

Analysis of Treatment Dose for Treatment of Speech Sound Disorder

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Abstract

Treatment dose for speech sound disorders (SSD) has not been thoroughly investigated. This information is critical to treatment planning for speech-language pathologists. The purpose of the present study was to examine the cumulative treatment dose required for children with SSD to reach 25%, 50%, and 75% accuracy on their treatment sound during a single session. The present study is a retrospective analysis of treatment data gathered in a previous study of two age groups of children – one group between the ages of 4 and 5 and the other between the ages of 7 and 8. This data is a count of each participant's correct and incorrect productions of their target sound over the course of each treatment session. The results show that there is no significant difference between the mean dose required for both groups of children to achieve 25%, 50%, and 75% accuracy; dose varied greatly between participants. Both age groups require a relatively similar treatment dose to achieve accuracy on their respective treatment sounds.

Keywords: speech sound disorder, treatment intensity, treatment dose

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As they mature, children gradually develop the speech sounds that make up their communication system. We expect children to acquire certain speech sounds at different ages during their development. For example, typically developing children are expected to have mastered the following sounds: /p, m, h, w, m, b/ by three years old (McLeod & Crowe, 2018). Children master these sounds early on because they are easy to produce. More difficult sounds like fricatives – sounds produced by placing the articulators closely together and forcing the air through – may not be acquired until later. For example, /th/ may not be acquired until the age of six, and /s/ by the age of seven—which is quite late in development (McLeod & Crowe, 2018). Fricatives are sounds produced by placing the articulators closely together and forcing the air through. The /f/ sound is produced by placing the top teeth on the lower lip. The sound is produced when air passes through. While we observe the childhood development of speech sounds according to a general timeline, some variation is accepted. Despite this variation, children are generally expected to correctly produce all sounds by four years old.

In observing the development of speech sounds in children, it is apparent that some children do not acquire these sounds at the same time as their peers. Children with speech sound disorders (SSD) have difficulty learning the sounds of their first language and struggle to correctly produce these sounds according to the expected timeline. Prevalence estimates for children with SSD vary between studies from 2.3% to 24.6% (Eadie, et al., 2015; Black, et al., 2015; Shriberg, et al., 1999; Law, et al., 1999; Wren, et al., 2016). Other researchers have found that peak prevalence for SSD in childhood occurs earlier for females (3 to 4 years) than for males (6 years) (Keating, et al., 2008). At its peak, the estimated prevalence of SSD for females is 1.8% and for males is 6.5% (Keating, et al., 2008). In a study of eight-year-old children, the prevalence

of persistent SSD is estimated to be 3.6% (Wren, et al., 2016). In a gender specific comparison, Wren and colleagues (2016) estimated the prevalence for boys to 4.6% and 2.5% for girls.

Research supports the claim that the occurrence of SSD is more frequent in males than females (McKinnon, et al., 2007; Eadie et al., 2015; Keating, et al., 2008; Wren, et al., 2016).

Observations about prevalence allow clinicians to gain a better understanding of the population they are treating and provides the opportunity to gather better evidence to treat these individuals. Such information can lead to better estimates of the resources and knowledge needed for successful treatment.

Certain factors put children at greater risk of SSD. Demographic factors include gender and homeownership. Boys are more likely to be diagnosed with SSD than girls (Wren, et al., 2016; Eadie, et al., 2015; Keating, et al., 2008; McKinnon, et al., 2007). Children with SSD are also likely to live in a rented home, rather than a home owned by their family (Wren, et al., 2016). Environmental and family factors have also been identified. Children with a biological parent with history of a speech impairment are more likely to be diagnosed than their peers with no family history (Felsenfeld & Plomin, 1997). Other research has also reported that family history can be used as a predictor for SSD (Eadie, et al., 2015). Some studies have shown that lower socio-economic status is a predictor of SSD (Wren, et al., 2016; Eadie et al., 2015). Other studies have found no relationship between socioeconomic status and SSD during childhood (Keating, et al., 2008). Knowledge about risk factors such as these, also provides clinicians with a better understanding of the population they are treating.

Comorbidity – the presence of two conditions simultaneously – is a continuing concern when working with individuals with SSD. The speech language pathologist should be aware of multiple diagnoses during treatment. In a study of four-year-old children with SSD, Eadie, et al.,

(2015) examined the comorbidity of SSD with other communication disorders and found that 40.8% of children with SSD also had comorbid language disorders. Keating, et al., (2008) noted that children with SSD have a greater number of mental health and ear disorders. These issues have the potential to interact with the diagnosis of SSD and may affect the type of treatment selected by the clinician.

The diagnosis of SSD can also be associated with reduced literacy skills. In fact, 20.8% of children with SSD also demonstrated poor pre-literacy skills when assessed for letter knowledge (Eadie, et al., 2015). Children with SSD performed lower on tests of phonological awareness and literacy (Bird, et al., 1995). In a longitudinal study, Nathan, et al., (2004) tested the literacy skills of children with speech difficulties alone, speech and language difficulties, or neither. Skills tested include speech, letter name knowledge, single word reading, prose reading, non-word reading, spelling, and spelling from pictures. Letter name knowledge was assessed by randomly presenting all 26 lowercase letters for naming. Spelling from pictures included one, two, and three syllable and scores were recorded based on correct phoneme representation. The risk of literacy delay was high for children affected by speech difficulties (Nathan, et al., 2004). They conjecture that the resolution of speech errors before literacy instruction will lead to improved literacy skills. If this is true, more knowledge about the treatment of SSD is important. Research about treatment dose will aid in providing efficient treatment to resolve speech errors before the initiation of reading instruction.

Children with SSD struggle with intelligible communication, but this diagnosis may also affect the perception of their intelligence and academic skill. Ebert and Prelock (1994) conducted a study in which teachers were asked to rank their students on overall classroom performance. Sixteen elementary teachers for grades 2 through 5 participated in the study. Eight teachers

participated in a training program focused on language in the classroom. This program consisted of 14 hours of instruction in speech and language and classroom topics as well as weekly attendance of collaborative meetings with the SLP. The other eight teachers did not attend trainings. Teachers in all participating classrooms were asked to rank their student compared to the rest of the class as high, middle, or low. The researchers found that teachers who had participated in the training program were better able to accurately rank students with communication disorders based on their academic ability. Teachers who did not participate in the trainings ranked a significant number of students without communication disorders higher than their peers with communication disorders despite similar classroom performance. Without such training, teachers were less able to accurately perceive the abilities of students with SSD which in turn impacts their ability to instruct students. Teachers who can accurately perceive the abilities of their students can provide correct instruction for each. Conversely, if children are perceived to have lower abilities than they truly do, they will not be challenged correctly. Knowledge about SSD and other communication disorders helps education professional and clinicians provide a more successful learning environment for children and avoid the negative educational results apparent for many children with SSD.

In children with SSD, it is important to consider the influence that SSDs will have as children grow into adults. Felsenfeld, et al., (1992) followed up with a group of adults who had a history of phonological disorder through the first grade in order to compare them to their typically developing counterparts. As adults, the group that previously struggled with speech sound production scored lower on articulation, expressive language, and receptive language measures. On measures of personality such as extroversion and neuroticism, the two groups scored similar to one another. A second follow up study showed that, generally, those with a

history of speech sound disorders received lower grades in high school, received more remedial academic services, and completed fewer years of education (Felsenfeld, et al., 1994). While the two groups differed in terms of ability and school performance, they did not differ in personality or employment status. In another study, Lewis and Freebairn (1992) examined individuals with a history of SSD in preschool. In this case, the researchers found that when compared to a control group, those with a history of disordered speech performed poorly in the areas of reading, spelling, and phonology – the systematic organization of speech sounds. Individuals with additional speech or language diagnoses performed more poorly when compared to those with a single disorder. By providing treatment to those who struggle with speech as children, clinicians can ease some of the difficulties these individuals must endure as they grow older.

When initiating treatment, clinicians must consider treatment intensity as one of the factors involved in providing their client with the best possible treatment. Treatment intensity is measured by combining the dose, dose form, session length, frequency, and duration. Warren, et al., (2007) introduce the terminology to explain treatment intensity. Treatment dose is defined as the number of teaching episodes in a single session (Warren, et al., 2007). Dose can vary depending on how treatment happens during a session. Specifically, if any component of treatment changes – dose form, session length, frequency, etc. – treatment dose changes as well. For example, changes in session length affect the number of teaching episodes the client is exposed to. A more intense session may include a higher number of repetitions of the target sound resulting in a higher dose for that session. Dose form is a description of the type of intervention or activity the clinician is using during a session. Dose form will depend on the task or activity the clinician has planned. Session length is the amount of time the clinician spends treating a client each session. Dose frequency can be defined as how often a clinician treats a

client, and is often measured in terms of the number of sessions per week. The duration of treatment describes how long this treatment protocol will last in weeks, months, or years.

Cumulative intervention intensity, therefore, can be defined by multiplying the values associated with these: treatment dose, treatment frequency, and duration of treatment. Each of these measurements must be determined by the clinician while planning treatment for an individual with SSD and may improve the efficiency and efficacy of treatment.

Treatment intensity is considered by clinicians when planning treatment for an individual. Despite the important implications this may have on the outcome of treatment, little research exists to suggest ideal treatment intensity for SSD. Researchers have shown that the ideal treatment intensity depends on the approach to treatment and the disorder being treated (Kaipa & Peterson, 2016). For example, in the treatment of SSD, children who were exposed to three sessions per week showed greater improvement than those receiving one session per week (Allen, 2013). In this study of preschool children with SSD, though the researchers did not control for the treatment dose, data showed that the treatment plan with greater frequency lead to greater improvement (Allen, 2013). More research concerning the dose required in treatment, will allow clinicians to make more informed decisions about intervention with each client.

While research that identifies the ideal treatment intensity for intervention of SSD is lacking, we do have data that describes the current trends in treatment. Session duration remains consistent whether students receive group or individual intervention (Brumbaugh & Smit, 2013). Typically, children with SSD are engaged in sessions with a duration of 21 to 30 minutes (Mullen & Schooling, 2010). In a systematic review of 134 intervention studies, Baker and Mcleod (2011) also found that these sessions most typically occur two to three times per week. After the second grade, we see a decrease in the frequency of sessions per week and the intensity

of these sessions as measured in minutes (Mullen & Schooling, 2010). A majority of these sessions were conducted by pulling these students out of class in groups of 2 to 4 (Mullen & Schooling, 2010). This reduction in time could be due to progress in treatment or differing abilities between older and younger children. For example, older children have the capacity to sit still and focus on one task more intently and for a long duration. This may result in a greater number of practice events in a shorter amount of time. Since most children typically acquire all speech sounds by 8 years old, older children may also have fewer sound errors to treat. Nonetheless, we cannot be sure if this is the ideal session length and frequency for intervention with children with SSD simply because it is the most frequently used. After all, this data only examines the way in which treatment is typically provided. It does not state best practice. The range of treatment duration for children receiving phonological intervention is 3 to 18 months or a total of 17.5 hours to 130 hours (Baker and McLeod, 2001). Because little data is provided about the dose presented and the observed results, we cannot evaluate the dose necessary to achieve improved results.

The present study will address the current gap in knowledge by investigating treatment dose in two different age groups. This research will create a better understanding of treatment and provide opportunity for better treatment practices. By looking at the dose required by children with SSD to attain specific levels of accuracy, we will examine the level of practice required for improvement by participants in both a young and an old group. During these different age ranges, children develop language differently. This study will examine the treatment dose needed for children with SSD to produce a treatment sound correctly at the ad-hoc determined levels of 25%, 50%, and 75% accuracy. The treatment dose required to reach these levels of accuracy will be determined and the results for the two groups, old and young,

will be compared. This information will help clinicians make better decisions about treatment dose in the treatment of SSD by comparing the two groups.

Method

The current study provides a post hoc analysis of datapoints describing the production of non-words containing each participant's target sound. These productions were recorded and evaluated as incorrect or correct. These data were collected for two treatment studies examining treatment effectiveness and efficacy for treatment of late-acquired sounds for young and old children. The procedures of the present study were approved by the Institutional Review Board at the University of Wyoming.

Participants

Participants for this study were recruited by word-of-mouth, through local speech-language pathologists, preschools, daycares, social media postings (e.g. Facebook, Twitter), and flyers on local community boards. Two age groups were targeted: "young" and "old." To be included in the study, participants were screened for normal hearing, typical receptive language, no motor speech impairment, typical non-verbal intelligence, and typical motoric and neurological development. The outcomes of these evaluations are included in Table 1. Each participant was assessed to confirm that they produced at least one late-acquired sound with less than 7% accuracy. Young participants were required to be between the ages of 4 years, 0 months and 5 years, 11 months. Of the eight participants in this group, three were treated on the treatment sound /r/, two on the treatment sound /th/, one on the treatment sound /l/, one on the treatment sound /s/, and one on the treatment sound /sh/. Old participants were required to be between the ages of 7 years, 0 months and 8 years, 11 months. Of the five participants in this group, /r/ was the treatment sound for four, and /th/ the treatment sound for one.

Table 1***Participant Data***

	ages		GFTA-3 SS		GFTA-3 PR	
	old	young	old	young	old	young
<i>M</i>	8;0	4;10.25	59.6	65	1.44	3.41
<i>SD</i>	7.48 months	7.51 months	15.58	14.44	1.46	3.43
range	6;11-8;11	4;2-5;9	40 - 77	40 - 79	.1 - 4	.1 - 9

	CTOPP PA SS		CTOPP PA PR		CTOPP PM SS		CTOPP PM PR	
	old	young	old	young	old	young	old	young
<i>M</i>	65.6	52	35.2	38	56.8	45.38	17.6	33
<i>SD</i>	29.86	33.25	30.08	26.12	35.7	39.19	14.91	26.38
range	20 - 94	21 - 100	9--93	3--89	12--98	11--107	3--68	3--68

	TOLD-P4 Listening IS		TOLD-P4 Listening PR	
	old	young	old	young
<i>M</i>	107	104	65.8	28.13
<i>SD</i>	9.08	10.89	20.31	24.55
range	94 - 119	88 - 119	35 - 90	27 - 90

Note: Ages are reported in years and months (year;months). The GFTA-3 was used to measure articulation. Both standard score and percentile rank are included. The CTOPP was used to measure phonological awareness and phonological memory. The TOLD-P4 can be used to assess spoken language in young children. Index scores and percentile ranks are included.

Procedures

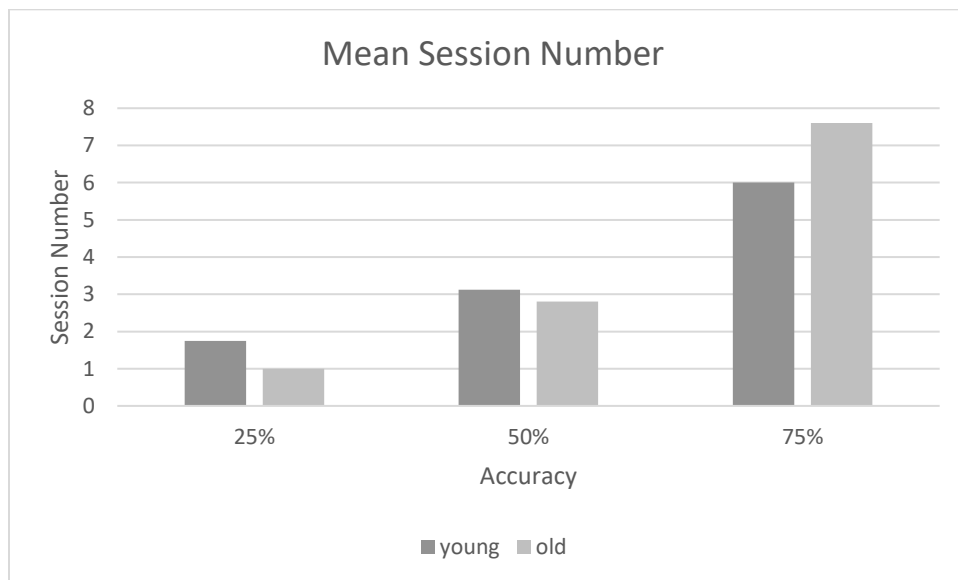
Participants in the previous study were being treated on late-learned sounds to examine whether age related differences existed. This was a single-subjects design conducted over four years. During each session, each child produced 10 repetitions of 8 nonword stimuli. For each repetition, only the first production was scored as correct or incorrect. A second opportunity was provided with corrective feedback if the initial was incorrect. The second productions were

recorded as correct or incorrect, but were not included in calculations of accuracy. Therefore, the dose – total number of productions and feedback occurrences – varied freely from child to child. The current study will examine the results of each session by examining the total number of productions.

Treatment dose for each participant was tallied to determine the number of repetitions required for each participant to reach predetermined levels of accuracy in a single session. The accuracy for each session was determined by comparing the number of correct productions to the total number of productions in the session. All learning episodes up to and including that session were added together to determine the total number of learning episodes required to reach 25% accuracy. The same procedure was followed to determine the amount of learning episodes required to reach both 50% and 75%. The session number in which the participant achieved 25%, 50%, and 75% was recorded as well. This data is shown in Table 2.

Table 2

Mean Session Number Required for 25%, 50%, and 75% Accuracy



Data Analysis

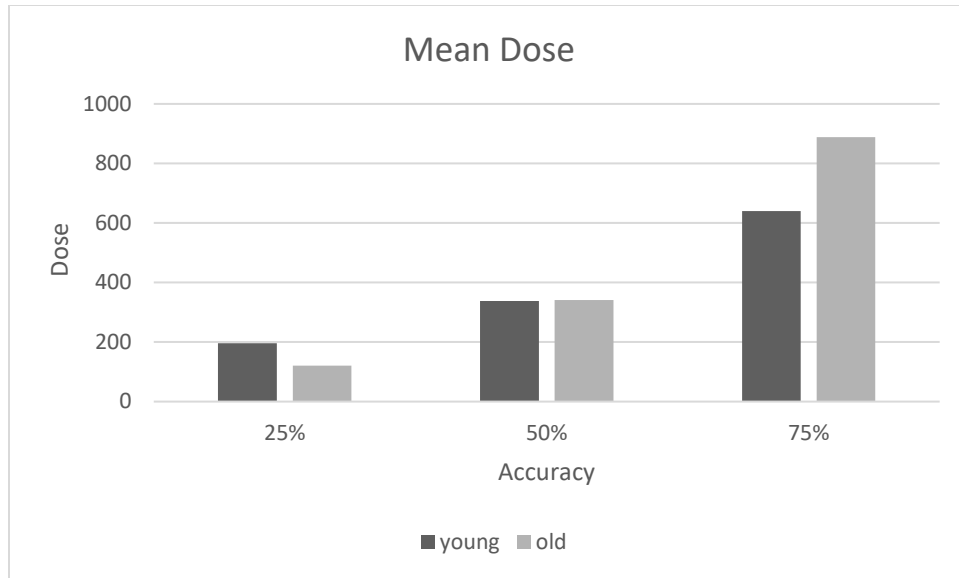
The mean dose required for the young group and the old group to achieve 25%, 50%, and 75% accuracy on their treatment sound within one session was calculated. Using the independent variable – the accuracy levels of 25%, 50%, and 75% - and the dependent variable – the dose required to reach each level of accuracy – an independent samples t-test was conducted to compare the mean dose between the two groups.

Results

The mean dose required to achieve 25%, 50%, and 75% accuracy was calculated and compared for each group. These results are shown in Table 3. Within each group, the treatment dose required for each participant varied. For both 25% and 50%, equal variances were assumed. The mean dose for the young group at 25% ($M=196.12$, $SD=150.99$, range 100 - 546) and the old group at 25% ($M=120.40$, $SD=20.32$, range 85-137) were not significantly different [$t(11)=1.09$, $p=.29$]. Mean dose for the young group at 50% ($M=337.62$, $SD=183.50$, range 100-722) and for the old group at 50% ($M=341.20$, $SD=379.18$, range 85-1006) were not significantly different [$t(11)=-.02$, $p=.98$]. For the 75% level of accuracy, Levene's test for equality of variances was found to be statistically significant, which violated the assumption of equality for t-tests, thus this required correction which was conducted within SPSS statistical analysis software. The mean dose for the young group at 75% ($M=640.37$, $SD=305.87$, range 304-1073) and for the old group at 75% ($M=888.00$, $SD=579.28$, range 85-1515) were not significantly different [$t(5.33)=-.89$, $p=.42$]. Despite this lack of significance, it is important to note that the variability within groups at this level of accuracy was high, which may have impacted the statistical power of this test.

Table 3

Mean Dose



Discussion

This study aimed to determine the treatment dose required for two groups of children with SSD to achieve 25%, 50%, and 75% accuracy during a treatment session. These participants were divided into an old group (between the age of 7 years, 0 months and 8 years, 11 months) and a young group (between the ages of 4 years, 0 months and 5 years, 11 months). A t-test revealed that young and old groups do not require a significantly different mean treatment dose to achieve 25%, 50%, and 75% accuracy. Through visual inspection, it appears that older children require a greater mean dose ($M=888$) than younger children ($M=640.37$) to produce their treatment sound with 75% accuracy. The t-test showed that despite the apparent difference, there was not a significant difference between the two.

This research lends support to evidence-based practice in the clinical setting—a cornerstone to the practice of speech-language pathology. Previous research has provided evidence for planning treatment frequency (Allen, 2013). Now, clinicians have applicable research concerning the treatment dose required during treatment with children who have SSD. Other research has been conducted concerning typical treatment in the field (Mullen &

Schooling, 2010). Data from a national survey showed that children received similar treatment during Kindergarten, first, and second grade (Mullen & Schooling, 2010). Once children reach third grade, there is a shift in which more children are treated in less intense sessions (as measured in minutes) and more children are treated less frequently (e.g. less than two times per week) (Mullen & Schooling, 2010). While older children may receive less intense, less frequent sessions this research does not examine the dose that children are receiving. Now, speech-language pathologists can combine previous research about treatment intensity with dose information to plan more efficient treatment sessions despite the differences in typical treatment.

Research in the area of treatment intensity is important in planning the most beneficial treatment plan for clients with SSD. These results have important implications for clinical application in treatment with children with SSD as previous studies have not examined treatment dose. By combining the present information about treatment dose with previous research about treatment frequency, clinicians can provide more successful treatment plans. Older and younger children likely require a similar treatment dose to reach the same levels of accuracy on their treatment sound. To reach 25%, 50%, and 75%, older and younger children should receive a similar treatment dose. Older children typically attend shorter, less frequent sessions. These sessions can be adjusted to include the same treatment dose that younger children receive during their more frequent sessions. Older children may show more improvement as the result of sessions in which they experience more learning episodes. Typically, session frequency and intensity measured in minutes are both lower for older children. Therefore, the clinician should adjust sessions to provide similar treatment doses for children in both age groups. This data also presents as a resource for clinicians in the event of a missed session. Treatment should be

adjusted accordingly to provide each child with enough practice events to meet their goals and achieve correct production of their treatment sound.

Conclusion

Knowledge about treatment dose is important in providing treatment to children with SSD. In similar sessions, both old and young children with SSD can achieve 25%, 50%, and 75% accuracy with similar treatment doses. Older and younger children tend to receive treatment that differs in frequency and intensity. Therefore, these sessions must be adjusted to provide each group with enough opportunities for sound repetitions to achieve accuracy.

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