we put weights on the leg. "Patient with right-sided weakness "ambulating with a strong side on an uneven surface, "would it still be appropriate to use an ankle?"

Yeah, you're saying exactly what I'm saying. So, Rose, you have it 100% correct. Laura, "Any additional recommendations "on personal anecdotes for severe pushing?" Gosh, too long of a question for me to try to get through. Okay, so step away, let them fail in a sitting approach. Let 'em lean down onto the unaffected elbow and try to have them push up on the unaffected elbow up to sitting, wherever they think they are at vertical, and then if they begin to push themselves over too far, let that happen with you sitting just far enough away that they can see that you're not the problem. Sometimes what happens with Pusher syndrome is also a degree of paranoia. Because there is a perceptual problem, they think you are the problem. They think you are pushing them.

So you have to do this in sitting first, lean 'em down onto an elbow, let 'em push themselves up. When they push themselves over too far, you allow pillows to be there. You are there to catch them, but you let them see, now you do that eight to 10 times in a row. Push yourself up. Remember what happened last time, you push yourself over too far? Try to see if you can stop yourself before you go over too far. I could go on and on about that for Pusher syndrome. The same thing could be done almost in standing. There's a lot of things that can be done there. "How can I work with a patient "that has

temporary loss of memory, "short-term memory that goes "in and out during therapy sessions?" Engage them by giving them an opportunity to feel productive. That's the one absolute thing that we miss out on. Rather than giving them a therapy experience, say, hey, I need your help to do this over here. Productivity is a common thread throughout every individual that lasts even into severe dementia. Allow a person to be helpful and productive, that's the one big thing that I would say. "Any ideas on addressing reflex sympathetic "dystrophy pain on hemiplegic side? "Is a major barrier for motivation to participate." I need a two-hour course to go through this with Karen. It's a wonderful question, I love it. There's not enough time in the next two minutes and 10 seconds to get through this, but what I would say is you wanna be able to give them a normalized experience. Neutrality is the biggest thing.

Keep it neutral. Don't keep it aggressive. Don't keep it warm. Don't keep it sharp. Don't keep it pressure-ful. Keep it neutral. Allow them to weight bear with some body weight support on the arm if you will. Keep it neutral by terms of warmth. Swaddle the arm as much as you possibly can. The management of hemiplegic shoulder requires central and peripheral techniques so it's not the same as everything that we went through here today. I wanna answer your question even more so offline, but go ahead and shoot me an email and I'll help you guide through this. Last question, "Economical methods "for weight assisted treadmill devices and strategy? "Is the device in your video expensive?" Charlene, email me offline. I can get you in contact. No, it's not expensive. We actually use the same device, the same overhead tracking for three different treadmills in our clinic, and Diane , "Please pull up "the question number five on the test. "Question's choice A and B read the same. "What should these answers and choices be?" One second. Oh, look like we've got... Hold on one second. I, oh, okay. Looks like it's not a problem. It looks like it's been fixed. Calista says, "That's been fixed," because I don't think there was a problem going into it, so maybe it was just a typo error. We've got 35 seconds left and we've addressed everybody's question. Calista, I'm gonna turn it back over to you.

- [Calista] All right, well, thank you so much, Mike, for sharing your expertise with us today and thank you everyone for attending this course and we'll hope to see you back in the classroom tomorrow. Have a great day, everyone, and great evening, and thank you again, Mike.

- [Mike] My pleasure, thank you so much.