Apraxia of Speech: Perceptual Analysis of Mono-, Bi-, and Trisyllabic Words Across Repeated Sampling Occasions

The primary characteristics considered to define acquired apraxia of speech (AOS) have continued to evolve, but a few characteristics remain controversial among researchers and clinicians (McNeil, Robin, & Schmidt, 2009). Particularly, the consistency or variability of speech sound errors in AOS (Croot, 2002). For years, variability of speech sound errors has been considered a primary characteristic of AOS (Deal & Darley, 1972; Johns & Darley, 1970; Wertz, LaPointe, & Rosenbek, 1984). Apraxic errors were considered to be variable with regard to the location of the error within a word (Johns & Darley; LaPointe & Johns, 1975) and the nature of the error (Johns & Darley; LaPointe & Horner, 1976) across repeated productions of the same stimuli.

Conversely, more recent research with "pure" apraxic speakers and speakers with AOS and accompanying aphasia has suggested that speech sound errors may not be variable (Mauszycki, Dromey, & Wambaugh, 2007; Mauszycki, Wambaugh, & Cameron, 2010a, 2010b; Mlcoch, Darley, & Noll, 1982; McNeil, Odell, Miller, & Hunter, 1995; Shuster & Wambaugh, 2003; Wambaugh, Nessler, Bennett & Mauszycki, 2004). However, there are limited data examining sound errors over time (i.e., beyond a single session). Furthermore, the influence of conditions of stimuli presentation on sound errors remains uncertain.

The purpose of this investigation was to further examine variability of speech production in individuals with AOS and aphasia. Of specific interest were the effects of repeated sampling and conditions of stimulus presentation (i.e., random and blocked by sound) on the variability of error types identified using narrow phonetic transcription.

Method

Participants

Eleven individuals with AOS and aphasia participated in the study (see Table 1 for participant characteristics and Table 2 for assessment results).

Experimental Stimuli

Eighty-four words comprised of seven word final target phonemes (i.e., /z, d, m, s, l, k, p/) served as experimental stimuli. Stimuli consisted of mono-, bi-, and trisyllabic words with four exemplars for each syllable length for each target phoneme for a total of 12 stimulus items for each phoneme. Syllable structure for mono-, bi-, and trisyllabic words were CVC, CV-CVC, CVC-V-CVC respectively with primary stress on the first syllable. See Table 3 for stimuli.

Procedures

Stimuli were elicited on three different sampling *occasions* over a 7-day period with each participant. Each sampling occasion was separated by 2 days (e.g., Tuesday, Friday, and Monday) with each administration occurring at the same time on each sampling occasion.

Stimuli were elicited under two *conditions*: blocked presentation and randomized presentation. The blocked condition consisted of all exemplars of a phoneme presented sequentially (i.e., all final /l/ words). The word order within the block was randomized as was the order of the blocks.

Data Analyses

All speech samples were analyzed perceptually utilizing narrow phonetic transcription via audio-recordings.

Analysis of each target phoneme segment involved coding segments as correct or incorrect. Then, errors on target phonemes were coded according to predetermined categories which included substitutions, distortions, distorted substitutions, and omissions (Odell et al., 1990, 1991).

Perceptual Analyses

Mean percentage of errors. The mean percentage of errors *overall, by syllable length* and for *each target phoneme* was calculated by determining the number of times the phoneme was in error and dividing by the total number of occasions the target phoneme occurred in that position providing a percentage for comparison *within* and *across* sampling occasions.

Dominant error type by sound. The dominant error type used on erred productions *overall* and for *each target phoneme* was examined by determining the number of productions that were produced with a dominant error type and dividing by the total number of erred productions.

Reliability

Fifteen percent of the productions were randomly selected for reanalysis of narrow phonetic transcription for the purpose of determining inter- and intrajudge reliability. Overall item to item interjudge agreement for narrow phonetic transcription was 83%. For intrajudge reliability, overall item to item agreement for narrow phonetic transcription was 91%.

Results

The overall mean percentage of errors for *all* target phonemes for the group in each condition across sampling occasions is displayed in Figure 1. The mean percentage of errors ranged from 73% to 78% for the group. In the blocked condition, the mean percentage of errors was slightly greater (i.e., 2-4%).

The mean percentage of errors by *word length* in both conditions across sampling occasions is presented in Figure 2. The mean percentage of errors was similar for mono- and bisyllabic words and slightly greater for trisyllabic words regardless of sampling occasions and conditions of stimulus presentation.

Figure 3 depicts the mean percentage of errors for the group for *each target phoneme* in both conditions across the three sampling occasions. The mean percentage of errors for target phonemes from least number of errors to the greatest number of errors was /l, m, p, s, k, d, z/ in both conditions.

The dominant error type across target phonemes was distortions. Figure 4 displays the overall percentage of error types in each condition of stimulus presentation. Overall, the dominant error type was distortions in both conditions of stimulus presentation followed by distorted substitutions. There were a similar number of substitution and omission errors in both conditions. Tables 4 and 5 provide a summarization of number of errors and error types (percentage) for each phoneme at the three sampling occasions in the blocked and random conditions respectively.

Discussion

This investigation was designed to examine speech production in 11 individuals with AOS and aphasia. Specifically, the effects of repeated sampling and conditions of stimulus presentation (blocked and random) on the number of errors and dominant error type for seven target phonemes in the word final position.

Repeated sampling was found not to have a significant impact on the overall percentage of errors made by the group. The overall mean percentage of errors and standard deviation was similar in both conditions of stimuli presentation across the three sampling times. A comparison of the number of errors produced for each target phoneme in both conditions across sampling occasions revealed a pattern of responding by the group with a greater number of errors in the blocked condition for three target phonemes (i.e., /l, m, s/) at each sampling time.

Trisyllabic word productions had a slightly greater number of mean errors for this group of speakers. The mean percentage of errors for each word length was comparable across sampling occasions and conditions of stimulus presentation. These findings suggest conditions of stimulus presentation and repeated sampling had no influence on the number of errors produced based upon word length.

Distortions were found to be the dominant error type for all target phonemes. An examination of the number of error types produced by the group in each condition across the three sampling occasions found no obvious pattern of responding by the group in either condition for individual phonemes. That is, condition of stimulus presentation did not appear to influence the type of error produced for a given phoneme.

The findings from this investigation revealed a greater pattern of consistency in speech sound errors for the group. It appears there was a predictable pattern of sounds errors uncovered for the group across target phonemes. The implications of these findings will be discussed.

References

Croot, K. (2002). Diagnosis of AOS: Definition and criteria. *Seminars in Speech and Language, 23*(4), 267-279.

Dabul, B. (2000). *Apraxia Battery for Adults-2*. Austin, TX: Pro-Ed.

Deal, J.L., & Darley, F.L. (1972). The influence of linguistic and situation variables on phonemic accuracy in apraxia of speech. *Journal of Speech and Hearing Research, 15*, 639-653.

Johns, D.F., & Darley, F.L. (1970). Phonemic variability in apraxia of speech. *Journal of Speech and Hearing Research, 13*, 556-583.

Kertesz, A. (1982). *The Western Aphasia Battery*. New York, NY: Grune & Stratton.

LaPointe, L. L., & Horner, J. (1976). Repeated trials of words by patients with neurogenic phonological selection-sequencing impairment (apraxia of speech). *Clinical Aphasiology, 6*, 261-277.

LaPointe, L. L., & Johns, D. F. (1975). Some phonemic characteristics of apraxia of speech. *Journal of Communication Disorders, 8*, 259-269.

Mauszycki, S.C., Dromey, C., & Wambaugh, J.L. (2007). Variability in apraxia of speech: A perceptual, acoustic and kinematic analysis of stop consonants. *Journal of Medical Speech-Language Pathology, 15*, 223-242.

Mauszycki, S. C., Wambaugh, J. L., & Cameron, R. C. (2010a). Variability in apraxia of speech: Perceptual analysis of monosyllabic word productions across repeated sampling times. *Aphasiology, 24*(6-8), 838-855.

Mauszycki, S.C., Wambaugh, J.L., & Cameron, R. M. (2010b). Apraxia of speech: Perceptual analysis of bisyllabic word productions across repeated sampling occasions. *Journal of Medical Speech-Language Pathology, 18*(4), 89-98.

McNeil, M. R., Odell, K., Miller, S. B., & Hunter, L. (1995). Consistency, variability, and target approximation for successive speech repetitions among apraxic, conduction aphasic, and ataxic dysarthria speakers. *Clinical Aphasiology*, *23*, 39-55.

McNeil, M. R., Robin, D. A., & Schmidt, R. A. (2009). Apraxia of speech: Definition, differentiation, and treatment. In M.R. McNeil (Ed.), *Clinical management of sensorimotor speech disorders (2nd Ed.)* (pp. 249-268). New York, NY: Thieme.

Mlcoch, A.G., Darley F.L., & Noll, J.D. (1982). Articulatory consistency and variability in apraxia of speech. In R.H. Brookshire (Ed.), *Clinical aphasiology conference proceedings* (pp. 235-238). Minneapolis, MN: BRK.

Odell, K., McNeil, M.R., Rosenbek, J.C., & Hunter, L. (1990). Perceptual characteristics of consonant production by apraxic speakers. *Journal of Speech and Hearing Disorders*, *55*, 345-359.

Odell, K., McNeil, M.R., Rosenbek, J.C., & Hunter, L. (1991). Perceptual characteristics of vowel and prosody production by apraxic, aphasic and dysarthric speakers. *Journal of Speech and Hearing Research, 34*, 67-80.

Raven, J., Raven, J.C., & Court, J. H. (1998). *Coloured progressive matrices*. Oxford, England: Oxford Psychologist Press, Ltd.

Shuster, L., & Wambaugh, J. L. (2003). *Consistency of speech sound errors in apraxia of speech accompanied by aphasia*. Presentation at the annual Clinical Aphasiology Conference, Orcas Island, WA.

Wambaugh, J.L., Nessler, C., Bennett, J., & Mauszycki, S. C. (2004) Variability in apraxia of speech: A perceptual and VOT analysis of stop consonants. *Journal of Medical Speech-Language Pathology*, *12*, 221-227.

Wertz, R.T., LaPointe, L.L., & Rosenbek, J.C. (1984). *Apraxia of speech in adults: The disorder and its management*. Orlando, FL: Grune & Stratton.

Yorkston, K.M., & Beukelman, D.R. (1981). *Assessment of intelligibility of dysarthric speech*. Austin, TX: Pro-Ed.

Table 1

Participant Characteristics

Characteristic	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11
Age	35	56	46	47	56	25	41	62	63	58	52
Gender	Male	Female	Female	Male	Female	Female	Male	Female	Female	Male	Male
Years of Education	18	14	12	13	10	12	14	15	13	20	11
Etiology	CVA	CVA	CVA	CVA	CVA	CVA	TBI	CVA	CVA	CVA	CVA
Yrs/Mos Post-onset	1 yr 9 mos	2 yrs 9 mos	1 yr 2 mos	15 yrs 7 mos	9 mos	9 mos	6 yrs 1 mos	4 mos	9 yrs 4 mos	4 yrs 10 mos	8 mos

Table 2

Assessment Results

Assessment Tool	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	P-11
Apraxia Battery for Adults-2 (Dabul, 2000)											
Level of Impairment	Mild AOS	Mild-Mod AOS	Mod-Severe AOS	Mod-Severe AOS	Mod-Severe AOS	Severe AOS	Mod-Severe AOS	Mild AOS	Mild AOS	Mod-Severe AOS	Severe AOS
Western Aphasia Battery (Kertesz, 1982)											
Aphasia Quotient	94.0	71.2	45.1	83.6	76.7	42.7	36.9	92.5	97.3	47.0	52.6
Classification	Anomic	Broca's	Broca's	Broca's	Broca's	Broca's	Broca's	Anomic	Anomic	Broca's	Broca's
Assessment of Intelligibility of Dysarthric Speech (Yorkston & Beukelman, 1981)											
Word Level	92%	94%	98%	84%	78%	82%	90%	98%	100%	92%	90%
Raven's Coloured Progressive Matrices (Raven, Raven & Court, 1998) (36 Possible)											
Total Score	33	30	28	30	30	35	32	33	31	36	28

Table 3

Experimental Stimuli

Monosyllabic Words with Final Phonemes

z	d	m	s	l	k	p
Jazz	Lad	Lamb	Gas	Pal	Tack	Cap
Tease	Bead	Team	Peace	Meal	Leak	Beep
Pose	Road	Comb	Dose	Goal	Poke	Pope
Fuse	Mood	Boom	Moose	Tool	Duke	Loop

Bisyllabic Words with Final Phonemes

z	d	m	s	l	k	p
Rabies	Nomad	Forum	Bogus	Vocal	Basic	Tulip
Topaz	Cupid	Salem	Recess	Rival	Lilac	Julep
Series	Lucid	Totem	Venus	Legal	Cubic	Gallop
Pisces	Moped	Serum	Cautious	Naval	Kodak	Bebop

Trisyllabic Words with Final Phonemes

z	d	m	s	l	k	p
Memorize	Latitude	Catacomb	Nemesis	Chemical	Bailiwick	Teletype
Paralyze	Renegade	Minimum	Paradise	Topical	Tomahawk	Leadership
Televise	Marinade	Synonym	Genesis	Parallel	Similac	Lollipop
Maximize	Solitude	Maximum	Populous	Monorail	Tillamook	Handicap

Table 4

Number of Errors and Error Types (Percentage) for Each Target Phoneme at Each Sampling Occasion in the ***Blocked Condition*** with Predominant Error Type in Bold

Phoneme	Sampling Time	Number of Errors	Distortion	Substitution	Distorted Substitution	Omission
/l/						
	Time 1	421	**71%**	3%	9%	17%
	Time 2	414	**62%**	4%	11%	23%
	Time 3	356	**65%**	3%	11%	21%
/m/						
	Time 1	414	**68%**	11%	17%	4%
	Time 2	451	**72%**	9%	16%	3%
	Time 3	434	**72%**	10%	15%	3%
/p/						
	Time 1	423	**77%**	8%	11%	4%
	Time 2	425	**84%**	2%	12%	2%
	Time 3	452	**83%**	3%	12%	2%
/s/						
	Time 1	495	**69%**	7%	20%	4%
	Time 2	476	**82%**	3%	12%	3%
	Time 3	522	**80%**	1%	17%	2%
/k/						
	Time 1	513	**66%**	4%	27%	3%
	Time 2	537	**73%**	2%	22%	3%
	Time 3	558	**73%**	2%	19%	6%
/d/						
	Time 1	622	**81%**	3%	14%	2%
	Time 2	627	**78%**	3%	13%	6%
	Time 3	635	**78%**	3%	17%	2%
/z/						
	Time 1	636	**82%**	4%	11%	3%
	Time 2	609	**83%**	3%	11%	3%
	Time 3	640	**84%**	1%	11%	4%

Table 5

Number of Errors and Error Types (Percentage) for Each Target Phoneme at Each Sampling Occasion in the ***Random Condition*** with Predominant Error Type in Bold

Phoneme	Sampling Time	Number of Errors	Distortion	Substitution	Distorted Substitution	Omission
/l/						
	Time 1	357	**68%**	2%	16%	14%
	Time 2	341	**64%**	2%	15%	19%
	Time 3	332	**68%**	3%	17%	12%
/m/						
	Time 1	388	**61%**	12%	21%	6%
	Time 2	400	**66%**	9%	21%	4%
	Time 3	388	**64%**	12%	21%	3%
/p/						
	Time 1	432	**73%**	3%	20%	4%
	Time 2	406	**80%**	3%	16%	1%
	Time 3	424	**80%**	2%	17%	1%
/s/						
	Time 1	457	**82%**	3%	12%	3%
	Time 2	455	**77%**	5%	16%	2%
	Time 3	478	**80%**	3%	15%	2%
/k/						
	Time 1	539	**62%**	5%	31%	2%
	Time 2	557	**68%**	3%	26%	3%
	Time 3	542	**66%**	6%	26%	2%
/d/						
	Time 1	612	**78%**	5%	15%	2%
	Time 2	627	**80%**	2%	15%	3%
	Time 3	631	**82%**	3%	13%	2%
/z/						
	Time 1	632	**79%**	3%	15%	3%
	Time 2	635	**84%**	2%	12%	2%
	Time 3	649	**85%**	1%	12%	2%

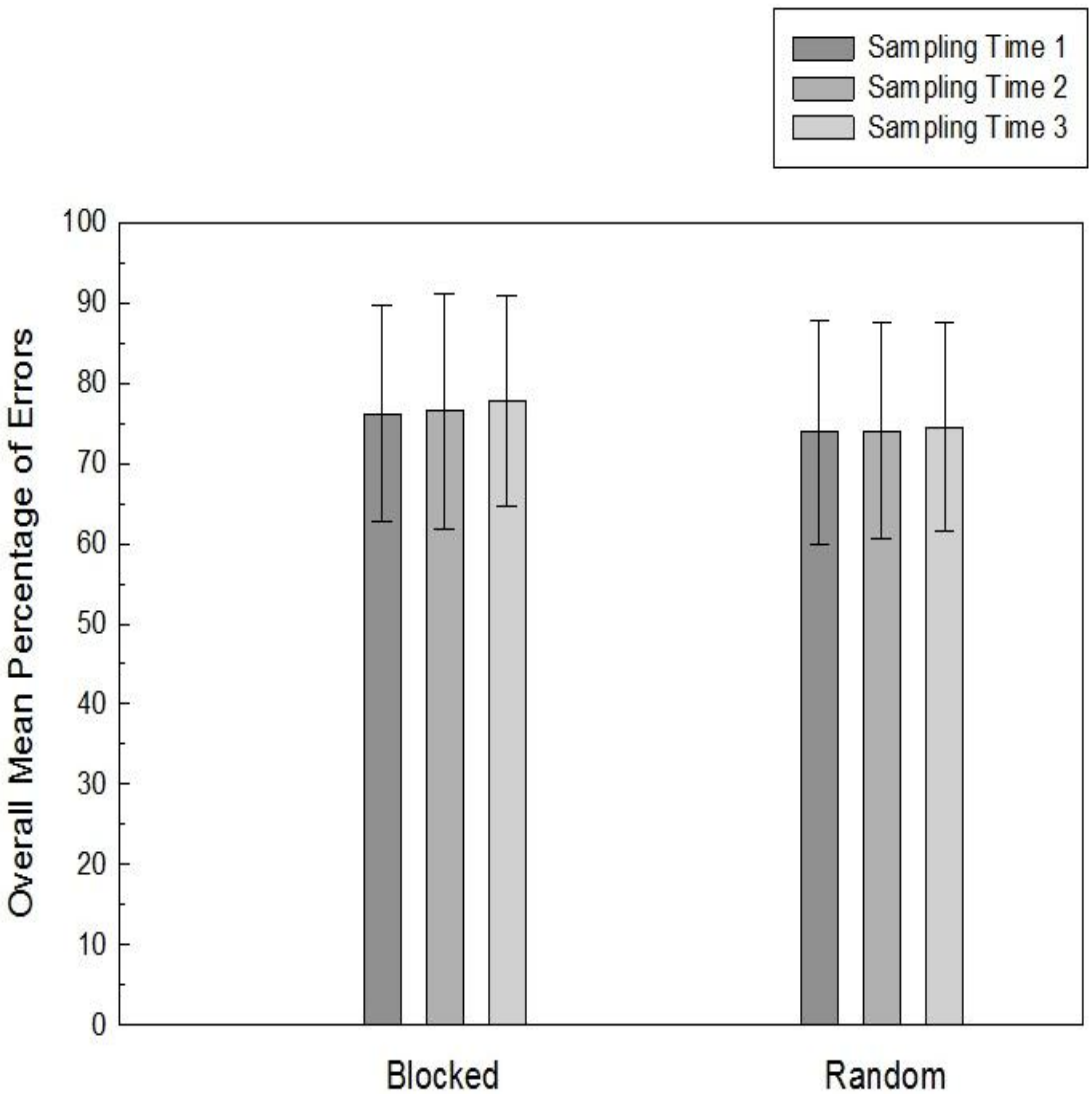

Figure 1. The overall mean percentage of errors and standard deviation (error bars) in the blocked and random conditions across the three sampling occasions

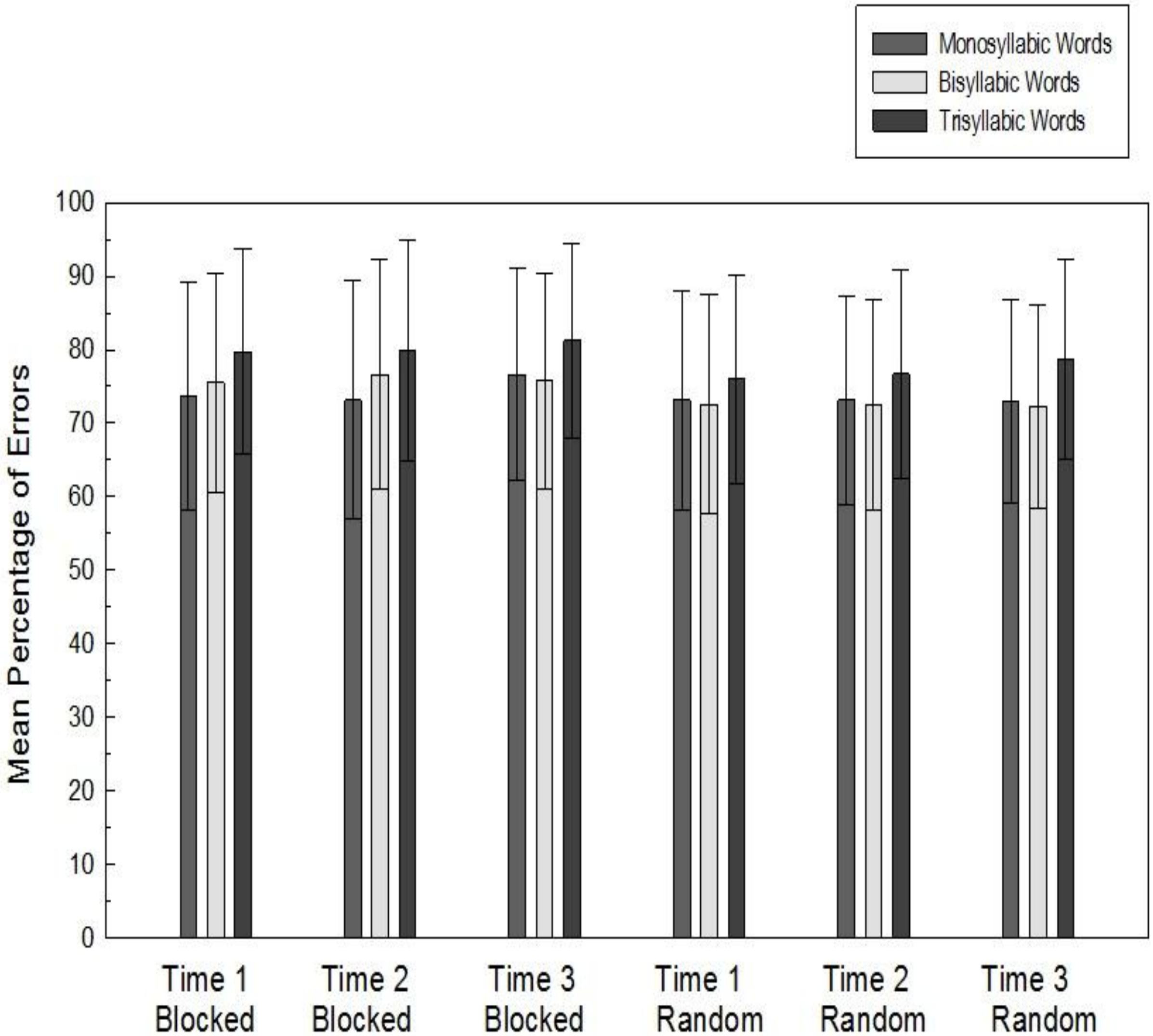

Figure 2. The mean percentage of errors and standard deviation (error bars) for each word length across sampling occasions in the blocked and random conditions

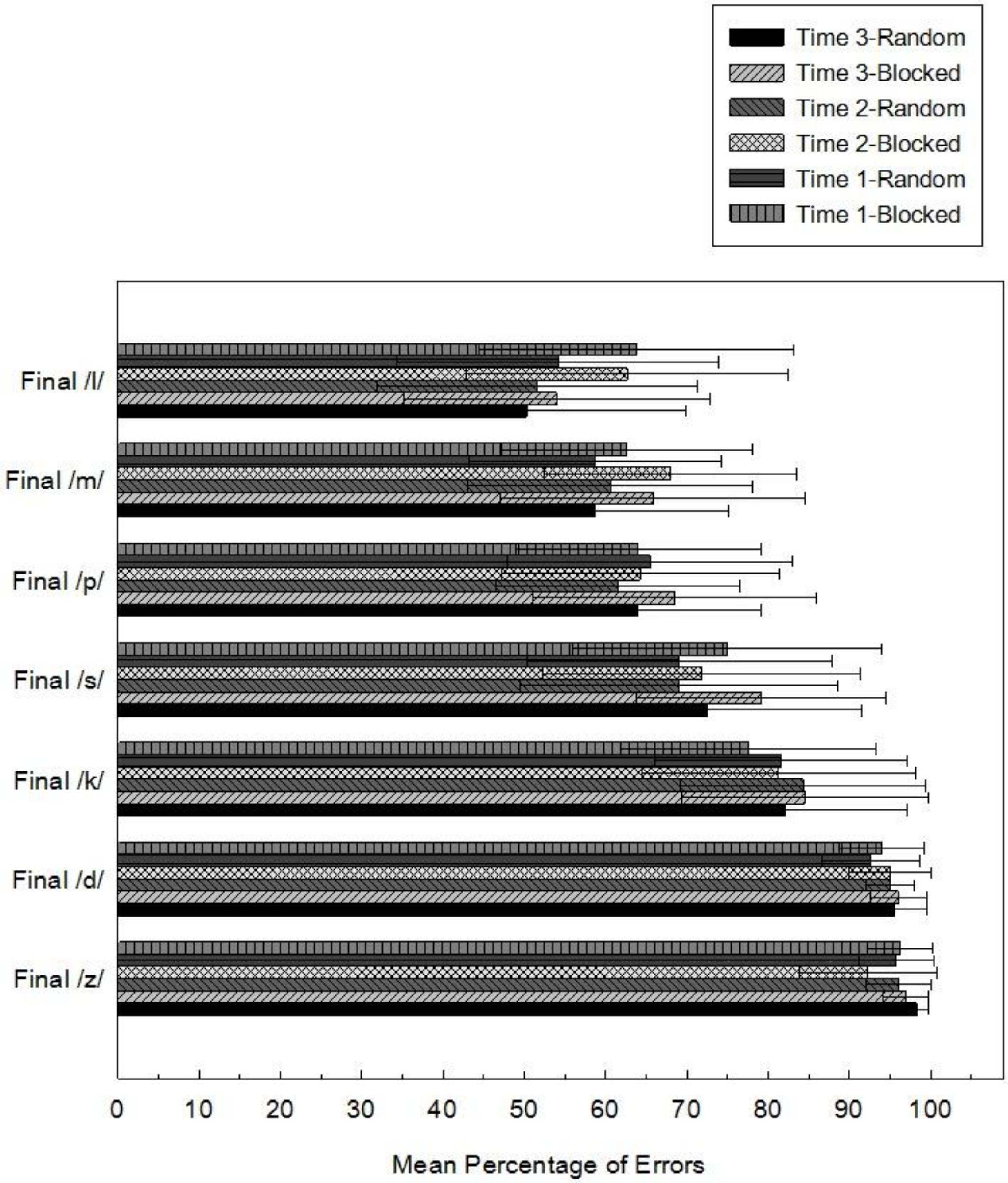

Figure 3. The mean percentage of errors and standard deviation (error bars) for the group for each target phoneme across conditions and sampling occasions

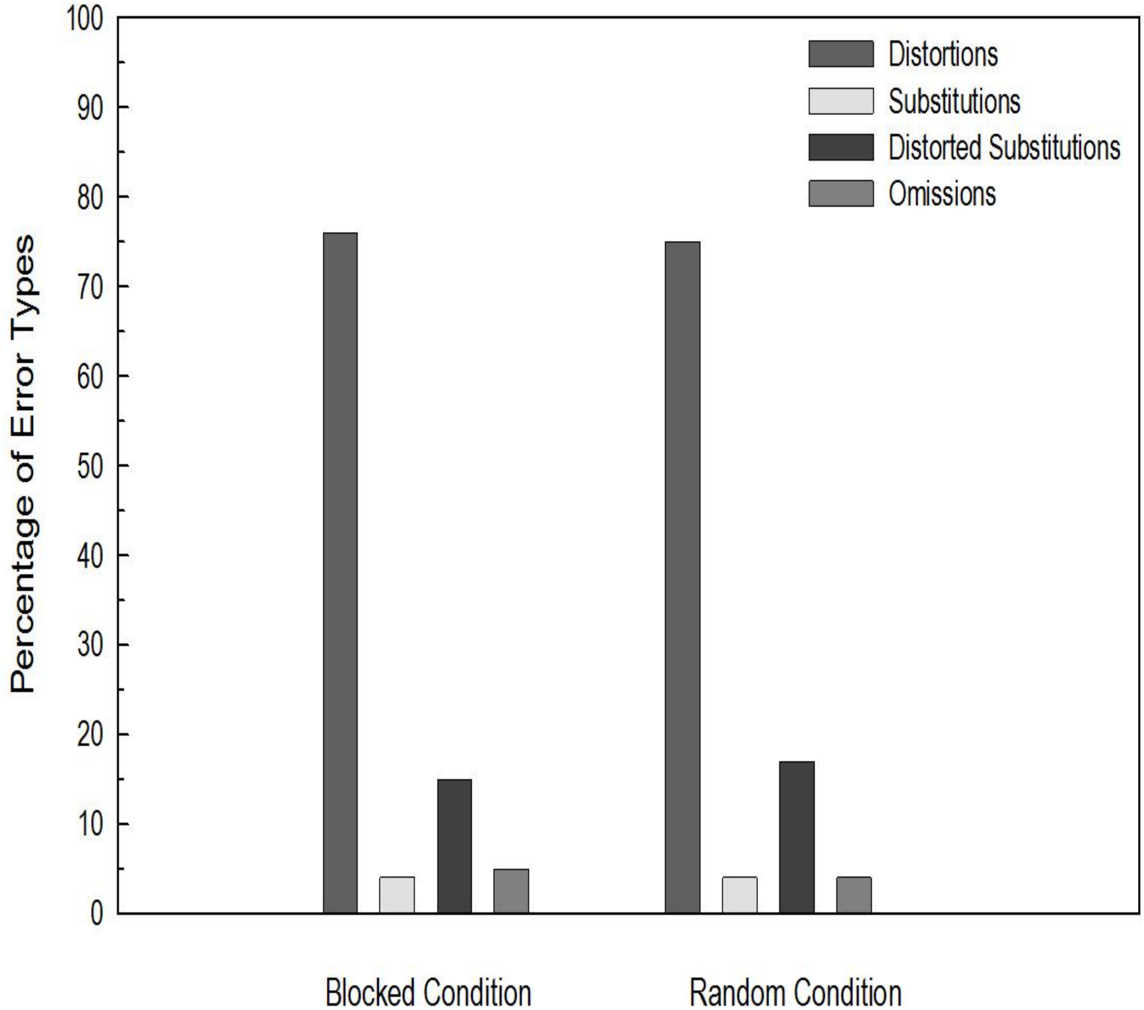

Figure 4. The overall percentage of error types in the blocked and random conditions for the group