Viewpoint: What Brain Research Can Tell Us About Accent Modification

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Abstract

The field of brain research has made numerous advances in the past few decades into how we learn new motor skills, from the value of sleep to the discovery of "mirror neurons," which fire when we watch others performing movements we are attempting to learn. Accent modification may be conceptualized as a form of sensorimotor skill learning – learning to produce a set of movement components and performing them as a whole automatically in spontaneous speech. Motor skill learning occurs in stages and motor habits are formed after acquisition of the new behavior, consolidation of the new brain patterns, and automatic production in appropriate settings. New neural pathways are formed and both cortical and subcortical brain regions participate. The author of this article reviews concepts from the neuroscience literature in the field of motor skill acquisition, work which has primarily focused on the learning of arm and finger movements, and attempts to apply them in a practical manner for the clinician working with non-native English speakers. Discussed are the neurophysiology of motor skill learning, stages of habit formation, intermittent practice, sleep, feedback, mirror neurons and motor imagery. Practical suggestions are given to optimize the accent modification process for the clinician and client.

In 2011, approximately 12.5% of the population of the United States consisted of legal immigrants from other countries (Migration Policy Institute [MPI] 2013), over 40 million individuals. Every year, many of these individuals attempt to modify their speaking patterns to improve their communication effectiveness. Changing the way one speaks can be difficult for some, as speaking style is a well-engrained motor habit. The fields of neuroscience and psychology have studied habit formation and motor learning for decades (Crossman, 2005; Newell, 1991). Most of this research, however, has focused on (and continues to focus on) human learning of new limb or finger movements including those involved in various sports and/or the playing of musical instruments. Work on the neural circuitry and neurophysiology involved in motor learning traditionally involved non-human primates (Hikosaka, Nakamura, Sakai, & Nakahara, 2002; Ojakangas & Ebner, 1994), although the advent of functional magnetic resonance imaging (fMRI) opened the door to examining blood flow changes corresponding to neural activity in the human brain during motor learning (see Doyon & Benali, 2005). Detailed study of the process and neural activity involved in learning to produce unfamiliar phonemes and novel prosody in running speech correctly and automatically has not yet been conducted. That being said, many of the recent findings regarding how motor habits are formed in non-speech tasks and the corresponding neural plasticity involved can offer possible hints as to the most effective means to help individuals modify their accent — that is the goal of this article.

Changing how one speaks entails changing the neural circuitry in the brain and how it functions. The study of the neural correlates of speech and speech processing indicates there are two main cortical pathways involved— the ventral and dorsal pathways. Contrary to the historical viewpoint, it has been demonstrated recently that the ventral stream, responsible for speech comprehension, is bilateral, involving both right and left hemispheres (Hickok & Poeppel, 2007). This theory, now supported by imaging experiments (Hickok, Buchsbaum, Humphries, & Muftuler, 2003), was developed by the authors based on their reflection of others' findings on the bilateral nature of the visual system (Goodale, 1998), lesion-deficit observations of stroke victims, and electrophysiological data from other labs (see Hickok & Poeppel, 2007). This neural pathway involves structures in the superior and middle temporal lobe. The dorsal speech stream consists of structures in the left frontal lobe and posterior portions of the left temporal lobe, and is unilateral in nature. This dual, parallel processing system to understand and produce speech is thought to allow for a redundancy in speech processing in noisy environments (Shannon, Zeng, Kamath, Wygonski, & Ekelid, 1995). Subcortically, researchers have also found basal ganglia involvement in first and second language processing and production (Abutelebi et al., 2013; Booth, Wood, Lu, Houk, & Bitan, 2007). Interestingly, the basal ganglia and cerebellum are also areas involved in the formation of motor habits (Graybiel, 2008; Lehericy et al., 2005; Ojakangas & Ebner, 1994. Motor learning research has not yet focused on how we learn to speak a new language with a different phonemic repertoire or make the more subtle changes in pronunciation that are involved in accent modification. Both behaviors require production of novel motor patterns and the development of automaticity (in the first example, so that one can be understood; in the second so that one's pronunciation more closely resembles that of native speakers). Research examining the involvement of cortical and subcortical brain areas during non-speech motor learning may offer clues for the speech-language pathologist (SLP) involved in helping clients with accent modification.

Two types of motor learning have been differentiated in the literature: *motor adaptation* and *motor skill learning*. Put simply, motor adaptation does not involve learning a new movement, per se, but is the process of scaling a previously learned movement to new environmental requirements. Examples of this are learning to walk through mud or adapting to a new car's brake pedal sensitivity. Learning to modify an existing sound for use in a second language in similar phonemic contexts could be viewed as adaptation. Examples of this is a native German speaker learning to produce an American/o/sound with less lip-rounding and a shorter duration, or an individual from an English-speaking country (e.g., Australia, India) who is modifying his/her accent to sound more "American." Motor skill learning, on the other hand, requires the formation of a new pattern of movement or sequence of movements not previously known, with speed and accuracy improving over time (Crossman, 2005). Examples of skill learning would include learning to swing a tennis racquet, learning to knit, or learning to produce and sequence novel speech sounds in a non-native language. Motor skill learning is a more difficult process, as it involves learning to produce a movement not previously in one's repertoire (Willingham, 1998). Additionally, we can call foreign accent refinement a type of *sensorimotor skill learning*, as the sensory system (auditory and kinesthetic) is required in order to produce new speech sounds and new speech sound combinations accurately.

Discovering the neural circuitry active during the process of all types of motor learning is an active focus of research. Motor skill learning involving limb and finger movements has been shown to occur in stages. The "early learning" stage occurs first, quickly, within the first session with much improvement noted. The cerebellum and anterior basal ganglia are active during the early phase of learning (Ungerleider, Doyon, & Karni, 2002). The second stage occurs over many sessions with continued advances (the "slow, later stage"). "Consolidation" of the new motor habit can occur after more practice if no other task has interfered. As motor learning becomes automatic, cerebellar and anterior basal ganglia activity decreases, while activity in posterior basal ganglia and many distributed cortical areas is seen (Doyon & Ungerleider, 2002; Graybiel, 1998; Jueptner, Frith, Brooks, Frackowiak, & Passingham, 1997; Ungerleider et al., 2002). Finally, "automaticity" of performance and "retention" occur (Doyon & Benali, 2005). How to facilitate each of these phases leading to automatic and retained new speech patterns is the focus of this review.

How long does it take to form a motor habit? Research into this question is scant as motor habits can range from simple to complex, and motivation and effort can vary. A recent study, which used a self-rated questionnaire that measured automaticity in new habit formation, found the range to be exceedingly large from 18–254 days (3 weeks to about 9 months; Lally, Van Jaarsveld, Potts, & Wardle, 2010). Expectedly, simple new habits (e.g., eating a piece of fruit after lunch) were automatized much quicker than more difficult motor habits (e.g., exercising at a certain time during each day). The median time in this study was 66 days, or about 10 weeks). Consolidation of skill at playing racquet ball can take weeks to months and can continue to improve for years (Pearce et al., 2000). An expert in the field of accent modification has generally found that significant changes in accent (although not total accent elimination), as measured on a repeated, video-taped measure, take three to four months with optimal motivation and effort (L. Sikorski, personal communication, August 7, 2009). No reliable data are available for how long it takes someone to reduce their accent to near non-existent, although this author has seen remarkable variability with different clients from four months (which is quite rare) to much longer. It is this author's personal opinion from experience that innate ability contributes along with motivation, intensity of practice, amount of socialization with native speakers and other factors. Admittedly, changing how one speaks carries considerable emotional weight, which varies from person to person and is highly situational. Additionally, talent for speaking foreign dialects may be "hard-wired," as a recent study found some individuals working as phoneticians possess differences in size and structure of their auditory cortices shown to be indicative of a special skill with foreign speech transcription (Golestani, Price, & Scott, 2011). The process and neurological underpinnings of accent modification and the ability to predict success from individual to individual is clearly an area ripe for more research.

Does it make a difference what time of day a session takes place? Does one learn more in the morning versus in the afternoon? What little research there has been into this question has revealed that for declarative material (facts, knowledge) learning can be more efficient in the morning, but motor learning appears to not show sensitivity to time of day training. Kvint and colleagues found no difference in improvement in the kinematics of a visuomotor task to targets using a digital tablet dependent on training in either the morning or the afternoon, nor was motor performance of a thumb adduction task (Kvint et al., 2011; Sale, Ridding, & Nordstrom, 2013). What seems to make a difference, however, is sleep.

Numerous studies are now supporting the benefits of sleep to aid in learning consolidation. While it is now well-supported that sleep aids in the retention of what has already been learned (Rasch & Born, 2013), recently the benefit of sleep has been shown to aid in not only consolidation of sensorimotor learning, but also generalization to similar tasks (Brawn, Fenn, Nusbaum, & Margoliash, 2008). Learning of auditory stimuli is also influenced by sleep. Recent studies have clearly shown the benefit of sleep for remembering auditory pitch sounds (Gaab, Paetzold, Becker, Walker, & Schlaug, 2004) and for retaining and generalizing perceptual learning of spoken language (Fenn, Nusbaum, & Margoliash, 2003). Sleep appears to help retain what has been learned throughout the day, as well as possibly improve learning and retention for similar tasks, whether procedural or declarative in nature. Memory for vocabulary is greater if sleep occurs within three hours of learning rather than if it occurs later (Gais, Lucas, & Born, 2006). How does this happen? Neural activity during the daytime learning may be repeated during periods of sleep and interleaved with knowledge learned earlier; it is postulated that the activity during sleep reorganizes the neural circuitry to enhance learning by making it less susceptible to interference from newer memories (Rasch & Born, 2007). Some research also supports the benefit of a daytime nap in the facilitation of motor learning (Debarnot, Clerget, & Olivier, 2011). Whatever the mechanisms, it is clear that recommending a good night's sleep to accent modification clients is supported; this can be extended to practicing before sleep, as the information will not be degraded by other daily events.

Practice sessions while learning a new motor skill can be organized close together in time (massed practice) or with a longer time between sessions (distributed practice). Recent literature in the fields of neuroscience and psychology support the notion of distributed practice sessions over massed practice as a means to aiding consolidation of the new behavior. In one study, memory consolidation for a visually-guided arm movement task with novel force fields applied was stronger for subjects who had trained with intermittent practice sessions than for the subjects who had trained with constant practice. Those with constant practice experienced difficulty with the interference of infrequent catch trials, but those who had trained with distributed sessions did not (Overduin, Richardson, Lane, Bizzi, & Press, 2006). Another study observing learning of a timed finger movement task supports the use of constant practice initially, until the motor skill is produced accurately and then the benefit of distributed practice with varied targets (Lai, Shea, Wulf, & Wright, 2000). Again, future studies more directly related to speech production would be beneficial.

The schedule of clinician feedback can be constant or intermittent. Generally, clinicians tend to utilize constant feedback with a client's speech production. Research, however, has pointed to the benefit of using intermittent feedback after a client has achieved the target but needs practice (Adams & Page, 2000). Delaying the feedback to the client allows self-reflection and increased attention rather than relying on the clinician's appraisal. Another recent study found that a 20% feedback schedule was most beneficial for clients learning to reproduce sentence-length utterances in a foreign language (Kim, Lapointe, & Stierwalt, 2012). Receiving too much feedback is interpreted as increasing dependence on the clinician while decreasing processing required for learning. When learning a novel movement, "Knowledge of Performance" type of feedback seems to be the most beneficial. This would include an explanation of what the client did in error. A "Knowledge of Results" type of feedback (a simple judgment call as to "right" or "wrong," or a supportive comment, such as "I know that is difficult,") is thought to be more useful once a behavior is in a client's repertoire (Maas et al., 2008).

Recently, it was discovered that primates performing a movement and watching another perform the same movement cause similar neuronal activity in distinct brain areas (Rizzolati, Fadiga, Gallese, & Fogassi, 1996). Neurons of the "mirror neuron system" are believed to be part of the way we humans also learn new motor actions — first by observing others performing the action and then by attempting it ourselves (Cochin, Barthelemy, Roux, & Martineau, 1999). Cochin and colleagues (1999) reported similar electroencephalography (EEG) activity in subjects watching others and in those performing finger movements. Research has shown that even imagining a movement being performed can activate the same neural systems involved in planning a movement (Jeannerod, 1995). The term *kinetic imagery* has been coined when a person imagines making a certain movement, while perceiving how it might feel (Jeanerrod, 2001). Remarkably, in one study involving learning of a finger tapping sequence, even imagining making a new movement over days lead to significantly improved performance (Nyberg, Eriksson, Larsson, & Marklund, 2006), although another study found that watching someone else perform the target action (in this case a hand and foot movement) resulted in increased learning over just imagining (Gatti et al., 2013). For musicians, auditory imagery involving the auditory, visual, proprioceptive, and other aspects of performing a musical number is also beneficial in improving performance (Keller, 2012).

Applied to speech, the human mirror neuron system, including Broca's area, has been shown to be activated while looking at still pictures of lip postures indicating vowel sound production (e.g.,/a/or/o/) during imitation of the same lip postures, and during free production of the same (Nishitani & Hari, 2002). Functional magnetic imaging during observation and imitation of syllables demonstrated that both processes involved the same neural pathways, but activation was greater during imitation than observation (Mashal, Solodkin, Dick, Chen, & Small, 2012). Taken together, these studies speak to observation of motoric actions, including speech, being an integral part of the motor learning process. The benefits of group sessions in accent modification can also be supported by this research. In a group setting, in which one listens and watches others practicing a new sound (e.g., the/ar/vowel combination, the mirror neuron system could be activated as one listens to the instructions (e.g., "Say the 'ah' sound and then bunch up your tongue,") and then attempts it oneself. Watching others produce a sound combination triggers kinetic imagery as one waits for a turn. Observation may improve one's own skill learning, as can mental practice of a new skill.

Application to Accent Modification Treatment

The previously reviewed research has several applications for the SLP working with individuals wishing to improve their accent in American English. Based on the research, although little research has been performed in the area of accent modification, the following ideas have been gleaned:

Expected Length of Time to Change Pronunciation

Clients should have appropriate expectations for the length of time required to change pronunciation, which is a complex motor skill. Appropriate counseling initially is necessary, describing how motor skill learning occurs. As most in the field are well aware of, auditory discrimination of the accurate from error production is necessary before successful learning can occur. Auditory discrimination exercises can be conducted during the early sessions interspersed with sound production training. Clients often improve very quickly in their ability to discriminate the correct sound from the error sound. Additionally, discussion of the process of motor skill learning is important; as within the first instruction session, the client may very well experience great improvement in an ability to articulate a particular phoneme or phoneme combination. While this is positive, the client must understand that the brain requires much more time to make a new skill automatic. The instructor could use an analogy from learning to play tennis: we can learn to swing a tennis racquet during the first session with an instructor, but the next day, out on the court again, we may not recall the details. Discussion of the thousands of repetitions required to perform the perfect tennis swing without having to think about it is useful. Additionally, overt mention of the "boring" aspect of repeated practice to form a new motor habit is also useful. Clients are usually very interested in learning the rules of standard North American English, as the rules can provide "aha" moments of understanding; it is the practice that is not as fun. Managing clients' expectations of this process is extremely beneficial, initially, as well as throughout training.

Lastly, this clinician often describes to her clients, a process many clients have described. Early on in training, the client practices and then totally forgets about it outside of the instruction or home practice sessions. Next, the client begins to notice how others speak, but seems unable to remember to change his or her own speech. Later, clients have reported noticing how they have made a mistake after they have spoken, and they can attempt to correct it. Finally, the awareness appears before speaking, and the client pronounces a previous error correctly on the first attempt. These observations speak to the involved and frequently lengthy process of creating new, automatic speech habits.

Value of Sleep

Although the role of sleep has not been studied in relation to accent modification, clients should be aware of the value of sleep and good health habits to their learning process. If a potential client is sleep deprived, and/or in a very busy time of his or her life, it may be wise to counsel the client to choose another time to try to begin changing a habit as complex as their speech. Progress will occur more quickly if a client can take advantage of the consolidation of learning that sleep can afford. Clients can also be advised to practice before bedtime, as this new learning will not be interrupted by further activities, and may, therefore, be consolidated more quickly. Again, it must be emphasized that the value of sleep for consolidation of new speech patterns has yet to be proven.

Intermittent Practice Sessions

The knowledgeable clinician should advise the client to practice daily in short, intermittent practice sessions, (e.g., four 15-minute sessions per day). Short practice sessions will require recall, practice to a more perfected level, and then allow for consolidation as the material is put away for several hours. The client can be counseled how frequent, short sessions throughout the day will achieve a higher degree of learning than one, more lengthy session. Attention may be more difficult to sustain with a longer practice, as well as one session will lack the needed recall that distributed practice sessions allow.

The Value of Mixing Target Phonemes and/or Speech Tasks

Likewise, within an instruction session, the clinician can apply the above research and attain better results by changing tasks frequently. It can also be advantageous to practice a few different phonemes together in one exercise after the client has demonstrated an ability to produce each one. Practice in which one must switch from one new motor skill to another will serve to encourage more permanent consolidation of both.

The Importance of Client Self-Assessment

While difficult to do, it is sometimes advisable to withhold giving immediate feedback during an instruction session, especially after each sound production. This allows the client to listen to him/herself and judge his or her own speech production. Often, letting the client know that for the next exercise the clinician will not comment after a production, and that the client will be expected to self-judge production is very useful. Tape-recording responses, especially when at the sentence level, and then replaying for assessment, is a valuable activity as well.

The Value of Listening and Watching Others In Group

The benefit of listening to others' speech should be reinforced. The clinician can describe to the client that the brain's activity when listening to others' speak is an early step in the process of his/her own change. Within group sessions, members should be told that listening to how fellow group members respond activates the neural circuitry for their own learning and is valuable. While imagining speaking with an American accent will not help as much as direct practice aloud, clients can be advised that there may be some benefit in doing so, especially when engaging in kinetic imagery by imagining articulator movement.

"Active" Television Watching Is Helpful

Clinicians should encourage clients to watch American television when possible and give the instruction to not only listen to the slang and speech idiosyncrasies they hear, but also to repeat aloud interesting utterances. This practice, in the privacy of one's own home, can improve speech and vocabulary.

Conclusion

Over the past few decades, neuroscience research has uncovered much about how we learn new movements and form new motor habits, although much of this work has been done on non-speech behaviors. Distributed neural activity, both cortical and subcortical is present while the movement is perfected during early and late learning, through consolidation, to automaticity and retention. This article has discussed some practical ideas gleaned from this research for the SLP engaged in accent modification training with individuals from different language or dialectical backgrounds. Accent clients respond favorably to learning the intricacies of neural plasticity and the latest research on motor learning. Research in the future should focus on determining the processes involved in modifying one's speech when speaking a foreign language or when learning a new accent or dialect, as well as the neurophysiological underpinnings. This type of motor skill learning is more perhaps more complex than the motor learning paradigms most often studied in the laboratory today (simple arm or finger movements), but is certainly more universally widespread and relevant to today's global society.

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