Prompt Conceptual and Theoretical Framework

The conceptual framework of PROMPT is consistent with Dynamic Systems Theory (DST) which states that motor speech production (like motor actions in general) is the result of coordinated actions between and amongst all parts. This also extends to all internal domains of the individual (Physical-Sensory, Cognitive-Linguistic and Social-Emotional) and the external forces from the environment.

If any of these global domains is disordered, delayed, or damaged, speech production may not develop normally. The PROMPT system of evaluating and treating individuals incorporates all these domains. PROMPT does not treat only “speech”. Instead all aspects of the client are addressed. We call these “aspects” domains.

Although the overarching theory behind PROMPT is DST within each domain several critical theories have been integrated. In the following section each will be briefly described as it relates to that domain and to the entirety of PROMPT’S model.
THEORIES THAT HAVE CONTRIBUTED TO THE DEVELOPMENT OF PROMPT’S CONCEPTUAL FRAMEWORK

STRUCTURAL/PHYSICAL-SENSORY DOMAIN
R.D. Kent Biological and Sensory Aspects of Speech

R.D. Kent examines both the sensorimotor aspects of speech development and the biology of phonological development. Kent explains that the essential components of speech development are each individual’s biological predisposition and the musculoskeletal and neuromotor maturation processes that are conditioned by experience and use. It is the interplay between biological and experiential factors that are necessary for the acquisition of motor speech patterns. When these areas are combined with the child’s emerging auditory-motor awareness of vocalization, the stage is then set for voluntary and intentional oral communication.

Kent also describes obstacles to speech development in the neonate. The neonate lacks cortical cell myelinization, is essentially reflexive in overall behavior, and is undergoing massive remodeling of its musculoskeletal anatomy and rapid development of the central nervous system (CNS). The neonate is ill equipped to produce speech, as the CNS is immature and reflexive. The infant arrives in the world with a biological predisposition and a set musculoskeletal system. The CNS is complete and ready to receive sensory input but the complexity and flexibility of the motor system is still immature. Pre-linguistic sound and early speech development are accomplished by using what limited resources the infant has available at the time. The developmental changes reflect a maturation and a remodeling of the system.

At birth, the infant’s system is flexible and ready to receive sensory, motor, visual, and auditory input. The system is able to adapt to the conditions in the environment, which then influences the outcome. The infant’s anatomical structures, which support oromotor development, change radically during the first two years. Very early on, the infant presents with a flat and broad oral cavity that is almost completely filled by the tongue (anterior tongue mass). Tongue movements are predominately anterior/posterior. The palate is short and slopes gradually into the oropharyngeal channel, where the velum and epiglottis are in close approximation. The pharynx is short and the larynx rests high. The jaw and tongue work together as a unit with no differentiation. At six months the jaw is the first structure used for the production of sounds. This is reflected in the vowels that are produced. Within this first year, but particularly around two to four months of age, the infant’s vocal tract is remodeled and begins to resemble an adult’s. The engagement of the pharynx and naso-pharynx in infancy forces the neonate to be an obligate nose breather a nasal vocalizer. The disengagement of the larynx and naso-pharynx occurs at around four to six months. It is at this time that the infant’s vocalizations change and babbling begins, with alternating closures and openings of the vocal tract. Naso-pharyngeal valving also occurs.

Flexible and refined motor control of the tongue is necessary for the production of speech sounds. The tongue is a unique muscular organ that contains intrinsic and extrinsic muscles; the extrinsic musculature connects the hard palate to the soft tissues of the head and neck, while the intrinsic have their insertion within the body of the tongue itself. The tongue forms its own skeleton “hydrostat” to support movement, performs movements
and shape changes. The tongue has the ability to flex by means of appropriate contractions of the intrinsic musculature. The tongue and jaw work as a unit in early speech development with differentiated movement occurring with maturation. As consistent movement patterns begin to be replicated and come under the infant’s control, the development of voluntary (rather than automatic or reflexive) motor behavior is seen. Also at this time, oral reflexes disappear and changes in visual behavior and the myelination of cortical cells occur. Many aspects of phonetic development can be linked to the anatomic-physiological changes of the speech apparatus. The emergence of vocal play in early stages of phonological development relies on the development of the musculoskeletal systems, auditory refinements, and vocal contagion with parents and caregivers, which provide a lead-off to turn taking and social interactions.

**Contribution to PROMPT:** The development of the organism has a distinct relationship to the development of sound production and the way in which sounds can be produced and used. If normal development within the musculoskeletal system does not occur within the expected time periods, it may impede (to greater or lesser degrees) the ability of the speech-motor system to develop adequate motor abilities for speech and, therefore, language.

**J.H. Jackson: Evolution and Dissolution**
Jackson described evolution as “ascending development in a particular order”. The progression was from CNS centers which were relatively well-organized at birth (medulla, Pons, midbrain,) or the lowest centers to those which were continually organizing through life, or the highest centers (cerebellum, cerebral cortex). Jackson felt that as maturation occurred this progression was from the most simple to the most complex, the most organized to the least organized and from the most automatic to the least automatic. Conversely he also felt that through age, disease or accident the neurological system could revert to earlier or more organized, less complex, more automatic behaviors.

**Contribution to PROMPT:** Jackson’s theory of evolution and dissolution reminds the clinician that early reflexes provide the initial or primary movement patterns, with which the infant contacts its world and begins the diversification of multiple action sets. As such, it is critical that the PROMPT clinician evaluate the client’s neurological condition and assess how much independence of movement may be achieved e.g. reflex actions to consciously controlled motor behaviors. The presumption is that as control at lower levels is established, more muscle interaction or integration at higher levels will be seen. Conversely in adults who have suffered trauma or stroke the reverse condition can prevail. In other words, more complex behaviors may be reduced back to uninhibited reflexes and loss of voluntary control.

**O. Sporns and G. Edelman: Neuronal Group Selection Theory**
Neuronal group selection theory (NGST) suggests that brain circuitry is plastic and responds to environmental changes. Depending on the outcome or success of repeated actions, which have used somatosensory inputs to relay tactual information, the neuronal maps are modified. The rutted in patterns or most efficient neural pathways are called engrams. Within the brain these neural pathways then provide integration across multiple sensory and motor areas and flexibly allow for the organism to pull forward the most effective, yet flexible, motor action to meet the task demands. NGST also postulates that...
motor-speech output is organized into gestural synergies or motor action sets and that these sets although holistic in nature are flexible enough to permit “motor equivalence” or the ability to reach a target with varying degrees of freedom.

**Contribution to PROMPT:** NGST supports the reason that dynamic tactual input is important in changing speech motor action sets or patterns of movement for speech production. It suggests that through somatosensory feedback, the more often the correct pattern is achieved and leads to success for useful or functional purposes, the more likely that existing neuronal maps will be altered and the stronger the connections or engrams will become. NGST provides a neural underpinning for Dynamic Systems Theory and suggests that both the organism and the environment are necessary for developing refined and flexible motor behavior.

**J. Kaas: Brain Plasticity**

J. Kaas’s position and research substantiate the fact that plasticity of the brain exists within the neuromotor pathways. The brain can reorganize itself in terms of sensory information depending on the information that is received. Tactile information may directly influence the development of neuromotor pathways. Kaas’s work has primarily focused on the sensory cortex. His contribution suggests that, as therapists, we can change the representation internally by what happens externally. We can use tactile and sensory information to augment the development of more intact or new pathways and cortical maps.

**Contribution to PROMPT:** Kaas’s research suggests that external input, especially that arising from sensorimotor experience (or direct tactile and kinesthetic manipulation), may change internal representations and create new pathways in the brain that affect both recognition and use of sensorimotor information.

**R.A. Schmidt: Schema Theory**

R.A. Schmidt’s theory, known as the “motor response schema,” describes how a motor skill is learned. A motor response schema allows the individual to exert skilled movement action in attempts to satisfy some goal. In order for a motor response schema to occur there are four necessary conditions need to be met.

1. **Initial conditions** for the movement: Information received by the muscular system from the various receptors prior to the response, such as proprioceptive information about the positions of the limbs and body in space, as well as visual and auditory information about the state of the environment. After the movement the initial conditions used to plan the movement are stored in the motor memory. (In speech, it would be the initial position of the articulators).

2. **Response specifications** for a motor program: The forces and speed involved in executing the movement in question. The subject must specify elements before the movement can be run off (speed with which it is run off). After the movement is executed, the specifications used are stored along with the other information received after the movement. This stored information serves as a record of the specifications of the movement produced, and serves as the basic motor plan (in speech, this would represent the basic motor plan for a phonetic sequence).

3. **Sensory consequences** embody the kinesthetic feedback produced by the motor response: During the movement, the subject compares the incoming feedback (feedback...
stimuli from the eyes, ears, proprioceptors, etc.) produced by the motor response.

(4) **Response outcome.** The outcome of the movement, or the success of the response in relation to the outcome originally intended is evaluated. The movement is stored and compared to what was intended. (In speech this refers to the actual outcome for the articulatory program). It is the interplay and relationship of these conditions that ultimately represent the schema for the movement type under consideration.

The theory describes two types of memory: Recall and Recognition. Recall memory is essential for the generation of motor commands; Recognition memory evaluates the response-produced feedback to derive error information. The theory, although having some empirical support, is weak in some areas in that it does not account for developmental influences, and does not make reference to individual differences in schema formation.

**Contribution to PROMPT:** It reminds the clinician that speech requires many different elements in both sensory and motor production in order to be successful. It also requires the clinician to evaluate the client’s ability to be able to both remember and recall movement sequences, and be able to compare and contrast them in order to change motor outcomes.

**Speech Motor Control**

**Implications for PROMPT**

1. **Traditional Conceptualization of Speech Motor Control**
   - Hierarchical, top-down models
   - Linguistic, phonological, phonetic, muscle contraction, movement, acoustic result
   - Limitations: Motor Control is not quite a simple linear process
   - Traditional models ignore many bottom-up influences, such as sensory aspects of motor control, biomechanical properties of muscles (such as tone), effects of reflexes, etc.

2. **An Improved Representation of Speech Motor Control from findings in Contemporary Neurophysiology**
   - Efficient speech production requires management of multiple biological conditions in order to produce **“equivalent” acoustic end-products**, even in the face of moment-to-moment biomechanical influences in the system. Current models attempt to account for moment-to-moment influences that require the system to constantly revise the intended motor goals.

3. **Speech Coordination**
   - Speech requires tight **temporal and spatial coordination** among movements that include:
     a. manipulation of air volumes
     b. generation of airway constrictions and volumes
     c. dynamic shaping and sizing of upper airway cavities
• Each function is, in turn, the result of multiple movements that must be tightly coordinated with regard to time of initiation and termination and magnitude of movement.

• Individual productions are not stereotyped; they vary based on points of initiation of articulators, muscle tension, lower-level reflexes, etc. But perceptually, the end results are equivalent; “motor equivalence”. Thus, there exists within normal systems the inherent ability to incorporate and accommodate changes in motor control based on physiologic conditions.

• The ability of the system to be flexible under different conditions facilitates the learning of skilled motor behavior (Abbs et al., 1984).

• **Flexible multimovement coordination** that is responsive to the **state of the system** and **varying contextual demands**, such as rate of production, loudness (shouting, whispering, normal speaking level), results in several treatment implications:
  a. Articulatory spatial targets are not stereotyped.
  b. Perceptually identical productions are achieved with motor variability, thus the system must be trained to respond to the variable conditions and yet achieve perceptually identical, similar utterances. This requires that **moment-to-moment flexible adjustment** be made by the system.
  
  c. At higher levels, the general structure of the motor act is defined in abstract terms (phonology), but only those properties that remain **invariant** are specified. (PROMPT candidates are intact at this level).

  d. At lower levels of organization, the muscles required and their temporal aspects of activation are defined based on sensory feedback, the conditions of the system, context, etc. (These are the parameters that PROMPT trains and retrains).

  e. It is hypothesized that PROMPT, through exaggerated sensory feedback:
   - first, reduces the degrees of freedom available to the system through stabilization and increased sensory feedback (most primitive level of learning); and
   - second, trains the system how to accommodate different and continuously varying “states” to produce equivalent perceptual end products.

• PROMPT does not train static spatial end products, nor does it train “phoneme” production alone. It highlights the most appropriate spatial and temporal aspects of each utterance, given the state of the patient’s system and the demands of the task. Given the conditions of the system and the demands of the task, and to achieve perceptual and acoustic equivalence, the PROMPT will vary for the same utterance by the same patient.
4. Sensorimotor Integration for Speech Motor Control

- Sensorimotor integration is active during both speech programming and execution. Some pathways are preferentially involved in programming (basal ganglia, cerebellum, supplementary motor cortex, and premotor cortex), and others in execution (projections to primary motor regions via the somatosensory cortex via the thalamic projections from orofacial regions).

- There is a firmly established interdependency between coordination of speech movements and sensory processes. For example, for both programming (apraxia, developmental and acquired) and execution (dysarthria, developmental and acquired) disorders, as well as disorders based largely in sensory disturbances (disordered speech due to hearing impairment).

- Thus, habilitation and/or rehabilitation that focus on the (re)establishment of control via the use of external efference (biofeedback) should be effective.

5. PROMPT Highlights Sensory Input by Encouraging:

- Pre-response postural tuning (pre-tuning) (Kelso & Tuller).

- Overall reorganization of a movement based on context after postural pre-tuning has been achieved (parameter estimation).

- On-line compensation by the collective of structures involved (on-line shaping).

6. The PROMPT-Appropriate client/patient should have:

- Relatively intact “underlying linguistic intentions” (pre-linguistic signaling)
- General Motor Goals targeted could be:
  - not learned
  - mislearned
  - partially lost or confused

7. Initial goals of PROMPT should be:

- Establish facilitative postural pre-tuning

- Reduce or restructure the number of degrees of freedom available to the system, i.e., setting the boundaries.

8. Intermediate goal of PROMPT:

- Once general parameters of movement are set, PROMPT aids patients/clients in the process of mastering redundant degrees of freedom to achieve motor equivalence; i.e., “controlling biomechanical and reflexive influences and utilizing sen-
sorimotor input effectively," and through efficient coordination of autogenic and non-autogenic responses.

9. Final goal of PROMPT:

- Organization of the speech process as a whole in which redundant degrees of freedom are controlled using flexible, expedient, and economic methods of overcoming all influencing variables, such as biomechanical conditions, reflexes, etc., i.e., flexible accommodation by the nervous system of multiple degrees of freedom.

**COGNITIVE-LINGUISTIC DOMAIN**

**E. Thelen: Dynamic Motor Action Theory**

E. Thelen hypothesizes that the human system is a complex yet coordinated system that works toward the most efficient end result, and that the production of speech requires the most complex and flexible contributions of all systems. Speech production involves the processes that examine the interplay between the receptive organism and the social/physical environment. The receptive organism involves the genetic and neurological integrity of the individual and the influence of the environment on that system. Thelen defines “coordination” as occurring when the activities of participating elements are related to one another in space and time in an ordered way. All the participating units involved exhibit flexibility and degrees of freedom in their movements across spatial planes within a limited framework to achieve a motor action. Degrees of freedom refer to the amount of movement in and across spatial planes.

In summary, all participating units of a dynamic system have certain degrees of freedom that stabilize and come together to perform a coordinative action. This action can be very specific to an individual and can result in an adequate or an inadequate patterned action. These preferred movement configurations or patterned actions are also referred to as “attractor states”. The attractor state has certain boundary conditions that are energetically efficient or specially preferred or learned by the individual system. Attractor states occur in normally or abnormally developing systems. When either outside constraints or developmental changes in the skeletal structures or their influence on musculature occur, a “phase shift” may result. In normally developing children, phase shifts occur continually throughout early speech and language periods. In contrast, some attractor states, which may be caused by structural and neuromuscular abnormalities, may continue to persist and thereby result in a motor system that is out of balance and impacts the development of efficient motor speech patterns.

**Contribution to PROMPT:** Changes and development of coordinated systems can emerge from the reorganization of internal or external (environmental) sources. Systematic reorganization (helping the child move from less efficient “attractor states” through “phase shifts” to more efficient “attractor states”) will produce the most efficient and flexible motor control for the development of speech.

**J. Piaget: Sensorimotor Aspects of Cognition**

Piaget’s work in the area of cognitive development had a great impact on many developmental language theorists. Piaget offers strong support for cognitive precursors to language skills. His view suggests that children must first learn to think symbolically (sensorimotor
actions developed through schemas) in order to develop language. He states that the cognitive precursors to language are both paralinguistic and linguistic, and include: imitation skills, knowledge of means-ends relationships, object permanence, and symbolic function (being able to ‘hold in mind’ nonpresent objects and events).

According to Piaget, children learn about the world through experiences and they learn to convey ideas through language. This is reflected in the actions, movements and concepts they use (schemas).

**Contribution to PROMPT:** The clinician is reminded to identify where the child is in the developmental sequence, and to remember that there is a general sequential pattern of ordinal skills development. Also important in intervention is to match the child’s mental stages and activities of compatible lexicons, both motorically and cognitive-linguistic, that are both cognitively appropriate and functional.

**L.S. Vygotsky: Social Cognition and Language**

According to L.S. Vygotsky, social interactions are the basis for language learning. Vygotskian theory requires the active, direct participation of an adult, who is the consenting communication partner. Vygotsky’s ideas about transactional learning suggest that all individual psychological functioning, including language, is acquired through social interaction with a more experienced and competent member of the society. Vygotsky feels that any function in the child’s development happens on the social and the psychological planes. This process of moving from other-regulation to self-regulation allows for independent problem solving by the child.

**Contribution to PROMPT:** The social aspects of intervention and mentorship (adult modeling of language and social behavior) are critical in the developmental relationship between the clinician and the client.

**K. Nelson: Event Knowledge**

K. Nelson’s research views the child’s knowledge of everyday experiences and their mental representations as the foundation for thinking, talking, and acting. She describes “event knowledge” as a dynamic mix that encompasses people, objects, and actions in one whole configuration, and explains that central to this idea is that everyday life routines provide a secure base of knowledge to the child. The event knowledge encoded in the child’s event representation includes understanding of the temporal sequence of sub-events making up the overall event and the roles of the participants. Nelson’s data suggest that language in familiar or routine events is more advanced talk than talk accompanied by toy-oriented free play. In planning language intervention, it stresses the building of familiar contexts within which to train language.

**Contribution to PROMPT:** It is critical to view the speech-language delayed child in both the cognitive and social domains and to structure intervention to include predictable social routines, which establish naturalistic speech and language forms.

**J. Bruner: Scaffolding in Language Learning**

J. Bruner uses the term “scaffolding” to refer to the process of transactional learning. Adults
scaffold the child’s language learning of a task by providing simpler talk, or “Motherese”, and by capitalizing on familiar, routine, highly constrained events that Bruner calls “formats”. Formats contain a sequential structure, marked roles, and scripts. This position, in which skills are transmitted in routine events, offers a more viable framework for teaching than the other theories discussed previously. A transactional learning approach specifies the role of the adult in language learning.

**Contribution to PROMPT:** That small-step progressions and guided interactions are necessary for social language learning. Also critical are routines and roles that provide consistency and import speech and language forms that are predictable, functional and appropriate.

**Bates and MacWhinney: Resource Allocation**
The competition model initially described by Bates and MacWhinney is a dynamic model of language performance. The model contains several key principles that are grounded in the way we engage information processes in the service of language performance and acquisition. They remind us that perceptual cues influence children’s language learning especially if they occur frequently and if used consistently within a task that this perception will grow in strength. They also suggest that if the cue is not always reliable, is difficult to perceive or detect that it will cost the child extra processing resources.

**Contribution to PROMPT:**
In the competition for “limited” processing resources, what gets attention and remembered may be determined by how important or relevant something is to the individual. In PROMPT intervention we must identify variables that influence the child’s attention, memories and how the child may compensate for processing problems.
A. Wetherby discusses the communicative functions of language. They can be pre-linguistic, linguistic, nonverbal, or verbal. These communicative functions represent a variety of specific purposes or reasons for which the child communicates. For example: to request, to protest, to call, to show off, to regulate the behavior of others, or to direct another’s attention to an object or event. Wetherby has developed research and test instruments analyze the communicative functions of young children. For example: the communicative temptations, which assess how a child responds, nonverbally, verbally, orally, visually, or gesturally; the reasons why a child communicates; and the type and number of turns taken.

Contribution to PROMPT: Clinicians are reminded that the intent to communicate, whether verbally or nonverbally, must be present before speech and language intervention can begin. Communicative functions are critical in the development of PROMPT intervention, and, where possible, every effort should be made to develop normalized “functions” along with expressive speech productions.

L. Bloom: Language development and emotional expression
Bloom feels that language acquisition is the result of an essential tension between the effort that is required and a child’s engagement. Her research supports a single resource model where different kinds of expressive action draw on the same pool of resources and will see the effects of collaboration and competition for resources between different behaviors. In general she feels that 1.) Actions depend on one’s interest and engagement in an event as well as the attention and effort that they require. 2.) That that development is enhanced when the child acts to resolve a mismatch between the child’s contents of mind and what others have in mind in the situation. 3. That the need to elaborate on ideas presses the child to act in increasingly more detailed ways to express the increasingly elaborated intentional states that developments in cognition make possible. 4. That language is not separate from the rest of cognition, action, and emotion for the young child. 3.) That language, emotional expression and actions in play tap into the same general resource pool where resources are fundamentally limited, and that effort is required to coordinate different expressive actions and integrate them into everyday activity. 4.) And finally, that Intentionality provides the connecting link.

Contribution to PROMPT: Bloom’s research supports a single resource model where resources are fundamentally limited. This reminds PROMPT clinician’s that while all aspects of the child must be considered in treatment, while one aspect is focused on, the others must take a lesser role or be less demanding. Emotions or emotional behavior also consume resources and so remind us that if a child is upset or anxious, other behaviors which might be normally well accomplished e.g. more accurate speech production or use of phrases, will likely suffer.