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Intensive Sound Production Treatment for Apraxia of Speech: An Analysis of Error Consistency

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Note

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ABSTRACT

In the past, clinicians have diagnosed acquired apraxia of speech based upon the presentation of an inconsistent error pattern. However, recent research studies have begun to suggest quite the contrary, pointing towards a consistent pattern of errors in the speech of those with apraxia. The present study utilized an intensive Sound Production Treatment (SPT) for a 51-year-old male with severe acquired apraxia of speech and moderate-severe aphasia. Treatment was administered over a period of five days per week, three hours a day, for two consecutive weeks. During this treatment, probes were gathered daily to evaluate the efficacy of the intensive SPT for apraxia. Baseline data and follow-up data for one, four and eight weeks post treatment were also collected. Based upon analyses of transcriptions from speech samples, collected during the baseline, probe, and follow-up testing,, accuracy data was used to evaluate the argument for *consistency* of errors in apraxia of speech. The analysis of consistency comprehensively focused on the manner of articulation in consonants including the categories: stop, fricative, affricate, nasal approximant, retroflex approximant, and lateral approximant. Results of this study support recent research indicating that errors are indeed consistent rather than inconsistent in the speech of those with apraxia. Future studies will seek to confirm these findings with analyses of a larger sample size and evaluation of vowels as well. These findings have important implications for increasing our understanding of the diagnostic criteria of apraxia of speech and its appropriate treatment.

Keywords: acquired apraxia of speech, treatment, intensity, error consistency

Intensive Sound Production Treatment for Apraxia of Speech: An Analysis of Error Consistency

Accurate diagnosis of a speech disorder is the first step to ensuring that proper treatment is administered, and optimal prognostic outcomes are reached. Arriving at a diagnosis can prove challenging for acquired apraxia of speech in adults, as some controversy surrounds the typical error patterns found in this disorder. Investigation of error consistency is important to better identifying apraxia of speech (AOS), particularly in the presence of aphasia.

Apraxia is a motor speech disorder. Motor speech disorders result in impaired ability to coordinate the muscles involved in speech production. An acquired form of apraxia often arises following left-hemisphere stroke or trauma. Stroke occurs when blood flow to a certain region of the brain is cut off, causing brain cells to die. When the left hemisphere of the brain becomes damaged, apraxia often co-occurs with aphasia and/or dysarthria of speech as well.

Historically, variability of errors has been thought to be a hallmark of apraxia of speech. The term error variability typically refers to two different dimensions: (a) inconsistency of error ***occurrence*** on the same speech unit across repeated trials, and (b) inconsistency of error ***types*** affecting the same speech unit across repeated trials (Zeiger et al., 2012). In some AOS literature error variability is maintained as a mandatory diagnostic criterion (Staiger et al., 2014). However, recent studies have suggested that error variability is not a valid diagnostic marker of AOS, prompting the need for further research on the error patterns (Haley et al., 2013).

Until recently, high variability of error has widely been used as a reference point to make a clinical diagnosis of apraxia of speech. Additionally, this variability of errors has been used to differentiate apraxia from dysarthria. Essentially, consistent error patterns were considered indicative of dysarthria. Consistency of errors indicates that the patient predictably exhibits the same amount and type of errors, regardless of context.

Making a differential diagnosis becomes further complicated with the presence of concomitant aphasia, which frequently co-occurs with AOS. Contrary to previous thought, error analyses in recent studies suggest that variability of error is in fact *not* a hallmark of apraxia. It appears that error variability *is* the better predictor of AOS compared to phonemic aphasic errors, but is this the case in a person with clear-cut AOS? Could it be that the concomitant severe aphasia makes AOS of speech characteristics more difficult to delineate? In this context, concomitant aphasia refers to patients who exhibit AOS, and aphasia, rather than simply one disorder.

Understanding whether or not variability of errors is a hallmark of apraxia of speech is important in being able to reach a differential diagnosis. A differential diagnosis is the act of differentiating a particular medical condition from all other medical conditions that carry the same symptoms. Thus, a differential diagnosis accurately distinguishes one disease or disorder from other very similar conditions, allowing for the highest quality treatment. Treatment quality improves because the appropriate disorder is being treated, rather than a similar, but inaccurately diagnosed, disorder.

Currently, error variability remains a criterion necessary for diagnosing AOS. Error variability indicates that the speech errors demonstrate no pattern or predictability in occurrence. For example, a person may not *always* produce a particular sound with an error, so a sound may be articulated correctly and intelligibly during one test session, but inaccurately during the next session. Moreover, when an individual does make a production error, it may not always have the same result. Thus, the sound /d/ may be substituted with a /t/ during one production in different contexts, a total of ten times each. Recent data suggests that variability of error is in fact not a reliable diagnostic marker. In a study by Staiger et al. (2012), four patients with mild-to-moderate AOS were asked to repeat eight target words. Using transcriptions of these speech samples, error variability was measured based on consistency of error occurrence and consistency of error type. Consistency of error occurrence refers to whether or not errors are present in particular sounds and positions. Additionally, consistency of error type refers to whether or not the same types of errors are made in terms of phonetic features and sounds. Phonetic features are distinctive and refer to how a sound is anatomically produced. Different features equate to different sounds. The results showed that both consistency of error type and error occurrence were relatively stable. This study also illustrated that error variability is hard to operationalize. Operationalization refers to the concept of defining the measurement of something that cannot be measured directly, in this case sound errors.

Thus, the results of the Staiger et al. (2012) study pointed towards consistency rather than inconsistency in errors, and due to the difficulty of measuring “errors”, it was concluded that error variability should no longer be considered a diagnostic marker of AOS. This data agrees with my hypothesis that contrary to historical beliefs, AOS does in fact manifest with error consistency. Thus, more research should be done to validate this consistency viewpoint and to learn more about how consistency presents itself in cases specific to AOS. Conducting such research is vitally important to making accurate diagnoses and providing the most effective forms of treatment.

Another study, conducted by Bislick (2015), looked at the nature of error consistency in AOS and aphasia. Differentiating between these disorders can be difficult, as each can arise from left hemisphere insult and share similar symptoms. Thus, it is important to understand which symptoms pattern to which disorder. Using a group of ten subjects with both AOS and concomitant aphasia, compared to a group of eleven subjects with aphasia and phonemic paraphasia, the study investigated group differences in consistency of error. Phonemic paraphasia is when a speaker unintentionally produces syllables, sounds, and words. Essentially phonemic paraphasias are unintentional speech outputs. An example of a phonemic paraphasia would be substituting the word /cap/ for /gap/. Note that the substitution results in a similar sounding word. Results of the Bislick (2015) study showed that error variability is greater in individuals with AOS and concomitant aphasia, than in individuals with aphasia and phonemic paraphasia. However, the studied noted that ***overall,*** errors made by those with AOS generally presented with a consistent pattern. Thus, this study essentially suggests that speech errors in AOS are more consistent than previously thought, making error variability an inaccurate manner in which to diagnose AOS. Although, compared to aphasia with phonemic paraphasia, individuals with both AOS and concomitant aphasia, did show greater degrees of variability.

Given that recent research has indicated that using inconsistency in speech errors in those with apraxia of speech, as a diagnostic criterion for AOS is inaccurate, many people have potentially been wrongly diagnosed and received less-effective treatment. Thus, future research is needed to determine a better clinical marker of AOS, so that patients can receive the best treatment for their particular diagnosis.

In considering the issue of error variability versus consistency, it is important to note which error types have shown the most consistency in recent data. Understanding which types of errors are known to show consistency will provide clinicians with further insight when making a diagnosis. In another study, Mauszycki et al (2010) investigated the same question of presence of error variability in AOS. Using twenty-eight monosyllabic words, researchers examined variability of sound errors in eleven subjects with both AOS and aphasia. Findings showed that repeated sampling did not influence errors and that condition of elicitation did not influence variability of error type for any given sound. Distortion was the most common error type, with /h/ being the phoneme with the least amount of error and /s/ with the greatest number of errors. Distortions are an error type in which the target sound is produced, but not in a typical or particularly intelligible manner. Therefore, data from this study also suggested that errors in AOS are not highly variable. Additionally, knowing which types of errors show consistency can potentially serve as a clinical marker when making diagnoses. For example, historically error consistency is considered indicative of dysarthria. However, given the results of recent research, both dysarthria and AOS show consistency in error production. Perhaps paying attention to which types of errors are more consistent in AOS, compared to dysarthria, can help form the basis of reaching a differential diagnosis, especially when attempting to differentiate between symptomatically very similar disorders.

Another study conducted by Mauszycki et al. (2005), examined variability in AOS, specific to stop consonants. The study investigated two subjects, one with moderate apraxia of speech and non-fluent aphasia and another with normal speech who served as a control. Non-fluent aphasia results in difficulties both communicating orally and in written form. Non-fluent aphasia may also be referred to as Broca’s aphasia. The subjects were then tested using eighteen words beginning with a word initial stop consonant. Word-initial signifies that a sound is the very first in the word. Stop consonants are articulated with a complete constriction in the vocal apparatus, which is suddenly released, resulting in a sudden burst of air when producing certain sounds. The stop consonants used in this study were: /b/, /p/, /t/, and /d/. During testing, the experimenter first read aloud a word, and then the subject was asked to repeat the word five times.

These samplings were then analyzed perceptually, acoustically, and kinematically. For the perceptual analysis, the samplings were phonetically transcribed. The acoustic portion of the analysis involved measuring the voice onset time of both the initial stop consonant and the total word. The term voice onset time refers to the amount of time between the release of the stoppage and the onset of vocal fold vibration. Vocal fold vibration indicates that voicing has begun. Finally, the kinematic analysis measured movements of the lower lip and jaw. Three kinematic measures were utilized: utterance duration, displacement and peak velocity, and spatiotemporal index. Combined, these measures provide information about how the articulators are moving and working together during speech production. This is important, as AOS is a disorder in the planning of speech motor movements. The results of this Mauszycki et al. (2005) study again showed that errors in AOS varies across sounds, with greater error consistency for some sounds compared to others. The percentage of errors for the stop consonant /d/ displayed the highest degree of similarity in errors, compared to /b/, /p/, and /t/. The study also showed the most common type of errors to involve voicing. Finally, the data showed that percentage of the same errors across all sounds was over 75%. This study highlights some specific consistencies in AOS, which can be useful knowledge for a clinician when trying to make a diagnosis.

Based on recent data suggestive of consistency of errors in AOS, it is essential that more research be conducted. Research may look at treatment studies to evaluate changes in error patterns. The most extensively researched treatment for AOS is Sound Production Treatment (SPT) (Wambaugh et al., 2013). Research has proven SPT to be effective in improving articulation of both treated and untreated sounds, across varying contexts (Wambaugh et al., 2013). However, more research is needed to determine the efficacy of *intensive* SPT in AOS. Currently, studies have examined intensive SPT in aphasia and shown positive results. Studies have also investigated intensive SPT for apraxia of speech, but results showed little difference compared to results from the typical treatment style (Wambaugh et al., 2013). The current study has further increased the dosage of intensive SPT to reevaluate its efficacy.

The present study examines consistency of errors in AOS. Specifically, consonants are analyzed for accuracy across productions elicited by intensive SPT (Wambaugh et al., 2013). The study comprehensively examines consonant production in one participant. This research may serve as a pilot study suggesting the need for further research regarding both consistency of errors and intensive SPT in apraxia of speech. Research on the matter of error consistency is important due to its diagnostic implications in AOS.

Method

Participant:

The participant was a single, fifty-one year-old, adult male, recruited from the Aphasia Groups at the University of Connecticut. This individual was 3.5 years post left-cerebrovascular accident and presented with significant right side hemiparesis (see Table 1). Following pre-treatment assessment, Western Aphasia Battery and Duffy's AOS protocol (2013), the participant was diagnosed with severe, chronic AOS, and moderate to severe aphasia (see Tables 4 & 5).

Stimulus Creation and Selection:

The word lists examined in this study were selected based upon the participant's pre-treatment assessment (see Tables 2 & 3). This design was modeled after previous research, which utilized a practice schedule for intensive Sound Production Treatment (Wambaugh et. al., 2013). Each of the four lists included thirty-six words, twenty-four of which were “treated” and twelve that were “untreated”. “Treated” words indicate that the participant received intensive sounds production treatment for that particular word. Words designated as “untreated” received no treatment at all. Untreated words were included to assess generalization of intensive sound treatment. However, in the context of the present study, all words in the data set were analyzed based on the production of all consonants within a word, not solely the target sound or treated versus untreated sounds. Vowels were not examined. Additionally, words that were not produced or unintelligible were discarded in the analysis of consistency. Unproduced words signify that when prompted to produce a given word, the participant simply did not respond at all. Unintelligible words indicate the participant did respond, but in such a way that a proper transcription could not be made. Thus, the experimental stimuli for the study consisted of consonants produced across 144 words, in order to evaluate consistency of errors.

Design and Procedure:

The single-participant first received a comprehensive pre-treatment assessment to evaluate the degree of severity of AOS and aphasia of speech. Following the pre-treatment assessment, four word lists were created to target problem sounds. Next, five baselines were gathered for the four lists. Following baseline collection, treatment was extended sequentially across the four lists.

The treatment lasted for a period of two weeks. During these two weeks, treatment was administered five days a week, for three hours a day. During the treatment period, three probes were collected per day. However, only the first probe of each day was analyzed for consonant consistency. Treatment began with the first list of 24 words. Treatment for the subsequent lists did not begin until the participant reached a threshold of 80% accuracy over three consecutive probes for the list being currently trained. For example, training for List 2 did not begin until the participant first produced accuracy results of 80% across three consecutive probes for List 1. Then training did not begin for List 3 until the same 80% accuracy threshold was met across three probes for List 2.

The participant in this study was assigned to the following treatment schedule for the four lists: intensive-blocked, intensive-random, intensive-blocked, and intensive-random. Each of the four lists included three target sounds each. Blocked presentation indicates that all of one particular sound from a list was presented in order. For example, the first target sound (eight trained words) would be presented, then the second target sound, followed by the third. Random signifies that there was a mixed presentation of the three of the sounds on that particular list.

After completion of the intensive SPT, follow-up samplings were gathered at one, four, and ten weeks post-treatment. Transcriptions were gathered for the four-lists across all baselines, probes, and follow-ups. Using the transcriptions, the present study analyzed all consonants produced in the thirty-six (twenty-four trained, twelve untrained) word stimuli, across all four lists. Consonant accuracy across baselines, probes, and follow-ups was determined based upon production accuracy across manner of articulation.

Manner of articulation refers to the configuration of the articulators involved in the production of a sound. The manner of articulation categories evaluated in this study includes: stops, fricatives, affricates, nasal approximant, lateral approximant, and retroflex approximant. A stop consonant is produced by a complete closure in the vocal tract, which is abruptly released, allowing the airflow to pass through. Fricatives are produced when air from the lungs passes through a partially constricted vocal tract. An affricate is initially produced similarly to a stop consonant, with complete closure of the vocal tract. However, production of an affricate ends more similarly to a fricative, as the complete closure of the vocal tract releases to a partial constriction, allowing the airflow to squeeze through. A nasal approximant is produced with a lowered velum, allowing air into the nasal cavity. A lateral approximant is produced when the tongue blocks the airflow through traveling down the middle of oral cavity, instead forcing the airflow out along the sides of the tongue. Finally, a retroflex approximant is produced with constricted airflow in the vocal tract and the tongue tip curled upwards.

Results

Data from the analysis of 3,564 consonant productions confirms the more recent studies reporting that inconsistent error patterns in AOS may not be a reliable diagnostic criterion (see Figure 1). In total 1240 stops, 885 fricatives, 137 affricates, 524 nasal approximants, 477 lateral approximants, and 301 retroflex approximants were analyzed.

In order to gauge error consistency, ***all*** consonants produced were initially assessed as being produced either accurately or inaccurately. Next, total number of production accuracies versus total number of attempted productions were calculated for each manner of articulation. Tracking production accuracy over time highlights that production errors are decreasing over time and more significantly that production errors change in a consistent manner over time.

The participant made stable and progressive improvements in production accuracy across all analyzed manners of articulation throughout the course of intensive SPT (see Figure 1). The stability in improvements suggests consistency, rather than inconsistency. If errors presented with an inconsistent pattern, the graph of production accuracy would show sporadic increasing and decreasing levels of accuracy, not the upward linear trend evidenced by this participant. In fact, almost every manner of articulation analyzed demonstrated this ***consistent*** upward trend in accuracy, or conversely downward trend in errors, indicating that error variability would not be a conclusive diagnostic marker for any category. The only possible exception to this consistent pattern was seen in the affricate category. The production accuracy of affricates displays some alternation between improvements and declines across sessions. However, this relatively less consistent error pattern may be due to affricates receiving the smallest sample size among all manners evaluated. Overall, results of this study align with researching findings by Mauszycki et al. (2010), which suggested error consistency among consonants in monosyllabic words.

Further, this stable improvement suggests that SPT, applied intensively, is a viable therapeutic option for individuals with severe AOS. Perhaps, this intensive repeated practice could potentially result in motor learning, as the number of errors decrease over time. Stability may have been reduced had a less intensive regimen been used.

Discussion

Reaching a differential diagnosis is incredibly significant in allowing for the best possible treatment and results. A differential diagnosis allows for accurate identification of a particular disease or disorder when several disorders may be suspected based upon shared symptoms. Two disorders that manifest very similarly are AOS and Broca’s aphasia. Differentiating between AOS and Broca’s aphasia can be difficult, especially in more severe cases. Broca’s aphasia results in impaired ability to produce the motor movements necessary for speech output and AOS arises from the inability to execute and coordinate the motor plan. Thus, both disorders present as a difficulty in producing speech due to motor dysfunction.

Currently, error variability is considered a diagnostic criterion for AOS, meaning that inconsistency in error outputs is considered indicative of the disorder. However, recent literature, such as Staiger et al. (2014), has shown error type and error occurrence to be relatively stable. Without appropriate and accurate diagnostic criteria, a differential diagnosis is essentially impossible. Thus, conducting further research on the merits of consistency versus inconsistency of errors in AOS is essential, to allow for more accurate diagnoses and more refined treatments.

However, this study confirms the most recent research which is strongly indicative of consistency of errors, thus inconsistency should not be considered reliable criteria when making a diagnosis. Improving understanding of the error patterns present in AOS will lead to immensely improved clinical outcomes. Thus, replicating findings of consistency of error in AOS is vital to helping patients receive the high-level of treatment they deserve and consequently higher levels of life satisfaction.

References

Bislick, P. (2015). The Nature of Error Consistency in Apraxia of Speech and Aphasia with Phonemic Paraphasia.

Duffy, J.R. (2013). Motor speech disorders: Substrates, differential diagnosis, and management (Third Edition).St. Louis, MO: Elsevier Mosby.

Haley, K., Jacks, A., & Cunningham, K. (2012). Error Variability and the Differentiation Between Apraxia of Speech and Aphasia With Phonemic Paraphasia. *Journal of Speech, Language, and Hearing Research, 56*, 891-905.

Mauszycki, S. (2005). Variability in Apraxia of Speech: A Perceptual, Acoustic, and Kinematic Analysis of Stop Consonants. *Aphasiology, 35*.

Mauszycki, S., Wambaugh, J., & Cameron, R. (2010). Variability in apraxia of speech: Perceptual analysis of monosyllabic word productions across repeated sampling times. *Aphasiology*, 838-855.

Staiger, A., Finger-Berg, W., Aichert, I., & Ziegler, W. (2012). Error Variability in Apraxia of Speech: A Matter of Controversy. *J Speech Lang Hear Res Journal of Speech Language and Hearing Research, 55*, 544-561.

Wambaugh, J. L., Nessler, C., Cameron, R., & Mauszycki, S. C. (2013). Treatment for Acquired Apraxia of Speech: Examination of Treatment Intensity and Practice Schedule. American Journal of Speech-Language Pathology Am J Speech Lang Pathol, 22(1), 84.

Ziegler, W., Aichert, I., & Staiger, A. (2012). Apraxia of Speech: Concepts and Controversies. *J Speech Lang Hear Res Journal of Speech Language and Hearing Research, 55*, 485-501.

Figures and Charts

ID	Age	Sex	YPO	Educ.	WAB AQ
S1	51	M	3.55	HS	27.4

Table 1. Participant Characteristics
This table describes the profile of the participant in regards to age, sex, years-post onset (from the stroke), education level, and WAB AQ scores.

Trained Items			
List 1- blocked	**List 2- random**	**List 3- blocked**	**List 4- random**
Guy	Core	Thin	Ski
Gay	Cap	Thumb	Star
Gore	Kay	Thor	Sled
Got	Cot	Thought	Swing
Game	Came	Thaw	Small
Gill	Keep	Thick	Spin
Go	Ken	Thank	Stem
Gas	Kin	Thief	Skit
Say	Fin	Clown	Vine
Sit	Fame	Black	Voom
Sill	Fear	Flag	Veer
Sue	Fit	Sled	Vet
Sam	Face	Glass	Vase
Seal	Feet	Plow	Via
Sew	Fell	Blue	Van
See	Fan	Glue	Vee
Lie	Wren	Joke	Puck
Low	Right	Jane	Gawk
Lit	Rain	Jill	Sack
Lee	Rash	Juice	Tack
Lay	Rack	Jet	Rick
Lick	Rip	Jab	Tick
Line	Rat	Join	Pack
Late	Row	Job	Tuck

Table 2. Experimental Stimuli
The above are the word lists the participant was trained for using intensive SPT. Stimuli were selected based upon the participant's pre-treatment assessment. Additionally, the consonants in the above words were analyzed for accuracy across manner of articulation.

Untrained Items			
List 1- blocked	**List 2- random**	**List 3- blocked**	**List 4- random**
Gun	Comb	Thigh	Step
Gal	Cut	Thorn	Slim
Get	At	Thing	Spill
Gate	Kit	Third	Skin
Sip	Fat	Clan	Vat
Soon	Fed	Slide	Vex
Set	Fun	Play	Vie
Sat	Fill	Bled	Vim
Lip	Ripe	Jam	Duck
Load	Ram	Gem	Deck
Light	Rim	June	Pick
Lame	Wreck	Jut	Book

Table 3. Experimental Stimuli
The above are the word lists the participant was not trained. Stimuli were selected based upon the participant's pre-treatment assessment. Additionally, the consonants in the above words were analyzed for accuracy across manner of articulation.

Western Aphasia Battery Aphasia Quotient Scores					
ID	**Pre-tx**	**Post-tx**	**Follow-up I (4 weeks)**	**Follow-up II (10 weeks)**	**Raw Change pre-treatment to Follow-up II**
S1	27.4	30.9	30.8	39.1	11.7

Table 4. Standardized Assessment Results
The participant made the most notable gains between pre-treatment testing and follow-up II. Gains were most pronounced between Follow-up I and Follow-up 2.

Pre- and post-treatment Western Aphasia Battery Aphasia Quotient Subtests					
Subtest	**Pre-treatment**	**Post-treatment**	**Follow-up I (4 weeks)**	**Follow-up II (10 weeks)**	**Raw change pre-treatment to Follow-up II**
Spontaneous Speech	3	3	3	5	2
Auditory Verbal Comprehension	7.5	7.55	7.4	8.15	0.65
Repetition	0.9	3	2.3	3	2.1
Name and Word Finding	2.3	3.1	2.7	3.4	1.1
Object Naming	20	21	17	24	4
Word Fluency	0	1	1	2	2
Sentence Completion	3	6	6	4	1
Responsive Speech	0	3	3	4	4

Table 5. Standardized Assessment Results
The above provides a breakdown of the participants score on the Western Aphasia Battery by subtest. The participant made the most notable gains on the object naming and the responsive speech subtests.

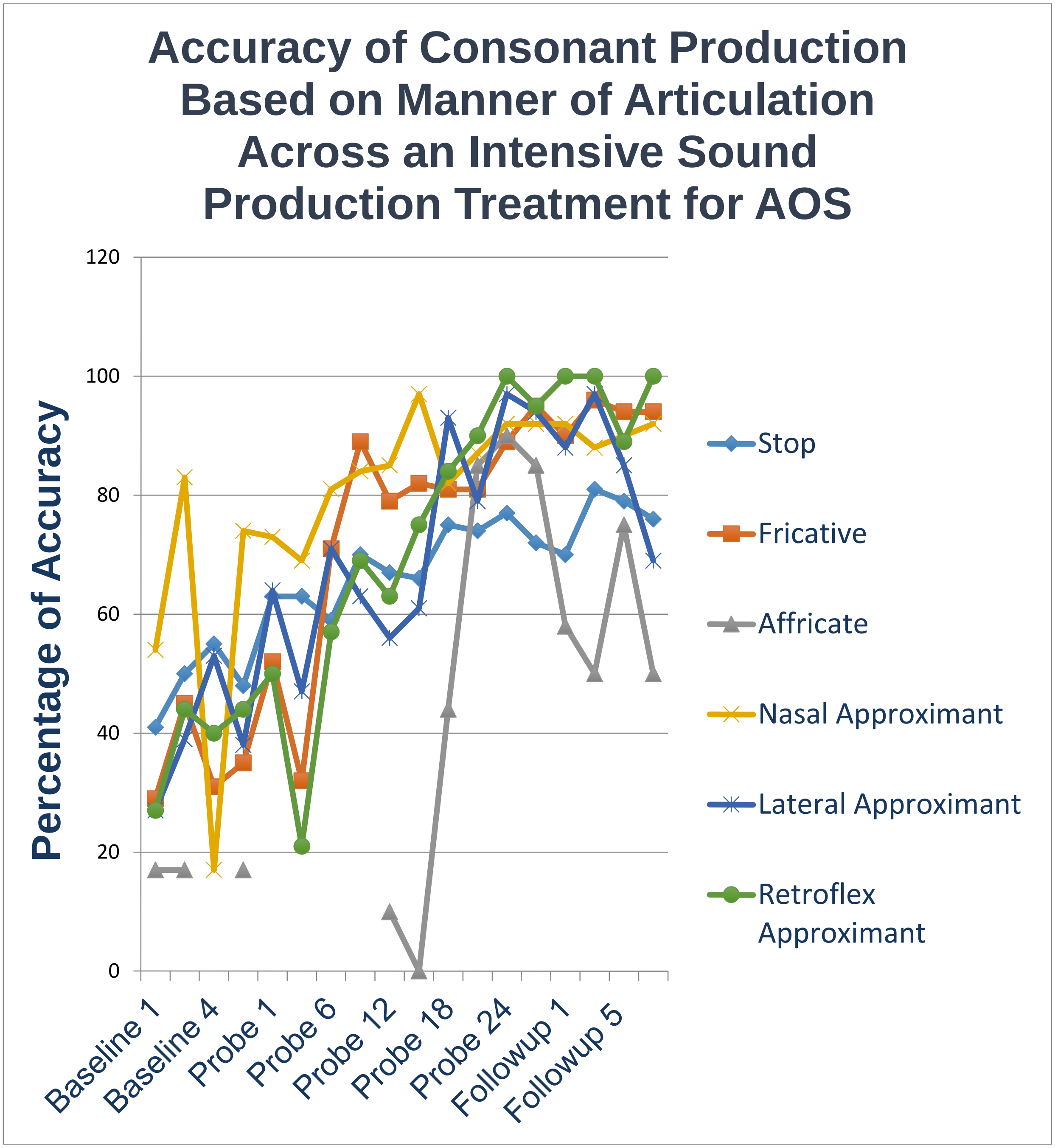

Figure 1. Accuracy of Consonant Production

Figure shows accuracy increasing in a steady manner across time. Steady upward trend is suggestive of consistency of errors.

Note: Missing data for baseline 2 and partial data for baseline 4 due to technical difficulties.