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Redefining Recovery: Applying Behavioral Techniques as Rehabilitation

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faculty spotlight: Dr. Edward Taub

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Dr. Taub serves as a testament to the success delivered by hard work and sincere passion. After numerous awards and great prestige for his work on Constraint Induced therapy (CI therapy), he continues challenging himself. He is a simple man whose interests revolve around his research and hearing his wife, Mildred Allen, a renowned lead opera singer, sing. He fearlessly challenged a medical dogma that had existed for more than half a century, and Dr. Taub remained resolute in the face of stinging criticism by trusting that thorough research can systematically answer questions. His work represents a shining example of translational research – taking laboratory bench data and integrating it into the clinical world. Dr. Carl McFarland, the Psychology chair who hired Dr Taub, describes him as "a guy who really loves what he does. Most days he comes in happy to work." Dr. Taub has brought millions of dollars in grant money to UAB and revolutionized the rehabilitative applications of behavioral techniques. He attributes his success to a modest set of tips and tricks; Dr Taub insists that research success comes from personal effort. His amazing rehabilitative stories reflect all the time, energy, and creativity he has poured into his projects.

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After Dr. Taub's undergraduate career at Cornell, he entered behavioral analyst training and obtained his Master's degree at Columbia. As one of the premier operant conditioning research centers in the world, Columbia gave him the opportunity to learn from famous mentors such as Fred Keller. He finished his formal education with a PhD at New York University, and he moved to the Institute for Behavioral Research in Maryland, where he carried out experiments on deafferented monkeys. This research led to his discoveries in neuroplasticity and rehabilitation therapy. His early experiments reshaped the field of behavioral neuroscience by disproving Sherrington's Reflexological position, a popular theory held for over 70 years. Nonetheless, Dr. Taub still deems Sherrington a great scientist. He argued that Sherrington's explanations were perfectly reasonable, but skewed because "mother nature isn't a lady." The history of science shows that the most reasonable explanation is not always the correct one.

In Dr. Taub's experiments, the monkeys' dorsal spinal nerves were severed. Although sensations were eliminated, motor-neural pathways controlling arm function remained intact. Dr. Taub's research team explored why the monkeys stopped using their arm. Several years of research showed that deafferentation created a window of disability, but, after a few months, the monkeys should have been able to use their arms again. However, they incorrectly learned that the arm was not usable. This phenomenon, dubbed "learned nonuse," stems from basic reinforcement. Through many different forms of punishment (losing coordination, falling, acquiring food less efficiently, etc.), the monkeys learned to not use the affected arm. Instead, they learned compensatory behavior using only the good arm. These compensatory behaviors were reinforced by partial successes. Together, these two reinforcement components produce a strong conditioning environment that leads to learned nonuse. Dr. Taub applied behavioral techniques that forced the monkeys to use their deafferented arm, and the results showed extraordinary promise.

Almost a decade passed before he could successfully transform these findings into a rehabilitation technique to convert a useless limb into a functional one. Because the laws of behavior are universal in all mammals, he thought he could translate his findings to human rehabilitation following a stroke. For example, patients really can't use an affected limb for a period of time after a stroke. Even later in recovery, when they really could they continue to often feel embarrassed in front of others when trying to use an affected limb. This adversive consequence dissuades usage of that limb, and successfully using only the unaffected limb positively reinforces the nonuse of an affected limb. Dr. Taub thought that the same behavioral interventions that were successful with monkeys could serve as a human rehabilitation technique. Over the next few years, Dr. Taub moved to UAB and developed on tests the basis of human rehabilitation treatment. This was his first experience with translational research, an uncommon practice at the time. He referred to this new application of his research as "following the string." He emphasized the importance of an open mind, which ultimately led him to ask whether the therapy could be translated from monkeys to stroke patients. Stroke patients mirror deafferented monkeys by presenting similar arm nonuse. Furthermore, these patients had previously been condemned by the clinical world, providing further negative reinforcements. Entering the field of stroke rehabilitation without formal training in the field gave him a fresh perspective, and he challenged the paradigm that stroke patients could not recover limb function more than one year after a stroke.

Dr. Taub's rehabilitation technique is known as Constraint Induced (CI) Therapy. Constraint in this therapy implies a dual meaning physical restraint of the good arm and behavioral constraint of the stroke-affected arm imposed by the training situations used in the therapy. His therapy allows stroke patients to recover significant limb function, regardless of the length of the period of disuse. This therapy centers on one-on-one work with a therapist, during which the patient is encouraged to perform numerous tasks with their affected limb while their unaffected limb is restrained. The program boasts an approximately 95% success rate by "rewiring" certain regions of the brain activating the affected area.

The fundamental basis of this therapy uses positive reinforcement to induce movement. After a patient performs a series of tasks with his affected limb, the therapist records evaluations and shows these to the patient. These help to motivate the patient to continue improving limb function. Dr. Taub described the process as "similar to an arcade game because humans are intensely competitive. They want to improve on their previous best performance, and they also want to reduce the effects of their stroke. They want to get normal." The average treatment lasts two weeks and has three central components: restraint of the unaffected limb, a transfer package (TP), and repetitive practice with minimum rests between exercises. The transfer package includes problem solving, homework, etc. All these exercises promote constant patient immersion in the therapy process for a substantial portion of the day. Some patients call the therapy magical; within two weeks, they regain at least half the former functionality of their limbs after a long period of disuse. Essentially, the therapy represents a behavioral modification to the wrongly learned habit of nonuse. Analysis of CI therapy has shown that the technique can consistently improve a patient's limb functionality; on average, a patient with only 9% functionality in his or her arm can improve to 52% functionality level.

Dr. Taub continues refining and expanding CI therapy. The therapy has been shown to improve patients of all age groups; he and his colleagues have successfully treated an 18-month old child as well as a 92-year old man. Furthermore, Dr. Taub has found that the program could treat any form of learned nonuse, such as patients suffering from traumatic brain injury. Another important application that Dr. Taub found for CI-therapy was to treat Focal Hand Dystonia, where artists suddenly find themselves unable to coordinate hand movements. He has worked with concert artists, such as Leon Fleisher, and they usually achieve almost complete recovery, allowing them to return to their passion. With his therapy, it has been shown that eight out of 10 phantom limb pain patients reduce the painful sensations. At UAB, Dr. Taub worked with speech language pathologists on CIAT II (Constraint Induced Aphasia Therapy). This targets aphasia, impaired language ability, which is usually borne out of stroke. The program was amazingly successful; on average, patients achieved a more than 10 times speech improvement. Through the many modifications of the CI-therapy program, a greater variety of patients have been able to utilize the program in their recovery, including patients with cerebral palsy, traumatic brain injury, and multiple sclerosis.

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In addition to his works on therapy, Dr. Taub also collaborates with other researchers to explore territorial plasticity and the conversion of different areas of the brain from one use to another; these projects have led to publications in major scientific journals like *Science* and *Nature*. Four of his German clinics use imaging software to further study the relationship between neuroplasticity and CI therapy as does his lab here at UAB. Using EEG and transcranial magnetic stimulation (TMS), it was shown that brain areas representing the arm shrank to 50% of the normal in patients suffering from stroke or traumatic brain injury. After CI therapy, though, this level almost returned back to normal. Just recently in 2008, Dr. Taub and graduate student, Lynne Gauthier, revealed CI therapy can be associated with an increase in the volume of brain matter corresponding to motor areas of the brain and in the hippocampus.

Throughout his illustrious research career, Dr. Taub's centered his central methodology on the concept of Strong Inference. This Baconian form of science explores a phenomenon by asking a question and using a set of possible answers to the question, which are characterized as hypotheses. Scientists try to eliminate all but one answer, which then provisionally stands as the truth. This method harbors no sense of absolute truth, and the last answer only stands until new research disproves it. Within this framework, Dr. Taub pioneered the use of behavioral techniques in the field of stroke rehabilitation, earning him accolades such as the Distinguished Scientific Award for the Applications of Psychology from the American Psychological Association (2004) and the William James Award from the American Psychological Society (1997). The Society for Neuroscience named his CI therapy one of the top ten Translational Neuroscience Accomplishments of the 20th century.

Dr. Taub was keen to offer advice to aspiring researchers. First, he stressed the importance of a good mentor; a researcher's views are strongly influenced by that mentor. He expressed his gratitude to his mentors who now reside as historical figures in psychology: Fred Keller, Joe Brady, and Neal Miller. Dr. Taub hailed Dr. Miller as "the greatest exemplar of strong inference in psychology and neuroscience in the 20th century." Second, he stressed that problem solving is the most important part of science. "That's the fun," mused Dr. Taub. He noted that because it has the same creative impulse as art on the most fundamental level, science has been called the great art form of the 20th century. Dr. Taub described the most important part of creativity in science is the identification and assessment of fruitful phenomenon. He says that once a scientist has learned to solve problems, it becomes easy to find different applications. However, just like art, he emphasized that it is not what one creates, but the process of creation that brings satisfaction. A scientist does not need to be brilliant; he or she just needs work hard and integrate his or her own unique perspective. Dr. Taub added "I work in rehabilitation of humans now, which is just as interesting as deafferentation in monkeys, which is just as interesting as other areas of research I have worked in. They are all interesting – it's what you bring to it in terms of the creative thrust."

After accomplishing such great strides in the field of neuroscience, Dr. Taub joked that he still sings in the shower. "I used to help my wife learn her lines when she sang for the Metropolitan opera. This is true! I used to sing her soprano arias in the shower. One day she came in with tears in her eyes and moved back the shower curtain and said 'Please don't sing. Please, they are all the wrong notes!' I wasn't offended, I knew she was right." Yet, he still continues to help her, just as he has continued his research and his passion for the art of science. He commented that if young scientists work hard, they can make their own luck. He emphasized that sometimes individuals are wrong and sometimes they are right. "[But] don't let being wrong stop you," he insisted, "because when you're right – you'll hit a jackpot."

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