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REPORT

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Fine motor abilities and parental input of spatial features predict object word comprehension of Turkish-learning children

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Abstract

Object word learning can be based on infant-related factors such as their manual actions and socio-linguistic factors such as parental input. Specific input for spatial features (i.e., size, shape, features of objects) can be related to object word comprehension in early vocabulary development. In a longitudinal study, we investigated whether fine motor abilities at 14 months and parental input for spatial features at 19 months predicted object word comprehension at 25 months. Twenty-seven Turkish-learning children were tested at three time points (Time 1: $M_{age} = 14.4$ months, Time 2: $M_{age} = 18.6$ months, Time 3: $M_{age} = 25$ months). We measured word comprehension through the parental report and fine motor abilities with Mullen at Time 1. We used a puzzle play session to assess parental input for spatial features at Time 2 and a standardized receptive vocabulary test at Time 3. We found that fine motor abilities were related to object word comprehension. However, parental input for spatial features at 19 months predicted object word comprehension at 25 months beyond fine motor abilities at 14 months. Early fine motor abilities and using different words for spatial features may foster infants' visual experiences in play and exploration episodes, leading to better object word learning.

Highlights

- We investigated whether fine motor abilities and spatial input of parents predicted children's later predicted object word comprehension.

- Fine motor abilities at 14 months and parents' spatial talk during puzzle play at 19 months predicted object word comprehension at 25 months.
- Fine motor abilities and hearing spatial features of objects foster infants' visual experiences, leading to better object word learning.

KEYWORDS
fine motor abilities, object word comprehension, parental input, spatial input

1 | INTRODUCTION

Language development is a complex and multi-dimensional process relating to children's cognitive abilities and their socio-cultural experiences (Parish-Morris, Golinkoff, & Hirsh-Pasek, 2013). Object exploration, facial expressions, gestures, eye movements and vocalizations are some of the early tools for infants' communication and language learning (Tamis-LeMonda, Kuchirko, & Tafuro, 2013). Fine motor abilities are related to word comprehension through manual exploration (Hellendoorn et al., 2015). Social cues, the quality of parental input, communication quality and lexical diversity in the input are associated with children's vocabulary learning (e.g., Bergelson & Swingley, 2013; Hirsh-Pasek et al., 2015; Jones & Rowland, 2017; Rowe, 2012; Rowe, Leech, & Cabrera, 2017; Yurovsky & Frank, 2017). However, less is known whether specific parental input such as spatial words contributes to vocabulary comprehension together with children's fine motor abilities. This longitudinal study examines the predictive role of early fine motor abilities at 14 months and parental input for spatial features of objects at 19 months on children's object word learning at 25 months.

Fine motor abilities provide stable and rich visual experiences. Infants explore three-dimensional views of objects through holding, turning, or transferring objects between two hands, which also support categorizing objects by their spatial features (Smith, 2013). Furthermore, early fine motor experiences have long-term effects on social and cognitive domains. For example, the motor training with sticky mittens at 3 months showed that early grasping experience predicted object exploration and visual attention at 15 months (Libertus, Joh, & Needham, 2016). Another example could be the referentiality problem in word learning. Holding an object influences what becomes apparent in infants' visual field. Parents' object naming efforts become more effective in word learning at 20 months when an object dominates the visual view of an infant after holding it (Pereira, Smith, & Yu, 2014). Parents' responsive behaviours and verbal input support the sustained holding events in word learning situations (McQuillan, Smith, Yu, & Bates, 2020). Additionally, infants at the end of their first year start multimodal feedback loops with their manual exploration that trigger mothers' action-related and informative linguistic input. Indeed, the input includes multimodal cues such as actions or gestures that support infants' word learning (Tamis-LeMonda et al., 2013). Thus, fine motor abilities during children's first year lead to better visual and manual experiences with objects and their spatial features, which would foster word learning of objects. As their caregivers accompany infants, parents act as supervisors in these active exploration settings.

Previous research suggests that children's immediate environment supports language acquisition; thus, early parental verbal input is related to children's later vocabulary knowledge (e.g., Hoff, 2003; Hurtado, Marchman, & Fernald, 2008). Specific types of parental verbal input, such as spatial features for objects' shapes or dimensions, predict infants' spatial language abilities (Levine, Ratliff, Huttenlocher, & Cannon, 2012; Pruden, Levine, & Huttenlocher, 2011). Furthermore, parental spatial verbal input for objects at 18 months can be effective for learning object names because infants form shape-based representations to learn object names between 12 and 36 months

(Smith, 2013). Parental verbal and manual involvements contribute to these learning processes by increasing the holding time of an object (McQuillan et al., 2020). During exploration, parents do not only utter object names but also supervise children's learning with other tools such as informative language or responsive behaviours (Tamis-LeMonda et al., 2013). Parents also tune their spatial input based on their children's knowledge of spatial words (Kısa, Aktan-Erciyes, Turan, & Göksun, 2019). Therefore, parental spatial input referring to object features can be related to object naming via tailoring visual and manual exploration for the shape-based object categories.

This longitudinal study investigates (a) whether parental input for spatial features of objects contributes to children's knowledge for names of objects and (b) the role of infants' manual actions in this process. We hypothesize that infants with better fine motor abilities at 14 months will have larger object word comprehension at 25 months after controlling their word comprehension at 14 months. Parental input for spatial features at 19 months will also positively predict object word comprehension at 25 months, controlling for age, word comprehension and fine motor abilities at 14 months.

2 | METHOD

2.1 | Participants

This study was part of longitudinal research investigating 58 Turkish-learning children's language and cognitive development between 14 and 36 months of age. The participants came from high-socio-economic status backgrounds with mothers' holding at least a college degree. All the infants in the study were full-term and monolingual Turkish-learning infants. For this study, we only included children who completed the tasks of this study at three time points. The final sample consisted of 27 children who participated at three time points of research (15 girls, 12 boys).[1] At Time 1, children were 12–16 months old (M_{age} = 14.4 months, SD_{age} = 1.28); at Time 2, they were 16–21 months old (M_{age} =18.7 months, SD_{age} = 1.54) and at Time 3, they were 22–27 months old (M_{age} = 25 months, SD_{age} = 1.66). Two parents did not complete Turkish-Communication Development Inventory (CDI) at Time 1. Koç University's Institutional Review Board approved the study (Protocol no: 2014.052.IRB.2.015). Parental consent was obtained from each participant.

2.2 | Materials and procedure

2.2.1 | Turkish Communication Development Inventory-I (TCDI-I)

We used the Turkish adaptation of MacArthur-Bates CDI to measure the word comprehension ability of infants at Time 1. TCDI-I is used for children aged 8–16 months to evaluate their receptive language, expressive language and early gesture use (Aksu-Koç et al., 2019). We used Vocabulary Checklist items to measure overall word comprehension scores at Time 1 for this study. Parents completed this inventory within 20 min.

2.2.2 | Mullen Scales of Early Learning (MSEL)

At Time 1, we administered the fine motor subscale of Mullen Scales of Early Learning (MSEL, Mullen, 1995) to measure infants' fine motor abilities. MSEL is a standardized tool administered from birth to 68 months of age. The Fine Motor Subscale includes 30 items starting from early reflexes until drawing shapes. Infants are expected to complete each item individually. The duration of the Mullen scales was approximately 20 min for each child.

2.2.3 | Play session

At Time 2, we presented a wooden puzzle toy to parents and children to freely play for 3 min (see Kısa et al., 2019 for detailed information). The experimenter demonstrated how to play with the puzzle by fitting pieces into the wooden puzzle board, but no specific instructions were given. All sessions were transcribed by two research assistants and coded for parents' speech by two other independent blind coders. The numbers of total words parents used were divided by the duration of the session to obtain normalized input scores. We coded parental input of spatial features using the coding scheme in Cannon, Levine, and Huttenlocher (2007) by adapting to Turkish. Spatial language consists of many parts such as shape, location information or motion of events. However, as we hypothesized, object-related spatial language input such as the shapes or features of objects can specifically support object word comprehension in children. Thus, for this study, we only used the category of *what* information, which included size (e.g., *küçük* 'small'), shape (e.g., *kare* 'square') and feature (e.g., *köşe* 'corner') information of objects. We coded both the total number of spatial feature words (token) and a unique number of spatial feature words (type). We summed all the spatial feature words of parents and divided them to play duration for the token part. Every unique word of parents in the puzzle session was summed and then divided to play duration to measure type part. Intercoder reliability for this task was measured via intraclass correlations (ICC) for both type and token calculations. A high degree of reliability was found for both token and type. The average measure ICC for token was 1.0 with a 95% of confidence interval from 1.0 to 1.0, and for type, ICC was 0.99 with a 95% confidence interval from 0.97 to 0.99.

2.2.4 | Turkish Expressive and Receptive Language Test-Receptive (TIFALDI-R)

At Time 3, infants were assessed using the TIFALDI-R subtest, similar to Peabody Picture Vocabulary Test for their word comprehension (Berument & Güven, 2010). The test includes 80 items. We excluded the action and abstract words from the raw scores for this study, leaving the final score composed of only object words. Children completed TIFALDI-R within 15 min.

Children were tested at Koç University Language and Cognition Laboratory.

3 | RESULTS

The descriptive statistics of variables can be seen in Table 1. There was no sex difference for any variables (all *p*s > .07), after controlling for age. We performed normality tests for all the variables. Results indicated that skewness ranged from −0.159 to 0.671 and kurtosis ranged from −1.08 to 1.388, indicating no violations of normality. To detect outliers in variables, we performed the analysis of standard residuals. The data did not include any outliers (Std. Residual Min = −1.63, Std. Residual Max = 1.85). Cook's distance for variables ranged from 0.0001 to 0.55 with a mean value of 0.059.

The correlation between type and token of spatial features input was very high ($r = 0.819$, $p < .001$). In a recent meta-analysis, quantity (i.e., token) of parental language input was more effective on linguistic outcomes at early ages than quality of input (Anderson, Graham, Prime, Jenkins, & Madigan, 2021). Additionally, the range for spatial features type was restricted in our sample, as we only used spatial input for object features. For these reasons, we used token of spatial features input in the regression model.

We used Jamovi stats software, an R-based statistic software, to run a hierarchical linear regression analysis (R Core Team, 2020; The Jamovi project, 2020). For our model, the first step included infants' age and word comprehension at Time 1, parents' total input at Time 2, and fine motor abilities at Time 1. In the second step, parents' spatial input (token) was introduced (see Table 2 for other correlations).

TABLE 1 Descriptive statistics of participants and age-controlled sex differences: sample sizes (*n*), Means, *SDs*, ranges, *F*, *p*, and partial eta-squared ($\eta^2 p$) values for ANCOVAs

	Descriptive statistics			ANCOVA		
	n	Mean (*SD*)	Range	F	p	$\eta^2 p$
Time 1 word comprehension	25	134 (82.6)	33–392	0.45	.51	0.02
Time 1 fine motor abilities	27	16.4 (1.24)	14–19	3.29	.08	0.12
Time 2 Parents' Total input	27	1.29 (0.43)	0.24–2.29	0.16	.69	0.01
Time 2 parents' input of spatial features token	27	0.03 (0.03)	0–0.10	0.63	.44	0.03
Time 2 parents' input of spatial features type	27	0.01 (0.01)	0–0.02	0.23	.64	0.01
Time 3 word comprehension for objects	27	12.2 (5.14)	5–23	3.07	.09	0.11

TABLE 2 Correlations between all variables

	Age at time 1	Word comprehension at time 1	Parents' total word	Fine motor skills	Spatial features token	Spatial features type	Object word comprehension of infants
Age at time 1	1						
Word comprehension at time 1	0.02	1					
Parents' total input	0.36	0.26	1				
Fine motor abilities	0.23	0.15	0.13	1			
Parents' spatial input token	0.38	0.40*	0.27	0.34	1		
Parents' spatial input type	0.68*	0.10	0.28	0.42*	0.82*	1	
Object word comprehension of infants at time 3	0.35	0.16	0.12	0.44*	0.55*	0.65*	1

*$p < .05$, for word comprehension of infants at time-1, $n = 25$, for other variables, $n = 27$.

The final model was significant and accounted for 50% of the variance, $F(5,19) = 3.78$, $p = .015$. Fine motor abilities were the only significant predictor ($\beta = 0.45$, $p = .028$) in the first step accounting for 33.3% of the variance. In the second step, parents' input of spatial features (token) was the only significant predictor ($\beta = 0.50$, $p = .021$) accounting for an additional 16.6% variance. Additionally, we performed a post-hoc sensitivity analysis using the G*Power software package (Faul, Erdfelder, Lang, & Buchner, 2007) to determine the effect size. The final sample size of 25 was used. The alpha level used for this analysis was $p < .05$, and the power was taken as 0.8. The sensitivity analysis revealed an effect size of 0.45, and our explained variance for the final model was above this effect size ($R^2 = 0.50$) (Table 3).

4 | DISCUSSION

This research examined whether early fine motor abilities and parental verbal input for spatial features of objects predicted children's later object word knowledge. Our results indicated that early fine motor abilities were related to children's later object word comprehension. More importantly, parental input for spatial features predicted object word knowledge at age 2, beyond early fine motor abilities and infants' word comprehension at 14 months.

Our findings show that early fine motor abilities are associated with object word comprehension around 2 years of age, after controlling children's early word comprehension abilities at 14 months. These results are in line with

TABLE 3 Regression analysis, object word comprehension of infants at Time 3 as the outcome variable

		Outcome: Object word comprehension at time 3				
Step	**Predictors**	ΔR^2	***F*-change**	β	t	p
1		0.333	2.49			
	Age at time 1			0.28	1.37	.19
	Word comprehension at time 1			0.10	0.50	.63
	Parents' total input			−0.04	−0.18	.86
	Fine motor abilities			0.45	2.36	.03*
2		0.166	6.28			
	Age at time 1			0.12	0.60	.56
	Word comprehension at time 1			−0.08	−0.45	.66
	Parents' total input			−0.04	−0.24	.82
	Fine motor abilities			0.35	2.01	.06
	Parents' spatial input (token)			0.50	2.51	.02*

*$p < .05$, $n = 25$.

previous studies conducted with both typical and atypical populations (Alcock & Krawczyk, 2010; Hellendoorn et al., 2015; LeBarton & Iverson, 2013; Tamis-LeMonda et al., 2013; West & Iverson, 2017) and expanded them with earlier ages (14 months for fine motor abilities, 25 months for word comprehension) and for specific word types (object words). Motor abilities contribute exploration of objects, which facilitate word learning in early childhood (Libertus et al., 2016; Libertus & Violi, 2016). The experience resulting from fine motor abilities provides noise-free and frequent visual and manual explorations that lead to word learning for objects.

Although there is a correlation between early fine motor abilities and later object word comprehension, parental verbal input for spatial features at 19 months predicted object word comprehension at 25 months beyond infants' fine motor abilities. Toddlers can learn novel object names better when objects have similar shapes (Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). Infants between 18 and 25 months can recognize pre-known objects from sparse information of object shapes (Smith, 2009) that can foster word learning of objects (Smith, 2013). Within these processes, parental input for spatial features enhances object word learning by expanding learning episodes and providing spatial information for infants. Previous studies showed that parental responsiveness and referential language during object interaction episodes contribute to word learning (McQuillan et al., 2020; Tamis-LeMonda et al., 2013). Furthermore, our study from a Turkish-learning sample showed that the role of parental spatial input might be critical for object word learning during the second year of life, beyond infants' fine motor abilities.

Our results indicate that the weight of fine motor abilities on object word comprehension may decrease across time. Parish-Morris et al. (2013) argued that word learning starts with associative processes that will later be influenced by socio-linguistic input in the developmental timeline (see also Hollich, Hirsh-Pasek, & Golinkoff, 2000). Previous studies showed that shape similarities and shape-based object knowledge foster word learning (Imai, Gentner, & Uchida, 1994; Smith, 2013). Parents' highlighting of spatial features of objects by their verbal input contributes to children's vocabulary development. By age, the effect of infants' exploration with fine motor abilities may decrease. Parental verbal input may become more effective due to an increase in the linguistic skills of infants. Moreover, infants' early fine motor abilities become more effective with parents' spatial input, which means there can be an interaction between these variables. Due to our sample size, we did not examine this possibility in our analyses, but future studies should focus on how these variables interact in predicting child outcomes within a developmental timeline.

Our results align with the developmental cascades approach, suggesting that later achievements in development depend on longitudinal connections of multiple domains with nonobvious trajectories (Oakes & Rakison, 2019). The development of object-word mapping depends on complex interactions among multiple domains across time, such as early fine motor abilities, sitting milestones, or interaction with parents (Smith, 2013). Our findings, even from a restricted puzzle play session setting, add to the previous studies (McQuillan et al., 2020; Tamis-LeMonda et al., 2013), specifically examining the relations among early fine motor abilities, parents' use of specific word types, and children's learning of object words. We assessed these interactions with small sample size and parental input from a short puzzle play session. Future research should examine these links in longer parent–child interactions in both naturalistic and experimental settings.

To conclude, this study demonstrated that early fine motor abilities and parental input for spatial features are related to children's later object word comprehension. These results underline the role of specific parental verbal input on children's vocabulary acquisition beyond children's motor development.

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ENDNOTE

[1] There was no difference between children who attended three time points and who dropped out for fine motor abilities, $t(53) = -1.13$, $p = .262$, and for word comprehension, $t(48) = 0.73$, $p = .470$. Note that not all children participated in all tasks.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request. We added this statement in the acknowledgments section (title page).

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