

The PROMPT model: Use and application for children with mixed phonological-motor impairment

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Abstract

PROMPT (Prompts for Restructuring Oral Muscular Phonetic Targets) a tactually grounded, sensori-motor, cognitive-linguistic treatment model is explored as a philosophy, approach, system and technique. The PROMPT Conceptual Framework and the Motor-Speech Hierarchy are described as frameworks for both assessment and treatment that help clinicians develop a holistic communication focus for treatment, while embedding motor, language and social interaction goals. The role of technique and tactual systems in PROMPT are explained with relevance to their use and application with children who have moderate to severe mixed phonological and motor impairment. General assessment guidelines and priorities for treatment, with one case study are discussed.

Keywords: *Dynamic system, speech-motor disorder, phonological disorder, mixed disorders, tactual-kinesthetic therapy approaches, somatosensory system, PROMPT therapy.*

Introduction

PROMPT is a tactually grounded sensori-motor, cognitive-linguistic model and approach for speech production disorders (Chumpelik, 1984). Originally created to enhance and restructure the oral muscular phonetic targets of speech, PROMPT has evolved into a complete model for both assessment and treatment (Hayden, 2004). In PROMPT the theories of many different scholars have been integrated into a synergistic whole. Contributions from the fields of neurobiology include Kent (1981; 2004), Kelso and Tuller (1983), Abbs (1988), Gracco (1990), Kaas (1991; 2004), Fletcher (1992), as well as Green, Moore, Higashikawa, and Steeve (2000). Cognitive and linguistic contributions include those of Piaget (1964), Bruner (1977), Vygotsky (1978), Menn (1982), Nelson (1986; 2004), Strand (1992) and Thelen (1995; 2004). Contributions relative to the social and pragmatic domains include those of Bates (1976), Bloom (1989; 2004), Gallagher (1991) and Wetherby (1991). PROMPT's focused use of active tactual-kinesthetic, and proprioceptive information was influenced by the early work of scholars and practitioners who explored the tactual system in the neurological organization of normal and diseased brains (Head, 1926; Jackson, 1958; Mountcastle &

Powell, 1959; Mysak, 1968) and those who accepted its use in the clinical treatment of motor disorders including speech articulation (Ayers, 1974; Bobath, 1971; 1980; Stitchfield & Younge, 1938). Fundamental to its framework, the PROMPT model is based on the belief that the whole child should be involved in treatment. Therefore, it does not treat individual components of the speech musculature or actions that are not completely involved in producing co-articulated speech.

First, the PROMPT model as a general system will be described. Then, a brief discussion about current philosophical divisions between linguistic and motor approaches and how PROMPT is different from existing phonological approaches will be presented. Finally, a complete analysis of a specific case (a child named Jarrod), and how PROMPT would conceptualize a treatment plan for that case is offered.

Philosophy

More than a hands-on method of speech correction, the philosophy and conceptual framework of PROMPT addresses the entire act of communication, including how the physical-sensory, cognitive-linguistic and emotional-social domains develop and interact in normally developing humans (Figure 1).

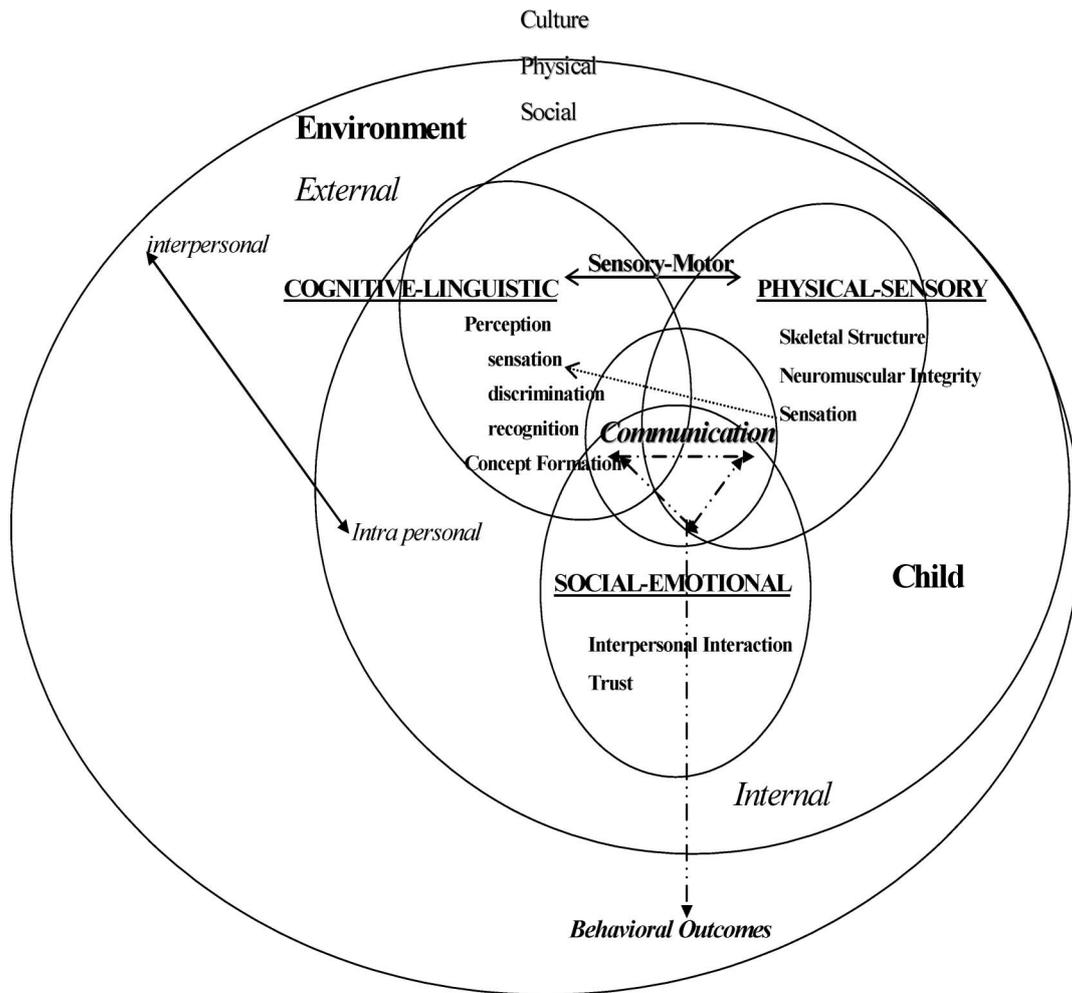


Figure 1. PROMPT conceptual framework.

As suggested by the framework, these domains are thought to be integrated and co-dependent. The framework also states that communication may be disrupted by a breakdown in any or all three domains and that, although a single domain may be viewed as the most impaired, all other domains will remain underdeveloped or impaired to some degree. Thus, to strengthen the weakest domain, all domains must be (re)integrated and that (re)structuring should alternate focus among all domains, realizing that the timing and order of focus will be individually determined (see Appendix 1). While it is realized that the domains are truly integrated in a functional human, they are separated in the PROMPT Conceptual Framework for the sake of assessment and for identifying similar processes or concepts. PROMPT also presupposes that one of the most important organizing factors in human development, affecting all domains, is active touch which refers to both surface contact and the co-occurrence of tactual, proprioceptive, and kinesthetic information (Cholewick & Collins, 1991). Touch then, is viewed as needed for helping to recognize and organize: (1) physiological states such as fight/flight alerting, settling, the ability to discriminate and focus; (2)

cognitive states such as association of information, and various levels of perception and concept formation; and (3) social-emotional states such as nurturing, the development of self, differentiating self from others and the ability to develop trust. From this position, touch may be viewed as the underlying glue that holds all other sensory systems (e.g. auditory, visual, and tactual information) together. Touch also promotes the amalgamation of focus, the development of cognitive-linguistic associations and greatly enhances the development and refinement of speech subsystems in oral communication.

Approach and System

The approach of PROMPT helps guide the speech-language pathologist's assessments or investigation of each domain and provides both conceptual and motor speech frameworks for organizing this information (Hayden, 1985; 1999; 2004; Hayden & Square, 1994). As an example of how assessment information is organized and analysed within each of the domains, the reader should refer to Jarrod's case study presented later in this chapter. The reader is

also referred to Hayden (2004) for critical questions that need to be answered within each domain before a global domain evaluation profile may be completed. The Global Domain Profile (Hayden, 1999) aids the clinician in organizing informal and formal assessment data from all domains to determine the relative strengths and weaknesses within and across domains. It also summarizes how the child learns best using different but cumulative sensory modality information (auditory, visual, tactual) and allows the clinician to develop an appropriate communication focus or foci for intervention, (e.g. self-help skills, interactive communication routines, academic skills, etc.). The selection of a communication focus then helps the speech-language pathologist and parents/caregivers determine priorities for the child. Additionally, the selection of a focus provides a context in which to embed motor, language, cognitive, and social interaction objectives into a cohesive approach to intervention.

Once all domains have been analysed, the speech subsystems are then evaluated. This evaluation may be informal, using tools such as the PROMPT System Analysis Observation (SAO) form (Hayden, 1985), or formal using tools like the Verbal Motor Production Assessment for Children (VMPAC) (Hayden & Square, 1999). Information obtained using these tools is then transferred to the Motor-Speech Hierarchy (hereafter the Hierarchy, see Figure 2), (Hayden, 1986; 2004; Hayden & Square, 1994). The Hierarchy is used to systematically evaluate the child's motor speech system and identify the levels or stages where problems occur. The Hierarchy identifies seven stages of motor-speech development and control. These stages are assumed to be hierarchically dependent, interactive and directly influence the development of succeeding stages. Of note, within the model prosody is shown in Stage VII where it is related to the production of suprasegmentals and stress changes which alter word and phrase meaning. However the arrows also denote that the beginning development and use of prosody is related to earlier stages (Stage II phonatory and Stage III mandibular) in the formation of prosodic contours. For a detailed description of the Hierarchy see Hayden (1986) and Hayden and Square (1994). In order to change speech production motor skill, it is assumed that the lowest levels need to be developed and/or refined before additional development or refinement can be expected at higher levels. Working with the subsystems is necessary to develop continued (1) speech subsystem motor refinements and/or, 2) new or normalized "attractor state" changes that will allow for more balance and equilibrium in the interaction of the speech subsystems. Attractor states, as suggested by Fogel and Thelen (1987), may be regarded as behaviours within a range of contexts and biological conditions that will retain a dynamic stability, or overall task orientation and offer resistance to minor perturba-

tions. The Hierarchy proposes that developmental motor speech treatment must proceed in a systematic fashion, first by establishing adequate physiological support for speech as pertains to tone, trunk control, respiratory function, phonation and then by establishing control of speech movements of the supralaryngeal articulatory systems, jaw, lips-face and tongue. The supposition inherent in this hierarchical model is that appropriate speech lip gestures will not be established unless appropriate speech jaw movements have been normalized. Likewise, it is presumed that normalized appropriate lingual speech movements will not emerge without the infrastructure of normalized labial and mandibular speech gestures. Put another way, if jaw speech gestures are inappropriate then, lip and lingual speech gestures as well as speech sequencing will be deviant. Indeed, there has been some recent evidence from the developmental speech motor control literature that mandibular movements are some of the first to stabilize, followed by labial, in normal motor speech development (Green et al., 2000; Kent & Vorperian, in press). While some motor speech disordered children may have fairly normalized mandibular speech movements, their speech labial movements may not be normal. Hence, it is likely that other subsystems will be abnormally influenced. Thus, PROMPT is applied to establish the appropriate degrees of freedom for speech movements for each subsystem, and the appropriate limits or boundaries of those movements. Enhancement of the feel of speech movements as well as their sound and visual appropriateness are the foci of PROMPT. Using these stages (e.g. phonatory control, mandibular control, labial facial control and lingual control, etc.) which are dynamically interconnected in normal development, phoneme and syllable inventories are rapidly expanded. Depending on the control within and among the various subsystems, early syllable shapes, words or phrases are developed. These syllables/words create the first of many expanding lexicons for the child (Hayden & Square, 1994; Hayden, Wetherby, Cleary, & Prizant, in preparation).

From the Hierarchy, at least three stages are prioritized. Prioritization of the stages allows the clinician to remember the importance of each stage's immediate contribution for either continuing developmental motor refinements or a needed "attractor state" change that will allow for more balance and equilibrium in the interaction of the speech subsystems (Thelen, 1991). As a point of reference, in PROMPT phonemes are conceptualized as abstract representations of mental constructs that represent the smallest units of sound that can change the meaning of a word or in the case of a phonological disorder where the child has difficulty organizing their speech sounds into a system of sound contrasts. However in PROMPT these abstract representations are thought to be brought about initially through the

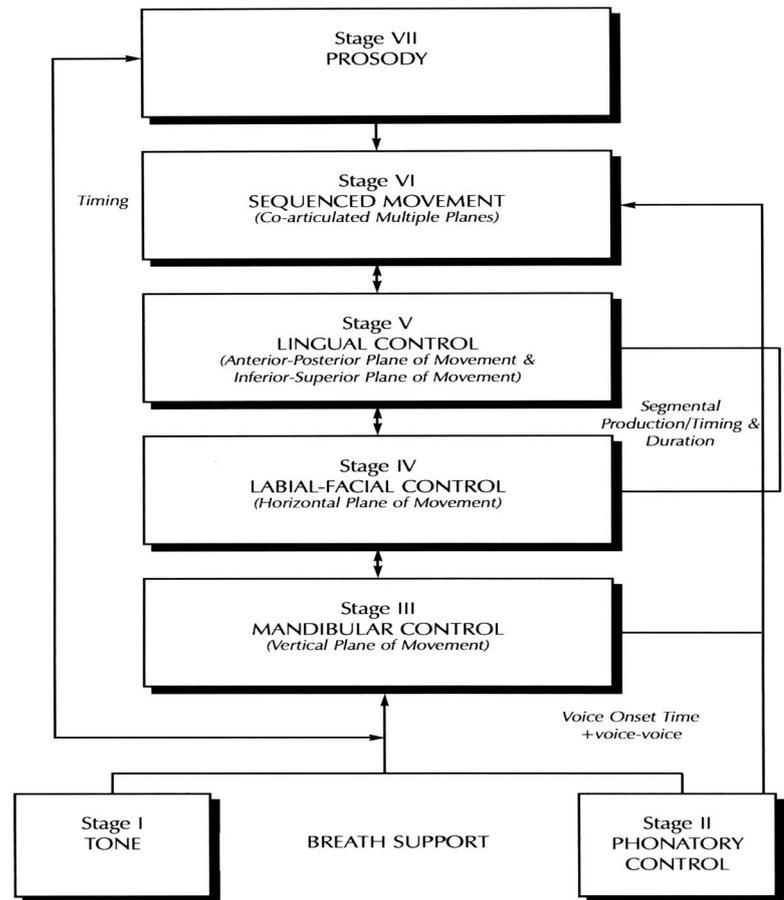


Figure 2. Motor-speech hierarchy. Adapted and reprinted with permission from the Motor-Speech Treatment Hierarchy by D. Hayden (1986).

motor speech system. The acoustic, tactual, proprioceptive, and kinesthetic feedback provided during motor learning are not simply overlaid on the cognitive-linguistic representation but rather help to construct that representation. Thus, cognitive-linguistic and motor learning are seen as parallel and interactive processes rather than being independent. Put another way, in PROMPT phonemes as abstract lexical representations are hypothesized to be grounded in the motor system. As a result of this interactive view, the term “motor-phoneme” is used in PROMPT to describe the motor requirements and interactions that produce the acoustic characteristics which represent cognitive and linguistic constructs, retain meaning and symbolize language and language form. Additionally, a speech-motor template may be thought of as a *static* representation defining the properties or features of a phoneme that are required to differentiate it from another in a language. These features define the tactual input given in PROMPT and how it is applied differentially across sounds (Chumpelik, 1984). A motor-speech schema then may be thought of as a well developed, unconscious or conscious, template for a speech motor *action*, as for example mouth opening or closing (Bellezza, 1987). When schemas are put together in various combinations, the term coordinative structure is used. An early example of a coordinative structure in speech may be represented by reduplicated

babbling (Kent, 1992; MacNeilage & Davis, 2000). In reduplicated babbling there are two schemas (jaw opening and jaw closing). These are then put together resulting in a coordinated structure or the first serial actions which will develop vowels plus bilabials. As the child in this early stage of development is using holistic “ballistic” movements, they are not yet able to grade jaw action as regards timing and pressure; therefore initially the resulting productions may be purely voiced [b], voiced + nasal [m] or if at the end of a breath, voiceless [p].

Therefore, as discussed above, depending on the control within and among the various speech subsystems, early syllable shapes, words or phrases are developed. These words, considered as the PROMPT lexicon, must be functional or be able to be used functionally for interaction, or with activities or tasks that provide a scaffold for the motor goals and also meet the cognitive and social requirements for the individual. Requisites for PROMPT lexicons must include:

- (1) Syllable or word forms that support chosen Motor-Speech Hierarchy priorities and motor goals. For example, if a child is having difficulty using appropriate mandibular excursion (i.e. range is overextended), most syllables or words would need to include high-mid vowels (e.g. /i/, /u/, /o/) that require

the jaw to be in a restricted position and/or low vowels (e.g. /æ/, /ɒ/), where a new restricted lower range boundary may be established. Several syllables or words with different vowel heights, but controlled initial or final consonants (e.g. /m/, /b/, /t/, /d/), would be necessary to teach jaw grading with stable midline control.

- (2) Syllable or word forms that are useful and function in a number of environments with different communication partners. For example, words that indicate agreement (e.g. *yes*), non-agreement (e.g. *no*), or reoccurrence (e.g. *more*, *want*, etc.) will be useful with many partners and in many environments. Nouns, while functional in some situations, must be considered for their motor complexity and relative frequency. Prepositions (e.g. *in*, *on*), pronouns, (*I*, *me*, *you*) and some verbs (e.g. *go*) are often more useful than nouns.
- (3) Syllable or words forms that are cognitively and semantically appropriate to the mental age of the child and to the activities, games and routines expected. For example when in an activity talking about *mom* in a very young child, aged 12 months to 24 months forms such as /ma/ or /mɒmɒ/ would be appropriate. Later between 24 months and 3 years forms such as /mam/ or /mami/ might be used. Later still, say age 4 years and up (depending on cultural standards, dialect issues and the amount of motor control that the child has acquired), forms that are more formal might be used for example *mother* /mʌðə/.

Activities are then selected to support the Communication Focus and provide a context in which to embed the motor, cognitive and social objectives. After careful examination of the child's overall functioning using the Global Domain Profile, the Systems Analysis Observation checklist and the Motor-Speech Hierarchy to organize the assembled information, the most salient modalities are used to support information processing, retrieval and production (Hayden, 1999; 2004).

As an example of this process, in a child who has phonological disorder with accompanying entrenched compensatory motor movements, attributed to an unbalanced speech subsystem development, the child's overall body posture and speech mechanisms need to be in a normalized state before beginning speech production tasks. Thus, within the constraints of any structural abnormality, the jaw needs to be up, the mandible and maxilla in alignment, the lips need to be in a neutral, at rest posture, and the tongue needs to be contained within the oral cavity. Incorrect positioning or posture at any level in the motor system makes it difficult for the child to execute the desired movements in a controlled and

refined manner. Using the tactual modality (as described below) allows the speech-language pathologist to help the child to position his/her body as well as set up the mandibular and labial-facial musculature, so that the child can be in an appropriate state of readiness for motor movement. This ready state is referred to as "postural-pre-tuning" (Kelso & Tuller, 1983).

Cognitive abilities will dictate to the speech-language pathologist the type of activities to encourage communication, as well as the level of language to be used. The impact of cognition on social and pragmatic skills is well documented (Kent, 2004; Rogers et al., in press; Wetherby & Hayden, 1990). Another important issue is an awareness of cognitive load. If the individual is struggling with one aspect of performance (e.g. speech motor control) requiring simultaneous performance of another difficult task (e.g. an activity which requires a high level of thought processing or one which requires fine hand-eye coordination), such a combination is likely to result in further difficulty (Bloom, 2004). Thus, there is a need to either reduce the load required for one task or to separate the two tasks. Establishing where a child's skills lie in each area usually requires input from the parents and a variety of professionals. This holistic view of the child assists in a more accurate targeting of skill acquisition at a level appropriate to the child, given the degree of involvement in each of the domains.

The role of technique and tactual systems in PROMPT

Technique involves the clinician providing *active* tactual-kinesthetic-proprioceptive sensory input to the child's articulators to facilitate speech production. Active touch provides both tactual information to the skin to enhance cutaneous sensations (tactile) as well kinesthetic information about spatial position and movement. This input is always directly paired with auditory sensory input. Visual information is considered secondary and is only used when specific attention to an aspect of motor production needs focus. For example, it may be necessary to show the child that they are using too much jaw extension or too much rounding. This multimodal input provides information to the child regarding the "sound", "sight" and "feel" of the desired speech movements and may be provided to help guide accurate development of the single sound (e.g. construct a motor-phoneme template) or provide motor planning for syllables or phrases by developing schemas or coordinative structures. Prompts may be delivered to the jaw, to provide midline stability, control of range and grading, to the labial-facial musculature, to develop appropriate rounding, retraction, closure and timing, or into the mylohyoid tissue from the anterior to the posterior, to signal information about place, timing and amount and width of contraction

within the tongue body. These prompts provide stability to the articulators and signal the most salient motor aspect of the sound (while also providing information about timing and transition). They also are used to combine stops with vowels which are rounded as in /u/ or retracted as in /i/ for early syllable shapes, or to specify as many features or motor properties necessary for the creation of a single motor-phoneme (see complete descriptions later in this section). In the original description of PROMPT (Chumpelik, 1984), each of the English phonemes had a corresponding Surface prompt. For each motor-phoneme, the following parameters were specified: jaw height, facial-labial muscle contraction, muscular tension, tongue height and advancement, duration of contractions, and air stream control at the laryngeal and oral-nasal valves. As PROMPT has developed over the years four prompt types have developed (e.g. Parameter, Syllable, Complex and Surface) which allow input into different aspects of the speech motor system and provide emphasis on training parameters (range) of movement and movement trajectories and acceptable boundaries of movement for each oral subsystem: jaw, lips and tongue. There is now a strong de-emphasis on training motor-phoneme end products. Instead PROMPT creates a functional lexicon of words that can be combined into phrases which embed the motor actions that need development, refinement, or emphasis.

Depending on the chosen Communication Focus or foci and developmental level of the child, Technique may be used to develop an interactive focus between the speech-language pathologist and child, for example, to direct tactual input to provide awareness and focus for initial communication exchange. Technique may also be used to provide associative mapping for a word or concept. The term "mapping", as used in PROMPT, may be described as providing tactual feed-forward information about motor plans (schemas) and their variations. Equally, because mapping directly links motor actions to lexical information, it is useful for associating motor schemas to cognitive and linguistic concepts. In mapping the clinician sequentially cues each sound along with the necessary transition and timing aspects into the next sound using Surface prompts. For example, the clinician may use surface prompting to map in a word form such as *up* to associate it with the child climbing up. No requirement for production is expected in this condition. Finally, Technique may be used to help organize, rebalance, or develop refinement and flexibility of the speech subsystems (Hayden, 1985; 1999; 2004). Consequently, to do PROMPT intervention well clinicians need to know the specific places where muscles insert and contract and how to apply deep pressure to soft tissue. They also must recognize that the length of time pressure is sustained will affect how well the motor system learns to recognize when to set up and

release muscle contractions, especially for movement transitions. As therapy progresses through the various phases, it becomes critical that a clinician has automatic skilled use of hand and finger placements.

Prompting requires that postural control of the body-trunk, neck and head are stable and supported. The speech-language pathologist normally uses his/her non-dominant hand to support the back of the head between the skull and the nape of the neck. This support provides head and neck stability and acts as a counter balance for pressure applied in prompts of the jaw, labial-facial musculature, and mylohyoid or the muscular tissue under the chin.

As previously stated there are four different PROMPT types (Chumpelik, 1984; Hayden, 1985). Briefly, the four types of prompts used in the Technique are:

- (1) *Parameter Prompts*. These prompts provide *maximal support and stability* to either the mandible or facial muscles, thus setting *either* the degree of opening of the mandible, *or* the broad action of rounding or retraction of the facial muscles. Parameter prompts function to stabilize facial structures or musculature so that other smaller structures (e.g. lips, tongue, and so on) can be freed up for more independent movement and become perceptually salient.
- (2) *Syllable Prompts*. These prompts shape beginning CV or VC syllables. They set and support *both* the mandible (degree(s) of opening) and actions of the facial muscles (rounding or retraction) e.g. /pi/, /bi/, /mi/, /pu/, /bu/, /mu/. The postures provided by Syllable prompts always reflect the vowel shape (e.g. rounded or retracted) and effectively reduce the motor load for the child and allow for early independent actions to be established.
- (3) *Complex Prompts*. These prompts provide information about how to produce a static neuromotor or single motor-phoneme template. They provide input to the mandible about the degree of opening and specific information to labial or facial muscles (for place, and if needed, the amount of lip rounding or retraction). They also give information about timing, degree and breadth of lingual muscle contraction. This sensory input tactually describes as many properties or features of the phoneme as possible, so that a holistic motor template for a phoneme can be constructed. Therefore, complex prompts are usually given in isolation, and then re-embedded in the same or different word form.
- (4) *Surface prompts*. These prompts provide the *most critical* but least information necessary

for the neuromotor system to recognize or produce a motor-phoneme schema and maintain its essence throughout co-articulated *movement* transitions. When used in syllables, words or phrases, surface prompts signal transition from one plane of movement to the next in addition to providing timing or place information. For example, in the word “mommy” surface prompts would be given for /m/, /d/, /m/ (in the vertical plane) and /i/ (in the horizontal plane). As the movements are sequenced, the timing, pressure and stress provided by the speech-language pathologist are combined to give input about the transition from one sound to the other.

Although each prompt type provides input to a different level of the speech subsystem and is used for a different purpose, they are almost always sequenced in varying combinations. For example, a series of surface prompts (e.g. /rid/ as in *read*) may be given followed by either a parameter prompt (to maintain proper jaw range or midline control) or a syllable prompt (to reduce the motor load and establish vowel shape). Alternatively, if the production of /r/ appears to need more refinement, it may be given a complex prompt, which as described above, is a static template for the single motor-phoneme. After the multidimensional tactual input is given and the sound is produced with more accuracy, it is then reinserted back into the word and supported by a series of surface prompts. This allows the individual motor template to now be transitioned into an active schema which is combined with other schemas to develop coordinative structures for the CVC /rid/.

How PROMPT approaches the current philosophical divisions between linguistic and motor approaches

The Conceptual Model for PROMPT is closely allied with a dynamic systems framework. This implies that changes may come from within or outside of the individual, through inherited or genetic predisposition as hypothesized by Chomsky and Halle (1968) or from situations or conditions that shape or change the internal biological structures (Kass, 2004; Kent, 1992; Kent & Vorperian, in press; Stiles, 2000; Stiles, Reilly, Brianna, & Moses, 2005; Thelen, 1995; 2004). For example, the PROMPT model is consistent with the idea that multiple forces, including, but not limited to genetic, anatomical, neurological, sensory, cognitive, environmental and social have different but merging and contributing interactions to the ongoing development of an individual over time. As Fogel and Thelen (1987) suggest, there is no formal difference between endogenous and exogenous changes in components and their relationships. Emergent states

can be created either by means of environmental support or as a result of changes of components within the individual.

In the last decade, and particularly in the last few years, several researchers have proposed that “perception-action linkages” may be modulated or changed due to the effect of both sensory and cognitive influences. While these linkages were suggested by Piaget and Vygotsky decades ago, this current support is offered by way of hard scientific data that validate this view (Kass, 2004; Kent & Vorperian, in press; Smith & Goffman, 2004; Stiles et al., 2005; Tremblay, Shiller, & Ostry, 2003). These recent findings suggest that, especially during speech and language development, there is a critical interface between the cognitive-linguistic and physical sensory systems. In other words, the child is still developing both biological structures and refining motor-speech schemas, while evolving in their understanding of how the natural language is structured and the rules of phonology underpinning that structure (Bellezza, 1987; Kent, 1997; Schmidt, 1975).

Coming from the core tenets and philosophy of PROMPT (see Appendix 1) the final and ultimate goal of PROMPT therapy is the creation of a state of equilibrium across and within domains to the highest level attainable by that individual. In the motor speech system, dynamic action or equilibrium refers to the ability of the varying speech subsystems to reach target positions or transitions using differing involvement of muscle groups. Put another way, muscle groups will have the ability to reach different targets, in different positions, with varying co-articulation constraints, degrees of freedom (range), and timing. This means that no speech action or target is produced in exactly in the same way over repeated trials or in differing word forms (Abbs, 1988). It is especially for this reason that PROMPT considers the developmental stage or refinement of the speech subsystems, their ability to interact efficiently and in a coordinated fashion across several speech subsystems and the current normal or abnormal “attractor state” that is operating (Fogel & Thelen, 1987; Hayden & Square, 1999; Hayden et al., in preparation; Kent, 1992; Square, Hayden, Ciolli, & Wilkins, 1999).

In children with unbalanced speech subsystems where one speech subsystem may override and be predominate over the others, it may be said that a dominate attractor state may be inhibiting the independent development of other speech subsystems. For example, if the jaw range is overextended, poorly graded, or unstable in its movements, it might hinder both independent movement of labial-facial action and tongue-jaw separation. This is especially critical to children developing speech. If such imbalances exist, although a child may produce a fixed position/action/phoneme somewhat accurately, in co-articulated speech these attractor states will

make transitions between movements, refined movements, or complex movement very difficult.

Speech is a refined and practiced activity. The more times the child produces an inaccurate target, or is pulled into overall muscle biasing patterns within a word or phrase form, the more often those schemas are incorrectly repeated and stored in memory or become recalcitrant. It is suggested that when this state prevails that the motor system will directly influence the phonological representations. Therefore, even if the underlying cognitive potential is fundamentally adequate, it may now be adversely influenced by the motor system.

PROMPT supports this dynamic system view and recognizes that in order to deal with how the child understands and uses speech and language, it is necessary to simultaneously consider how they are able to produce and store the associated motor patterns. The two systems (sensory-motor and cognitive-linguistic) must be treated together (Square, Goshulak, Bose, & Hayden, 2000). Understanding this, the tactual system then becomes especially linked with the motor and auditory for laying down normalized motor patterns, while in production it plays an equally important part in determining if the correct action or series of actions has been executed (Guenther, 2005; Guenther, Ghosh, & Tourville, in press; Nasir & Ostry, 2006; Ostry & Tremblay, 2006; Schmidt, 1975) For information on PROMPT efficacy research over the last 30 years see Hayden (2004) or the PROMPT website (<http://www.promptinstitute.com>).

Application of the PROMPT framework for a child with mixed phonological and motor speech impairment

Background and History: Domain Analysis

Jarrold, the 7;0 old male subject of this case study, has received extensive speech and language services over a 3 year period. By all assessments he has been judged to now have a severe phonological disorder (Holm & Crosbie, 2006). His speech production disorder appears to impact his academic potential, social interaction and behaviour. All information presented in this case study was obtained through documents, audio and DVD recordings of Jarrold's testing, and reports (e.g. speech-language pathology, guidance counsellor, etc.). Extensive transcription of phonological testing was also provided in Holm (2005). A clinical profile of these areas is described below.

The physical-sensory domain

Standardized test results and observations

Jarrold's prenatal and birth history and his achievement of gross motor milestones were reported as

normal. It was reported that he had a history of early ear infections and asthma. Hearing was reported to be within normal functional limits for the right ear in 2003, but no further information was provided. Jarrold has also been diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and is currently taking Ritalin. Children with ADHD are felt to have hereditary factors that may affect brain functioning in those areas that are responsible for inhibiting and modulating behaviour. Early history indicates that Jarrold was not using words until approximately 30 months of age. Problems were also indicated in fine motor control through psychology and guidance officer reports and by several individuals including statements from his grandparents that he appeared "clumsy". Reports state that at age 5;0 years he was still using a palmer, whole-hand, pencil grasp, while his peers were able to achieve an adult-like, finger-thumb grasp. Sample printing from the non-word spelling response sheet (QUIL, Dodd, Holm, Oerlemans, & McCormick, 1996) shows letter reversals and poor control for print. Almost all reports indicated that Jarrold has had difficulty staying still for any length of time. For example, there were consistent reports of general postural control problems and arm and hand fidgeting and difficulty with maintaining eye contact. His most current speech-language pathology report (Holm, 2005) stated that he had the ability to perform independent non-verbal actions of the tongue to within normal range.

The *Verbal Motor Production Assessment for Children* (VMPAC) (Hayden & Square 1999) was administered by Holm (2005) and yielded the following scores as shown in Figure 3: global motor control 95%, focal oromotor control, 46%, sequencing, 57%, connected speech and language control 53% and speech characteristics 85%. Average scores for children of Jarrold's chronological age are 100% across all areas. These scores placed him *significantly* below the 5th percentile for his age group with the

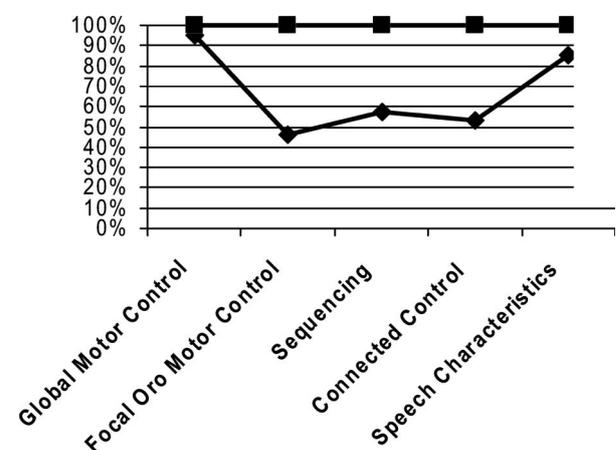


Figure 3. VMPAC Scores for Jarrold compared with scores for an average 7 year old child. ◆ Jarrold; and ■ average.

exception of global motor control which was below the 50th percentile for his age or within the low normal range. Due to difficulties with test administration, modality score data were not obtained. However, on two occasions additional tactual input was added to support his productions, and in both instances, it resulted in improved quality and sequencing for speech.

The motor-speech hierarchy

Comparison of data for Jarrod against the Motor-Speech Hierarchy (Hayden, 1986; 1994; Hayden & Square, 1994), (see Figure 2) suggests the following clinical profile:

- Stages I and II: all functions achieved;
- Stage III: assessed in connected speech, he showed poor stability and symmetry of jaw movement, as well as over excursion of the mandible and poor mandibular grading. Bilabial production most often occurred through the mandible, but when the mandible was up, independent labial productions could be achieved;
- Stage IV: in general precise medial labial contacts and independent bilabial productions, without aid of the jaw, were not always achieved. Individual labial actions for /f/, /v/ were rarely achieved. Lip rounding and retraction (e.g. /u/, /i/) were poorly produced and showed either inappropriate muscular contraction or timing or both. It was observed in the DVD recording of the VMPAC administration that over contractions in the upper labial and facial musculature occurred for /f/ and were reduced for rounding and timing for /œ/, and /u/;
- Stage V: in controlled single phonetic productions (isolated sounds), when the mandible was stable and in a neutral position, Jarrod was able to use anterior to posterior tongue contractions with adequate control. However, in connected speech lingual actions were severely compromised. The tongue tip was held down against the lower teeth and bunched in the middle often using the blade and mid-tongue for lingual alveolar productions thereby prohibiting independent movement;
- Stage VI: Jarrod had difficulty when crossing from the vertical to the horizontal plane of movement as well as difficulty moving from the anterior to the posterior plane. This was observed in non-speech sequenced actions (e.g. bite, blow) as well as in single sound productions, /a/-/u/, and observed in words for example *umbrella* [||ʌm'bʷʌ:tʰʌ||] or *kangaroo* [||beiou ʌʌu||] or *birthday cake* [||bɜfde:pʰeɪ? ʌ||]. He did better when overall mandibular movement was restricted (e.g. when

producing high-mid vowels), when the mandible was kept in the horizontal plane (e.g. *bee*), or when a strictly vertical trajectory without over excursion was maintained (e.g. *gone*). Depending on Jarrod's resting posture, or the place in which he began each word, and the anticipatory affect of vowel height, Jarrod's word forms appeared to be variable. This was clearly demonstrated in the *Diagnostic Evaluation of Articulation and Phonology* (DEAP, Dodd, Hua, Crosbie, Holm, & Ozanne, 2003) inconsistency subtest where over 40% of repeated words were found to be inconsistent.

- Stage VII: Jarrod marked syllable junctures in connected speech, but depending on the motor complexity of the production (as seen above), his timing and prosody suffered. Inconsistent resonance was occasionally evidenced across co-articulated speech which may have been the result of timing issues during transitions.

General impressions

Overall Jarrod had normal tone and well balanced skeletal relationships for gross motor development. Fine motor skills for arm, hand, and speech subsystems control were poor. Unbalanced speech subsystems were observed with poor motor control and over excursion of the mandible. Generally most lingual actions could be achieved when the mandible range was restricted and only one plane of movement was used at a time. This suggests that Jarrod was exhibiting an overall mandibular "attractor" state that inhibited further control, refinement, and sequencing of other speech subsystems. Phonological patterns that result from these imbalances included: deletion of final consonants, stopping, fronting, gliding, cluster reduction, and voicing of unvoiced consonants. These patterns were evident on the DEAP where he achieved a standard score of 3 (i.e. the lowest – average is 7–13) and *Children's Test of Nonword Repetition* (CNRep, Baddeley & Gathercole, 1996) where he achieved a score below the available norms for his age (no words were correctly imitated). For example /pɪg/ was produced as [||beə ʌ||], /faɪv/ as [||bai ʌ||], /reɪn/ was [w:eɪn ʌ||], /spaɪdə/ became [bai ʌ də||], and /splæʃ/ was produced as [||wʌʃ ʌ||]. Contributing factors to his underlying motor control issues appear to have been mild, early auditory sensory impairment (a product of the frequent middle ear disease) and apparent difficulty with modulating attention and organizing sensory information (as suggested by the ADHD diagnosis).

The cognitive-linguistic domain

Standardized test results

In the cognitive-linguistic domain, *perception* as defined by Nicolosi, Harryman and Kresheck

(1989), is considered as the “meaningful awareness and affective appreciation of a stimulus or stimuli which is the result of a complex pattern of stimulation plus the effect of experience and attitude” (p. 194). There was no formal testing of this realm. However, Jarrod’s diagnosis of ADHD, observational data, and information obtained from previous reports (e.g. effortful behaviour and difficulties with attention and processing) suggest that Jarrod may have deficits here. These difficulties may be especially apparent when he is involved in tests of phonological processing or with higher level auditory discrimination tasks such as the *Same-Different Test* (Bridgeman & Snowling, 1988).

At a more complex level, discrimination may be viewed as the process of distinguishing among stimuli and responding appropriately as well as tasks involving a comparison of stimuli with other competing stimuli. This process may also include selection of relevant from irrelevant stimuli in the environment and selection of the most appropriate stimuli given the situation and task being carried out. In the area of auditory discrimination, Jarrod’s scores ranged from within normal limits (*Auditory Lexical Discrimination Test*, Locke, 1980) to two standard deviations below the mean for his age (*Same-Different Test*, Bridgeman & Snowling, 1988). Jarrod was able to discriminate feature differences and lexical word forms but had difficulty with non-word forms and with sequence differences. Overall, Jarrod’s performance relative to his age group ranged from mildly to severely-impaired if scores on phonological awareness tests were added. Tests in this category included, respectively: *Preschool and Primary Inventory of Phonological Awareness* (PIPA; Dodd, Crosbie, McIntosh, Teitzel, & Ozanne, 2000), the *Sutherland Phonological Awareness Test-Revised* (SPAT; Neilson, 2003), and the *Queensland University Inventory of Literacy* (QUIL; Dodd et al., 1996). These test results suggest that Jarrod recognized and could discriminate real and meaningful word forms. It also suggests that he does not yet completely grasp the underlying rules of the phonology especially in tasks that are not associated with meaningful or direct experience.

Recognition or the process of interpreting, comparing and matching stimuli to previously stored information to gain awareness of meaningful, repeated patterns appeared to be a strength for Jarrod, especially when supported through visual information. On the *Clinical Evaluation of Language Fundamentals-4* (CELF-4; Semel, Wiig, & Secord, 2003), which was administered at age 6;11, Jarrod scored within normal and high normal limits for his age group on all subtests with the exception of Expressive Vocabulary (Standard score = 6). Of all core language scores, Language Content (Standard score = 94) which reflects his vocabulary and understanding of relationships between words, was slightly reduced.

Similarly, in Concept Formation or the process of thinking or imagining and/or the ability to abstract

and categorize appeared to be an area of strength for Jarrod. Cognitive testing using the *Wechsler Pre-School and Primary Scales of Intelligence* (WPPSI; Weschler, 1967) in June, 2003 indicated that Jarrod was within normal limits (Full scale intelligence quotient = 81). On non-verbal subtests, his intelligence quotient was 93 or within average range, and on verbal subtests he achieved borderline scores or an intelligence quotient of 71. Overall, comments in recent reports suggest his expressive conceptual language abilities are now more in line with his non-verbal areas and are within the average range.

General impressions

Jarrod appears to be within normal limits for most areas in the cognitive domain. Exceptions include sensation and discrimination tasks that involve processing of non-word forms, sequenced lexical tasks, and abstract phonological segmentation tasks. Taken together, as suggested in the Physical-sensory domain, these areas may have been influenced by his early hearing history (i.e. infections) and his poor fine motor control.

The social-emotional domain-behaviour

There are numerous reports of behavioural and attention difficulties especially as they relate to expressive language production, academic achievement and social interaction from as early as four years of age. Poor eye contact and poor fine motor skills are also mentioned. On the Questions for the child component of the *Speech Participation and Activity-Children* (SPAA-C, McLeod, 2004), Jarrod named only one peer and his parents as people he liked to talk to. He also deflected questions with “I don’t know” when asked “what is the best thing about your life” and “when do you like to talk to other people” and said he felt “sad” when other people did not understand him. Jarrod has received intensive sessions concentrating on behavioural expectations for improving processing and attention for learning. In video segments for this case study it was noted that when Jarrod was presented with difficult tasks in either non-word lexical production or in real words, with complex speech subsystem movements, his behaviour and attention deteriorated immediately. Even if these tasks could be said to be repetitive and boring Jarrod’s behaviour on these tests was seen as an indicator of his reduced tolerance. Therefore the observed behaviour appeared to indicate performance anxiety for motorically complex material.

General impressions

Although Jarrod was seen in video-taped segments to interact readily with the examiner, even when he was grossly unintelligible, it is suspected that he is aware of his communication difficulties and that this

awareness may contribute to anxiety behaviour. It is also suspected that his continued but largely ineffective efforts to try and change his speech patterns may be impacting his emotional state. The anxiety behaviour that then likely results from this awareness may be viewed as a mitigating factor in his performance. It may also be seen to contribute to the paucity of social-emotional relationships. The fact that Jarrod has normal cognitive capacity exacerbates this disequilibrium between domains.

Summary impressions

From reports, tests results and observation Jarrod shows normal cognitive ability that has and is still being compromised by mild, fluctuating auditory hearing loss and fine motor control deficits. In spite of normal cognition, these factors may have contributed to Jarrod's inability to accurately produce, in connected speech, normal speech patterns and grammatical structures. Complex language learning may be affected adversely by his speech motor disability which in turn may have impacted the development of reading and spelling. Jarrod's sensitivity and awareness of his difficulties may be compounding his difficulty with self-regulation particularly when he is presented with challenging language and oral tasks. In other words, both underlying motor-speech templates/schemas and coordinative structures need to be targeted within a social and academic focus.

Treatment focus and goals

Given the information above, the following communication foci and motor speech treatment goals were identified for Jarrod. Communication foci were selected to develop interactive communication routines for social interactions, develop normal speech subsystem control and flexibility, and improve academic proficiency and literacy skills. Within the speech subsystem focus the selected priorities would be to: (1) reduce jaw excursion, develop stable midline control and grading; (2) develop independence of the tongue from the jaw, (3) develop independent and normalized movements of the labial-facial musculature. Initially these goals would be incorporated at the syllable, word and phrase levels. Secondary goals of therapy would include developing better ability to wait, listen, discriminate and turn-take. Initial planning would also identify caregivers/peers who be enlisted to support targeted PROMPT lexicons and phrase types and to participate in game-like activities directed at the above goals.

Core treatment elements in PROMPT therapy

There are ten core elements that are considered fundamental in PROMPT intervention and are applied to Jarrod's treatment plan (see Appendix 2).

These values form the basis for PROMPT sessions and embody the Philosophy, Approach, System and Technique of PROMPT. Most importantly for a therapy session to be considered PROMPT, all of these core elements must be present. These elements and the PROMPT treatment phrases, which detail general objectives within the therapy process, are described in detail in Hayden (2004). Since this special issue of *Advances in Speech-Language Pathology* deals with perspectives on intervention and most are presented from a phonological point of view, it was decided to describe several target selection factors which appear in the phonological literature (see Bowen, 2005). First, these factors are briefly discussed as they would be considered in PROMPT and then as they would be applied in organizing Jarrod's treatment plan.

PROMPT target selection factors for Jarrod

Sound or system. In PROMPT, classes of "motor-action" sets are prioritized. For example, mandibular (vertical plane movements), labial-facial (horizontal plane movements), lingual (anterior to posterior plane) and the motor-phonemes, that can be created from those sets, are targeted. For illustration, an open vowel such as /ɒ/, would be considered in the vertical plane because it uses a fairly open jaw position, as would the consonant /b/ if produced through jaw movement. The vowel /i/, however, would be considered in the horizontal plane due to its restricted aperture as would the consonant /b/, if it was made solely through independent bilabial movement without aid from the jaw. Anterior to posterior plane lingual actions may also be mixed with either vertical or horizontal movements. For example, /mɒmɒ/ would be considered in the vertical plane, while in /mAmimAmi/ the first syllable /mAm/ is considered vertical and the second syllable /mi/ horizontal or a combination of vertical and horizontal. A word like *take* /teɪk/ would be considered to combine horizontal + anterior-posterior plane movements. For Jarrod, initially PROMPT would target vertical, anterior, productions to set normal mandibular, speech boundary conditions and develop grading. For example, *pot* /pɒt/ and *top* /tɒp/ or horizontal anterior productions *seat* /sit/ and *meat* /mit/ where having restricted jaw movement independent labial and lingual actions could be used. Once more consistent control was established within each plane then two planes of movement would be combined. Finally all planes of movement would be incorporated. As each plane of movement was added, voicing and timing features would be carefully monitored. If these features could not be maintained, then intervention would move back to less complex interactions with fewer intersecting planes of movement.

Stimulability. The sensory modalities of auditory, visual, and tactual-kinesthetic-proprioceptive are

probed during informal and formal testing as well as within single sound productions and in connected speech. Depending upon how much of, and what type of sensory input(s) it will take for the child to produce accurate productions and then self-correct those productions when in error, one or more of the above sensory modalities would be stressed. In a child such as Jarrod who has mild auditory concerns, poor fine motor control and where auditory-visual models have not been completely successful in changing his coarticulated speech patterns, the tactual modality would be used.

For Jarrod, matching auditory input closely with tactual-proprioceptive feedback, which is given by the clinician through prompted information, would be important for the creation of accurate motor-speech schemas. These would include using parameter prompts to provide midline support, mandibular control and reduced range, surface prompts for mapping transitions within a single plane or across planes (e.g. vertical to horizontal or anterior to posterior within words, phrases and sentences), and occasionally using complex prompts to set the boundary and feature conditions of a single phoneme. The tactual modality would also be used for mapping semantic, syntactic, phonological forms into the system to create stronger linkages and associations between domains and finally, for the creation of better interactive exchanges (e.g. tactually prompting speech at the right moment to continue interaction).

Developmental expectations. PROMPT evaluates how the child has progressed in normal speech subsystem development (e.g. refinement, independent and coordinated movements across all planes and subsystems) and does not work strictly from traditional developmental phoneme norms. For example, PROMPT does not necessarily assume that the sound /t/ is always mastered before the sound /ʃ/. Instead decisions are made about what level of control is available, what is possible to change, and what is needed to be able to produce certain intelligible word or phrase forms.

In Jarrod's case, it is known that in isolation he can produce fairly accurate phonetic placements. It is also known that he understands differing word forms, although the analysis herein suggests that he does not produce them accurately in connected speech due to a strong mandibular "attractor" state. Therefore, in order to break the attractor state pattern, the mandibular range must be reduced, and lingual actions must be released and separated from the lower jaw and differentiated from the anterior to the posterior (or tip through to the dorsum). Traditionally, in phonological approaches the term "developmental expectations" is used to describe how a phoneme repertoire is chosen (as above), but in PROMPT this term is more broadly conceptualized and discussed here with relevance to activity choices. Those choices

are made consistent first with the child's mental age, and secondarily their chronological age and the selected task demands on central resourcing (Bates & MacWhinney, 1987; Bloom, 1989).

For Jarrod, this means choosing activities that are cognitively challenging, academically and socially relevant but do not involve other areas of motor competition. As just one such example of an activity that illustrates this choice and incorporates the selected communication focus is the game *Clue Jr.: The case of the missing cake* (Parker Brothers, 2003). The goal of this game is to solve the mystery by discovering who ate the cake, with what drink and at what time. In this game the child must wait, listen, process, think, problem solve, sequence events and use oral language appropriately, intelligibly and interactively.

To tailor this game for Jarrod, the names of the characters and objects can be changed or kept to reflect the *motor-action set* choices, while grammar and semantic concepts are embedded. Mass practice of motor-phonemes, syllables or word forms would be carried out immediately before playing and then embedded in more natural interactions (distributed practice) during the game. Such an activity, while working directly on motor-phoneme targets/processes, can be practiced and later played with peers and parents to provide a scaffold for social communication competence.

Consistency. In PROMPT the clinician would usually select sounds that are both inconsistent and consistently in error. Inconsistent sounds would be selected as they may easily lead to immediate change, thereby expanding forms in his lexicon and improving interaction. Targeting errors that are consistent may lead to a new set of motor schemas thereby expanding the development or refinement of motor-phonemes and creating new coordinative structures.

For Jarrod, as he is inconsistent in approximately 40% of his productions (Dodd et al., 2006), the goal would be for him to articulate sound patterns consistently and to change muscular system biasing patterns (e.g. developmentally inappropriate attractor states). In the initial phase of treatment the three main speech subsystem priorities would be to: (1) stabilize, reduce and grade mandibular actions which would target primarily the vowels /i/, /u/, /ei/ /æ/, /ɒ/, and consonants /p/, /b/, /m/ in the vertical plane of movement, (2) increase lingual independence from the mandible, which would include targeting /t/, /d/, /n/ then /s/, /l/ and finally /ʃ/, /r/ or movements from the anterior to mid-back lingual regions, and (3) use appropriate range and independent contractions in labial-facial musculature which would also include the targets /i/, /u/, /œ/ and consonants /p/, /b/, /m/ and /s/, but specifically to do so in target forms that focus on the horizontal plane of movement. After he demonstrates that he can use these motor-phonemes with moderately good control in word forms, then

diphthongs (which cross two planes of movement) plus all additional vowels would be added as well as velars /k/, /g/, /ŋ/. Next the independent, single labial actions /f/, and /v/, and interdentals /θ/, /ð/, and then affricates /tʃ/, /dʒ/, and sibilant /ʒ/ would be included, and finally consonant clusters in all word positions.

Most vs. least knowledge. The notion of most vs. least knowledge in phonology has been traditionally applied in a cognitive-linguistic sense, quite independent of motor considerations. In the PROMPT model, knowledge is viewed more broadly. In PROMPT the clinician selects motor-phoneme targets that are the least effortful for the child to produce but will be immediately useful in the context of functional, social interactions that expand competence.

In Jarrod's case this means organizing the chosen phonemic repertoire to create words and phrases that can be used initially in structured routines and activities. For example, phonemes would be selected for Jarrod (based on priorities of speech subsystem control) and incorporated into the *Clue Jr.* game; the clinician could use character names such as *Tom* (vertical), *Mom* (vertical), *Bob* (vertical), *Betty* (horizontal), *Sue* (horizontal), and *Pete* (horizontal) instead of character names such as Col. Mustard or Mrs. Green. Object names could be changed to reflect priorities by replacing the word planter with the word *pot* (vertical) or the word chair with *seat* (horizontal). Carrier phrases or phrase types that represent the plane of movement choices and provide for linguistic expansion would also be developed. For example, "I want a ____" (vertical) or "Do you need the ____" (horizontal) could be used. These predetermined grammatical structures, used by both the clinician and child in turn-taking, provide a scaffold in which to embed varying planes of movement but with a reduced overall motor load.

Intelligibility. Patterns first to be targeted would be those that are either most motorically attainable or communicatively useful, or those that are most destructive of communicative intent and adequacy (i.e. those that have the greatest impact on intelligibility). For Jarrod, this would initially mean creating stable, normalized range with better grading by focusing on context sensitive voicing and closing syllables. As well, a PROMPT approach would involve working to free up the tongue from the jaw "attractor" state and releasing and creating a better balance of facial muscle groups by targeting palatal fronting, weak syllable deletion and cluster reduction.

Deviancy. As stated above, intelligibility and oral communication for use in interaction are considered to be the primary focus. A secondary focus would be deviant patterns that did not inhibit refinement of the speech subsystems as for example, initially targeting the jaw-tongue closing gesture (schema) to create closing of the CVC syllable. In fact as the speech

subsystems gain more independence, flexibility and smooth integration of the deviant sound patterns should disappear.

In Jarrod's case, it is hypothesized that when better control of mandibular and labial functions is achieved, these patterns (i.e. final consonant deletion, palatal fronting, weak syllable deletion) will be significantly reduced and normalized.

Social factors. Social language factors rank high in choosing motor-phoneme targets and activities (Hayden, Mastronardi, & Fung, 1998). Syllables or words that give the child power and control to express their needs, wants and provide interactive communication exchanges are considered very important. The daily needs of the child and family are considered as well as a realistic assessment of the child's ability in both motoric and cognitive arenas. Activities that can be transferred, almost immediately, into the natural environment and provide for both practice and social interaction are also highly valued. For Jarrod, as an example, a game activity (*Clue Jr.*) was selected to illustrate how several aspects (motor, linguistic, cognitive, and social) can be embedded at the same time into a dynamic and holistic focus.

Markedness. The term markedness is used in phonology in a number of ways. At its most basic level, it is used to refer to the specification for a feature (Trubetzkoy, 1938) as being either present (marked) or absent (unmarked). There are no intermediate conditions. Certain linguistic categories are defined by the sharing of status (i.e. marked vs. unmarked) on particular features. It has been argued (e.g. Chomsky & Halle, 1968) that learning a language requires figuring out the features that are important for that particular language. Markedness theory would suggest that marked features are less common in the world's languages. This may reflect something more inherently complex or difficult about those features which would thus make them more difficult to learn than unmarked features.

In PROMPT, the notion of features being either present or absent is replaced by the idea that features of expressive speech exist along a continuum of interacting motor difficulty and grammatical expansion. For example, one of the easiest forms to produce is vertical + nasal or /m/, followed by vertical + voiced /b/ and then vertical - voice /p/. Adding additional levels of motor complexity (e.g. maintaining voicing) while grading mandibular movement and lingual actions simultaneously, as in the affricate /dʒ/, further complicates the motor system's ability to hold on to all aspects of valving, transition, timing and pressure. The system's ability to orchestrate these intricate movements and maintain them over time in ever increasingly complex forms is challenged. Thus, the developing child is faced with both motor and linguistic challenges as they strive to create ever more demanding

neuromotor schemas, while at the same time learning to understand and use appropriate language forms (Smith & Goffman, 2004).

In Jarrod's case, as classes of motor-action sets are targeted such as mandibular movement (vertical range), all actions within that class are also targeted. Therefore, the marked and unmarked features of each target phoneme are taken into consideration regarding the refinement of muscular contraction and timing is needed to recognize and produce salient differences in phonemes (e.g. /m/, /b/, /p/ or /t/, /d/, /n/). For Jarrod, who has demonstrated difficulties maintaining voicing contrasts in complex action sequences, initially word forms would use all voiced consonants as in /mæd/ or /mɒm/. Then voiceless consonants would be placed in the final releasing position as in /bæt/ or /mæp/. Finally a mix of both voiced and voiceless consonants would be included in all positions as for example /sən/, /səndi/ or /səndi skul/. In other words, the addition of voicing contrasts would be introduced systematically as more control and refinement among speech subsystems was achieved.

Systemic factors/distinctions. As a dynamically-based, tactual, motor learning approach it is considered important to try to provide as many accurate target productions as possible within syllable or word forms. In other words, speech movements that lead to intelligible productions should be used. As control improves more multi-opposed targets may be incorporated.

In PROMPT, words are selected that are created through prioritized and embedded motor-action sets. This serves two purposes. First, it creates speech subsystem changes and second, by choosing real, functional words, it also provides opportunities for phonemic change within a more natural context. When choices must be made in an activity, this also increases saliency and hence learnability (Bowen, 2005). For example, with Jarrod we could include words such as *pot*, *top* or *pan* and *pot* within the *Clue Jr.* game. Later words such as *meet* and *meat*, or *eye* and *I*, (which include the diphthong /aɪ/ in both the vertical and horizontal plane) could be added.

Lexical properties. As stated in previous sections, words that are the easiest to produce motorically and can be used in many situations with many different partners are targeted first. Second, words that have high communicative intent or those which are useful in communicative interactions are targeted. Initially words are chosen based on the child's level, control or refinement of the speech subsystems; this would mean selecting words with high motor density or similar but slightly differing motor patterns. After more control and grading are possible, and transitions among and within planes of movement are established, words that have low motor density are used.

In Jarrod's case this would mean initially choosing words of high motor density in either the vertical and

horizontal planes but not combining movement planes. Only after better control was established, would interacting movement planes be targeted and more complex word and phrase forms of low motor density used. For example, dinosaur names or polysyllabic word forms such as *kangaroo* or phrase types which might include pronouns or irregular verb forms, be considered for use in an activity. Activity expansion within early high motor density stages could also include print using reading and writing of items and names as well as the creation of simple instructions for players. At a later, low motor density stage, this would evolve to include story writing. Aside from being an age appropriate and literacy building activity this would support his motor productions while reading and provide a systematic way to increase complex grammatical and lexical forms.

Final remarks

Jarrod's case clearly illustrates the connection between the arenas of speech motor control and phonological-linguistic growth and how they may interact and influence the development of social and literacy skills. As researchers and clinicians, it is incumbent upon us to recognize these connections and to utilize methods and sensory modalities to help support the development of normalized speech actions leading to normal processes and language. PROMPT as one such model, proposes that a more comprehensive framework needs to be considered when evaluating and treating mixed phonological and motor disorders and that tactual information and somatosensory systems need to be included in our treatment hierarchies. These additions, used with knowledge and applied at the right time, will not only further our understanding of these interactions but ultimately enable children such as Jarrod to gain access to communicative oral language that is successful and leads to positive growth and competence.

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Appendix 1: PROMPT tenets

1. Human beings are internally and externally driven by the mental, physical and emotional domains.
2. These domains are fully integrated and co-dependent in a functional human.
3. Communication represents the purest integration of all three domains.
4. Humans need to connect with other humans on all three levels.
5. Communication may be disrupted by a breakdown in any or all three domains and although a single domain may be viewed as the most impaired, all other domains will be out of necessity and function, impaired to some degree.
6. To strengthen the weakest domain, all domains must be reintegrated in a systematic fashion.
7. Restructuring should alternate focus among all domains but the timing and order are individually dependent.
8. No communication intervention can produce permanent change without involving all domains.
9. The final and ultimate goal of PROMPT therapy is the creation of a state of equilibrium across domains to the highest level attainable by that individual.

Appendix 2: Core treatment elements in PROMPT therapy

1. Thorough analysis of the global domains and motor systems to determine a Communication Focus for treatment (e.g. an aspect of development in which to embed and focus communication intervention, such as self-help or activities of daily living, interactive communication routines, play skills or pre-linguistic, pre-academic or academic learning).
2. The use of tactual-kinesthetic-proprioceptive information as a critical modality for recognizing developing/re-balancing and integrating cognitive-linguistic, social-emotional and motor behaviour.
3. Developing goals and embedding objectives that embody the Communication Focus and work towards motor/language, cognitive and social function.
4. Determining three priorities within the speech-motor subsystem that need immediate development or re-balancing and create an initial PROMPT lexicon.
5. Deciding on the purpose of prompting and what types of prompts should be used to support and develop speech-motor control for speech and language and/or interaction and cognitive development.
6. Immediate use and transfer of the newly-learned PROMPT lexicon into activities and the natural environment for use with parents, caregivers or peers.
7. Understanding how limited and competing resources are intimately tied to modality processing and the production of motor actions, thereby directly affecting activity, toy or material choices.
8. Insuring that within each session: (a) a high degree of motor-phoneme rehearsal (mass practice using prompts for accuracy of production) is achieved, and (b) generalization of these motor-phonemes across various vowel contexts, and transitions (distributed practice), is embedded into novel syllables and words within naturalistic activities.
9. The inclusion of reciprocal turn-taking and/or “choice-making” in almost every interaction.
10. The presentation of the same/similar activities (actions, routines or scripts that can be expanded) over time to provide a structure in which increased motor and language complexity and cognitive learning of events and sequences can be trained.