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Telemedicine in pediatric speech therapy: characteristics of child, mother, and speech-language pathologist vocal interaction.

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Telemedicine in Pediatric Speech Therapy: Characteristics of Child, Mother, and Speech-Language Pathologist Vocal Interaction

By

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ABSTRACT

Telemedicine is a potential solution to provide distant or underserved clients with access to their clinician. The purpose of this thesis is to examine how the use of telemedicine affects the vocal characteristics of children who received cochlear implants (CI), their mother, and a speech-language pathologist (SLP) as they engage in a speech-language therapy intervention. The children (*n* = 5), her caregiver, and the SLP engaged in one 30 minute in person session and one 30 minute telemedicine session in a counterbalanced order. The frequency of vocalizations, vocal turns, and between-speaker pause (BSP) duration in both sessions were examined. The results indicate that the SLP produced fewer vocalizations whereas the mother produced more vocalizations in the telemedicine compared to the in-person session. Additionally, there were fewer turns between the SLP and child and more turns between the mother and child in the telemedicine than the in-person sessions. The number of turns between the SLP and the mother and the occurrence of simultaneous speech were not affected by session type Finally, BSP duration was longer during telemedicine than the in-person session during SLP-Child and Child-SLP, Child-Mother turns. These results indicate that the vocal interaction between child, caregiver, and clinician are impacted by the use of telemedicine.

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INTRODUCTION

The National Institute on Deafness and Other Communication Disorders (NIDCD) defines cochlear implants (CIs) as devices used to provide hearing to individuals with severe-to-profound hearing loss (NIDCD, 2016). CIs mimic the function of the cochlea and use electric currents to stimulate the auditory nerve (Zeng, Rebscher, Harrison, Sun & Feng, 2008). As of 2012, roughly 38,000 CI's have been implanted in children in the United States (NIDCD, 2016). Children who wear CIs often require speech-language therapy intervention in order to develop language skills at an appropriate rate (Niparko et al. 2010). However, due to a shortage of professionals with necessary knowledge, in the US, only 50% of US children with cochlear implants (as compared to 93% of children in European countries) receive early intervention and therapy services (Houston, Muñoz, & Bradham, 2011; Joint Committee on Infant Hearing, 2007; Sorkin, 2013). This shortage is especially pronounced in rural areas, such as the Appalachian region which covers 13 states and makes up 8% of the population (Bush et al., 2014).

One potential solution to provide early speech-language therapy services to rural or underserved populations is the utilization of telemedicine. The American Speech-Language-Hearing Association (ASHA) describes telemedicine as the application of telecommunications technology to deliver professional services at a distance by linking the clinician to the client (ASHA, 2005). A typical application of telemedicine involves videoconferencing equipment (such as a laptop with a Webcam) set up in a patient's home through which they can communicate with a clinician on their computer monitor screen for a synchronous (real time) interaction (McCarthy, 2010). Telemedicine has been increasingly been recognized as a viable method to improve access to care at sites distant from the clinician (Gonzalaz-Espada, Hall-Barrow, Burke, & Smith, 2009).

Grogan-Johnson and colleagues (2013) examined the effectiveness of telemedicine in speech-language therapy sessions. In their study, Grogan-Johnson and colleagues (2013) studied children (aged 4-12 years) who were receiving speech-language therapy from their school-based speech-language pathologist (SLP). The children in this study were normal-hearing (NH) and exhibited articulation, language, or fluency disorders. Grogan-Johnson and colleagues (2013) divided the subjects into two groups (*n* =38). In the first group (*n* =17), the subjects received speech-language therapy by telemedicine for four months and then subsequently they received in-person speech-language therapy for four months. The second group (*n* =17) received in-person therapy for four months followed by telemedicine treatment for four months. Grogan-Johnson and colleagues (2013) found the children made similar progress in either the telemedicine or face-to-face therapy treatment conditions. There was no significant difference in the language scores of the subjects (from the National Outcomes Measurement System and Goldman-Frisco Test of Articulation) between treatment conditions (Grogan-Johnson et al. 2013). Additionally, satisfaction surveys indicated that the subjects and parents overwhelmingly supported telemedicine as a modality for speech-language therapy (Grogan-Johnson et al. 2013). This study supported the use of telemedicine because there was no significant difference in participant's outcome measures and parents had a high satisfaction level with the modality.

In another study, McCarthy, Muñoz, and White (2010) examined the use of telemedicine in speech-language therapy sessions for children who are deaf or hard-of-hearing. McCarthy, Muñoz, and White (2010) surveyed previous research regarding the use of telemedicine in speech-language therapy sessions for children (*n* = 100) in the Royal Institute for Deaf and Blind Children (RIDBIC) in Australia. The RIDBIC has utilized telemedicine to provide families who live in rural areas in Australia with the same quality of service they would receive in a metropolitan area. McCarthy, Muñoz, and White (2010) found that most clinicians and caregivers enrolled in the telemedicine program were very satisfied with the use of telemedicine. Caregivers noted that the use of telemedicine offered many advantages compared to an in-person session such as reduced travel time and flexibility in scheduling. Additionally, McCarthy, Muñoz, and White (2010) found that clinicians noted that parents seemed to engage more and acquire more strategies in the telemedicine sessions. The caregiver shifts from teaching to coaching the parent how to implement educational activities with their child (McCarthy, Muñoz, & White, 2010). However; McCarthy, Muñoz, and White (2010) found that there has not been a comprehensive evaluation of a child’s developmental outcomes and the cost effectiveness of telemedicine. This study supported the use of telemedicine because caregivers of children who are deaf or hard of hearing were satisfied with the modality.

However; previous research has also suggested that telemedicine may pose challenges for the fluency and connectedness of a clinician and child interaction. The child may struggle remaining within a view of camera, directing their attention to the screen, and maintaining that attention for the duration of the therapy session (Gibson et al. 2010; Grogan-Johnson et al. 2013). The clinician is not in the same location as the child (Anderson et al. 2014) and may find it more difficult to effectively prompt the child (Anderson et al. 2014; Keck & Doarn, 2014). Parents of children with hearing loss may have limited experience with technology and may have to assist the clinician with technical difficulties, loss of child’s attention, or safety issues (Grogan-Johnson et al. 2013). In addition, technical issues such as the audio and video quality or delays which may disrupt the vocal interaction (Keck & Doarn, 2014). The use of telemedicine offers many potential advantages compared to an in-person session such as increased access for underserved patients, reduced expenses associated with travel, and more coaching strategies for caregivers. However; the use of telemedicine may have disadvantages such as the difficulty of maintaining the child's attention and the risk of technical or equipment issues.

The purpose of this honor's thesis is to examine the characteristics of vocal interaction between children with severe-to-profound hearing loss who have received cochlear implants (CI), their mothers, and a clinician as they engage in a speech-language therapy intervention in both in-person and telemedicine sessions. Specifically, this study will investigate the quantity of vocalizations, turn-taking, and temporal characteristics of those turns, between all three participants during the in-person and telemedicine sessions.

Social interaction, including turn-taking, is essential for child language development since it affects child language outcomes (Kuhl et al. 2008). Turns vary in length, but are mostly short, about 2 sec in length on average, and consist of one syntactic clause (Levinson & Torreira 2015; Sacks et al. 1974). In a recent study (Romeo et al., 2018) studied the language environment of children, aged 4 to 6, (*n* = 36) in order to understand the neural mechanisms involved in the relation between language experience and linguistic development. Romeo and colleagues measured the language environment of normal-hearing children (n = 36) for two days from home audio recordings. Then, Romeo and colleagues had the children engage in a story-listening functional MRI task to determine which neural regions were activated while the subjects were processing language. Romeo and colleagues found that the children who experienced more conversational turns with adults in their home audio recordings exhibited greater left inferior frontal (Broca's area) activation during the story-listening task. This finding suggests that conversational turns may support children's language skills in part by influencing Broca's area activation during language processing. In a similar study, VanDam and colleagues (2009) demonstrated that hearing impaired children who engaged in more conversational turns demonstrated stronger linguistic outcomes (specifically receptive language skills) than hearing impaired children who engaged in fewer conversational turns.

Previous research about children with hearing loss who have received cochlear implants suggests that the child's hearing status affects vocal interaction. Dyads (child and mother) with children who received CIs engage in fewer vocalizations compared to normal-hearing dyads (Kondaurova, Bergeson, & Xu, 2013). Additionally, there are fewer vocal turns between mothers and children who received CIs compared to normal-hearing dyads (Kondaurova et al. 2019; Tait et al. 2007). CI children speak at a slower rate than their NH peers (Vanormelingen, De Mayer & Gillis, 2016). Normal-hearing mothers of children who received Cis adjust characteristics of their speech while they engage with their child. For example, mothers adjust their pause duration and speaking rate to the hearing experience rather than to the chronological age of their children who use CIs (Bergeson et al. 2006). There is currently a gap in our knowledge of how the use of telemedicine affects the vocal characteristics of children with hearing loss. There have been 23 peer-reviewed papers (from 1996 to 2017) that examine the use of telemedicine for speech therapy (McCarthy, Leigh, & Arthur-Kelly, 2018). Most of these papers (16) rely on anecdotal evidence while few (7) analyze the effectiveness of telemedicine compared to an in-person session.

In the current study, it is hypothesized that there will be differences in the quantity of vocalizations made by each participant in the in-person sessions compared to the telemedicine sessions. There could be fewer vocalizations between the clinician and the child during the telemedicine as compared to the in-person session because the clinician is not in the same environment as the child (Anderson et al. 2014; Grogan-Johnson et al. 2013). There could be more vocalizations between the clinician and the caregiver because the clinician can assume the role of a trainer for caregivers (McCarthy, Muñoz, & White, 2010; Snodgrass et al. 2017,). Finally, there could be an equal number of vocalizations between the child and her caregiver during the telemedicine as compared to an in-person session, although this may depend on the caregiver's experience with technology (Grogan-Johnson et al. 2010).

METHODS

Participants

Five normal-hearing (NH) mothers and their five hearing-impaired (HI) children (Male 3; Female 2) were recruited from the Heuser Hearing Institute in Louisville, KY. The HI children (*N* =5) aged 3 to 6 years old at the date of testing, had profound hearing loss, and had received cochlear implants (CI). The mean chronological age of the children at the date of testing was 5 years 2 months (SD 1 year, 3 months). The mean age of CI activation was 3 years (SD = 1 year: 10 months); and the mean length of hearing experience with CI's was 2 years (SD= 1 year: 7 months). Tables 1 and 2 present the demographic information of the 5 children.

Table 1.

The Communication method, etiology, cochlear implant device information.

Participant	Device (L-left ear; R-right ear, HA- hearing aids)	Etiology	Communication Method
1	MED-EL (L,R)	Unknown	OC suppl. with ASL
2	N6 Cochlear Americas, Nucleus (L,R)	Usher 1B	OC
3	N6 Cochlear Americas, Nucleus (L,R-HA)	Unknown	OC
4	N7 Cochlear Americas, Nucleus (L,R-HA)	Unknown	OC suppl. with ASL
5	N7 Cochlear Americas, Nucleus (L,R)	Unknown	OC

Table 2.

The demographic information of the participants.

Participant	Child Sex	Age (months)	Age at CI activation (months)	Hearing Age (months) 12 month visit
1	F	73	60	13
2	M	81	14	67
3	M	49	38	11
4	F	58	37	21
5	M	47	21	26

On average, the mean age of the NH mothers (N=5) was 34.6 years (SD= 2 years) at the time of testing. The mothers had no self-reported hearing loss, were primarily college educated and were monolingual English speakers as determined by a background questionnaire. All mothers were reimbursed $40 for their participation. Additionally, one speech-language pathologist (SLP) was recruited from the Heuser Hearing Institute to participate in this study. She was reimbursed $90 per hour of work.

Procedures

Recordings. The mother, child, and SLP engaged in a telemedicine (tele) and in-person (face) speech language therapy intervention. The order of tele and face sessions was counterbalanced across participants. Participants engaged in one session for 30 minutes (either face or tele), had a five- minute break, and then returned to engage in the other session for 30 minutes (either tele or face). During the face sessions the SLP, caregiver, and child sat at a table facing each other in a quiet room. The SLP conducted the session teaching the child specific sounds and words (“sheep,” “sling-shot”) using stickers and toys. The SLP also interacted with the child’s caregiver during the session. Three digital cameras were positioned in the room in order to create recordings of the session. Figure 1a depicts the layout of the face-to-face session. After a five-minute break, the SLP, caregiver, and child moved to separate rooms to engage in the tele sessions.

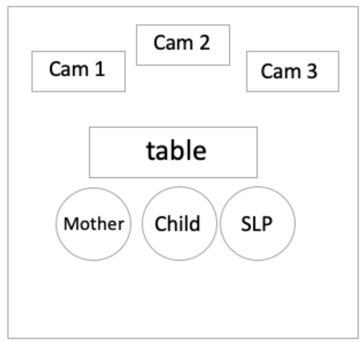

Figure 1. The layout of the in-person session.

During the telemedicine session the SLP, sat in Room 1 facing the computer. The caregiver and the child sat in Room 2 in front of the computer. The SLP and the mother-child dyad had the same sets of toys (“sheep”, “slingshot”). The SLP conducted a therapy session teaching the child a specific sound/word and simultaneously interacted with the child’s mother for 30 minutes. The specific videoconferencing equipment used in this study was the Doxy.me software. Like the in-person session three digital cameras were positioned in the room of Room 1 and Room 2 to make audio-visual recordings. Figure 2 depicts the layout of the tele session.

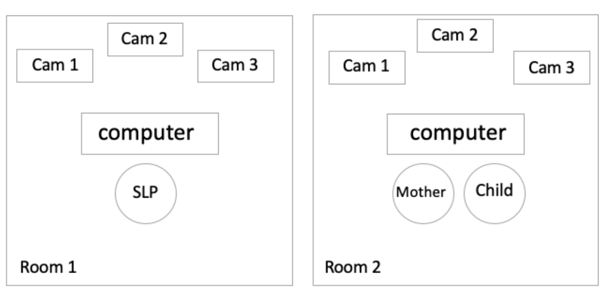

Figure 2. The layout of the telemedicine session.

Analysis of Recordings. The recordings from both sessions were analyzed to examine the quantity and sequence of vocalizations made by all participants. First, each recording was manually segmented into 4 types of events: a mother vocalization; a child vocalization, a SLP vocalization, and simultaneous speech. Non-speech behavior (e.g. cry, laugh, gasp) were excluded from the analysis. The start and end of mothers' vocalizations, child vocalizations, SLP vocalizations, and simultaneous speech were measured using PRAAT 5.0.21 speech editor (Boersma & Weenink, 2005). Figure 3 presents an example of a coded transcription in PRAAT.

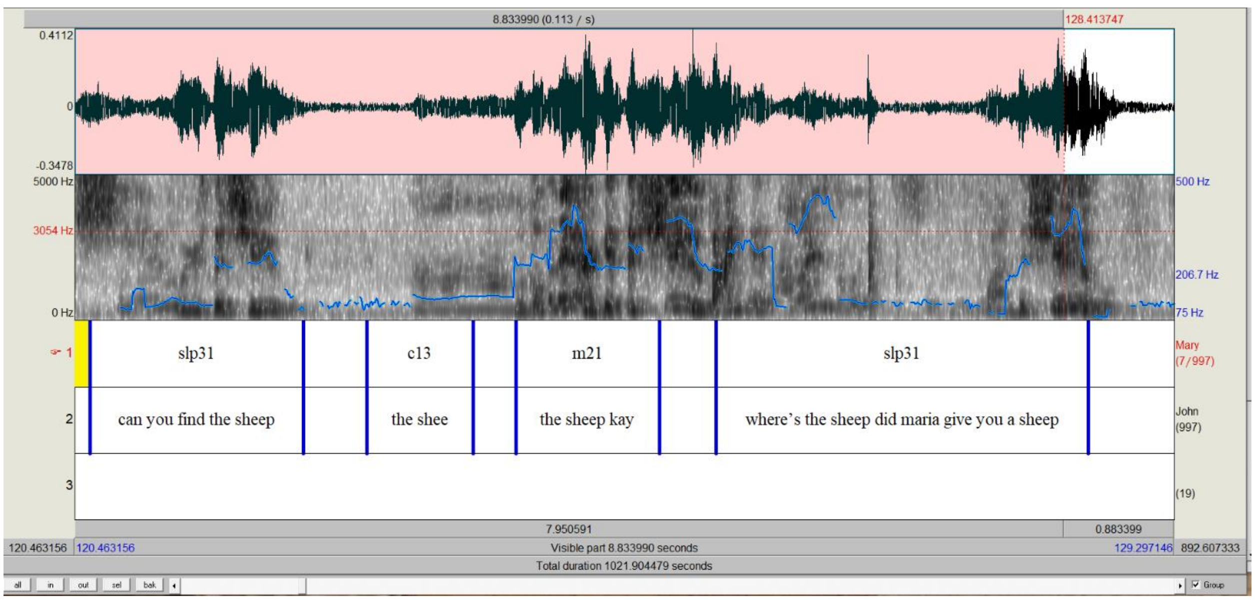

Figure 3. PRAAT example.

Vocalizations. A mother, child, or SLP vocalization was defined as the production of vocal sound by the same speaker that was continuous or included a silence < 300 ms. If the silence following an audible vocal sound from the same speaker was > 300 ms, two successive vocalizations were coded (Gratier et al., 2015).

Simultaneous speech. Simultaneous speech (s) was coded when the mother, child, or SLP vocalized over the vocalization of one another. The entire vocalization was coded as simultaneous speech even if it partially overlapped (Depowski et al., 2015; Fagan et al., 2014).

Turn- Taking. A turn was defined as a vocalization followed by vocalization from a different speaker within 3 sec. There were six turns that could have occurred in the telemedicine and face sessions; a child vocalization followed by a SLP vocalization (C-SLP), child followed by a mother's vocalization (C-M) a mother followed by a child's vocalization (M-C), a mother followed by a SLP vocalization (M-SLP) a SLP followed by mother vocalization (SLP-M), and a SLP followed by a child vocalization (SLP-C).

Between-Speaker Pauses. The between-speaker pause (BSP) was defined as a pause that occurred between the two speaker's vocalizations (i.e., child-mother) that lasted up to 3 sec.

Statistical Analysis

Counts of Vocalizations. First, all vocalizations produced by each participant in the face and tele sessions were calculated. Then, the rate of these vocalizations was calculated. The rate of these vocalizations was defined as the number of vocalizations by a participant divided by the duration of the recording) in order to normalize/take into consideration the difference in recording time. Then, the rate of these vocalizations was compared between face vs. tele sessions for each participant.

Counts of Turns. First, the proportion of turns was calculated. The proportion of turns was defined as the proportion of participants' vocalizations (out of all vocalizations of this participant) that followed the partner's vocalization. For example, the proportion of mother child turns was calculated as the number of child vocalizations following maternal vocalization out of all child vocalizations. The proportion of SLP child turns was calculated as the number of child vocalizations following SLP vocalizations out of all child vocalizations.

Reliability.

The first author of the thesis and her advisor independently coded twelve samples from the participants chosen in a random order. The intra-class correlation coefficient for the total number of SLP, child, and mother vocalizations was 0.973 and point by point agreement was specific classification type was 87.9% that suggests a high reliability between the coders.

RESULTS

Frequency of Child, Mother, and SLP Vocalizations

Overall the dataset consisted of 3,879 vocalizations (1249 child; 1857 SLP; 493 maternal; 280 simultaneous) in the face sessions. The tele sessions consisted of 3,781 vocalizations (1203 child; 1293 SLP; 1032 maternal; 253 simultaneous) in the tele sessions. In the face sessions, children produced on average 249.8 vocalizations (SD = 56.6), the SLP produced 371.4 vocalizations (SD = 82.9), and mothers produced 98.6 vocalizations (SD=19.6). During the tele sessions, children produced on average 240.6 vocalizations (SD = 94.8), the SLP produced 258.6 vocalizations (SD= 100.9), mothers produced on average 206.4 vocalizations (SD = 90.9). Table 3 presents the number of vocalizations produced in the face versus tele sessions.

Table 3

The number of vocalizations made by child, mother, and speech-language pathologist in the telemedicine and in-person sessions.

Participant	Number of Vocalizations	
	Face	Tele
Child	1249	1203
SLP	1857	1293
Mother	493	1032
Simultaneous Speech	280	253

Vocalization Rate

To normalize the count of vocalizations, since the durations of the recordings were different for each session, we calculated the vocalization rate defined as the number of utterances per second for each participant. Figure 3 presents the average vocalization rate of the child, mother, and SLP in tele and face sessions.

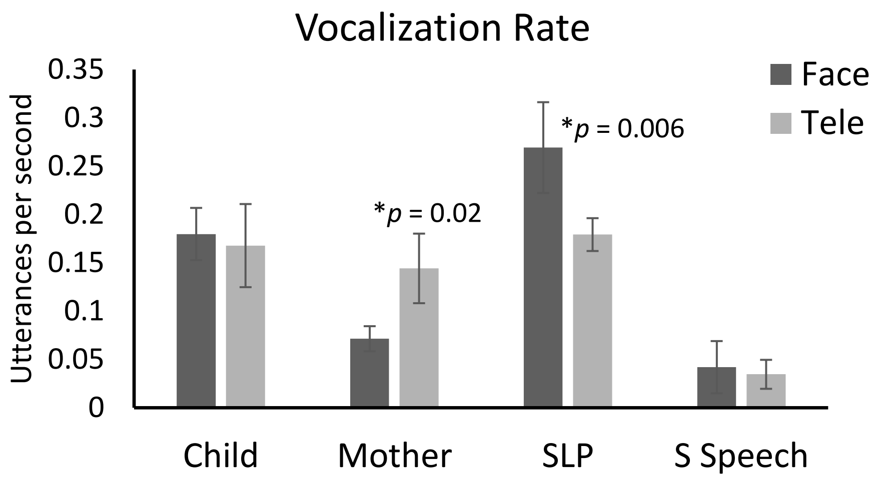

Figure 4. The mean vocalization rate of the child, mother, and SLP in tele and face sessions.

To examine whether there was a difference in vocalization rate between face and tele sessions, we used a paired sample t-test for each participant (SLP, child, mother). Only significant results are reported. For SLP, the results demonstrated that there was a significant difference in the vocalization rate between the two sessions (Face: $M = 0.2692$, $SD = 0.047$; Tele: $M = 0.179$, $SD = 0.017$), $t(4) = 5.2$, $p = 0.006$). These results suggest that the SLP had a higher vocalization rate in the face than the tele sessions. For the mother, there was also a significant difference in vocalization rate between the two sessions (Face: $M = 0.071$, $SD = 0.013$; Tele: $M = 0.144$, $SD = 0.036$) $t(4) = -3.65$, $p = 0.02$). These results suggest that the mother had a higher vocalization rate in the tele than the face session.

Turn-Taking

Overall the data set consisted of 1,620 turns. Table 4 presents the turn types and the number of turns for each type in the face and tele sessions.

Table 4

The six turn types and the total number of turns for each type.

Turn-Type	Face	Tele
SLP-Child	730	386
Child-SLP	673	285
Mother-Child	102	329
Child-Mother	84	315
SLP-Mother	17	8
Mother-SLP	14	10

Proportion of Turns

Figure 5 presents the proportion of 6 turn types (SLP-C: SLP-Child; C-SLP:Child-SLP; M-C: Mother-Child; C-M: Child-Mother; SLP-M: SLP-Mother; M-SLP Mother-SLP) out of all utterances produced by each participant.

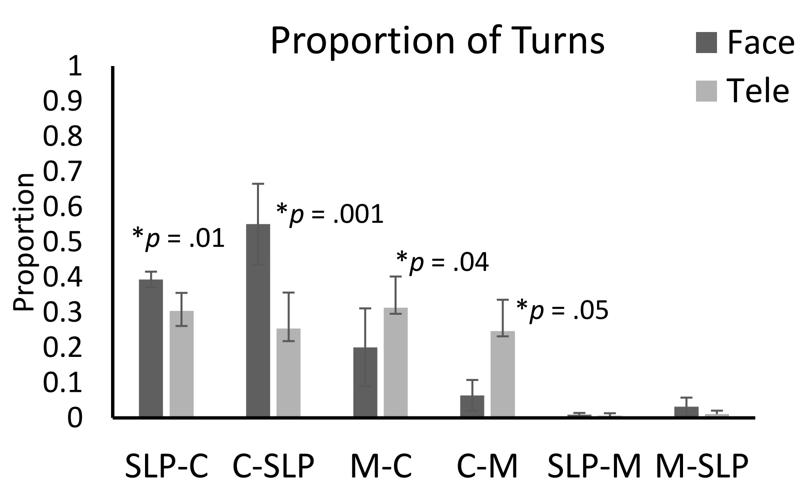

Figure 5. The six turn types and their proportion.

To examine whether there was a difference in proportion of turns for each participant between the face and the tele sessions, a paired sample t-test for each turn type was used. Only significant results are reported. There were more SLP-Child (Face: *M* = 0.393, *SD* = 0.022; Tele: *M* = 0.304, *SD* = .051), *t* (4) = 4, *p* =. 01), and Child-SLP (Face: *M* = 0.550, *SD* = 0.115; Tele: *M* = 0.254, *SD* = 0.102), *t* (4) = 7.9, *p* = .001), turns in the face than the tele session. There were also more Mother-Child (Face: *M* = 0.200, *SD* = 0.111; Tele: *M* = 0.312, *SD* = 0.089) *t* (4) = 2.9, *p* =. 04) and more Child-Mother (Face: *M* = 0.063, *SD* = 0.044; Tele: *M* = 0.246, *SD* - 0.089), *t* (4) = -5.6, *p* =. 005) turns in the tele than the face session.

Between-Speaker Pause Duration

Figure 6 presents the between speaker pause duration for each turn type.

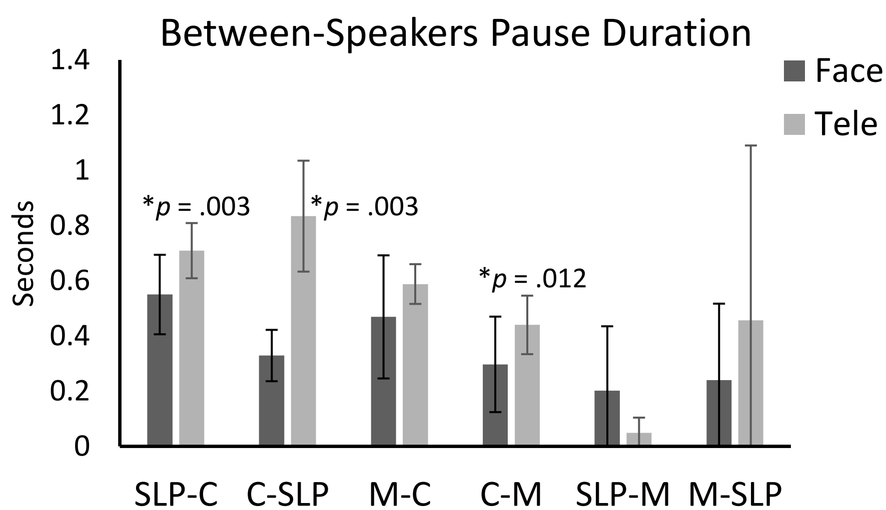

Figure 6. Average between-speaker pause duration for each turn type.

To examine whether there was a difference in the BSP duration for each turn type between the face and the tele sessions, a linear regression analysis with one predictor variable Group (*Face, Tele*) was run with following Wald t-tests. Only significant results are reported.

The results demonstrated that there was a longer BSP duration in SLP- child (Face: M = 0.55, SE = 0.144; Tele: M = 0.709, SE = 0.1), β = .147, p = .003, and child-SLP (Face: M = 0.329, SE = 0.093; Tele: M = 0.834, SE = 0.201), β = .52, p = .003, turns in tele compared to the face session. The results also demonstrated a longer BSP duration in the child-mother (Face: M = 0.297, SE = 0.173; Tele: M = 0.44, SE = 0.106), β = .202, p = .012 turn.

DISCUSSION

The purpose of this study was to examine the quantity of vocalizations, turn-taking, and between-speaker-pause duration in triads (child, mother, and SLP) with children who received CIs in both an in-person and telemedicine session. The results demonstrated that the SLP produced more vocalizations in the in-person than the telemedicine session. The mother produced more vocalizations in the telemedicine than the in-person session. There were no differences in the occurrence of vocalizations in the child's speech. Furthermore, the results also demonstrated that there were more SLP-Child and Child-SLP turns in the in-person than the telemedicine sessions. There were also more Mother-Child and more Child-Mother turns in the telemedicine than the in-person sessions. Finally, BSP duration was longer during telemedicine than the in-person session during SLP-Child and Child-SLP, Child-Mother turns.

Frequency of Vocalizations

The SLP produced fewer vocalizations during the telemedicine compared to the in-person sessions. This finding is consistent with previous research that has suggested the SLP may have difficulty prompting the child in a telemedicine session since they are not in the same physical environment (Anderson et al., 2014; Grogan-Johnson et al., 2013). The lack of physical proximity between the child and SLP may have made it difficult for the SLP to direct the child's attention and effectively cue and or comfort the child throughout the session (Akamoglu et al., 2018). The SLP may have produced fewer vocalizations in the telemedicine session because the distance between the child and clinician made it difficult for the SLP to effectively cue and maintain the child's attention. This finding suggests that that the use of telemedicine may decrease the overall effectiveness of a speech therapy intervention because the SLP produces fewer vocalizations.

The mother, on the other hand, produced more vocalizations during the telemedicine sessions compared to the in-person sessions. Previous research has suggested that the use of telemedicine requires additional support (such as a therapy aide or caregiver) in the same environment as the child in order to help the child maintain focus during the session (Akamoglu et al., 2018). The mother may have produced more vocalizations in order to direct the child's attention to the SLP (Grogan-Johnson et al., 2013). It is possible that the mother vocalized more to direct her child's attention at the task at hand, for example, when the child was directed to place a sticker on a paper. Previous research has also suggested that additional support is required in telemedicine sessions to monitor the child's behavior (Akamoglu et al., 2018). The mother may have produced more vocalizations in the telemedicine session in order to manage the child's behavior (Chen & Liu, 2017). Additionally, the mother may have vocalized more to ensure her child was focused on the task and behaving correctly.

There was not a significant difference in the frequency of simultaneous speech by all participants between the telemedicine and in-person sessions. Additionally, there was not a significant difference in the frequency of child vocalizations between the telemedicine and the in-person session. Previous research has suggested that the clinician may rely on additional support (such as a therapy aide or caregiver) to keep the child engaged throughout the session

(Hines et al. 2015). The presence of the caregiver in the same environment as the child may have helped to keep the child involved in the telemedicine session.

Turn-Taking

It was hypothesized that there would be an equal number of vocalizations between the child and her caregiver in both of the sessions. However; the results demonstrated there were more Mother-Child and Child-Mother turns in the telemedicine compared to the in-person session. The mothers who participated in this study experienced no technological issues which could have impacted their engagement in the telemedicine session (Grogan-Johnson et al., 2010). These results suggest that the use of telemedicine also affects the vocal interaction between the child and the caregiver. An increased number of turns between child and caregiver could mean the use of telemedicine increases the effectiveness of a speech-language therapy session. Vocal turn-taking is a predictor of a child's language skills (Romeo et al. 2018; VanDam et al. 2009). Additionally, the more vocal turns the child engages in with the mother is associated with better expressive language skills and linguistic development (Vanormelingen, De Mayer, & Gillis 2016, Zimmerman 2009). Additionally, joint attention between the child and caregiver may contribute to the child's language development. Previous research has shown that more interactions that create moments of joint attention between children and their caregiver can have an impact on a child's lexical development (Markus et al. 2010).

There were fewer SLP-Child and Child-SLP turns in the telemedicine session compared to the in-person session. This finding is consistent with the hypothesis that there may be fewer vocalizations between the clinician and the child during the telemedicine session because the clinician is not in the same environment as the child (Anderson et al., 2014; Grogan-Johnson et al., 2013). These results provide evidence that the use of telemedicine affects the vocal interaction of the child and clinician. A decrease in vocal turns between child and clinician may diminish the effectiveness of a speech-language therapy intervention since vocal turn-taking is a predictor of a child's language outcomes (Romeo et al, 2018; VanDam et al. 2009). The results of the current study suggest that use of telemedicine may decrease the effectiveness of a speech-language therapy intervention because there is less engagement between the child and clinician. However; it remains unclear whether this reduction engagement diminishes the effectiveness of the speech-language therapy intervention because the child is engaging in more vocal turns with the caregiver.

There were no significant differences between the frequency of SLP-Mother and Mother-SLP turns between the telemedicine and in-person sessions. This result was unexpected because previous literature has suggested that the SLP coaches the caregiver in a telemedicine session (McCarthy, Munoz, & White 2010; Snodgrass et al. 2017). There was no increase in mother and SLP engagement during the telemedicine session suggesting that the SLP may not assume the role of a trainer to the caregiver. These results can be explained by the fact that the SLP administered a child-focused rather than caregiver-focused intervention. Both the SLP and mother directed their attention to the child and task at hand.

Temporal Characteristics of Turns

There was a longer BSP duration in the SLP-Child, Child-SLP, and Child-Mother turns in the telemedicine session compared to the in-person session. This finding suggests that participants in the telemedicine session made a less efficient temporal estimation of turn duration (Levinson & Torreira, 2015). There was no known technology or equipment issues. Consequently, the use of technology may not have affected the temporal characteristics of vocal turns. Previous research has demonstrated that a longer BSP duration is indicative that a participant's ability to coordinate their timing in dialogue may be immature (Smith & McMurray, 2018). These results suggest that there is a less efficient mutual comprehension and coordination of turns between speakers in the telemedicine sessions (Beebe et al. 1988; Garrod & Pickering 2015; Jaffe et al. 2001; Jasnow & Feldstein 1986; Smith & McMurray 2018). This finding suggests that the use of telemedicine may decrease the overall effectiveness of a speech therapy intervention because there are less efficient coordination in SLP-child and Mother-child vocal interaction.

Limitations and Future Research Directions

The present study had certain limits. First, this study had a small sample size ($n = 5$) which limits the results' generalizations to a larger pediatric population. Future research could include a larger sample size to see if the results are replicated. Next, this study focused on children of a select age group (aged 3 to 6). Future research could include children of different ages to examine how telemedicine affects the vocal interaction of different participants. Thirdly, this study did not survey the clinician, caregiver, or child regarding their attitudes towards the use of telemedicine. This survey could have provided a useful analysis into how the participants viewed the effectiveness of telemedicine. In the current study, the inclusion of only one SLP helped to reduce any variability that may have occurred between the inclusion of several SLPs. For example, if the study had included several SLPs, it would better control any variation in their vocalization rate and individual differences.

Summary

Overall, the current study provides quantitative results that the characteristics of vocal interaction between child, caregiver, and clinician are affected by the use of telemedicine. The results demonstrate the use of telemedicine affects the frequency of vocalizations, turn-taking, and temporal characteristics of turn-taking (BSP) from participants. These results help inform the clinician and caregiver about their own behavior in the telemedicine session. Additionally, these results provide the clinician more information regarding the vocal interaction with children who received CIs as they engage in a telemedicine session.

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