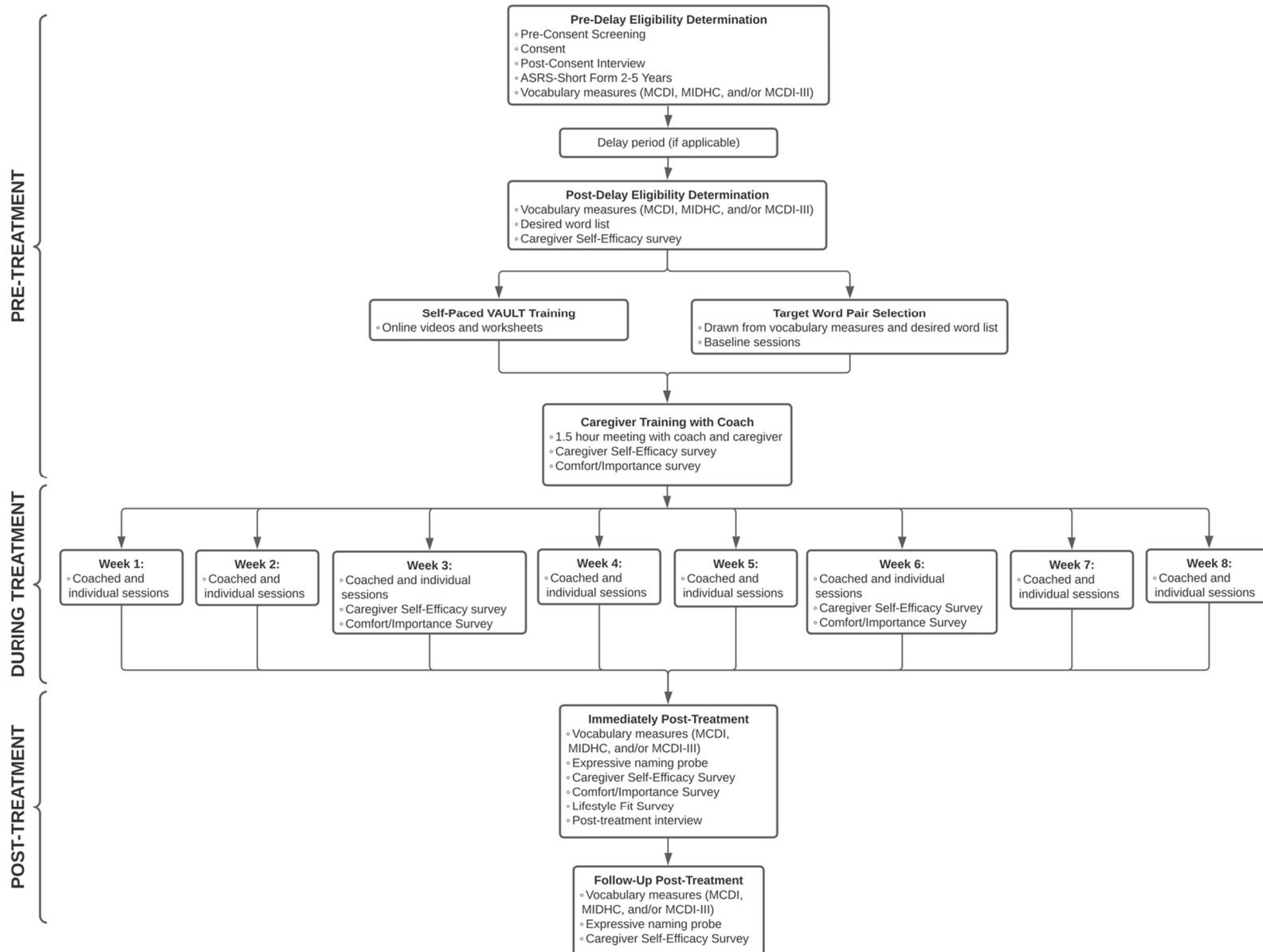


## **Supplemental Material S1.**

1. Flowchart of Steps Involved in VAULT Caregiver Training
2. Sample Schedules of Coached and Individual Sessions
3. Administration Timeline of Caregiver Surveys
4. Quantitative and Qualitative Measurements of Fidelity to Treatment Across All Caregivers Each Week
5. Posttreatment Interview Results
6. Child Performance on Expressive Naming Probes
7. General Rate of Expressive Word Learning by Study Phase
8. Caregiver Self-Efficacy
9. Individual Caregiver's Self-Efficacy Ratings for VAULT Principles Before, During, and After Training and Treatment

### S1.1 Flowchart of Steps Involved in VAULT Caregiver Training



## S1.2 Sample Schedules of Coached and Individual Sessions

*Sample Schedule of Coached and Individual Sessions for a Family with 4 Targets Per Week*

*Sample Schedule of Coached and Individual Sessions for a Family with 2 Targets Per Week*

<b>Monday</b>	<b>Tuesday</b>	<b>Wednesday</b>	<b>Thursday</b>	<b>Friday</b>
9:30–10:00 am <i>Coached session</i> Targets: -spoon -nose	3:50–3:58 pm <i>Individual session</i> Target: -paper	8:30–8:45 am <i>Individual session</i> Targets: -sun -paper	11:15–11:23 am <i>Individual session</i> Target: -spoon	5:00–5:15 pm <i>Individual session</i> Targets: -sun -nose

<b>Monday</b>	<b>Tuesday</b>	<b>Wednesday</b>	<b>Thursday</b>	<b>Friday</b>
	9:30–10:00 am <i>Coached session</i> Targets: -spoon -nose	3:50–3:58 pm <i>Individual session</i> Target: -spoon	5:00–5:08 pm <i>Individual session</i> Target: -nose	

### S1.3 Administration Timeline of Caregiver Surveys

Survey	Before training	After training/before treatment	After 3 weeks of treatment	After 6 weeks of treatment	Immediately posttreatment	4–6 weeks posttreatment
Caregiver Self-Efficacy	X	X	X	X	X	X
Comfort + Importance		X	X	X	X	
Lifestyle Fit					X	

### S1.4 Quantitative and Qualitative Measurements of Fidelity to Treatment Across All Caregivers Each Week

Treatment parameter	Treatment week															
	1		2		3		4		5		6		7		8	
Quantitative <sup>a</sup>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Dose Number	70.6	3.6	68.8	3.3	64.7	7.4	65.8	5.9	66.8	2.5	69.0	7.3	60.9	16.0	69.1	1.7
Session Length (MM:SS)	7:00	0:52	7:28	1:06	7:36	1:05	6:53	0:57	8:38	2:07	7:44	0:52	6:53	1:45	7:31	1:02
Dose Rate (doses/min)	10.3	1.7	9.4	1.3	8.7	1.5	9.8	1.9	8.1	1.7	9.1	1.8	8.9	1.6	9.4	1.5
Qualitative <sup>b</sup>																
Focused Stimulation	4.5	0.4	4.4	0.5	4.5	0.0	4.8	0.5	4.5	0.5	4.9	0.3	4.9	0.3	4.9	0.3
Low Pressure Interaction	3.9	0.8	4.9	0.2	4.8	0.5	4.8	0.5	5.0	0.0	4.6	0.5	5.0	0.0	5.0	0.0
Grammatical Utterances	4.9	0.3	4.8	0.5	5.0	0.0	5.0	0.0	4.8	0.3	5.0	0.0	5.0	0.0	5.0	0.0
Engagement	4.4	0.5	4.8	0.5	4.9	0.3	4.9	0.3	4.7	0.6	5.0	0.0	5.0	0.0	5.0	0.0
Varied Sentences	4.4	0.5	4.8	0.3	4.5	0.0	4.8	0.5	4.8	0.3	5.0	0.0	4.9	0.3	4.9	0.3
Varied Contexts	4.5	0.4	4.6	0.5	4.5	0.6	4.9	0.3	4.7	0.3	4.8	0.3	5.0	0.0	4.9	0.3

<sup>a</sup>These numbers reflect averages for one target in a coached session.

<sup>b</sup>Qualitative measurements came from the coach and reliability tracker’s weekly rating of how well the caregiver implemented each VAULT principle, on a five-point scale (1 = *lowest quality*, 5 = *highest quality*).

## S1.5 Posttreatment Interview Results

### *Quotes, Themes, and Codes from Posttreatment Caregiver Interviews*

<b>Theme</b>	<b>Codes</b>	<b>Quote</b>
Coach	Coach was helpful (good activity ideas, approachable)	“Both [senior research staff] and [coach] are super helpful, and like they knew that, I mean I don’t have any experience in this, so they were really understanding and were able to give me pointers on like what to do, um, which was like nice.” (C2)
	Appreciated support planning activities	“And I have ideas for activities, but you don’t always think of the same ones. So sometimes she had some really fun ones for ‘nose.’ Like I would never have thought of being seals. That was amazing. He loved that.” (C4)
	Caregiver-coach as a partnership	“So we really had to come up with some ways to get him more focused. And um so that was definitely a shared responsibility, you know...I feel like we worked through some big challenges together.” (C1)
	Coach’s feedback was positive and constructive	“Sometimes it was hard to think of how to put the word at the beginning of the sentence or at the end, depending on what the word was. And she was really supportive. I liked that she gave feedback on how I could improve things or tweak things. And it was in a very friendly, supportive way. It’s not like critical.” (C4)
Training	Training was beneficial	“The trainings were helpful.” (C2)
	Worksheets were challenging but necessary	“I feel like it helped me do better at the training in the end, so I quickly forgot about how much work it was and took what I learned from it and was able to apply it better.” (C1)

Theme	Codes	Quote
	Training was time-consuming	“It was a lot of work to go through those trainings.” (C1)
	Training was simple	“It was a simple training. Like it was easy to understand.” (C3)
Generalization and caregiver outcomes	Teaching new words with VAULT principles (finding opportunities, focused stimulation, varied sentences, lower pressure, more repetition, grammatical utterances, engagement)	“I’ve looked for opportunities to teach him new words...if I find something interesting or he sees something he’s interested in, I’ll do it for a few minutes until he loses interest, you know.” (C1)
	Works on difficult words with child	“I’ve been doing XX like some words, so that they pop a little bit more to him...Like for example, like the word ‘fork.’ He has trouble saying the word ‘fork,’ so we’ve been kind of using that one more.” (C2)
	Increased awareness of communicative pressures on child	“...it has made me um think about like games we’re playing or how I’m questioning and pausing or the expectations on him. So it has made me think about maybe how he learns language more and being more mindful. Like when we’re trying to- not learn a new word, but when we introduce a new thing, to talk about it often.” (C4)
	Gained knowledge	“I feel like it was a really good support for me...you don’t have that-, well maybe some parents do-, like that knowledge of how to help your kid talk when they’re not talking.” (C4)
	Caregiver plans to continue using what they learned in the program	“...now it’s my go-to, and I want to do it with other kids too.” (C3)

Theme	Codes	Quote
	Caregiver would like more families to know about VAULT	“I think I would like for more families to like know about this.” (C2)
Child outcomes	Child has increased confidence (/openness?) to attempt speaking	“I definitely think they’ve gotten more open to talking...and I think people have noticed too...they’re like, ‘Oh my god, they’re talking more!’” (C3)
	Vocabulary burst	“He’s just started picking up words all of a sudden *laughs* and it all started with, you know, ‘spoon’ and ‘nose’ and the ones we learned in VAULT. And then all of a sudden, he’s just started picking up much more language.” (C1)
	Combining words	“He’s trying to put words together.” (C2)
	Clearer articulation	“His speech, I think, has gotten better um since doing the program...he’s trying to say them better.” (C2)
	Child more talkative	“He roared and quacked, and he could sign for ‘more.’ But really, he probably had five words, and that was generous. And now I would say he has at least a hundred. So in that like two-month period of time, he really has gone from nothing to having enough to super communicate and to engage us in little conversations as such.” (C4)
	Child’s communication is improving	“...who knows, you know, if you didn’t do it, but his language is just starting to take off now, and it all started with a few words that-, you know, his few VAULT words.” (C1)
Telehealth	Child disliked video chat	“...like this morning he brought us a dog, He said ‘puppy puppy,’ because he wanted to play with it. XX sated and happy.” (C4) “I don’t think he liked the aspect being on camera. He doesn’t like to see himself on the screen either.” (C4)

Theme	Codes	Quote
Research Context	Screen prevented child’s engagement	“If he could see the computer screen, he would only focus on that. So I put it up and away. I would cover it.” (C1)
	Initial discomfort with VAULT (due to newness, people watching) improved with practice	“So it felt a little unnatural at first, but then, the more I did it, the more I practiced, it got better.” (C3)
	Research as an available intervention	“The waitlist for speech therapy is five months, so it was nice to [have] that um support for me to see what I could do to help in the meantime.” (C4)
	Number of treatment words was appropriate	“It’s like eight words a week, <sup>a</sup> and so we’d do two coached sessions with two words, so so you’d do half of them in a coached session and half of them on your own. That was a perfect amount for me. So it would be- if I had to do any more than that, it would be hard.” (C1)
	Not bothered by people watching	“...sometimes it felt like they weren’t even there...it was nice and comfortable.” (C2)
	Uncomfortable with people watching	“I didn’t love the idea of being recorded or of other random people watching in the background. It kind of made me self-conscious, especially when I wasn’t super familiar with VAULT.” (C4)
	Most aware of being watched when struggling	“When you start struggling with a session or a word, it’s kind of like oh man, I know I’m just repeating the same sentence, and they’re sitting there thinking, ‘Oh he’s just repeating the same sentence.’ *laughs* Yeah, but I didn’t mind too much at all.” (C1)
	Used methods that distracted from people being on screen	“So I just didn’t switch my screen to see anyone. I just kind of pretended that it wasn’t there.” (C4)

Theme	Codes	Quote
VAULT in family context	Caregiver happy to help in research effort	“Happy to give you guys the data, as well. So it was really- I felt like it was a really good, you know, like we got something. You got something. Everybody’s happy.” (C1)
	Applied VAULT principles to family’s context	“I’ve been able to apply it, you know, in everyday situations.” (C1)
	VAULT became a routine	“We’d call it school. We’d say, ‘We’re going to go to school today,’ and he’d get all excited.” (C1)
	Individual sessions were more flexible for child’s needs	“I could wait until he was in a good mood and be like, ‘He’s in a good mood to learn.’ Where the coached session was like, sometimes he is, sometimes he’s not.” (C1)
	VAULT fits into family’s context (family-centered, schedule, accessible at home)	“I like that it was like family centered. Like you guys just made it easy to, you know, like access our home and then just be available to our family in our-, and accommodate our schedules. Um which I really, really enjoyed. That was the part I liked the most, I think.” (C3)
	VAULT was time-consuming but good	“All in all it was very good. Very time-consuming, you know, not gonna lie, but very good.” (C1)
	VAULT was not time-consuming	“It’s not a hard thing to dedicate, you know, a few hours to your child and doing the speech therapy with them. It’s not bad at all.” (C2)
	Good experience	“It was a really good experience for us. And it came at a time when we needed support when no one else could- would-, I don’t know, give it to us.” (C4)
VAULT sessions	Activities/materials were engaging	“I would put stuff together, and they really, really enjoyed it. So I think that they liked, you know, the activities that we did.” (C3)

<b>Theme</b>	<b>Codes</b>	<b>Quote</b>
	Child liked sessions	“I think that overall it was a good experience, and he liked it and enjoyed it.” (C2)
	Child tolerated high input	“I don’t think they were even bothered by it...” “Right, even though they were hearing the word lots and lots of times.” (interviewer) “Right, yeah, they didn’t seem annoyed.” (C3)

*Note.* False starts or repetitions were removed to increase clarity if they did not impact the meaning of the message. “XX” refers to an unintelligible utterance.

<sup>a</sup>This caregiver had four targets a week, each treated twice.

### S1.6 Child Performance on Expressive Naming Probes

Participant	Study phase											
	Pretreatment				Immediate posttreatment				4–6 weeks posttreatment			
	Targets		Controls		Targets		Controls		Targets		Controls	
	R	C	R	C	R	C	R	C	R	C	R	C
T1	0	0	0	0	3	4	2	2	2	4	2	2
T2	0	0	0	0	2	8	1	1	4	9	4	5
T3	0	0	0	0	3	4	0	0	0	4	0	0
T4	0	0	0	0	0	2	0	0	1	2	0	0
T5	0	0	0	0	4	10	4	9	8	10	9	9

*Note.* R = raw; C = cumulative. Cumulative probe scores included unique productions from the current probe and previous data in treatment and probe sessions.

### S1.7 General Rate of Expressive Word Learning by Study Phase

Participant	Rate of word learning (words/week)		
	Delay	Treatment	Posttreatment
T1	2.4	1.5	2.1
T2	— <sup>a</sup>	4.6	14.8
T3	2.3	12.0	29.8
T4	5.2	15.6	48.8
T5	1.1	13.4	8.9

*Note.* T1 = Toddler 1; T2 = Toddler 2; T3 = Toddler 3; T4 = Toddler 4; T5 = Toddler 5. Participants’ rate of word learning was calculated by (2nd time point MCDI – 1st time point MCDI)/number of weeks between the time points. Bilinguals’ total expressive scores from the MCDI and MIHDC were combined with unique words from their MCDI-III scores as applicable. Partial weeks were included (e.g., 3.6 weeks for 3 weeks, 4 days).

<sup>a</sup>T2 did not undergo a delay phase.

## **S1.8 Caregiver Self-Efficacy**

One of the new VAULT materials was a caregiver self-efficacy measure. Self-efficacy describes a person’s belief in their ability to carry out a behavior (Bandura, 1977; Bandura & Schunk, 1981; Gist & Mitchell, 1992). It can influence one’s willingness to try a behavior and the effort they put into it (Bandura, 1977; Brown & Inouye, 1978; Schunk, 1981). In Ingersoll et al. (2016), caregivers in 27 child–caregiver dyads increased in self-efficacy on the Parenting Sense of Competence Scale and in treatment fidelity. No other caregiver-led language intervention studies via telehealth have examined caregiver self-efficacy to our knowledge, missing a potentially fundamental variable. Given the lack of self-efficacy evidence in the literature, the current study examined self-efficacy across all VAULT principles at multiple time points; this will contribute to preliminary evidence of caregiver self-efficacy changes during language intervention.

### ***Research Question***

What trends exist between caregiver self-efficacy and both caregiver treatment fidelity and child outcomes? We predicted a positive trend between caregiver self-efficacy and caregiver fidelity and between caregiver self-efficacy and child outcomes. That is, caregivers with high self-efficacy would demonstrate high treatment fidelity, and high self-efficacy would pair with positive child outcomes (e.g., the child starts to produce target words).

### ***Caregiver Self-Efficacy Measure***

We created a caregiver self-efficacy<sup>1</sup> (CSE) survey that specifically tapped into self-efficacy for administering VAULT (Supplemental Material S3.3, pp. 5–6). Specific CSE measures generally yield higher validity (Wittkowski et al., 2017), sensitivity (Crncec et al., 2010) and accuracy (Bandura, 1997) compared to general CSE measures, which tap into overall caregiver self-efficacy. We used Likert-style questions to ask caregivers to rate themselves on how well they could administer VAULT and its principles. Answer scales ranged from 1 (*strongly disagree*) to 7 (*strongly agree*). We asked three questions per VAULT principle. We reported on the average of each principle’s three questions. We asked one standalone question addressing caregivers’ rating of their ability to combine all VAULT principles simultaneously. Caregivers completed the CSE survey at multiple time points (Supplemental Material S1.3, p. 4). Because this survey was created for the current study, reliability and validity data are not available.

### ***Analysis Plan***

We visually analyzed the level, trend, and variability of the relevant data across the entire time series rather than by phase to describe each caregiver’s self-efficacy over time. When comparing self-efficacy to other variables, only relevant time points were examined.

### ***Results***

Supplemental Material S1.9, p. 17, shows graphs of each caregiver’s self-efficacy ratings on each VAULT principle before and after training as well as during and after treatment. One caregiver had relatively high self-efficacy throughout (C1). Another decreased in self-efficacy for Focused Stimulation, Engagement, and Varied Contexts between pre- and posttraining, but increased in self-efficacy during the treatment phase for all principles except Grammatical

Utterances, which remained high (C2). Another increased in self-efficacy for Focused Stimulation, Varied Sentences, and Varied Contexts between pre- and posttraining (C3). The final caregiver slightly increased in self-efficacy for Focused Stimulation, Low Pressure Interaction, Engagement, and Varied Sentences pre- and posttraining (C4). During the treatment phase (between *Posttraining* and *Immediate Posttreatment* time points), all caregivers either maintained their relatively high self-efficacy for all principles or showed trends of gradual increases in self-efficacy.

With regard to caregiver self-efficacy and treatment fidelity, we compared trends from self-efficacy ratings during the treatment phase (data points corresponding to *3 Weeks into Treatment* and *6 Weeks into Treatment*) to trends from the coach's and reliability person's qualitative ratings of caregivers' implementation of VAULT principles. No patterns emerged. Starting with Treatment Week 2 and beyond, all caregivers were rated 4 or higher (maximum 5) on all VAULT principles, regardless of whether they maintained high self-efficacy (C1 and C4) or increased their self-efficacy (C2 and C3).

Regarding trends between caregiver's self-efficacy and child outcomes, we examined both children's treatment-specific word learning, and their general word learning measured by changes in word-learning rate on the MCDIs. We visually analyzed data from the treatment phase. We found no patterns between self-efficacy and treatment-specific word learning. Caregiver self-efficacy increased the most in the first 3 weeks of treatment (between the *Posttraining* and *3 Weeks into Treatment* time points), regardless of whether their toddler had said a target or not during that time, as evidenced by production of targets in Figure 1. All caregivers' self-efficacy remained relatively stable and at a high level for the remainder of treatment and after treatment ended, regardless of whether their toddler showed significant learning of targets (C1, C2, and C4) or not (C3), per our Tau-U analyses. We examined patterns between self-efficacy and changes in MCDI word-learning rate before and during treatment for the four toddlers who had a delay period. For the caregiver who showed relatively high self-efficacy throughout treatment, their toddler did not show a change in word-learning rate (C1). The other three toddlers with a delay period (C3 and C4) showed large increases in word-learning rates, and their caregivers showed the largest increase in self-efficacy during the first 3 weeks of treatment, with it remaining high and level for the remainder of the program.

## **Discussion**

Individual differences in self-efficacy ratings emerged mostly around training and early on during the treatment phase. The greatest number of caregivers showed the most visually noticeable increase in self-efficacy for Focused Stimulation and Varied Sentences. Coaches did provide caregivers with 3–5 sample sentences for all target words each week, which supported their implementation of these principles. However, this finding suggests caregivers might benefit from additional coach support in these areas to support their self-efficacy. Ratings for Varied Contexts underwent less change across caregivers, but this might have been influenced by coaches providing weekly activity ideas. Though not inherently problematic, this extra support might have elevated caregivers' ratings for this principle. Future work could examine how reducing coach support for Varied Contexts affects caregiver self-efficacy for this principle because, as alluded to above, providing as much caregiver support as in the current study might not be feasible for practicing clinicians.

We hypothesized that there would be a positive trend between self-efficacy and fidelity. No major trends were found, so this hypothesis was not supported. This was also an encouraging

finding because caregiver treatment fidelity does not appear to trend with their self-efficacy. Even caregivers experiencing growth in their self-efficacy can deliver VAULT with consistently high fidelity. Some might argue that having only two data points for self-efficacy during the treatment phase limited our ability to detect patterns between this and fidelity, data for which was collected for each of the 8 weeks of treatment. Although having more data points during treatment would provide a comprehensive picture, we point out that scores for both self-efficacy and fidelity were relatively high for all caregivers at all time points. Therefore, having data from more time points likely would not have revealed different results. Additionally, neither the self-efficacy survey nor the fidelity rating scale was a validated measure. It is possible that adjustments to the rating scale (e.g., increasing the range from 1–5 to 1–10) could improve our ability to detect individual differences among caregivers, thus better equipping us to discover trends between self-efficacy and fidelity. Our small sample size might also have limited our detection of patterns between these variables.

We hypothesized that there would be a positive trend between caregiver self-efficacy and child outcomes. However, no major trends were found, as measured both by children's treatment-specific word learning and general word learning, and so this hypothesis was not supported. It was surprising but encouraging that caregivers' self-efficacy increased or remained high even when their child did not learn the words they were treating and even when the child's general rate of word learning did not increase during treatment. It might have been that our front-loaded training and ongoing coach support (including weekly face-to-face meetings during which caregivers received constructive feedback) helped caregivers increase and maintain high self-efficacy throughout. However, it is also possible that our small sample size limited our ability to detect patterns. Another possible explanation is that caregiver self-efficacy was a product of positive changes that caregivers observed in their children during the program. As mentioned earlier, during posttreatment interviews, all caregivers reported positive outcomes from the treatment (e.g., child was more talkative or combining words). Observing these changes in their children might have also played a role in their high self-efficacy. The self-efficacy measure was created for the current study and has not been validated, which could be a source of measurement error. Nonetheless, available, validated measures would not have appropriately captured the constructs of interest in this study (see Introduction). Future studies should validate this measure.

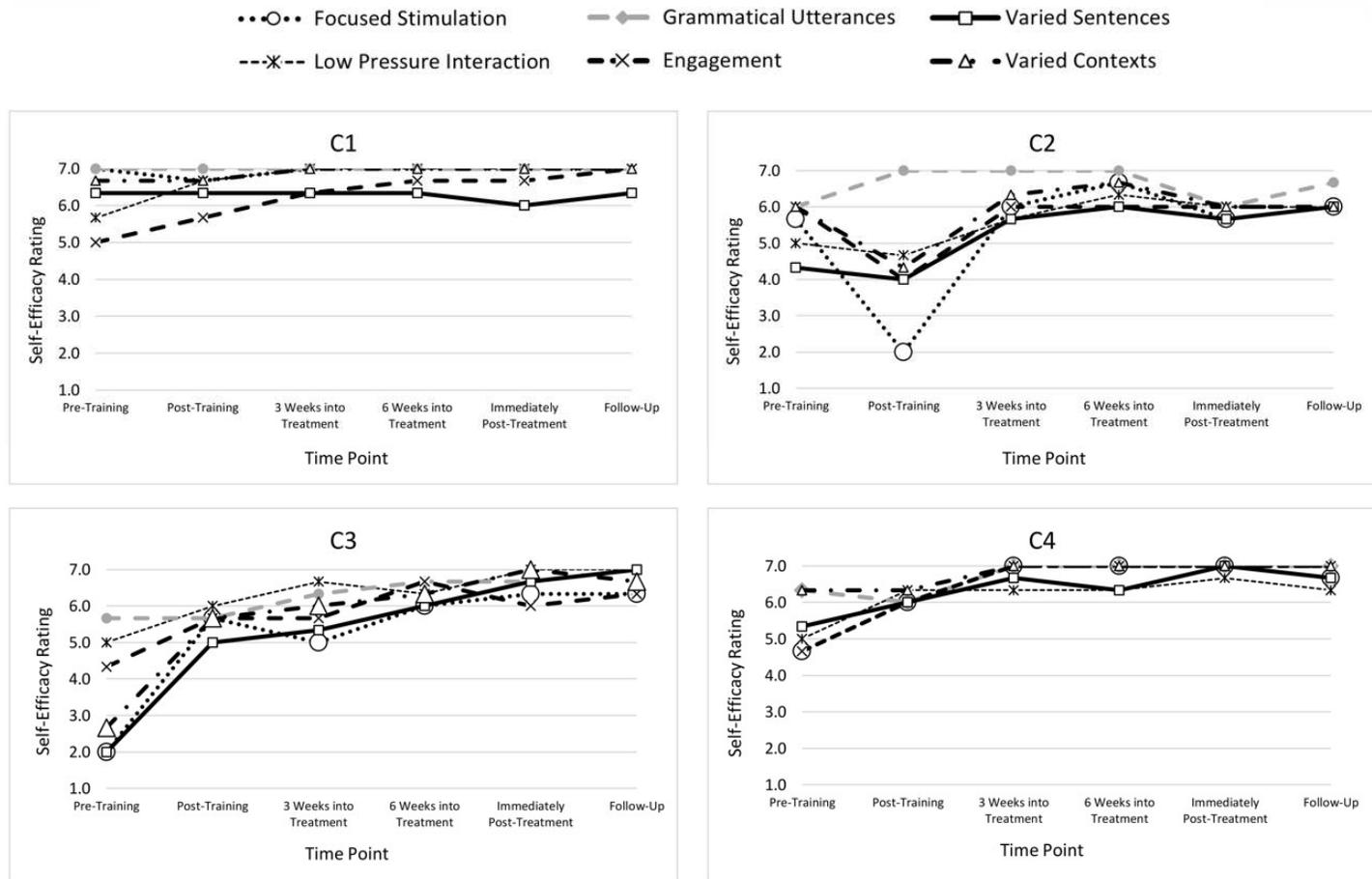
In conclusion, no trends were detected between self-efficacy and child outcomes or self-efficacy and fidelity. Future work should create and validate caregiver self-efficacy measures to further explore whether there is a link between self-efficacy and outcomes in a caregiver-implemented treatment model.

## References

- Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191–215.
- Bandura, A., & Schunk, D. H. (1981). Cultivating competence, self-efficacy, and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology*, *41*(3), 586–598. <https://doi.org/10.1037/0022-3514.41.3.586>
- Brown, I. J., & Inouye, D. K. (1978). Learned helplessness through modeling: The role of perceived similarity in competence. *Journal of Personality and Social Psychology*, *36*(8), 900–908.

- Crnec, R., Barnett, B., & Matthey, S. (2010). Review of scales of parenting confidence. *Journal of Nursing Measurement*, *18*(3), 210–240. <https://doi.org/10.1891/1061-3749.18.3.210>
- Gist, M. E., & Mitchell, T. R. (1992). Self-efficacy: A theoretical analysis of its determinants and malleability. *The Academy of Management Review*, *17*(2), 182–211. <https://doi.org/10.2307/258770>
- Ingersoll, B., Wainer, A. L., Berger, N. I., Pickard, K. E., & Bonter, N. (2016). Comparison of a self-directed and therapist-assisted telehealth parent-mediated intervention for children with ASD: A pilot RCT. *Journal of Autism and Developmental Disorders*, *46*(7), 2275–2284. <https://doi.org/10.1007/s10803-016-2755-z>
- Schunk, D. H. (1981). Modeling and attributional effects on children's achievement: A self-efficacy analysis. *Journal of Educational Psychology*, *73*(1), 93–105. <https://doi.org/10.1037/0022-0663.73.1.93>
- Wittkowski, A., Garrett, C., Calam, R., & Weisberg, D. (2017). Self-report measures of parental self-efficacy: A systematic review of the current literature. *Journal of Child and Family Studies*, *26*, 2960–2978. <https://doi.org/10.1007/s10826-017-0830-5>

### S1.9 Individual Caregiver’s Self-Efficacy Ratings for VAULT Principles Before, During, and After Training and Treatment



*Note.* C1 = Caregiver 1; C2 = Caregiver 2; C3 = Caregiver 3; C4 = Caregiver 4. For C4, the data points for Focused Stimulation and Engagement overlapped at each time point, resulting in only one being visible.