

Research Article

Just-in-Time: A Caregiver-Mediated Intervention for Toddlers With Autism

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ABSTRACT

Purpose: We investigated effects of an adaptive telehealth coaching model on caregiver implementation of enhanced milieu teaching (EMT) with newly diagnosed toddlers with autism.

Method: Three caregiver–child dyads participated in a multiple-baseline-across-behaviors, single-case design. Caregivers were taught EMT via telehealth using the teach–model–coach–review approach. EMT strategies were taught sequentially in four components corresponding to design tiers. Caregivers reported their needs for support and adaptation via weekly surveys. Primary outcomes were measures of caregiver’s implementation, including (a) a fidelity checklist for wholistic use of EMT and (b) a percentage of correct use of a subset of key EMT strategies (e.g., matched turns, target talk, expansions, play actions, milieu episodes). Generalization and maintenance of caregiver strategy use in uncoached home activities were measured. The number of different words used by children was measured as a secondary, descriptive outcome. Social validity data were collected through ratings and interviews at the end of the study.

Results: There was a functional relation between the intervention and caregiver’s implementation of EMT for all dyads. Caregiver’s use of EMT strategies often generalized and maintained post-intervention. Child response to intervention was variable. Social validity data indicated that the model was beneficial to caregivers and children.

Conclusions: An adaptive telehealth coaching model is effective for teaching caregivers of toddlers with autism to implement EMT and potentially helps to bridge the gap between diagnosis and comprehensive intervention. Further exploration of the relation between caregiver fidelity and dosage of active ingredients and child spoken language outcomes is needed.

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Timely access to early intervention services is essential for toddlers with autism spectrum disorder (ASD)¹ because these services can improve social communication, language, and behavioral outcomes (Landa, 2018). The estimated average delay from ASD diagnosis to services ranges from 9 months to 3 years (Dimian et al., 2021; Yingling et al., 2018). Some studies have found an association between earlier enrollment in intervention and greater improvements in social communication (Guthrie et al., 2023; Landa, 2018). Without deliberate efforts to reduce delays in accessing services, families may miss the

benefits of early intervention, especially services tailored to the needs of toddlers with ASD. The discrepancy between recommendations for early intervention immediately following diagnosis and delayed access to early intervention is indicative of a notable ethical dilemma (Bailey et al., 2009).

Access to early intervention services may be impeded by several factors. Shortages of early intervention service providers can create long waiting lists (Murphy & Ruble, 2012; Wise et al., 2010). Additionally, states differ in their

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¹At the time of this study, caregivers indicated their families’ preferences for person-first language. As such, person-first language (e.g., toddlers with autism) rather than identity-first language (e.g., autistic toddlers) is used throughout this article.

early intervention eligibility requirements and service delivery processes (Stahmer et al., 2019), making families' access to services highly variable. Notably, delays may be exacerbated among minoritized groups, families with lower income or education, Medicaid-enrolled families, and families residing in geographically rural areas (Bailey et al., 2004; Dimian et al., 2021; Murphy & Ruble, 2012).

Identifying effective early interventions that could be delivered to families rapidly after diagnosis is critical to closing the diagnosis-to-treatment gap. There is an emerging body of literature that supports telehealth as an effective service delivery approach for young children with ASD and their caregivers, with potential to resolve several service provision barriers (Dimian et al., 2021; Vismara et al., 2013; Wainer & Ingersoll, 2015). During the COVID-19 pandemic, early-intervention providers quickly pivoted to telehealth out of necessity, and their successful implementation demonstrates the potential for wide-scale adoption by early intervention programs. Telehealth interventions appear to effectively allow families to access important information, education, and individualized support from a distance (Wetherby et al., 2018). While clinicians have reported using telehealth to provide both direct and caregiver coaching services (Biggs et al., 2022), recent systematic reviews have identified that effective telehealth interventions for children with neurodevelopmental disabilities typically employ a coaching approach (Camden et al., 2020; Simacek et al., 2021).

Naturalistic developmental behavioral interventions (NDBIs; Schreibman et al., 2015) are interventions that blend developmental and behavioral principles to promote skills in young children with ASD. NDBIs are well suited for teaching language skills in the period immediately following an early diagnosis because they have potential for facilitating cascading effects across the domains of child development (Schreibman et al., 2020). In line with recommended practices for young children with ASD (Hume et al., 2021), NDBI models include some form of caregiver implementation of intervention (Schreibman et al., 2015). Importantly, caregiver coaching is associated with improvements in child skills and caregiver-child interactions (Landa, 2018) and potentially empowers families to navigate future services and feel more confident in supporting their children's development (Minjarez et al., 2020).

Recent findings suggest that these positive outcomes are also possible when telehealth coaching models are employed. Studies of telehealth NDBI models have noted improvements in child social communication and language, caregiver fidelity of intervention implementation, and caregiver self-efficacy (Camden et al., 2020; Ingersoll et al., 2016; Pickard et al., 2016; Quinn et al., 2021). Notably, two recent reviews of literature endorsed synchronous

coaching of caregivers as being particularly important across telehealth studies and associated live coaching with greater improvements in child and caregiver outcomes (Camden et al., 2020; de Nocker & Toolan, 2023). Caregivers have indicated high levels of satisfaction within telehealth caregiver coaching models (Neely et al., 2022; Pickard et al., 2016).

Just-in-time adaptive interventions (JITAI; Nahum-Shani et al., 2018) are an emerging telehealth service model and are characterized by the (a) immediacy of intervention delivery when circumstances require it and (b) adaptability of the type, timing, and intensity of services according to the needs of the individual receiving services (Nahum-Shani et al., 2018). Applications of JITAI have typically involved the use of mobile devices to collect information about participant experiences and deliver tailored intervention according to their responses (Wang & Miller, 2020). These interventions have been limited to medical and behavioral health fields in extant literature, and notably few studies have evaluated JITAI used in conjunction with synchronous coaching interventions. One compelling example found that addition of JITAI to cognitive behavioral therapy prevented recurrence of clinical symptomatology at follow-up compared to a condition without JITAI, indicating the potential value of these interventions in maintaining intervention effects once participants exit their primary intervention (Juarascio et al., 2022). Notably, there are currently no published examples of just-in-time early interventions for families of children recently diagnosed with ASD. Taken together, it is plausible that teaching caregivers to implement NDBIs within a telehealth, just-in-time framework may reduce inequities in early intervention access following an ASD diagnosis.

Enhanced milieu teaching (EMT) is an evidence-based NDBI that has been shown to promote language development in children with intellectual and developmental disabilities, including those with ASD (Hampton & Kaiser, 2016; Hampton et al., 2020). EMT is effectively used within the context of everyday interactions to promote language acquisition and functional use of new language forms with caregivers (Kaiser, 1993). Studies have demonstrated children generalize skills acquired during EMT across settings and communication partners (Hancock & Kaiser, 2002; Kaiser & Roberts, 2013). During intervention sessions, EMT involves the coordinated use of several language support strategies, including environmental arrangements, responsive interactions, specific language modeling and expansions, and milieu teaching prompts. Extant research has shown that caregivers can effectively learn and implement EMT strategies with their children when systematic approaches to teaching are employed (i.e., teach-model-coach-review [TMCR]; Kaiser & Roberts, 2013). In addition, EMT has been systematically adapted

for hybrid telehealth delivery. Findings from initial feasibility testing showed that all caregivers learned to use language strategies with fidelity, which led to increases in the number of child communication acts and the number of different words (NDW; Quinn et al., 2021).

The Current Study

Building on recent studies examining the feasibility of a hybrid (in-person and telehealth) delivery of EMT, we adapted EMT for telehealth delivery for children with ASD and their caregivers. In this study, we investigated the effects of a just-in-time model of telehealth caregiver coaching, involving (a) supporting caregivers of children who had received an ASD diagnosis but had not yet accessed other services; (b) teaching caregivers naturalistic strategies for promoting engagement, language, and play in their children; and (c) adapting intervention procedures and materials as needed in response to continuous feedback from caregivers. This model was designed to bridge the gap between diagnosis and intensive intervention by preparing caregivers as communication partners through responsive telehealth coaching while possibly promoting modest improvements in child language outcomes. Our research questions for this pilot investigation were as follows:

1. Is there a functional relation between telehealth coaching and caregivers' use of EMT strategies with their young children recently diagnosed with ASD?
2. What are the effects on caregivers' generalized and maintained use of EMT strategies?
3. How does children's language use change when caregivers are taught EMT using this model?
4. How do caregivers view the acceptability of an adaptable, just-in-time intervention?

Method

This project was approved by the Vanderbilt University Institutional Review Board (#202517). In this study, caregivers of children with ASD were taught EMT strategies in a multiple-baseline-across-behaviors design, replicated across three caregiver-child dyads. The primary outcome, caregiver fidelity to intervention procedures, was assessed using both a fidelity checklist of all EMT strategies and a timed-event sampling of key intervention components. One measure of child language use was included as a secondary analysis. Social validity data were collected several times throughout the study via formative (i.e., MyCap surveys) and summative methods (i.e., post-intervention interview, follow-up survey). Ongoing monitoring of social validity and caregiver requests allowed for an adaptive

protocol that was responsive to caregivers' needs for support or changes during sessions.

Participants and Setting

Children and caregiving family members were recruited through the Vanderbilt Treatment and Research Institute for Autism Spectrum Disorders and social media (i.e., Facebook). Children were included in this study if they (a) were between 18 and 48 months of age; (b) were formally diagnosed with ASD; (c) scored at or below the 10th percentile on the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 2007); (d) had sufficient visual perceptual and processing skills for participating in EMT, defined as age equivalency of 18 months on the Mullen Scales of Early Learning Visual (MSEL) Reception subscale (Mullen, 1995); and (e) were reported to have at least two spontaneous, communicative words for the intervention approach to be considered appropriate. Children were excluded from the study if they (a) had a primary diagnosis of any disability other than ASD, (b) had a major medical condition, (c) had a language other than English spoken as the primary language at home, or (d) already received at least 5 hr of intensive intervention per week. Caregivers were included in this study if they were a family member involved in the care of a child who met the criteria above and indicated interest in receiving coaching in EMT as the primary interventionist. Caregivers of qualifying children were not eligible for inclusion if they had been previously enrolled in an intensive parent coaching program for delivering language intervention.

Three caregiver-child dyads were enrolled in this study. While any caregiver of eligible child participants could volunteer for study participation, all caregivers who enrolled in the study were mothers. Participating children (two boys, one girl) ranged in age from 27 to 35 months ($M = 27.67$). Children had all received medical ASD diagnoses within the past year ($M = 6.75$ months between diagnosis and enrollment; range: 3 weeks to 12 months), and none had enrolled in intensive services. At intake, all children had limited language repertoires, ranging from nine to 22 words produced on the CDI Words and Gestures. Educational background, ethnicity, and income varied across caregivers. Sessions were conducted within participant homes. Detailed family and child demographic characteristics are available in Table 1.

The first author, a White female doctoral student in early childhood special education, served as the interventionist for all dyads. She had a master's degree in special education and board certification in behavior analysis. She had several years of experience in both direct intervention with young children with disabilities and caregiver coaching prior to the study. Four individuals, including three

Table 1. Child and family demographic characteristics.

Dyad	Dyad A		Dyad B		Dyad C	
Caregiver and family demographics						
Relationship to child	Mother		Mother		Mother	
Age in years ^a	20		48		43	
Employment outside the home	Full-time		Part-time		Full-time	
Occupation	Legal		Sales		Education	
Education level	Some college		College graduate		Some college	
People living at home	5		4		3	
Annual family income	—		\$76,000–\$100,000		\$15,000–\$30,000	
Distance from research center	67 miles		15 miles		460 miles	
County designation	Urban		Urban		Rural	
Hours of ABA services/week ^a	0		3		0	
Hours of speech services/week ^a	1		1		0	
Child demographics						
Sex	Male		Female		Male	
Age in months ^a	27		35		31	
Diagnoses	ASD		ASD		ASD, OCD	
Race	White		White		White	
Ethnicity	Hispanic		Non-Hispanic		Non-Hispanic	
Child descriptive measures	Pre	Post	Pre	Post	Pre	Post
CDI WG						
Total words understood	97	126	145	246	164	190
Total words produced	9	67	12	13	22	92
Language sample						
Number of different words	1	10	0	1	0	5
MSEL VR ^b	53	—	24	—	36	—

Note. ASD = autism spectrum disorder; OCD = obsessive-compulsive disorder; CDI WG = MacArthur-Bates Communicative Development Inventories Words and Gestures Vocabulary Checklist; MSEL VR = Mullen Scales of Early Learning Visual Reception subscale.

^aAt study onset. ^bT score.

graduate students (two doctoral students, one master’s student) and one full-time research assistant, coded all data. Three coders were White females, and one coder was an Asian female. Primary coders were naive to study phase and did not view the graphed data for any participant while data were being collected.

Materials

To administer standardized assessments via telehealth, we mailed caregivers a physical assessment kit containing the standard required materials. An easel ring binder containing stimulus book pages, a cue card script with precise wording that could be read by the caregiver, and test materials organized in numbered bags corresponding to each item were provided. A Bluetooth headset and an iPad on a tripod were also provided for use in assessment and intervention sessions. Assessment instructions were delivered by an experienced, master’s level staff member using a Bluetooth headset and Zoom video conferencing.

Intervention information was delivered via screen sharing to caregivers using Microsoft PowerPoint presentations.

Presentations were jointly created by three interventionists (first, fourth, and fifth authors) who were experienced in EMT for children with ASD. These presentations included strategy explanations, written examples and rationales, and annotated video exemplars of each strategy (available upon request). Each dyad was mailed a standard set of toys valued at \$100 for use during sessions (see Supplemental Material S10 for exact toys provided to families). Families were allowed to keep the iPad and toys after the study.

The MyCap application was used to collect ongoing data from caregivers about their use of the intervention outside of telehealth appointments and their needs for additional information or support. MyCap is a user-friendly application within the Research Electronic Data Capture (REDCap) data management system that is designed to collect survey information using participants’ mobile devices (Harris et al., 2022). All sessions were video-recorded using Zoom software. Videos of sessions were stored using Box, a cloud-based content management software, and coded data were entered into the REDCap web platform (Harris et al., 2019). Session data were coded using Datavyu (Datavyu Team, 2014) and Systematic

Analysis of Language Transcripts (SALT; Miller & Iglesias, 2012) software.

Description of the Intervention

The interventionist used TMCR, an evidence-based systematic coaching protocol that has been used in numerous evaluations of EMT (Kaiser & Roberts, 2013; Wright & Kaiser, 2017). For the purposes of this study, EMT strategies were divided into four modules (i.e., tiers) and taught to caregivers during 1:1 workshop sessions. Specifically, we taught caregivers to implement (a) strategies for promoting child engagement, (b) language modeling and verbal expansion strategies, (c) play expansions with accompanying language models, and (d) communication prompting strategies. Following each of the four workshop sessions, caregivers and their children were scheduled to meet with the interventionist 3 times per week to practice strategies with synchronous coaching. Detailed definitions of EMT strategies by tier are available in Table 2.

In the first tier of intervention (engagement), we taught caregivers to be responsive to their children by matching turns and promoting engagement with preferred activities. In addition to sustaining engagement, an additional purpose of this tier was to reduce caregivers' questioning (test questions, yes/no questions) and giving behavioral directions. In the second tier of intervention (language), we taught caregivers to model diverse linguistic structures appropriate to their children's emergent communication skills. We also taught caregivers to use linguistic expansions with their children. Specifically, caregivers learned to contingently expand their children's words into grammatically correct simple sentences containing a specific noun followed by a predicate (i.e., "Toy Talk"; Hadley & Walsh, 2014). The third tier of intervention (play + talk) involved teaching caregivers to expand their children's play actions into multistep play routines by adding objects and actions to their children's play while modeling target language (Frey & Kaiser, 2011). In the final tier of intervention (prompting), caregivers learned how to use systematic prompting procedures to teach their children new words during instances of requesting or following caregiver-presented communication temptations.

The order of intervention tiers is structured in a logical sequence, enabling caregivers to progressively develop their skills. This sequential approach ensures that the skills acquired in earlier tiers lay a strong foundation for success in later tiers. For example, Tier 1 engagement strategies focus on enhancing caregivers' abilities to sustain responsive interactions with their children. Once caregivers master these skills, they can transition to Tier 2 language strategies, which are designed to support caregivers' integration

of language facilitation strategies within their preestablished responsive interactions.

Experimental Design

We used a concurrent multiple-baseline-across-behaviors design to evaluate the effect of telehealth coaching on caregiver implementation of the four tiers of the intervention (Gast et al., 2018). The multiple-baseline design was replicated across three caregiver-child dyads. During baseline, the interventionist conducted a minimum of five sessions, continuing until data were stable. Decisions about condition changes were made by the research team using visual analysis of level, trend, and variability of caregiver performance data (Barton et al., 2018). Once caregivers entered the first treatment phase, they submitted weekly MyCap surveys to their interventionist that were reviewed prior to upcoming sessions. Once caregiver implementation data were stable in baseline, teaching and coaching in Tier 1 (engagement) began. Due to the multiple-baseline-across-behaviors design, strategies from other tiers were not introduced until the caregiver demonstrated substantially improved and stable levels of using the previous strategy. That is, caregivers continued to practice Tier 1 strategies until visual analysis indicated that caregivers' Tier 1 data had stabilized at a higher level than in baseline. Once this occurred, Tier 2 (language) strategies were introduced. This process was repeated when introducing the remaining tiers of the intervention. Once a strategy was introduced, caregivers continued to receive coaching on that strategy throughout the entire intervention. Caregiver's uncoached, self-recorded generalization data were collected in each phase of the study. Uncoached maintenance probes were collected 1–2 months after the last intervention session.

Study Procedure

Pre-Intervention Assessment

The CDI Words and Gestures (Fenson et al., 2007) was completed by caregivers to screen children for inclusion and to characterize their expressive and receptive language. The MSEL Visual Reception subscale (Mullen, 1995) was administered to screen for inclusion and characterize the visual-perceptual and processing skills of child participants. Caregivers delivered the MSEL to their children while receiving coaching from an interventionist via Zoom. The MSEL administration continued until both basal and ceiling scores were reached on the visual reception subscale. All MSEL items were consensus scored by two master's level clinicians before data were summarized.

A structured language sampling protocol was administered to characterize children's language use while controlling for the quality and quantity of examiner linguistic

Table 2. Enhanced milieu teaching strategies taught across four tiers.

Tier	Strategy name	Definition
1. Engagement	Physical space	The adult sits face-to-face and has defined a space for the child to play with preferred objects available without too many distractions.
	Follow child's lead	The adult follows the child's lead when appropriate.
	Imitate actions	The adult joins in the child's play by imitating their actions.
	Give	The adult attempts to hand the child objects while verbally pairing them with their label to promote engagement.
	Responsiveness	The adult responds to all child communication.
	Matched turns ^a	The adult takes turns that are temporally and semantically contingent during their interactions with their children.
	Avoid directions	The adult uses language that is open-ended and not directive or questioning.
2. Language	Target talk ^a	The adult uses object names and simple active declarative sentences.
	Expansions ^a	The adult expands their child's word(s) into "Toy Talk" sentences.
	Point and show	The adult clearly points to or shows objects while verbally labeling to make the object names more salient.
	Pantomime	The adult pantomimes (or acts out) an action that either the child or the object is doing. Must be paired with an active declarative sentence.
3. Play + talk	Set the focus	The adult joins in play and verbally sets the focus of the routine.
	Add objects ^a	The adult adds objects to play to grow established routines. Objects added must be paired with a label.
	Add actions ^a	The adult (a) imitates a child action and (b) extends play by adding a related action while pairing with an active declarative sentence.
	Restart play	The adult restarts the base routine when appropriate.
	Behavior support	The adult uses behavioral strategies to extend engagement and play.
4. Prompting	Frequency ^a	The adult attempts to set up a sufficient number of milieu episodes.
	Flexibility	The adult sets up prompts in more than one way.
	Quality ^a	The adult consistently implements high-quality prompting episodes.
	Appropriately abandon	The adult appropriately stops prompting as soon as the child loses interest.

Note. Caregiver implementation across all 20 strategies was evaluated using a fidelity checklist of overall quality.

^aKey strategies that were additionally evaluated using timed-event sampling.

input (Krok et al., 2022). Caregivers read 24 scripted prompts that accompanied animated line drawings on an iPad. Prompts consisted of one model (e.g., "The ice is breaking") followed by a new picture and structured questions to probe the child's expressive language skills (i.e., "What's happening here?"; "Tell me about the egg!"). The interventionist also conducted a family story interview via Zoom following intake assessments (see Supplemental Material S3). The family story interview is a semistructured interview protocol designed to promote rapport and collect information about everyday routines and interactions, child activity preferences, and caregiver learning preferences to promote effective goal setting prior to intervention (Peredo, 2016).

Baseline

We aimed to keep the structure and format of sessions as consistent as possible across baseline and intervention phases. Rather than omitting didactic instruction and modeling entirely during baseline sessions, the interventionist followed the TMCR approach to provide caregivers with information about developmental milestones.

Five developmental trainings adapted from the Centers for Disease Control and Prevention Learn the Signs, Act Early campaign (Centers for Disease Control and Prevention, 2019) were available to caregivers during baseline. Caregivers rank ordered the trainings based on their preference for content. Developmental information that potentially overlapped with the current intervention was omitted. No information about speech, language, or social communication skills was presented or discussed.

Developmental information was delivered to caregivers in a 1:1 workshop held once per week in the order of their preference. Workshop sessions included (a) didactic instruction about the developmental content for the session, (b) video models and explanations of developmental content, and (c) discussion connecting the workshop's content to their experience with their child. Caregivers also participated in one to two practice sessions each week following the workshop sessions. During baseline practice sessions, the interventionist briefly reviewed developmental information covered in the workshop, observed the caregiver interacting with the child for 10 min, and reflected on

the session with the caregiver. No coaching or feedback on EMT strategy use was provided. Workshop sessions averaged 40.5 min (range: 24–57). Baseline practice sessions averaged 22.3 min in length (range: 16–35).

Intervention

Like baseline, intervention sessions included workshop and practice sessions. During workshop sessions, the interventionist delivered EMT content according to the tier of the multiple-baseline design and facilitated a discussion about how the caregiver could use intervention strategies with their child. Following the workshop, caregivers were scheduled to meet with the interventionist 3 times per week for coaching following the TMCR approach (Roberts et al., 2014). Based on caregiver availability, the number of scheduled sessions that were completed each week ranged from one to three sessions. Workshop and practice sessions varied slightly in length due to natural differences in the review, discussion, and reflection that occurred with caregivers. Intervention workshop sessions lasted 58.7 min on average (range: 36–90 min), and practice sessions were 28 min on average (range: 16–56 min). Dyads received an average of 37.3 intervention practice sessions in total (range: 31–45). The number of practice sessions per tier varied across participants. Dyad 1 averaged nine practice sessions per tier (range: 6–13), Dyad 2 averaged 7.8 sessions (range: 5–11), and Dyad 3 averaged 11.3 sessions (range: 5–21).

Post-Intervention Assessment

Immediately following completion of the intervention, caregivers were sent another CDI Words and Gestures assessment form and were scheduled to participate in a second structured language sample. All post-intervention assessment procedures were identical to those at pretest. Caregivers completed all post-intervention assessments an average of 1.1 months after the last intervention session (range: 0.5–2 months).

Maintenance

To assess the degree to which caregivers retained intervention skills over time in the absence of coaching, one maintenance probe was conducted for each dyad via Zoom. Maintenance sessions were conducted once all post-assessments were completed, averaging 1.8 months after the last intervention session (range: 1–2.3 months). During maintenance, the interventionist briefly reviewed the purpose of the session and told caregivers to practice the EMT strategies they had learned to the best of their ability. The interventionist then observed the caregiver interacting with the child for 10 min but did not provide feedback. Following this, the interventionist reflected generally on the session with the caregiver. No coaching or feedback on EMT strategy use was provided.

Generalization

Caregivers submitted videos of themselves practicing EMT with their children at home throughout the study without the interventionist present. Caregivers logged onto an automatically recorded Zoom meeting and practiced with their children for 10 min. If more than 10 min was recorded, only the first 10 min were coded. No feedback was provided to caregivers about their generalization sessions. Caregivers each submitted six generalization sessions, and each caregiver submitted at least one generalization session per tier.

Intervention Adaptation

Aligned with extant just-in-time interventions, we piloted procedures for adapting the intervention to meet the unique needs of families and children with newly diagnosed ASD. Caregivers were enrolled into the MyCap system and instructed to download the MyCap app to their mobile device. A push notification with a prompt to complete their survey was delivered to participant's phones at the beginning of the week for the duration of the intervention. Caregivers were prompted to report adaptations they would like in upcoming sessions and additional support needed for implementing the intervention at home. The interventionist reviewed MyCap entries each week and discussed possible adaptations and additional supports with caregivers during their next session. The MyCap survey is in Supplemental Material S4.

Caregiver Dependent Measures

The primary dependent variable in this study was caregiver use of EMT strategies. Two concurrent measurement systems were used. The first measurement system involved a fidelity checklist measure to assess the broad quality of implementation for all EMT strategies. The second measurement system involved transcription using SALT conventions and timed-event sampling of a subset of key EMT strategies that were identified and defined in previous studies (Kaiser & Hampton, 2017; Quinn et al., 2021). The use of two measurement systems allowed the research team to monitor both global intervention fidelity and the precise quantity of key strategies used by caregivers.

Fidelity Checklist of Overall Quality

The fidelity checklist measure involved rating the caregiver's use of each EMT strategy (see Table 2). Coders assigned categorical ratings for each EMT strategy following criteria for receiving no (0), partial (1), or full credit (2). Ratings were informed by timed-event sampling data (described below) as well as environmental quality indicators. For each tier of the design (i.e., engagement), scores for relevant strategies were summed.

This number was divided by the total number of points possible to create a percentage for each tier of the design (e.g., percentage of correctly implemented engagement strategies). The fidelity checklist with criteria for categorical ratings is available as Supplemental Material S2.

Timed-Event Sampling of Key Strategies

A subset of key intervention strategies was evaluated using timed-event sampling. In the first tier, matched turns were defined as an adult communicative act that was (a) within 3 s of a child communicative turn (or after 3 s with no child or caregiver turns) and (b) conceptually related to ongoing activities and child communicative bids. Caregiver turns were coded as “matched turns” if they met both the required temporal and semantic features of this definition. In the second tier, “target talk” was defined as the caregiver’s use of either object labels or simple active declarative sentences, including simple active declarative sentences, such as “The ball is rolling,” and object labels, such as “dog.” Requesting words taught during the last phase of intervention also were counted as targets (e.g., *help*, *open*, *more*). Linguistic expansions were coded when caregivers’ responses to child utterances (a) included all content words from the child’s utterance and (b) transformed the child’s words into a simple Toy Talk sentence within 3 s. In the third tier, expanding play included both adding objects and adding actions. “Add objects” was defined as adding novel toys to an ongoing play routine by setting them out in the child’s line of vision and labeling. “Add actions” was defined as a sequence in which the adult first imitated the child’s play and then immediately modeled a novel action with the same toy. Caregivers were taught to pair an active declarative sentence with their modeled action. Notably, play expansion strategies used count as the metric instead of percent, as there was no feasible method for quantifying missed opportunities. Finally, the fourth tier included milieu episodes, which were scored when all required elements of the prompting episode were implemented as intended (e.g., correct prompting sequence, interresponse time). The full coding manual for timed-event sampling data is available in Supplemental Material S1.

Child Dependent Measures

The primary outcome measure for children was the NDW used during each session. For toddlers who are early-on in acquiring single words, NDW represents the acquisition of vocabulary and diversity of utterances. This is an important developmental target for children at this stage of language learning. NDW was defined as the frequency of different word roots produced via any communicative mode (i.e., spoken or signed), not including

articles or social phrases (e.g., *hello*, *wow*). Each child utterance was transcribed using SALT conventions.

Data Analysis

Both fidelity checklist and timed-event sampling data were coded immediately after each session and then graphed for visual analysis (Barton et al., 2018). Visual analysis was also used to evaluate the effects of caregiver use of EMT on child outcomes. Ongoing visual analyses and phase change decisions were made by the first, third, and last authors.

We calculated the within-case standardized mean difference (SMD) and log response ratio (LRR; Pustejovsky, 2018) across baseline and intervention phases within the multiple-baseline designs to provide a secondary, descriptive analysis of changes in caregiver implementation. Within-case SMD is an effect size metric in which the change in mean between two phases is divided by the standard deviation of the baseline phase. LRR is an effect size metric for single-case research based on calculating the natural log of the change in mean between two phases (e.g., baseline and intervention). We used an online calculator to calculate the SMD and LRR between adjacent phases (<https://jepusto.shinyapps.io/SCD-effect-sizes/>; Pustejovsky et al., 2022). Effects on children’s NDW from baseline to intervention were also evaluated using SMD and LRR. Effect sizes were not calculated for phases that were entirely at zero levels, as these estimates do not perform well when baseline values are consistently at zero. Additionally, LRR was not calculated for caregiver’s fidelity checklist outcomes, as LRR is only appropriate for ratio data.

Interobserver Agreement

Coders were initially trained to 90% point-by-point interobserver agreement on coding of all dependent variables for three consecutive videos. Then, point-by-point agreement data were collected for a randomly selected 33% of sessions for each participant to measure the continued reliability of dependent measures across coders. Primary data collectors were naive to which sessions were selected for reliability coding. Across caregivers, the average interobserver agreement on the caregiver fidelity checklist measure was 91.3% (range: 79.0%–100%). For caregiver timed-event sampled measures, the interobserver agreement was 94.2% (range: 88.9%–98.1%). Average interobserver agreement for timed-event sampled child data was 95.4% (range: 66.7%–100%). The wide range in interobserver agreement for timed-event sampled child data is due to occasions when the child’s total NDW was low (e.g., disagreement on one out of three possible child words). Detailed agreement data are in Table 3.

Table 3. Interobserver agreement and implementation fidelity data.

Dyad	Mean percentage (range)			
	IOA: Caregiver outcomes		IOA: Child outcomes	Implementation fidelity
	Fidelity checklist	Timed-event sampling		
A	91.6 (84.2–100)	94.5 (90.1–97.3)	98.9 (80–100)	99.5 (93.8–100)
B	91.2 (79.0–100)	93.2 (88.9–96.8)	98.7 (80–100)	98.1 (87.5–100)
C	91.0 (79.0–100)	94.9 (90.5–98.1)	95.4 (66.7–100)	98.2 (87.5–100)

Note. The caregiver fidelity checklist was a measure of overall intervention quality across 20 enhanced milieu teaching (EMT) strategies. Caregiver timed-event sampling data included the percentage of correct use of a subset of key EMT strategies. Child outcomes included number of different words (NDW) data. Implementation fidelity data included the interventionist's fidelity to teach–model–coach–review procedures. IOA = interobserver agreement.

Implementation Fidelity

A graduate student used a checklist to evaluate the interventionist's fidelity to TMCR procedures (Roberts et al., 2014) in a randomly selected sample of sessions (33.3%–42.9%) for all phases and participants. Implementation fidelity checklists included items on whether the interventionist (a) included didactic instruction about targeted strategies with applied examples (i.e., teach–model); (b) adhered to specific criteria for the quality and pacing of in vivo coaching (i.e., coach); (c) facilitated a discussion after coaching that included reflection and generalization to other routines at home (i.e., review); and (d) facilitated high-quality telehealth interactions, following criteria outlined by Henry et al. (2022). The interventionist did not know which sessions would be coded for implementation fidelity in advance of conducting sessions. The average implementation fidelity across caregivers was 98.6%. Detailed fidelity data are in Table 3.

Social Validity

Both formative and summative social validity data were collected. Formative social validity data were collected throughout the study using the MyCap application. In addition to questions about intervention adaptation, this survey asked caregivers how often they used EMT strategies the previous week, whether the strategies had been helpful, and whether they accessed teaching materials or recorded sessions.

Caregivers were also given the opportunity to comment on their experiences in the study using semistructured interviews and a follow-up survey. A member of the research team who was not the primary interventionist conducted the semistructured interviews. The interview included 24 main questions about the caregiver's relationship with their child, their experiences in learning EMT, and whether they believed any adaptations to the intervention protocol would have been helpful to them. The

follow-up survey was sent to caregivers approximately 7 months after their participation in the study. This survey included 28 questions about (a) children's enrollment in subsequent intensive interventions, (b) whether participation in the study prepared the child and caregiver for later interventions, and (c) the feasibility and acceptability of the intervention. Protocols for all social validity measures are available as Supplemental Materials S5 and S6.

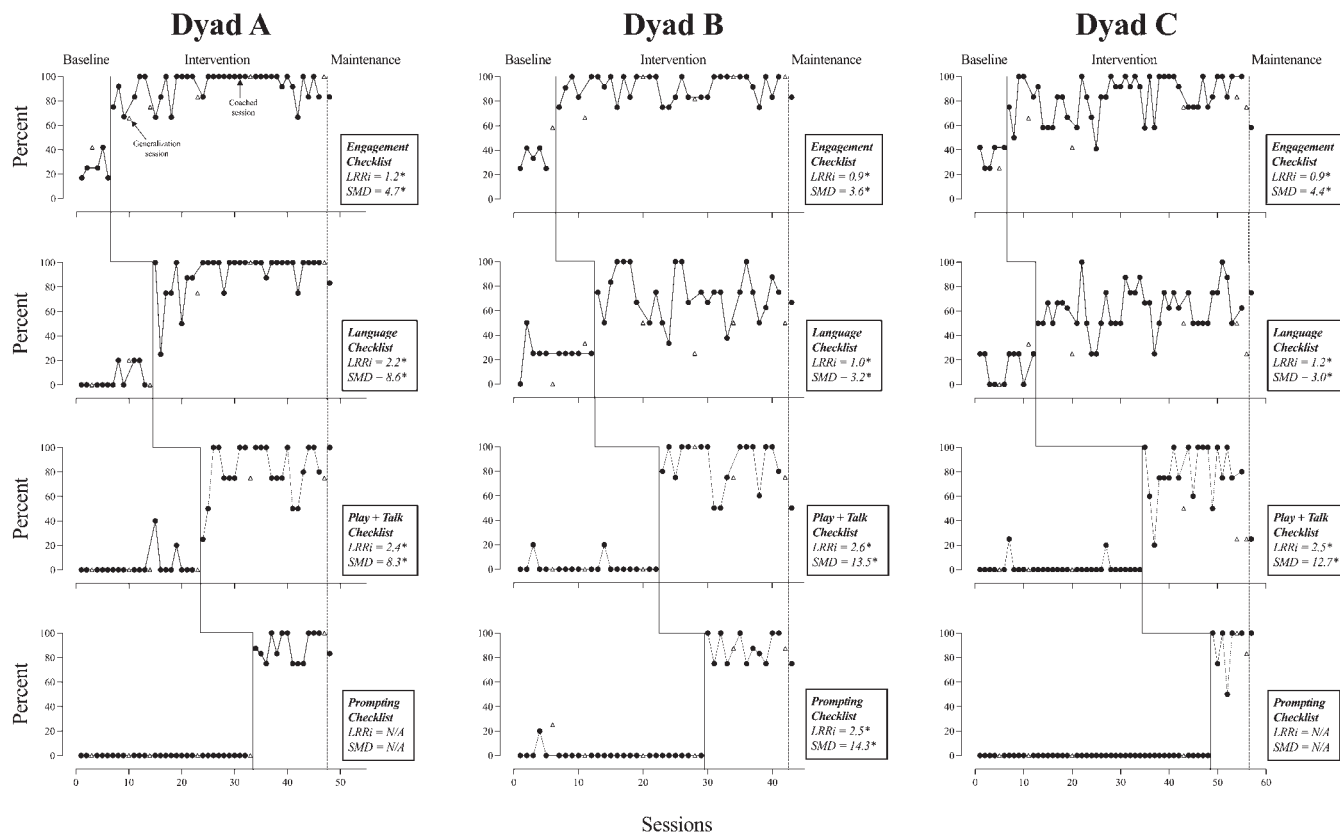
Results

Caregiver Performance

Fidelity Checklist of Overall Quality

Figure 1 depicts session-by-session caregiver implementation data using the fidelity checklist. All caregivers demonstrated low to moderate levels of fidelity within each tier during baseline. Increases in the level of data following introduction of coaching were observed across all tiers for all three caregivers. The immediacy of shifts in level following the introduction of coaching and overall low levels of overlap between all baseline and intervention phases indicated four demonstrations of effect for each participant (out of four total opportunities). Functional relations between the introduction of telehealth coaching and caregivers' use of EMT strategies were identified for all three caregivers. Generalization data indicated that caregivers typically implemented strategies at similar levels during coaching sessions and uncoached sessions. Similarly, maintenance data indicated that caregivers continued to implement most EMT strategies without coaching for several weeks after the intervention phase (range: 1–2.3 months), with one exception (i.e., Dyad C's use of play + talk). We calculated the SMD effect size estimates with associated standard errors and 95% confidence intervals between adjacent phases for all participants (see Supplemental Materials S7–S9). SMD effect size estimates comparing baseline to intervention phases were significant for all comparisons.

Figure 1. Evaluation of caregiver enhanced milieu teaching (EMT) implementation via fidelity checklist. LRRi = log response ratio increasing; N/A = not applicable; SMD = within-case standardized mean difference.



Timed Event Sampling of Key Strategies

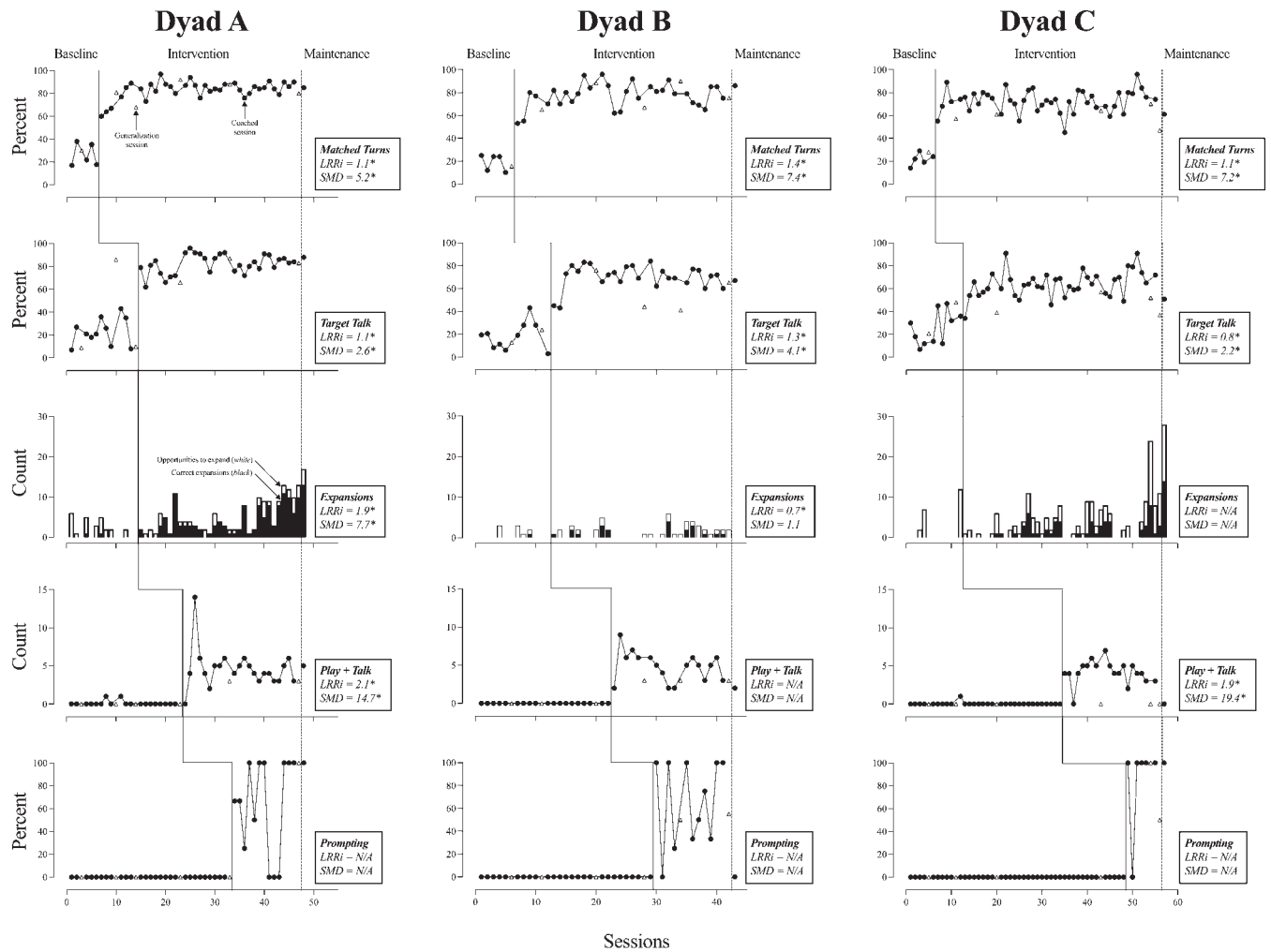
Figure 2 depicts data on a subset of key, timed-event sampled measures of caregiver performance within each tier of intervention. Graphs of matched turns, target talk, and prompting used percentage as the metric (i.e., a proportion of the “target” behavior to all possible behaviors for a given tier), whereas graphs of expansions and play + talk used count as the metric. Visual inspection of data indicated four demonstrations of effect for Caregivers A and C. Three demonstrations of effect were identified for Dyad B due to the infrequent opportunities for using the expansions strategy. As at least three demonstrations of effect between baseline and intervention phases were identified for each caregiver, functional relations were identified between the introduction of telehealth coaching and caregiver’s implementation of key EMT strategies. Generalization data indicated that caregivers typically implemented strategies at similar levels during coaching sessions and uncoached sessions, with some exceptions (i.e., Dyad B target talk data; Dyad C play + talk data). Maintenance data indicated that caregivers continued to implement most EMT strategies without coaching for several weeks after the intervention phase. Exceptions included Dyad B’s use of prompting and Dyad C’s use of

play + talk. LRR increasing (LRRi) effect size estimates were significant for all comparisons, and SMD was significant for nine of 10 comparisons. LRRi effect sizes permit an analysis of percentage change for each comparison. For Caregiver A, the percentage increase across adjacent phases ranged from 208% to 731%. For Caregiver B, the increase ranged from 97% to 316%. For Caregiver C, the increase ranged from 129% to 593%.

Child Performance

Child NDW served as a secondary, descriptive outcome measure. The multiple-baseline design across behaviors did not provide an opportunity to demonstrate experimental control for child outcome variables. Rather than evaluating the presence or absence of functional relations, we sought to use these data to describe general trends in NDW associated with caregiver intervention acquisition. General trends in NDW were highly variable across children (see Figure 3). Child A demonstrated steady gains in NDW throughout intervention, with an accelerating trend in the last phase of intervention. This pattern was not observed for Child B and Child C. Visual analysis of Child B’s data did not indicate consistent change in NDW

Figure 2. Evaluation of caregiver implementation of key enhanced milieu teaching (EMT) strategies via timed-event sampling. LRRi = log response ratio increasing; N/A = not applicable; SMD = within-case standardized mean difference.



throughout intervention or when her caregiver was at fidelity. Child C's NDW increased in variability with relatively fewer sessions at zero levels in later intervention phases, but no clear trend emerged from his session data.

Statistical indices of change (LRRi, SMD) comparing child data during baseline to intervention sessions (including generalization and maintenance) indicated significant increases in NDW for one participant (Child A LRRi: 0.7, 102% increase; SMD: 1.2). The secondary analysis revealed a 34% increase for Child B, but the change estimates were nonsignificant. Statistical comparisons for Child C revealed a 62% increase but were again nonsignificant.

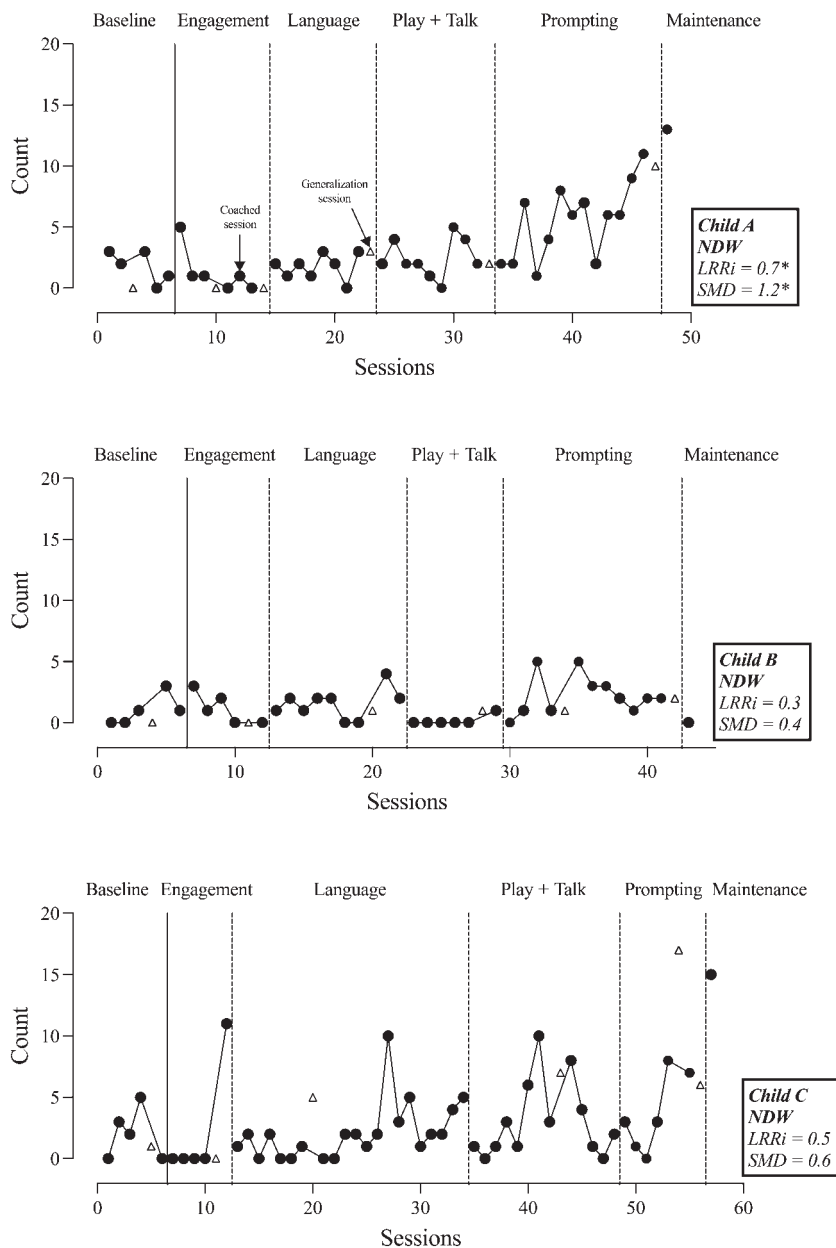
After intervention, the CDI and a structured language sample were administered to describe children's communication skills (see Table 1). Relative to performance at intake, all children demonstrated an increase in the number of words understood, and two of three

children demonstrated increases in number of words produced on the CDI. On the language sample, each child produced a modest increase in NDW following intervention. In the absence of a control group, changes in pre- to postmeasures should be interpreted with caution.

Intervention Adaptation

During intervention, caregivers filled out 68% of their weekly MyCap surveys on average (range: 52%–88%). Caregivers were more likely to forego the MyCap survey in later phases of intervention. Caregivers occasionally requested adaptations for upcoming coaching sessions, and all requests for modifications were discussed with caregivers and fulfilled beginning with the next practice session. Caregiver A requested an additional review of one workshop before an upcoming practice session. Caregiver C requested that practice sessions be divided into two

Figure 3. Number of different words used by child participants in-session. NDW = number of different words; LRRi = log response ratio increasing; SMD = within-case standardized mean difference.



segments with a break in the middle. Caregiver B did not request any changes to teaching or coaching procedures but did request e-mail reminders prior to sessions.

Caregivers also occasionally requested additional support for implementing the intervention successfully outside of practice sessions. Caregivers A and C both requested specific help with learning to embed EMT strategies into their day-to-day routines. Caregivers A and C also requested access to additional written materials and practice activities for their personal review outside of

sessions. Caregiver C requested additional video examples of the interventionist implementing strategies. Caregivers B and C both asked for consultation about responding to their children's general challenging behavior.

Social Validity

Data on caregivers' perceptions of the acceptability and feasibility of intervention procedures were collected through weekly MyCap surveys during the intervention

phase of the study, semistructured interviews immediately after the study, and a social validity survey approximately 7 months after completion of the study.

Formative Social Validity

MyCap data were reviewed by the interventionist each week to determine if caregivers were using the intervention at home and if they were finding the intervention helpful. On a 5-point Likert scale in which 0 was *extremely unhelpful* and 5 was *extremely helpful*, the average score for helpfulness of the intervention procedures was 4.2 (range: 3–5). On a measure of how often caregivers were implementing strategies within the past week (0 = *I didn't use them*, 5 = *I used the strategies several times a day*), caregivers reported an average of 4.2 (range: 3–5).

Summative Social Validity Interview

All caregivers participated in the semistructured interview. In response to a question about changes in their child's communication, caregivers noted a variety of changes in their children's communication following participation in the intervention. One caregiver described that her child was newly able to use specific vocabulary to request their preferred toys, whereas another caregiver identified that her child would now use words to comment instead of only using them for requesting. Caregivers were also asked about how their relationship with their child has changed. One caregiver noted a change in her ability to successfully interact with her child, saying, "Before, I knew he wasn't going to talk, so I would just kind of, not. You know? But now, we spend a lot of time [interacting with each other]." Another caregiver said:

I think [our relationship] looks a little different. I think she's more—She is more exactly that. Wanting to be near me, not wanting to just go and be on her own. [...] There was a point like I think at some point in the middle, early of the intervention even where it was like all of a sudden she just was constantly like, coming up to me. That's so great right?

Two caregivers specifically noted that they continued to use the strategies often, even though coaching had ended. One caregiver expressed this by saying, "Honestly, I use it all the time. The entire strategies from the beginning. That's how I play with my [other child]." Likewise, a second caregiver said, "It's embedded in my brain. I use it every day."

When asked about her opinion on the telehealth modality, one caregiver indicated that participating via telehealth did not meaningfully change the intervention for her, as their family had primarily experienced care via telehealth thus far due to COVID-19. In contrast, another caregiver reflected on the challenges of telehealth coaching

and stated that being on camera during instances of challenging behavior led to initial nervousness about whether the interventionist would judge her parenting skills negatively. All three caregivers mentioned their comfort and ease in contacting the interventionist, and one caregiver specifically indicated that the general support she received from the interventionist outside of the 10 min of coaching was helpful.

When asked about the use of MyCap for intervention adaptation, caregivers generally indicated that they had sufficient contact with the interventionist in-session and also often contacted her outside of sessions using other methods (e.g., phone calls, text message, e-mails), rendering MyCap irrelevant. Multiple caregivers reported, however, that MyCap could be more beneficial for parents who were less comfortable with their coach. Additionally, caregivers indicated that while the MyCap survey was quick to complete, the frequency of surveys was too high. Suggestions for an improved frequency of MyCap surveys ranged from 1 to 2 times per month.

Summative Survey of Social Validity

Two of three caregivers returned the follow-up social validity survey. On 5-point Likert scales, both caregivers reported that participation was "somewhat helpful" in preparing their child for other therapies but reported it was "very helpful" in preparing them as the caregiver for future services. One caregiver wrote that the intervention "mimicked how an [ABA] therapy session would go," making the transition to later therapy easier for both her and the child. Both caregivers indicated that the intervention did not put any added stress on their families; however, both also indicated that they would have benefitted from connection to additional supports immediately following their child's diagnosis (i.e., parent support groups, counseling). Both caregivers rated the intervention as highly reasonable and helpful.

Discussion

The primary aim of this study was to evaluate a just-in-time model for teaching caregivers of toddlers recently diagnosed with ASD on their acquisition, generalization, and maintenance of EMT strategies. In addition, we (a) examined the effects on caregiver's generalized and maintained use of EMT strategies, (b) explored changes in children's language skills, and (c) evaluated the acceptability of a just-in-time adaptive approach to telehealth caregiver coaching. Findings indicate that all caregivers were able to implement EMT at-fidelity with their newly diagnosed children with ASD following systematic telehealth coaching. Caregivers demonstrated moderate evidence of

generalization to independent interactions at home and maintained use of most EMT intervention strategies at follow-up. It is possible that this intervention may promote positive language outcomes for some children with ASD; however, the lack of experimental control for child outcomes in this design precluded definitive evaluation of impact on child NDW.

Formative and summative analyses of social validity indicated that caregivers perceived that participation in the intervention was beneficial to their children. In addition, caregivers indicated that their involvement in the intervention was helpful and prepared them for their children's subsequent intensive interventions. This model may be able to effectively bridge the resource gap for caregivers and children during the time immediately following diagnosis, when accessing services can be challenging. The results of this study are well aligned with those from other research on the positive effects of caregiver-implemented interventions for children with ASD (Hampton & Kaiser, 2016; Minjarez et al., 2020). Telehealth caregiver coaching is a well-documented and socially valid service delivery model (Ingersoll et al., 2016; Pickard et al., 2016; Quinn et al., 2021). Indeed, telehealth coaching may improve caregivers' ability to support their children's development while reducing barriers to service access.

JITAI is a recent methodological advancement in intervention that involves treatment adaptations that are responsive to the momentary needs of participants (Nahum-Shani et al., 2018). To date, no studies have evaluated the use of JITAI in the context of early language intervention. This study was a preliminary demonstration of components of a just-in-time adaptive early intervention model for caregivers of toddlers newly diagnosed with ASD. For this study, we defined this model as having two core features: (a) enrollment into the intervention following diagnosis and before the family has access to other services and (b) strategies for being responsive to caregivers' indicated needs for support.

Limitations

The small sample and minimal diversity across participants limit the potential generalizability of these results. Future research should aim to recruit a sample of caregivers and children that represent the racial, ethnic, and economic diversity of children with ASD and their caregivers. This research design did not allow for direct evaluation of child outcomes; however, observed change in NDW was variable and modest across children. Previous research has demonstrated that caregiver-mediated intervention can meaningfully impact children's social communication outcomes, including both prelinguistic and linguistic measures (Heidlage et al., 2020; Pak et al.,

2023). A prelinguistic measure would likely have been more appropriate than NDW for some children in this study. Additional child outcome measures, such as play skills or engagement, were not collected but may have improved as a result of the intervention and warrant further consideration. Future researchers should (a) consider designs that control for maturation and (b) include child outcome measures that are developmentally appropriate and likely to be immediately responsive to intervention.

Due to the nature of the telehealth intervention, caregivers submitted their own generalization videos. Reactivity therefore potentially limits the validity of our measures of caregiver generalization. One caregiver did not complete the follow-up survey, which potentially impacted findings about the social validity of the intervention. Additionally, the method of descriptive assessment administration was atypical (i.e., caregivers administered the MSEL to their children while receiving support via Zoom) and represents one potential limitation. However, it is important to note that while the caregiver administered the test items, multiple steps were taken to ensure the rigor of the assessment administration and scoring. Future studies might consider evaluating the assessment validity of such approaches.

Researchers have previously hypothesized that the brief nature of intervention (e.g., limited number of sessions) may contribute to modest or delayed effects on child outcome measures (Wetherby et al., 2018). In this study, children performed better later in intervention once parents had acquired more skills. As the intervention did not continue beyond caregivers' initial training in EMT, we are unable to determine any growth children made once caregivers were consistently implementing at sufficient fidelity and dosage. Caregiver's mastery of intervention skills is likely a prerequisite to examining changes in child outcomes. Therefore, future researchers should plan to continue intervention until there is evidence of sufficient overall dosage that is likely to impact children's language development.

Finally, although we collected data on requests for adaptations using MyCap, we did not systematically track comments and requests that may have occurred during the review portion of coaching sessions. We were responsive to parent requests for support in-session, but we are unable to quantify these conversations. These conversations may have been important for understanding caregiver needs, as evidenced by one caregiver in their interview, who emphasized the value of the support they received in-session beyond the 10 min of coaching. The overall support provided to families during EMT may be a factor that influences caregiver outcomes. Future researchers should collect detailed field notes on caregivers' comments about (a) what intervention practices are going well, (b) requests

for adaptation, and (c) concerns about their own and their child's progress, both during and outside of coaching sessions.

Conclusions

A just-in-time adaptive early intervention model of telehealth service delivery is a tenable method for teaching caregivers of children with ASD to implement evidence-based language intervention with their children between initial diagnosis and subsequent intensive intervention. In addition to these primary findings demonstrating caregivers can learn, generalize, and maintain their use of EMT, there is mixed evidence regarding children's response to treatment that should be studied further. Finally, social validity data indicate that this adaptive model was both acceptable to caregivers and may be a valuable resource to families in the gap between diagnosis and eventual enrollment in more intensive services. This just-in-time approach to early intervention, including (a) children's enrollment into telehealth intervention immediately following diagnosis and (b) responsiveness to individual families' ongoing needs and requests, may result in potentially community-viable interventions that can fill important gaps in available resources and decrease disparities in service access for families of children with ASD.

Data Availability Statement

The data sets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Acknowledgments

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