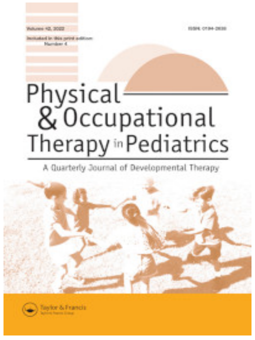

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Physical & Occupational Therapy In Pediatrics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ipop20

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To cite this article: Natalie A. Koziol, Christiana D. Butera, Kari S. Kretch, Regina T. Harbourne, Michele A. Lobo, Sarah W. McCoy, Lin-Ya Hsu, Sandra L. Willett, Audrey E. Kane, James A. Bovaird & Stacey C. Dusing (2022): Effect of the START-Play Physical Therapy Intervention on Cognitive Skills Depends on Caregiver-Provided Learning Opportunities, Physical & Occupational Therapy In Pediatrics, DOI: 10.1080/01942638.2022.2054301

To link to this article: https://doi.org/10.1080/01942638.2022.2054301

Published online: 29 Mar 2022.

PHYSICAL & OCCUPATIONAL THERAPY IN PEDIATRICS
https://doi.org/10.1080/01942638.2022.2054301

Effect of the START-Play Physical Therapy Intervention on Cognitive Skills Depends on Caregiver-Provided Learning Opportunities

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ABSTRACT

Aims: This study evaluated whether caregiver-provided learning opportunities moderated the effect of START-Play physical therapy intervention on the cognitive skills of young children with neuromotor delays, and whether START-Play impacted caregiver-provided learning opportunities over time.

Methods: One hundred and twelve children with neuromotor delays (7–16 months) participated in a multisite randomized clinical trial evaluating the efficacy of START-Play. Children were assessed at baseline and 3 (post intervention), 6, and 12 months post baseline. Cognition was scored from the Bayley Scales of Infant & Toddler Development, Third Edition, cognitive scale. The proportion of time caregivers spent providing learning opportunities was coded from a 5-minute caregiver-child free play interaction.

Results: Baseline caregiver-provided learning opportunities moderated the 3- and 12-month effects of START-Play on cognition. Cognitive gains due to START-Play were more pronounced for children whose caregivers provided more learning opportunities. START-Play did not impact caregiver-provided learning opportunities over time.

Conclusions: START-Play may have a lasting effect on children's cognition, but this effect is contingent on caregivers providing their child with ample opportunities to practice cognitive skills. Strategies for improving caregivers' uptake and transfer of START-Play principles to their daily routines should be evaluated.

Trial Registration: ClinicalTrials.gov NCT02593825

ARTICLE HISTORY
Received 21 December 2021
Accepted 8 March 2022

KEYWORDS
Cognition; early intervention; infant development; neuromotor delays; parent-child interaction

There is a longstanding history of educational, psychological, and neurological interest in the complex and interdependent relationship between sensorimotor experience and the emergence of cognitive skills across development (e.g., Damasio, 1994; Merleau-Ponty, 1964; Piaget, 1952). Theories of embodied or grounded cognition suppose

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cognitive and conceptual processes are grounded in the same neural and psychological systems as those used for perception and action (Barsalou, 2008, for review). Quantitative links between motor and cognitive development have been widely demonstrated in typical infant populations (Adolph & Hoch, 2019 for review), premature infants (Oudgenoeg-Paz et al., 2017 for review), and individuals with neuromotor disorders (e.g., Ballester-Plané et al., 2018; Dalvand et al., 2012; Fluss & Lidzba, 2020). Despite these developmental links between cognitive and motor abilities, physical therapy early intervention (EI) tends to emphasize fulfillment of motor milestones (Palisano, 1991) without a focus on simultaneously developing interdependent cognitive skills (Mahoney et al., 2004). Subsequently, few studies examining the effectiveness of EI approaches for children with motor delays have considered cognitive outcomes (Morgan et al., 2016, for review). There is a critical need to develop comprehensive therapeutic rehabilitation strategies for children with motor delays that target interrelationships between motor and cognitive development in infancy and early childhood, and to evaluate their impact on future cognition (Harbourne et al., 2018; Lobo et al., 2013).

The Sitting Together And Reaching To Play (START-Play; Harbourne et al., 2018, 2021) physical therapy intervention utilizes activities which encourage motor learning and problem-solving embedded in play with a primary goal of enhancing motor-based problem-solving and the early motor skills of sitting and reaching. This intervention is grounded in models of embodied cognition, and in evidence that performing motor acts on objects, and observing the perceived effects of those acts can enhance problem solving (e.g., Brandone, 2015; Lobo et al., 2013; Zelazo et al., 1997). A major tenet of this intervention is that therapy occurs in a child friendly environment, usually the home, and in collaboration with caregivers. Therapists scaffold caregivers' abilities and confidence in setting up the child's play environment and tasks and encourage them to integrate intervention strategies into their daily family routines. Caregivers assist directly with identifying appropriate levels of challenge for their child, and participate in skill building of object permanence, means-end understanding, body/object affordances, and joint attention through social and motor-based interactions with the child.

Harbourne et al. (2021) found that children who received START-PLAY plus usual care EI (UC-EI) demonstrated greater short-term (baseline to 3 months post baseline) growth in sitting and fine motor skills and greater long-term (baseline to 12 months post baseline) growth in fine motor skills than children who received UC-EI only, but they observed no differences in cognition *when aggregating across the full sample*. However, Harbourne et al. also found that children varied in their response to intervention. Upon disaggregating the sample by severity of motor delay at baseline, the intervention had positive short-term effects on cognition (among other outcomes) for children with significant delay.

Understanding the factors that contribute to response to intervention is vital for providing appropriate individualized care (Field-Fote, 2019). A moderation analysis can be performed to determine whether the direction and/or magnitude of an effect differs as a function of a third variable. In this study we examine whether caregiver-provided learning opportunities moderate the effect of START-Play on cognition of children with motor delays, based on research linking caregiver-provided learning opportunities to cognitive development. Efforts by caregivers to scaffold play, or to direct and maintain a child's attention, result in greater engagement with objects, looking at people, and joint attention (Mendive et al., 2013). In addition, caregiver-provided learning opportunities in infancy have been found to improve cognitive outcomes like means-end problem solving in intervention studies (Lobo & Galloway, 2008). Maternal guided object stimulation in infancy also predicts later cognitive skills (Olson et al., 1984). Caregiver involvement and education are common factors in intervention programs supported as effective for infants under 2 years of age (Morgan et al., 2016) and in the neonatal intensive care unit (Khurana et al., 2021), and may improve cognitive outcomes in infants at risk for motor delay (Palmer et al., 1988).

Cognition is also strongly associated with socioeconomic status (SES; e.g., Bradley et al., 2001; Larson et al., 2015; Nelson et al., 2016; Tucker-Drob et al., 2011) and access to enriching toys (Bradley et al., 1979; Bradley & Caldwell, 1980; Elardo et al., 1975). However, the cognitive benefit of having access to enriching toys is greatest when these resources are used to facilitate caregiver-child interactions to support skills like pretend play, problem-solving, and reciprocity (Milteer et al., 2012). In our analyses we control for SES and access to toys to isolate the unique effect of caregiver-provided learning opportunities.

Caregivers' behavior is more malleable than SES and physical resources and is thus a promising construct to target in intervention given its links to cognition. In this study we additionally examine whether START-Play impacts caregiver-provided learning opportunities over time, as caregiver involvement is a key ingredient of the START-Play intervention.

Given the critical role that families play in children's development and early intervention experiences, our first aim evaluated whether the effect of START-Play on cognition is moderated by caregiver-provided learning opportunities. We hypothesized that response to intervention would vary as a function of learning opportunities, consistent with findings that early intervention programs promoting family involvement and training are most impactful (Blauw-Hospers & Hadders-Algra, 2005). We did not hypothesize a specific direction for the effect. The START-Play effect could be more pronounced for caregivers who come into the study providing more learning opportunities, as these caregivers are already cognitively engaged with their child which should allow them to adjust their interactions more easily in response to training on the key principles of the intervention. Alternatively, the START-Play effect could be more pronounced for caregivers who come into the study providing fewer learning opportunities, as these caregivers are likely to benefit most from an intervention that emphasizes caregiver involvement in brainstorming and directly scaffolding cognitive-motor interactions. Our second aim evaluated whether START-Play impacts caregiver-provided learning opportunities over time. We hypothesized that START-Play would have a positive effect, as the intervention intentionally targets the caregiver-child interaction.

Methods

Details of the study methods are given in the trial protocol (Harbourne et al., 2018).

Design

A multisite randomized clinical trial (NCT02593825) was conducted to evaluate the efficacy of the START-Play physical therapy intervention on the motor, cognitive, and language outcomes of young children with neuromotor delays. Using stratified permuted block randomization, children were randomly assigned with equal allocation to either START-Play plus UC-EI or UC-EI only. Randomization was stratified by clinical site and the child's baseline movement ability, which was classified as mild, moderate, or severe based on a rubric developed by the study investigators. The rubric considered the child's scores on the Gross Motor Function Classification System and Manual Ability Classification System Reference, along with information about the child's distribution of motor impairment and level of active movement.

Participants

Recruitment, intervention, and data collection occurred in the surrounding areas of five sites: Newark, DE; Omaha, NE; Pittsburgh, PA; Richmond, VA; and Seattle, WA. Central (Duquesne University) and site-specific (Virginia Commonwealth University, University of Nebraska-Lincoln) Institutional Review Boards granted ethical approval to carry out the trial. Written informed consent was provided by the child's primary caregiver prior to enrollment. Families were recruited via mailings, social media, and the study website, and based on referrals from medical center and therapy providers. Child inclusion criteria were: 7 to 16 months of age (prematurity-adjusted); neuromotor disorder; greater than 1 SD below the mean on the Bayley Scales of Infant & Toddler Development, Third Edition (Bayley-3; Bayley, 2006) gross motor scale; ability to sit with arms propped but not transition in and out of sitting; and ability to spontaneously move the arms. Exclusion criteria were: a primary diagnosis other than a neuromotor disorder; medical complications or planned hospitalizations that would limit participation; and plans to move out of the area before the end of the study.

An a priori power analysis indicated that a sample size of 152 children, assuming 8% attrition and setting $\alpha = .05$ (two-tailed), was necessary to detect 3-month intervention effects of .48–.66 with power $\geq .80$. A consort flow diagram is provided by Harbourne et al. (2021). One hundred and fifty-five children were assessed for eligibility and 134 were randomized. Among the children who were randomized, 14 developed medical complications or received an alternate diagnosis post baseline that made them ineligible based on the a priori inclusion and exclusion criteria. Eight children did not meet the criteria at baseline but were mistakenly randomized. Final analyses were based on 112 children, 57 in START-Play + UC-EI and 55 in UC-EI only, who met all eligibility criteria. Twenty-one percent dropped prior to the final assessment.

Correcting for prematurity, the mean age at baseline was 10.8 months (SD = 2.6). Thirty-five percent were born pre-term and 21% were born very pre-term (<32 weeks gestation). The children were predominantly White (70% compared to 10% Black, 8% Asian, 8% multiple races, and 4% other) and non-Hispanic (82%), with more boys (57%) than girls and more with a mild motor delay at baseline (55%) than a significant delay. At baseline, a subsample of children were reported by their caregiver as having ever had visual problems (28%), hearing problems (19%), seizures (19%), or a brain injury or hydrocephalus (26%). Seventy-seven percent had received EI services in the 3 months prior to baseline, and 35% had received outpatient therapy services. The median annual gross household income was \$60,000 to \$79,000. Most caregivers reported completing some college (26%), a bachelor's degree (26%), or postgraduate degree (33%), with 2% reporting less than a high school diploma or GED and 13% a high school diploma or GED. Intervention group differences in demographic and household characteristics were non-significant (Table 2, Harbourne et al., 2021). Likewise, differences in baseline cognition were small ($g = .03$) and non-significant (Table 3, Harbourne et al., 2021).

Measures

The Bayley-3 cognitive scale was used to measure cognition at baseline and 3, 6, and 12 months post baseline. Interrater reliability evidence was strong (ICC = 0.98 based on 20% of videos). Raw scores were analyzed to measure absolute growth as opposed to growth relative to a normative population. The Bayley-3 motor scale was used to classify the child's baseline motor delay as significant ($\geq$2.5 SD below the mean) or mild (<2.5 SD below the mean).

Caregiver-provided learning opportunities were coded from a 5-minute unstructured caregiver-child free play interaction task performed at baseline and 1.5, 3, 6, and 12 months post baseline. Caregivers were asked to play with their child as they normally would. Caregivers had access to a standardized set of toys with use of these toys or other toys in the room optional. Datavyu software was used to code the cumulative amount (expressed as total duration of time) in which caregivers provided the child with learning opportunities within the five-minute play interaction. Learning opportunities were defined by the study investigators in accordance with the "cognitive opportunities" key principle of the START-Play intervention fidelity measure: "[P]arent provides opportunities, through motor activities, for practicing cognitive skills including object permanence, means end, body-object or object-object affordances, and joint attention" (Table S1, An et al., 2021). To account for out of view frames and slight differences in total task duration, proportion scores were computed as the summed duration of caregiver-provided learning opportunities divided by the total duration of the task that was codeable. The average total duration of codable task time was >4.99 minutes across visits for both intervention groups. Intra-rater reliability for behavioral coding was strong, with 93% agreement (Cohen's $k = .83$) across frames based on a subsample of videos (Kretch et al., in press).

Baseline motor delay, prematurity-adjusted age, and clinical site were included in the models as covariates to increase precision of the estimates and account for age-related differences in the Bayley-3 cognitive raw scores. Access to toys in the home and SES were also included as covariates to isolate the unique effect of caregiver-provided learning opportunities that is unrelated to physical resources and SES. Primary caregivers completed the Affordances in the Home Environment for Motor Development–Infant Scale (AHEMD–IS; Caçola et al., 2015) at baseline as a measure of the child's home physical environment. For each of 20 toy groups, caregivers were instructed to report "the number of equal or similar toys you use in your home to play with your infant," with response options 0 = None, 1 = One-two, and 2 = Three or more. A composite score was computed by taking the average of the caregivers' responses to the 20 items ($M = 1.1$, $SD = 0.4$). Internal consistency evidence was strong ($\alpha = .89$). SES was computed from the primary caregiver's highest education level and household poverty income ratio (PIR), information that was obtained from a baseline demographic survey completed by the caregiver. High SES (60% of the sample) was defined as having at least some college and a PIR ≥ 2, and low to middle SES was defined as having a high school diploma/GED or less and/or a PIR < 2.

Procedure

Depending on caregiver preference, assessments and intervention typically took place in the child's home or childcare setting, and less commonly in the lab or clinical setting. At least one caregiver was present at each session. Neither interventionists nor caregivers were blinded to group assignment. Assessors had backgrounds in physical therapy and child development and were blinded to intervention group. All assessments were video recorded to be scored at a later date by blinded coders.

For children randomized to START-Play, a total of 24 sessions of START-Play intervention were offered twice weekly across a 12-week period, with children participating in an average of 21 sessions ($SD = 3.9$). Sessions lasted between 40 to 60 minutes ($M = 51.5$ minutes, $SD = 4.4$), depending on the child's behavioral state (Harbourne et al., 2021). The interventionists were licensed physical therapists who completed three days of on-site training, passed an adherence threshold in practice intervention sessions, received ongoing monitoring and feedback from an on-site principal investigator, and annual retraining. Based on a subsample of 64 intervention sessions that were recorded and scored via an intervention-specific fidelity measure, overall adherence to START-Play principles was deemed adequate for three of four START-Play behaviors (An et al., 2021). The rate interventionists provided information on cognitive-motor interaction or brainstorming with caregivers about how they could implement START-Play principles outside of the therapy sessions was below the criterion (.27 vs. $\geq$.30).

For ethical reasons, no restrictions were placed on the UC-EI services that children received, regardless of group assignment. UC-EI services included federally funded early intervention (EI) and outpatient therapy. These services were diverse and did not prescribe to one model or intervention approach. Applying the fidelity measure to a subsample of 39 UC-EI sessions revealed program differentiation between START-Play and UC-EI, with statistically significant differences observed on all START-Play fidelity indicators (An et al., 2021).

Data Analysis

Analyses were performed in Mplus Version 8.5 (Muthén & Muthén, 1998–2020). Statistical significance was set at $\alpha = .05$ and hypothesis tests were 2-tailed. Cohen's d and Hedges' g were computed to measure effect size. Using full information maximum likelihood (FIML) estimation with nonnormality robust standard errors and adhering to an intention-to-treat perspective, analyses were based on all available data regardless of dropout. Baseline characteristics that were not covariates but were associated with dropout (child race, ethnicity, visual problems, outpatient therapy services) were included as auxiliary variables.

Linear piecewise mixed modeling was performed to address the study aims. Separate linear time slopes (pieces) were modeled for the intervention period (baseline to 3 months) and post-intervention period (3 to 12 months). Random effects allowed for child-level variation and covariation in the intercept and slopes. The model for Aim 1 included all main, 2-way, and 3-way interaction effects involving time, intervention, and baseline caregiver-provided learning opportunities, on child cognition. Baseline motor delay, corrected age in months, access to toys in the home, SES, and their interactions with time, as well as clinical site, were included as covariates. The model for Aim 2 included time, intervention, and time by intervention interaction effects on caregiver-provided learning opportunities. Motor delay, age, access to toys in the home, SES, and their interactions with time, as well as clinical site, were included as covariates.

Results

Descriptive statistics for the study outcomes are provided in Table 1.

Moderating Effect of Baseline Learning Opportunities (Aim 1)

Baseline caregiver-provided learning opportunities significantly moderated the short-term (baseline to 3 months post baseline) (Est. = 2.23, SE = 1.00, p = .026) and long-term (baseline to 12 months post baseline) (Est. = 5.20, SE = 1.54, p = .001) START-Play effects on cognition. The short- and long-term START-Play effects were .31 SD and .43 SD more positive, respectively, for each 1 SD increase in baseline caregiver-provided learning opportunities.

Learning opportunities was treated as a continuous variable in the model. However, to illustrate the pattern of moderation we plotted the model-predicted trajectories of cognition, by intervention group, for children whose caregivers spent an average amount of time (i.e., 20% of the total caregiver-child interaction task duration) at baseline providing learning opportunities (Figure 1, panel a) and for children whose caregivers spent an above average (+1 SD) amount of time (i.e., 45% of the total task duration) at baseline providing learning opportunities (Figure 1, panel b). Among the

Table 1. Descriptive statistics for the study outcomes.

	Total sample		START-Play		UC-EI	
	N	M (SD)	N	M (SD)	N	M (SD)
Bayley-3 cognition (raw score)						
Baseline	112	28.83 (6.79)	57	29.25 (7.14)	55	28.40 (6.45)
3 months	103	34.84 (7.24)	54	35.94 (7.25)	49	33.61 (7.10)
6 months	95	37.71 (7.71)	51	38.24 (7.19)	44	37.09 (8.30)
12 months	88	44.01 (12.10)	48	44.63 (12.23)	40	43.28 (12.05)
Caregiver-provided learning opportunities (proportion of time)						
Baseline	108	.20 (.24)	55	.22 (.26)	53	.19 (.22)
1.5 months	96	.36 (.32)	49	.44 (.35)	47	.28 (.27)
3 months	98	.41 (.32)	52	.46 (.32)	46	.34 (.31)
6 months	92	.48 (.32)	49	.49 (.32)	43	.46 (.32)
12 months	83	.63 (.30)	43	.65 (.31)	40	.62 (.30)

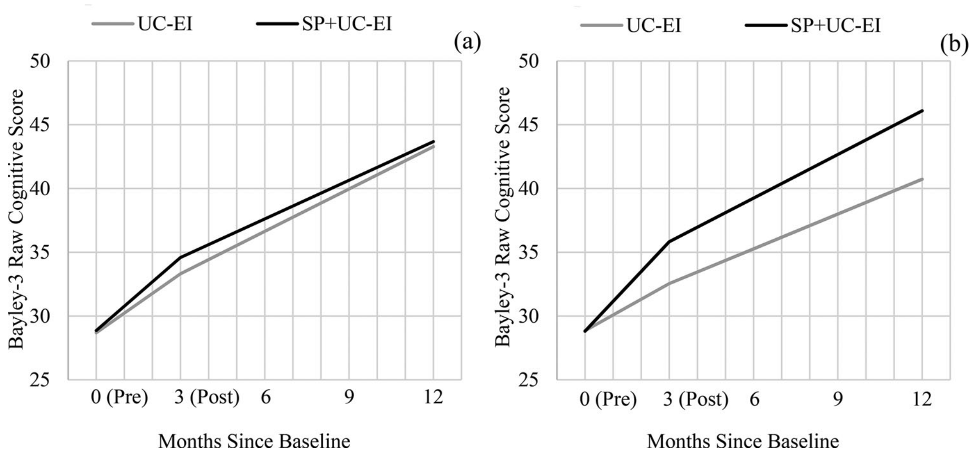

Figure 1. Model-predicted trajectories for Bayley-3 cognitive scores by intervention group (a) among children whose caregivers spent an average amount of time at baseline providing learning opportunities and (b) among children whose caregivers spent an above average (+1 SD) amount of time at baseline providing learning opportunities. UC-EI = usual care early intervention. SP = START-Play. Learning opportunities were treated as a continuous variable in the model but dichotomized to illustrate the pattern of the moderation effect.

former, there was no significant difference in short-term (Est. = 1.09, SE = 0.80, p = .172, Std. Est. = 0.15) or long-term (Est. = 0.21, SE = 1.54, p = .892, Std. Est. = 0.02) cognition between the START-Play and UC-EI groups. Among the latter, children in the START-Play group demonstrated significantly higher short- (Est. = 3.33, SE = 1.39, p = .017, Std. Est. = 0.46) and long-term (Est. = 5.41, SE = 2.09, p = .010, Std. Est. = 0.45) cognition.

START-Play Intervention Effect on Learning Opportunities (Aim 2)

Caregivers spent an average of 20% (SD = 24%) of the free-play interaction providing learning opportunities at baseline and 63% (SD = 30%) of the interaction providing learning opportunities at 12 months post baseline. Figure 2 illustrates the model predicted trajectories of learning opportunities by intervention group over the course of the study. Group differences were non-significant at baseline (Est. = 0.06, SE = 0.04, p = .192, g = 0.23) and START-Play intervention did not have a statistically significant short-term (Est. = 0.07, SE = 0.05, p = .181, g = 0.22) or long-term (Est. = −0.03, SE = 0.07, p = .645, g = −0.10) effect on learning opportunities. Parents in both UC-EI and START-Play + UC-EI demonstrated significant average short-term (Est. = 0.14, SE = 0.04, $p < .001$, d = 0.51; and Est. = 0.22, SE = 0.04, $p < .001$, d = 0.64, respectively) and long-term (Est. = 0.40, SE = 0.05, $p < .001$, d = 1.10; and Est. = 0.37, SE = 0.05, $p < .001$, d = 1.06, respectively) increases in learning opportunities.

Discussion

The grounded view of cognition posits that children's perceptual-motor experiences and cognitive processes are intricately linked (Barsalou, 2008). Accordingly, Lobo et al.

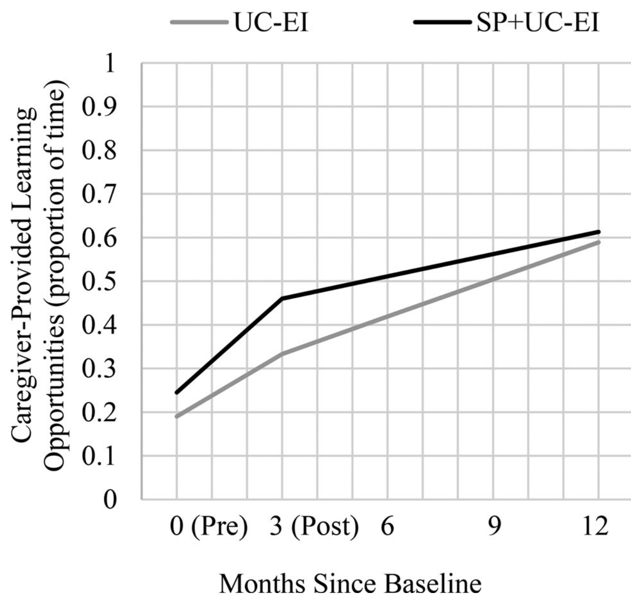

Figure 2. Model-predicted trajectories of caregiver-provided learning opportunities by intervention group. UC-EI = usual care early intervention. SP = START-Play.

(2013) called for research to evaluate the effect of perceptual-motor interventions, such as the START-Play intervention, on children's global development. Prior research indicated that START-Play had a positive short-term effect on cognition among children with severe motor delays, but no effect on cognition when aggregating across the full sample (Harbourne et al., 2021).

Moderating Effect of Baseline Learning Opportunities (Aim 1)

Given the importance of children's social and cultural environment, we evaluated whether the aggregate effect of START-Play on cognition was moderated by caregiver-provided learning opportunities. As hypothesized, response to intervention depended on baseline caregiver-provided learning opportunities. Cognitive gains due to START-Play plus UC-EI relative to UC-EI only were more pronounced for children whose caregivers provided more learning opportunities, even after controlling for SES and the home environment. This finding reinforces recommendations to educate caregivers on the benefits of engaging with their child through play (Milteer et al., 2012) and directly relates to one of the key ingredients of START-Play: "Parents brainstorming and assisting directly with the 'just right' challenge of blended motor/cognitive skills" (p. 497; Harbourne et al., 2018). Whereas therapists' interactions with the child are undoubtedly important, the child spends far more time with caregivers and thus it is the caregivers who serve as the primary conduit for enhanced experiences.

Although we hypothesized a moderating effect, we were unsure of the direction of the effect. It was also plausible that the START-Play effect could be more positive for caregivers who provided fewer learning opportunities at baseline, as these caregivers were most likely to benefit from an intervention promoting caregiver involvement. That this pattern of results did not emerge may be due to the START-Play intervention not impacting the proportion of time that caregivers spent providing learning opportunities, which we discuss below.

Our finding that response to START-Play intervention depends on the way caregivers interact with their child is significant based on evidence that caregivers' behaviors are malleable (Rayce et al., 2017). Caregivers observed as providing fewer learning opportunities at baseline could be provided with additional or different training opportunities, depending on their learning needs or priorities. Providing more individualized or targeted training to parents of differing abilities/needs may lead to increased information uptake and increased dosage of learning opportunities for the child.

START-Play Intervention Effect on Learning Opportunities (Aim 2)

Given the emphasis of the START-Play intervention on caregiver engagement in motor-cognitive activities, we also evaluated whether START-Play had an impact on caregiver-provided learning opportunities. Caregivers of children in both groups increased their provision of learning opportunities over time, on average, likely in response to their child's advancing motor and cognitive skills. Contrary to our hypothesis, START-Play did not have short- or long-term effects on the proportion of time caregivers spent providing learning opportunities.

One possible reason for the null finding is that START-Play therapists did not meet the adherence criterion for providing information on cognitive-motor interaction or brainstorming with caregivers about how they could implement START-Play principles outside of the therapy sessions (An et al., 2021). Additional training and fidelity checks are needed to improve START-Play therapists' adherence to this key intervention ingredient, and parental uptake of the information should be formatively assessed. On the other hand, An et al. (2021) found that START-Play therapists spent significantly more time providing information and brainstorming with caregivers and encouraging caregiver-led activities/caregiver-provided intervention than community EI therapists of children in the UC-EI group. In addition, caregivers of children in the START-Play group were rated as more highly engaged with the therapist and child during the START-Play session than caregivers of children in the UC-EI group during their community EI session. This suggests that caregivers of children in the START-Play group received additional education and modified their interactions with their child but did not transfer their added knowledge and behavioral changes to a setting outside of the therapy session.

Alternatively, the null finding may be due to how the construct of learning opportunities was operationalized. START-Play encourages caregivers to apply the "just right" challenge (Harbourne et al., 2018)—to tailor interactions with their child in response to the child's skill level, behavioral cues, and overall readiness for longer and more advanced developmental play experiences. Simply measuring the proportion of time that caregivers spend providing learning opportunities does not capture the nuances and dyadic nature of the "just right" challenge.

Limitations

The clinical trial was underpowered to detect the a priori hypothesized intervention effects. Both the sample size and observed START-Play intervention effect sizes for caregiver-provided learning opportunities were smaller than anticipated. In addition, group assignment was confounded by dosage. For ethical reasons, children assigned to the START-Play group continued to receive UC-EI. Thus, it is unclear whether the effects of START-Play on cognition are due to differences in the principles underlying the interventions or differences in dosage.

Caregiver-provided learning opportunities were coded from a 5-minute video-recorded free play task. It is unclear whether caregivers' behaviors during this task generalize to daily interactions with their child, as this information was not collected. Although caregiver-provided learning opportunities did not differ between groups during this brief, researcher-observed interaction, the groups may have differed in the provision of learning opportunities during everyday routines. Moreover, this measure only focused on the caregiver's behavior, not on the child's engagement in or readiness for the interaction—a key component of the "just right" challenge. In addition, we examined learning opportunities provided by a single caregiver. Our study cannot speak to the importance of other caregivers' interactions with the child.

Implications for Practice and Future Directions

Children with neuromotor delays may benefit from perceptual-motor interventions, such as the START-Play physical therapy intervention, that are founded on principles of grounded cognition and promote caregivers' abilities and confidence in providing "just right" cognitive-motor interactions. However, the original START-Play protocol may not be sufficient for affecting behavioral change and transfer of knowledge beyond the therapy sessions for some caregivers, at least not with respect to duration of caregiver-provided learning opportunities. While caregivers were engaged in the intervention sessions and encouraged to brainstorm activities that could be completed between sessions, caregivers were not explicitly asked to provide a specific dose or document the use of intervention strategies between sessions. As well, the protocol did not provide explicit instruction for communicating START-Play principles to other caregivers in the child's life. Strategies for improving caregivers' uptake and transfer of START-Play principles and communicating START-Play principles to other caregivers should be developed and evaluated. Additional research is needed to capture the dyadic nature of the "just right" challenge, and to evaluate other moderators (e.g., neurophenotypes [Overfeld et al., 2020], race/ethnicity), developmental outcomes, and caregiver settings/interactions.

Conclusions

The START-Play physical therapy intervention may have a lasting effect on children's cognition, but this effect is contingent on caregivers providing their child with ample opportunities to practice cognitive skills. This is consistent with the theory that children's perceptual-motor skills and cognition are highly interrelated and dependent upon their social environment. START-Play did not impact the proportion of time caregivers spent providing learning opportunities during a free play task. Research is needed to identify strategies for promoting learning opportunities within families' daily routines and formatively measure those opportunities, within the dyadic context of caregiver-child interactions.

Acknowledgements

The authors extend their heartfelt thanks to the families, children, and community therapists who participated in this study. The authors are also grateful for the talented team of START-Play interventionists and assessors whose unwavering enthusiasm and hard work made this possible.

Disclosure statement

The authors report no competing interests to declare.

Funding

This work was supported by the US Department of Education, Institute of Education Sciences, National Center for Special Education Research, Early Intervention and Early Learning in Special Education under Grant no. R324A150103.

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