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Novel word learning ability in 24-month-olds: The interactive role of mother's work status and education level

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Abstract

Using both online and offline measures, this study investigates how maternal education and work status (stay-at-home, part-time, full-time) are jointly associated with infants' word learning ability and vocabulary size. One hundred 24-month-old infants completed a lab-based mutual exclusivity task, which assesses infants' novel word learning ability. Caregivers reported infants' productive vocabulary size using the MCDIs. There was no evidence for an association between infants' productive vocabulary size and maternal education, maternal work status, or their interaction. However, infants' novel word learning ability was significantly related to both maternal factors and their interaction. The positive association between maternal education and word learning performance was attenuated for infants of part-time and full-time working mothers compared to infants with at home mothers. These findings suggest that using real-time measures with high task demand may better capture developmental differences in infants and expand our understanding of maternal factors contributing to early language development.

Keywords: novel word learning; infant; maternal employment; maternal education; socioeconomic status

Introduction

In 2019, 55.4% of women who were older than 16 were employed, and 49.3% of them were mothers. Of these working mothers, nearly two-thirds (63.8%) had children under the age of 3, according to a report from the U.S. Bureau of Labor Statistics (2021). Previous surveys have shown that for families with working mothers and children under age 5, child care arrangements are split between relying on other familial members (29.3% fathers, 42.1% grandparents, siblings, or other relatives) and child care settings (53%) (Laughlin, 2013). Although there is no consistent evidence showing that mother's entering the workforce has a negative impact on children's development (Brooks-Gunn

et al., 2010; Côté et al., 2007), mothers continue to report guilt and shame when returning to work postpartum (Hoffman, 1974; Segura, 2016).

The discussion regarding how maternal employment influences child development is far from settled. Studies have shown that children of working mothers who use non-maternal care resources may have better language outcomes due to the richer language input compared to children who stay at home, while their mother is working (Milne et al., 1986; Yoshikawa, 1999). Meanwhile, modeling work based on large samples has also suggested that maternal employment, especially in the case of mothers returning to work in the first year postpartum, relates to a decline in children's later language and cognitive scores (Baum, 2003; Hill et al., 2005; Waldfogel et al., 2002). A recent longitudinal study has found that infants who experienced a change in their care due to a shift in their mother's work status (i.e., from home to part-time, home to full-time, or part-time to full-time) were more likely to have better language outcomes by 18 months of age compared to infants with stay-at-home mothers and full-time working mothers (Laing & Bergelson, 2019). Laing and Bergelson (2019) speculated that this effect may be due to the improved variability of language input. Social constructivism theory posits that language development is a result of social and cultural environments, emphasizing the importance of caregiver-child interactions and caregiver assistance (Kaufman, 2004; Tomasello, 2009). Maternal employment can thus be viewed as a critical environmental factor influencing language development as it impacts the amount and quality of infant-mother interactions, caregiver assistance, as well as language input received by children (Baum, 2003; Booth et al., 2002).

Compared to maternal employment, another family-related factor that has consistently shown a positive relationship with child language development is socioeconomic status (SES) (Hoff, 2003; Letourneau et al., 2013; Pungello et al., 2009). SES refers to a family's social and economic standing, which may be indicated by household income, parental occupation, parental education level, or combinations of these factors. According to bioecological systems theory, a child's development is influenced by multiple levels of the surrounding environment (e.g., home, neighborhood, community, government, etc.) and their interactions. Both SES and maternal employment can be viewed as components of the distal environment that impact a child's development by interacting with their immediate environment (e.g., family, school; Bronfenbrenner & Evans, 2000; Bronfenbrenner & Morris, 1998). For instance, a mother's employment status and education level, though not part of the child's immediate family structure, can influence children's language development indirectly through influencing the time and quality of a child's at home interactions with the mother. Moreover, prior research has suggested that SES may modify the associations between maternal employment and developmental outcomes (Baum, 2003; Hoff, 2003; Letourneau et al., 2013). Though recent studies have begun to focus on how these familial factors (i.e., maternal employment and SES) relate to, and may even be responsible for language outcome differences (Berry et al., 2016; Davies et al., 2021; Hsin & Felfe, 2014), it remains unclear if maternal work status and education are associated with infant's language development differentially. More research is needed to explore these relationships to better understand the complex interplay of factors that influence language development in infants.

Importantly, the existing studies relating maternal factors to infants' language outcomes primarily relied on offline measures, such as parental reports of vocabulary size to assess young children's language ability. Such methods may overlook a potentially important area of examination because recent evidence suggests that lab-based online

measures are more sensitive and reliable in capturing variations in language development than parental reports. This is because parental reports rely heavily on the parents' familiarity with and sensitivity to their children's language development, which affects their reliability (Laing & Bergelson, 2019). This underscores the concern that using online reliable measures of language abilities is essential to ensure the validity of the findings regarding maternal factors and child language. To address this issue, the current study uses both offline and online measures to examine how maternal work status and maternal education attainment relate to 24-month-olds' language learning ability.

Maternal employment and child development

The impact of maternal employment on young children's development has been studied extensively, although its effects remain a contentious debate among researchers. Some studies claim that children benefit from their mothers being employed (Gregg et al., 2003; Hsin & Felfe, 2014; Vandell & Ramanan, 1992), while a body of research suggests that maternal employment (or mothers returning to the workplace) in infants' early life is negatively associated with child outcomes, including vocabulary, reading skills, and mathematical skills (e.g., Baum, 2003; Berger et al., 2008; Brooks-Gunn et al., 2002, 2010; Hill et al., 2005; Waldfogel et al., 2002). However, it is important to note that the negative associations between maternal employment and children's later outcomes were mainly limited to maternal employment during the first year of infants' lives (e.g., Baum, 2003; Waldfogel et al., 2002). Once children grow beyond one year of age, maternal employment in the second and third year of their life yields a positive effect on cognitive skills at 7 or 8 years of age (Waldfogel et al., 2002). Brooks-Gunn et al. (2002) further specified that the negative association between maternal employment and children's outcome is most pronounced during the first 9 months after childbirth. In addition, the type of maternal employment matters. Brooks-Gunn et al. (2010) demonstrated that mothers' full-time employment during infant's first year of life is negatively associated with cognitive outcomes later on, whereas mothers' part-time employment has a positive effect on children's cognitive development. Similarly, Waldfogel et al. (2002) analyzed a large-scale NICHD sample and demonstrated that maternal employment with more than 21 hours per week in the first year may negatively affect children's vocabulary outcomes in later years.

The above-mentioned negative associations between early maternal employment and later child outcome have received strong criticism from researchers. Many studies have shown that maternal employment has a positive effect on child development and brought out that mothers who are employed tend to be more educated and have higher incomes than those who do not go back to work, all of which in turn positively relate to child outcomes (Gregg et al., 2003; Hsin & Felfe, 2014; Vandell & Ramanan, 1992). In addition, working mothers tend to send their children to high quality center-based child cares and exhibit more maternal sensitivities (Brilli et al., 2013; Brooks-Gunn et al., 2010). Children of working mothers who use non-maternal care resources (i.e., center-based child care, home-based care, other caregivers' care) may benefit from a richer and more diverse language input, such as interactions with peers and teachers, various educational toys and books, and thus develop better language skills (Milne et al., 1986; Yoshikawa, 1999). Moreover, studies have indicated that employed mothers score higher on maternal aptitude tests, which positively predict children's reading achievement (Vandell & Ramanan, 1992).

Although being employed may take mothers' time and energy away from maternal care, and possibly decrease the quantity and quality of mother-child interactions (Baum, 2003; see Heinrich, 2014 for review), there remains a large number of variabilities for families. A number of studies have shown that working mothers place more emphasis on the quality rather than quantity of shared activities, such as educational and structured playtime with their children (Booth et al., 2002; Hsin & Felfe, 2014). For hetero co-parenting families with working mothers, fathers' engagement in parenting and interactions with children tend to increase, which compensate for maternal employment and benefit child development (Hsin & Felfe, 2014). Altogether, the specific association between maternal employment and children's later outcomes depends on when the mother is employed, what type of employment, and how the family manages child care when the mother is not available.

Socioeconomic status and language development

While a few studies have failed to detect SES variations in child language outcomes by highlighting child vocalization counts (Piot et al., 2022; Sperry et al., 2019), a large number of studies support the pattern that SES is positively associated with children's language skills and development (Farah & Noble, 2005; Letourneau et al., 2013; Noble et al., 2006; Pungello et al., 2009). A meta-analysis has shown that SES as a composite measure is positively related to language and literacy development among children aged 3 to 12 years old across different cultures (Letourneau et al., 2013). As early as 18 months, infants from higher-SES families (i.e., based on maternal education and occupation) tend to outperform their peers from lower-SES families on productive vocabulary size and language processing efficiency (Fernald et al., 2013; Hoff, 2003; Rescorla & Alley, 2001). As children's age increases, their vocabulary gap becomes wider (Hart & Risley, 1995). Beyond lexical knowledge, SES is also related to grammatical development, especially for complex sentences, with children from higher SES backgrounds (i.e., identified by maternal education as higher than college degree) producing more complex sentences in their speech than peers with mothers whose educational attainment was equivalent to college or less (Vasilyeva et al., 2008). Additionally, studies suggest that children from higher-SES families have better ability to express their thinking and ideas compared to their middle- and lower-SES peers (Pappas et al., 2003; Pungello et al., 2009).

The possible variations in language development across SES strata are primarily due to the varied language environment children experience (Hoff, 2003). SES backgrounds may lead to varying amounts of economic resources children are exposed to at home. For example, economically advantaged families tend to have more language learning resources, such as more children's books and longer or more frequent reading time between parent and child (Bradley et al., 2001). The stimulating experiences provide a positive learning environment, which facilitates children's language development (Linver et al., 2002). In addition, parents from more educated and advantaged backgrounds tend to provide a greater amount and higher quality of language input (e.g., higher lexical diversity and syntactic complexity) when directly interacting with their children (not overheard talk) than parents with less educated and disadvantaged backgrounds (Dailey & Bergelson, 2022; Hoff, 2003; Rowe, 2018). The high-quality language input may better attract children's attention or highlight critical components in speech and therefore facilitate infants' language learning and development (e.g., Fernald & Mazzei, 1991; Hoff, 2003).

Interaction between maternal employment and maternal education

Informed by bioecological systems theory and socio constructivism theory, both maternal employment and SES can be regarded as playing important roles in child development. Prior studies suggest that maternal employment and SES may interactively impact children's development, including language development (Baum, 2003; Hsin & Felfe, 2014). For instance, high SES may function as a mitigating factor in the relationship between maternal employment and child outcomes. In the event that maternal employment brings a negative impact, a high family income may counteract the negative effects of maternal employment on an infant's development at an early stage (Baum, 2003). This can be explained by the fact that families with higher income are more likely to send their infants to high-quality child care centers, which offsets the missed interactions with mothers due to maternal work. Similarly, highly educated mothers are more likely to balance child care and work well compared to mothers with low educational attainment (Hsin & Felfe, 2014), and be more engaged and responsive when interacting with their children (Hart & Risley, 1995; Huang et al., 2022).

Similarly, maternal work status may modify the associations between SES/maternal education and children's language development. When mothers work either full time or part time and children experience nonmaternal care, it can serve as a protective factor against the potential negative impacts of impoverished home environments on child outcomes (Berry et al., 2016; Davies et al., 2021; Watamura et al., 2011). For instance, research suggests that there may be a connection between children receiving care outside the home and a decrease in aggressive behaviors, particularly in children whose mothers have obtained low educational attainment (Côté et al., 2007), and that this is likely due to the quality interaction and guidance provided by other caregivers (Belsky, 2006; Mashburn et al., 2008). Conversely, when mothers are highly educated and available, they can offer diverse and high-quality language input, engaging children in interactive activities during shared reading, such as asking questions or providing feedback (Hart & Risley, 1995; Magnuson et al., 2009; Tracey & Young, 2002). Consequently, infants tend to benefit from the presence and engagement of their highly educated mothers, especially when they are stay-at-home mothers.

Less educated and low-income working parents often have to contend with unstable work schedules, financial strain, and limited time and effort to maintain high-quality interactions with their children (Masarik & Conger, 2017; Newland et al., 2013). Thus, children, including those from economically diverse backgrounds, may experience developmental advantages associated with maternal employment, such as enhanced language development, improved social skills, and a reduction in aggressive tendencies (Mashburn et al., 2008; Yoshikawa, 1999). The potential benefits for children's development may be linked to the increased opportunities for engaging with skilled educators and caregivers that can come with maternal employment. Taken together, it is very likely that maternal education and employment have an interaction effect on children's language abilities, while it remains unclear how their interaction is associated with children's language learning.

The current study

Based on bioecological systems theory and previous empirical studies, both maternal work status and education level are considered significant factors in predicting infants' language development. These factors are closely related to the language environment

that infants are exposed to (Dailey & Bergelson, 2022; Rowe, 2012). A significant number of studies have demonstrated the associations between the individual maternal factors (maternal education or employment) and language outcomes (Gregg et al., 2003; Laing & Bergelson, 2019; Magnuson et al., 2009). However, to the best of our knowledge, no study has examined the combined influences of both maternal factors on infants' language development. To obtain a comprehensive understanding of the relationship between maternal factors and early language development, it is crucial to take into account the interactive contributions from various maternal factors. In addition, most existing studies used offline measures for language development, such as comprehension or productive vocabulary size based on parental reports, to assess infants' language abilities in relation to maternal education and/or work status (e.g., Brooks-Gunn et al., 2010; Magnuson et al., 2009). Compared to parental reports of vocabulary size, a real-time language processing assessment may be more objective and sensitive in reflecting potential learning differences due to variations of maternal factors (Laing & Bergelson, 2019).

Using a Mutual Exclusivity (ME) task, Bion et al. (2013) demonstrated that while 2-year-olds as a group can reliably identify the correct object among two items upon hearing a label, only some of the participants performed at above-chance level in a retention task that involved novel word learning. The large individual differences within this age group on the ME-based novel word learning task is of particular interest for two reasons. The first is that previous studies, together with Bion et al. (2013), have suggested a partial dissociation between differentiating familiar objects and learning new words (e.g., Horst & Samuelson, 2008), and that MCDI-based parental reports were not designed to assess the latter. In addition, modeling work has shown that the learning process for retaining novel object-label mapping differs from that of disambiguation (McMurray et al., 2012), and that a retention task based on novel word learning is more challenging. This more challenging aspect of lexical development, however, has not been investigated within the context of maternal care and education.

The main goal of the current study is to examine the interaction between maternal work status (i.e., at home, part-time working, full-time working) and maternal education attainment, and how they relate to 24-month-old infants' language abilities using both online and offline language measures. We have two specific research questions that we aim to address in this study:

- 1) Does the interaction of maternal employment and education attainment correlate with both online and offline measures of language abilities in 24-month-old infants? Based on previous evidence and the nature of the assessment of infants' language abilities, we hypothesize that the interaction between maternal employment and education is more likely to be associated with infants' ability to learn novel words online, compared to their parent-reported productive vocabulary size.
- 2) How do maternal employment and education interact with each other and relate to language learning in 24-month-old children? Based on theoretical frameworks and prior research, we expect that the positive association between mothers' educational level and infants' language learning will be influenced by mother's work status. Specifically, we expect the association between maternal education and infants' language learning to be most pronounced among infants with stay-at-home mothers.

Crucial to our interest, we have implemented the more challenging, retention, trials in an ME task to assess real-time utilization of skills related to lexical development. We examined 24-month-old infants for two reasons: 1) since previous studies reported negative effects of maternal employment on child development when infants were younger than one year old and positive effects when they enter the 2nd and 3rd year of their lives, we should expect that as infants grow and amass more linguistic knowledge, this older age group may start to benefit from maternal employment and child care experience in all aspects of language development; 2) the more challenging ME-based retention trials from Bion et al. (2013) were not learnable to 18-month-olds, whereas some 24-month-olds were able to succeed in the task. This age group would therefore allow us to investigate the potential effects in infant language development with abundant developmental differences.

Method

Participants

One hundred and eight 24-month-old infants participated in the study ($M = 24.5$ months; range = 24.02 – 27.07 months, 59 females). All participants were typically developing children from monolingual English-speaking families in a Midwestern city in the U.S. The racial and ethnic composition of the participating families was comparable to that of the local demographic distribution, with most of the participants (89.5%) being Caucasian, 2% Hispanic, 2% Black, and 6.5% from multiracial backgrounds. Most of the parents obtained a college degree (mothers, 69%; fathers, 64%). Over half of the mothers (59%) reported having a job at the time of study participation and the rest (41%) reported being stay-at-home moms. The majority of the fathers (91%) reported having a job and 3 fathers were unemployed; 6 fathers did not report their job status. Caregivers reported household income on a 7-point scale: 1 = <\$24999, 2 = \$25000–\$49999, 3 = \$50000–\$74999, 4 = \$75000–\$99999, 5 = \$100000–\$124999, 6 = \$125000–\$149999, 7 = >\$150000, and the average household income reported was 3.49, indicating an average household income for the sample was around \$75000. Recruitment was done at the local children's museum, a baby and families fair, and through free hospital birthing and neonatal care classes to ensure inclusivity of different SES backgrounds. No participants reported hearing or speech problems. Participating families received monetary compensation for their time.

Measures

Maternal education

Parents completed a survey reporting basic family background information including maternal education, as well as their occupations. Mothers chose the highest degree they have earned from seven options: 1 = eighth grade completion, 2 = high school diploma, 3 = two-year college degree, 4 = some college, 5 = four-year college degree, 6 = master's degree, 7 = doctoral degree. Their responses were then coded into the years of education completed: 1 = 8 years of education, 2 = 12 years of education, 3 = 14 years of education, 4 = 15 years of education, 5 = 16 years of education, 6 = 18 years of education, 7 = 22 years of education. Two raters checked all participants' input and coding; interrater agreement reached 100%.

Maternal work status

In the demographics survey, parents provided their current occupation and work hours. Responses in the maternal occupation question including “unemployed”, “caregiver”, or “stay-at-home mom” were coded as “At Home”. Other responses that indicated a specific occupation were coded based on reported working hours. Following Laing and Bergelson (2019), mothers who worked longer than 30 hours per week were coded as “Full Time”, and those who worked 5 to 28 hours per week were coded as the “Part Time”. Two raters checked all participants’ input and coding; interrater agreement reached 100%.

Productive vocabulary

Productive vocabulary was measured using a standardized parental report vocabulary checklist: the MacArthur-Bates Communicative Development Inventory: Words & Sentences (MCDI; Fenson et al., 2006). Parents were asked to identify the words that they thought their child is able to produce in daily life. The identified words parents reported were counted and used for participants’ productive vocabulary score.

Novel word learning ability

Infants’ novel word learning ability was measured by a mutual exclusivity (ME) task (adopted from Bion et al., 2013) and took place in the lab. The visual stimuli were pictures of six familiar objects (truck, bubbles, blanket, cheese, balloon, spoon) and two novel objects (see Fig. 1), each centered on a gray background in a 640×480 pixel space. The speech stimuli were sentences consisting of brief carrier frames that each ended in the name for one of the six familiar objects or two novel objects (e.g., *modi* and *dofa*), followed by simple questions that introduced prosodic variability across trials (e.g., Where is the truck? Can you see it?). A female native speaker of American English first recorded multiple tokens of each sentence. The duration of the target nouns and the intensity of the phrases was normalized using Praat speech analysis software (Boersma, 2001).

TRAINING TRIALS

Where’s the modi?



RECOGNITION TRIALS

Where’s the truck?



RETENTION TRIALS

Where’s the modi?

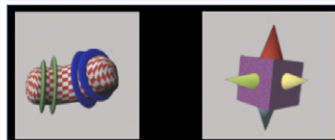


Figure 1. Three types of trials in the Mutual Exclusivity (ME) experiment.

Procedure

Accuracy in identifying the correct target picture was assessed using the Looking-While-Listening procedure (see Fernald et al., 2008). Participants sat on their caregiver's lap and viewed pictures of objects as they listened to speech naming one of the pictures. On each trial, a pair of pictures was presented on the screen for approximately 6s, with the speech stimuli starting after 2s, followed by 1s of silence. Each infant was presented with 28 trials, consisting of three different trial types (Fig. 1): on twelve Training trials, each novel object served as the target six times, with both a familiar and novel object presented during labeling. On eight Recognition trials, each novel object was paired with a familiar object, and the familiar objects were named during labeling. On eight Retention trials, both novel objects were shown side by side, with one of them named during labeling.

The Recognition and Retention trials were interspersed after the Training trials. The target object was named only once per trial. Pairings of novel and familiar objects were counterbalanced across participants. The side of presentation of the target was also randomized, with the constraint that the target did not appear on the same side of the screen in more than two consecutive trials. To maintain attention, six filler trials with colorful and visually complex scenes appeared after every four trials, accompanied by attention-getting phrases such as "Hey, look at that! That's cool!" spoken in a child-directed manner. Caregivers wore opaque glasses so that they could not influence infants' looking behavior. The entire procedure lasted 5 minutes.

Coding and analysis

Infants' looking behavior during the trials was video-recorded. Trained coders who were unaware of the experimental conditions analyzed videos of infants' eye movements at 33 ms intervals. They recorded whether the child was looking at the left or right image, shifting between images, or off-task (Fernald et al., 2008). The study excluded trials where the infant was not looking at either image at noun onset (24.8% of the dataset) or looked away for more than 1000 ms continuously within the 3000 ms analysis window (26.7% of trials). A table with summary statistics for the included trials by three maternal work status subgroups is provided in Appendix A. Twenty-five percent of trials from all participants were randomly selected and independently coded for whether an infant was looking at the picture on the left or the picture on right, transitioning between pictures, or off task. The agreement between coders within a single frame was greater than 99%.

Consistent with previous studies, trials in which infants were looking away from both pictures or shifting (i.e., a rapid change of gaze) from one to the other were not included in these analyses (Fernald et al., 1998, 2006). The entire looking behavior since target word onset was captured, though the accuracy before 300 ms was not included since shifts to the target occurring in this window had presumably been initiated before the onset of the noun (Haith et al., 1993). Following the rationale in Bion et al. (2013), we also adopted a longer window (3300ms, which encompasses the entire trial duration) because on the majority of trials the visual stimuli included one or two novel objects, which elicited more shifting back and forth between target and distractor than do sequences of trials on which only familiar objects are presented. Following their approach (Bion et al., 2013, p. 43), when the infant was gazing at a picture at the beginning of the speech stimulus during the trials, their precision was measured by calculating the duration of their fixation on the intended object, divided by their fixation on both the intended object and the distractor, between 300 to 3300 ms after the target word was presented.

Mean accuracy was then computed for each participant on each trial type as the mean proportion of time looking to the target divided by the mean proportion of time looking to the target or to the distracter. Though our primary interest lies in the results from the Retention trials, which are the most challenging, we also analyzed the Training trials to ensure that learning has occurred.

Data preparation

Four participants were excluded from the analysis because they did not report either maternal education or maternal occupations. In the rest of 104 participants, 13 parents (12.5%) had not reported the CDI vocabulary, and 26 participants (25%) had missing data in ME retention trials. Little's MCAR test indicated that the data were missed completely at random, $\chi^2(8, N = 76) = 3.583, p = .694$. Expectation Maximization (EM) was used to deal with the missing data. In the full data with EM, Shapiro–Wilks tests indicated that the distribution of productive vocabulary was normally distributed, $W = .982, p > .05$, while the ME performance was not normally distributed, $W = .959, p < .01$. Four outliers on ME retention trials were then removed from the dataset (skewness & kurtosis, out of the range from -2 to $+2$; George & Mallery, 2010), and 100 participants were included in the final analytical sample. The demographic information of the analytic sample was summarized in Table 1.

Results

Descriptive analysis

All analyses were conducted in SPSS 25.0 (IBM Corp, 2017). The reported productive vocabulary size ranged from 10 to 645, and the mean of the sample's productive vocabulary size was 279.47, $SD = 146.59$. The mean accuracy of the sample's novel word learning performance was .53, $SD = .11$. Table 2 provides descriptive statistics for the three maternal employment groups in terms of child age, maternal education, productive vocabulary, and word learning ability. There was no significant difference among the at home, part-time, and full-time working groups apropos of child age, productive vocabulary, and novel word learning performance. However, mothers with a higher education level tended to work more hours a week, $F(2, 97) = 5.12, p = .008, \eta^2 = .10$. Productive vocabulary and word learning performance were closely connected, $r = .403, p < .001$. This is expected and consistent with previous studies (e.g., Bion et al., 2013). Maternal education was not significantly associated with productive vocabulary, $r = .053, p = .604$, but significantly associated with word learning performance, $r = .207, p = .039$. When examining the correlations between maternal education and novel word learning across maternal employment subgroups, results showed that only at home mothers' education, but not full-time or part-time working mothers' education, was related to infants' novel word learning performance, $r = .598, p < .001$.

Interaction of maternal factors and productive vocabulary

To examine the association between the interaction of maternal education and work status and children's productive vocabulary at 24-months, a moderation model controlling for child age was conducted using Model 1 in PROCESS Macro in SPSS (Hayes,

Table 1. Demographic Information for the Analytic Sample (N = 100)

	M (SD)	Range	%
Child age (in months)	24.5 (0.36)	24.02 – 27.07	
Child sex			57% females
Ethnicity			100% reported
Caucasian			92%
Hispanic			2%
Multiracial			6%
Family income			93% reported
<\$24999			3%
\$25000-\$49999			24%
\$50000~\$74999			29%
\$75000~\$99999			15%
\$100000~\$124999			12%
\$125000~\$149999			4%
>\$150000			6%
Maternal Education (years)	16.33 (2.25)	(12 - 22)	
Maternal Work Status (work hours per week)	16.66 (17.07)	(0 - 50)	
At Home		0	41%
Part Time		5-28	29%
Full Time		30-50	30%

Table 2. Means (and SDs) of Child Age, Maternal Education, Productive Vocabulary and Novel Word Learning Performance in Three Maternal Employment Groups

Groups	At home (n = 41)	Part time (n = 29)	Full time (n = 30)	<i>p</i>
Child Age	24.48 (.23)	24.48 (.23)	24.56 (.55)	.62
Maternal Education	15.56 (1.70)	16.52 (2.13)	17.2 (2.70)	.008**
Productive Vocabulary	285.09 (141.42)	289.41 (143.09)	262.19 (159.86)	.74
Novel Word Learning	.51 (.11)	.55 (.09)	.53 (.13)	.45

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

2018). Maternal education was mean centered to reduce multicollinearity. We used the *mcw* option to tell PROCESS that moderator Maternal Work Status is a multicategorical variable, so it automatically dummy coded the moderator and created interaction terms (Hayes, 2018).

Table 3. Coefficients Results for the Moderation Model with Productive Vocabulary

Model	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	95% CI
Constant	-39.38	215.10	-.18	.86	[-466.47, 387.72]
Maternal Ed	20.85	13.74	1.52	.13	[-6.44, 48.14]
W1	394.48	306.66	1.29	.20	[-214.41, 1003.36]
W2	270.98	278.88	.97	.33	[-282.74, 824.71]
W1*Maternal Ed	-24.83	19.01	-1.31	.19	[-62.56, 12.91]
W2*Maternal Ed	-19.07	17.11	-1.11	.27	[-53.05, 14.91]

Note. Dependent Variable: Productive Vocabulary Size. Maternal Ed = Maternal Education; CI = confidence interval. Dummy coding was used on maternal working status, with at home group as reference, W1 = part-time working group; W2 = full-time working group.

The at home group was set as the reference group; W1 represents the part-time working group, and W2 represents the full-time working group. The model was not significant, accounting for only 3% of the variance in productive vocabulary, $R^2 = .03$, $F(5, 94) = .60$, $p = .70$. The model summary is presented in Table 3. Maternal education and maternal work status were not significant predictors of infant's productive vocabulary, $b_1 = 20.85$, $t(96) = 1.52$, $p = .13$; $b_2 = 394.48$, $t(96) = 1.29$, $p = .20$; $b_3 = 270.98$, $t(96) = .97$, $p = .33$. Both interaction terms were not significant, $b_4 = -24.83$, $t(96) = -1.31$, $p = .19$; $b_5 = -19.07$, $t(96) = -1.11$, $p = .27$. Moreover, the test of highest order unconditional interactions indicated that adding the interaction terms did not significantly result in incremental variance explained in 24-month-olds' productive vocabulary, $\Delta R^2 = .02$, $\Delta F(2, 94) = .95$, $p = .39$. It suggests that there is no evidence of a difference in two-year-olds' productive vocabulary size as a function of either factors alone or together.

Interaction of maternal factors and novel word learning

To ensure that infants were able to reliably identify familiar object-label mappings in this task, we first tested their performance on recognition trials. As one group, a one-sample *t*-test showed that participants performed above chance (.50) on the recognition trials, $M = .75$, $SD = .12$, $t(99) = 20.60$, $p < .001$, Cohen's $d = 2.08$. Consistent with previous studies using the same paradigm (e.g., Bion et al., 2013; Fernald et al., 2006), infants looked more at the familiar object when they heard its label in this task. Similarly, infants performed above chance level on the training trials, $M = .55$, $SD = .12$, $t(99) = 4.26$, $p < .001$, Cohen's $d = .42$; and retention trials, $M = .53$, $SD = .11$, $t(99) = 2.55$, $p = .006$, Cohen's $d = .27$. Since our primary focus was to investigate how infants' ability to use ME to learn novel word-object mappings may differ due to maternal factors, we analyzed their performance on the retention trials as well as the recognition and training trials by maternal employment subgroups. For these *a priori* one-sample *t*-tests, we treated infants' looking behavior as the dependent variable and compared it to the chance performance (.50).

All three maternal employment subgroups showed above chance level performance on the recognition trials: at home group, $M = .77$, $SD = .11$, $t(40) = 15.80$, $p < .001$, Cohen's $d = 2.45$; part-time working group, $M = .72$, $SD = .15$, $t(28) = 7.68$, $p < .001$, Cohen's $d = 1.47$; full-time working group, $M = .77$, $SD = .11$, $t(29) = 13.97$, $p < .001$, Cohen's $d = 2.45$. Similarly, the three subgroups performed better than chance on the training

trials: at home group, $M = .56$, $SD = .08$, $t(40) = 4.46$, $p < .001$, Cohen's $d = .75$; part-time working group, $M = .55$, $SD = .15$, $t(28) = 1.77$, $p = .043$, Cohen's $d = .33$; full-time working group, $M = .54$, $SD = .13$, $t(29) = 1.74$, $p = .046$, Cohen's $d = .31$. These patterns suggest that infants across different maternal employment status were able to look longer at familiar objects when they heard the familiar labels and looked more at the unfamiliar objects when they heard a novel label. For the retention trials, only the part-time working group significantly performed above chance, $M = .55$, $SD = .09$, $t(28) = 2.75$, $p = .005$, Cohen's $d = .56$. Infants with at home mothers and full-time working mothers performed at the chance level in the retention trials: at home group, $M = .51$, $SD = .11$, $t(40) = .85$, $p = .20$, Cohen's $d = .09$; full-time working mothers, $M = .53$, $SD = .13$, $t(29) = 1.20$, $p = .12$, Cohen's $d = .23$. A plot illustrating the three maternal employment subgroups' looking behavior in the retention trials is included in [Appendix B](#).

Next, we conducted a similar moderation model through PROCESS Macro with novel word learning performance as a dependent variable. Since productive vocabulary size was associated with novel word learning performance, infants' productive vocabulary size was entered as a covariate here. The model results are summarized in [Table 4](#). Overall, the model was significant, accounting for 28.6% of the variance in novel word learning performance, $R^2 = .286$, $F(6, 93) = 6.21$, $p < .001$. Maternal education was a significant predictor of infant's novel word learning performance, $b_1 = .03$, $t(95) = 3.55$, $p < .001$. Similarly, part-time work status in mothers was associated to marginally better novel word learning performance than at home group, $b_2 = .39$, $t(95) = 1.95$, $p = .054$; and full-time work status was significantly related to stronger novel word learning in infants compared to at home group, $b_3 = .59$, $t(95) = 3.25$, $p = .002$. The interaction term W1*Maternal Education was not significant, $b_4 = -.02$, $t(95) = -1.90$, $p = .06$, suggesting that the slopes relating maternal education to novel word learning in the at home and part-time working groups did not significantly differ from each other. However, the interaction term W2* Maternal Education was significant, $b_5 = -.04$, $t(95) = -3.24$, $p = .002$, indicating that the relation between maternal education and novel word learning for the at home and full-time working groups significantly differed from each other. Moreover, the test of highest order unconditional interactions indicated that adding the

Table 4. Coefficients Results for the Moderation Model with Novel Word Learning (Retention Trials)

Model	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	95% CI
Constant	-.06	.14	-.46	.65	[-.34, .21]
Maternal Ed	.03	.01	3.55	.001	[.01, .05]
W1	.39	.20	1.95	.054	[-.01, .79]
W2	.59	.18	3.25	.002	[.23, .96]
W1*Maternal Ed	-.02	.01	-1.90	.06	[-.05, .001]
W2*Maternal Ed	-.04	.01	-3.24	.002	[-.06, -.01]
Productive Voc	.00	.00	4.03	.000	[.0001, .0004]

Note. Dependent Variable: Novel word learning performance (in Mutual Exclusivity task). Maternal Ed = maternal education; Productive Voc = productive vocabulary; CI = confidence interval. Dummy coding was used on maternal working status, with at home group as reference, W1= part-time working group; W2 = full-time working group.

interaction terms significantly resulted in an incremental variance explained in 24-month-olds' novel word learning performance, $\Delta R^2 = .08$, $\Delta F(2, 93) = 5.26$, $p = .007$.

As shown in Figure 2, maternal work status moderated the association between maternal education and novel word learning in 24-month-olds. Having a higher level of education had the greatest positive association with infant's novel word learning for the at home group, compared to the other two working groups. The partial correlations between maternal education and novel word learning performance after controlling for productive vocabulary size across three maternal working groups indicated that the positive relation between novel word learning performance and number of years of education completed by mother was strongest for the at home group ($r_{\text{partial}} = .56$, $p < .001$), but the associations were not significant for the part-time ($r_{\text{partial}} = .27$, $p = .173$) and full-time working groups ($r_{\text{partial}} = -.09$, $p = .628$).

To further determine if the divergent findings on productive vocabulary and novel word learning were due to the online versus offline measures, we also conducted a moderation analysis on the recognition trials in ME task, which represents an online measure for infants' ability to recognize familiar words. The model was not significant, accounting for only 5.8% of the variance in recognition trial performance, $R^2 = .058$, $F(5, 94) = 1.16$, $p = .336$. As shown in Table 5, both maternal education and employment status were not significant predictors of infant's recognition accuracy on familiar word-object mappings. In addition, the interaction terms $W1 \times \text{Maternal Education}$ and $W2 \times \text{Maternal Education}$ were also not significant, suggesting that the interaction of maternal education and work status did not significantly influence 24-month-olds' familiar word recognition ability.

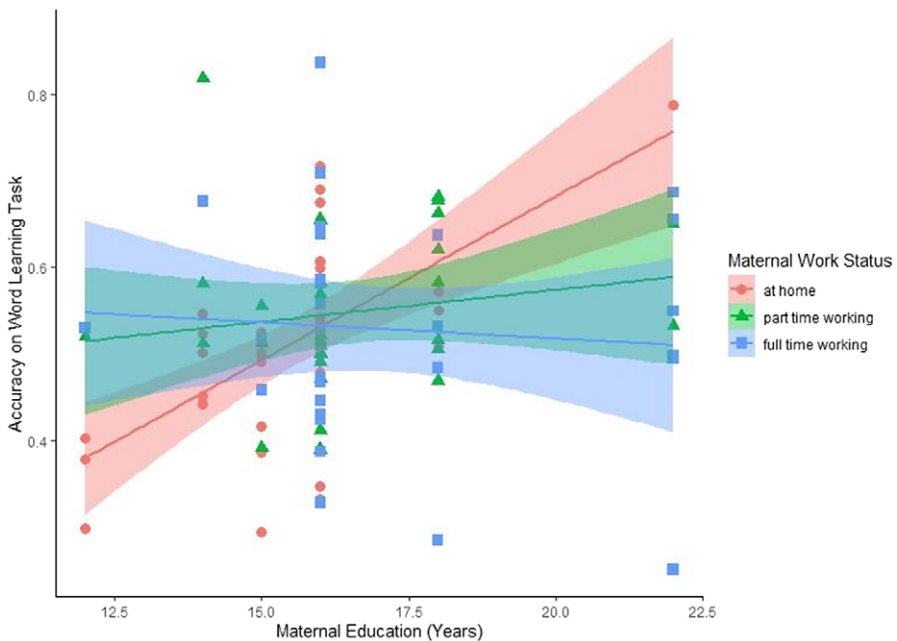


Figure 2. A visual representation of the conditional relationship between years of maternal education (SES) and novel word learning ability (in a Mutual Exclusivity task) as a function of maternal work status.

Table 5. Coefficients Results for the Moderation Model with ME Recognition Trials

Model	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	95% CI
Constant	.69	.18	3.89	<.001	[.34, 1.05]
Maternal Ed	.00	.01	.43	.67	[−.02, .03]
W1	−.19	.25	−.76	.45	[−.70, .31]
W2	.01	.23	.05	.96	[−.45, .47]
W1*Maternal Ed	.01	.02	.51	.61	[−.02, .04]
W2*Maternal Ed	−.00	.01	−.08	.93	[−.03, .03]

Note. Dependent Variable: Recognition trials performance (in Mutual Exclusivity task). Maternal Ed = maternal education; CI = confidence interval. Dummy coding was used on maternal working status, with at home group as reference, W1= part-time working group; W2 = full-time working group.

Discussion

The current study investigated how different components of maternal background (maternal education and work status) relate to two-year-olds' language development, specifically productive vocabulary size and novel word learning ability. Consistent with our hypothesis, while we did not find evidence for differences on infants' vocabulary size as a function of maternal education or work status, these factors and their interaction were associated with infants' ability to learn new words. Mother's education attainment holds a strong positive relationship with infant's novel word learning ability when mothers stay at home, while this relationship was largely weakened in infants of part-time and full-time working mothers.

Perhaps surprisingly, in our sample, no evidence was found associating infants' productive vocabulary size with either maternal education level or maternal work status. This is partly inconsistent with previous studies that found a positive correlation between maternal education and children's vocabulary development (Bruce et al., 2022; Friend et al., 2022; Hoff, 2003). Additionally, using longitudinal data from the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development (NICHD SECCYD), Magnuson et al. (2009) found that increases in maternal education between infants' 24th to 36th months were associated with infants' productive and receptive language skills at 36 months. It has also been posited that children of mothers with less educational background could face challenges in language development as these children may experience a lower degree of maternal responsiveness and less maternal language input (Hoff, 2013; Lonigan et al., 2013). However, when we considered both maternal education and maternal work status in our study, no evidence for a difference in 24-month-old infants' concurrent productive vocabulary size was found.

Instead, we found that there was a significant interaction of maternal education and work status on infants' novel word learning ability, which is measured by the lab-based ME task. By using the more challenging online task, we examined infants' ability beyond recognizing familiar object-label mappings. One of the possible explanations for the inconsistency is that infants' productive vocabulary size measured by the MCDIs may not capture certain variations in language abilities related to maternal factors due to its offline nature. As discussed previously, the validity of a parental report depends on parental characteristics, such as how much time the parent spends with the infant, and how much

attention they pay to the infant's language development (Laing & Bergelson, 2019). This possibility, however, is proven unlikely to be the main factor contributing to the null result since the recognition trials in the ME task also did not show outcome differences as a function of maternal factors (shown in Table 5). The fact that both an offline task (i.e., MCDI) and an online task (i.e., recognition trials in the ME task) yielded similar findings, and that the differences in language abilities related to maternal factors were exclusively detected in cognitively challenging retention trials suggests that task difficulty may be a more possible explanation. The ME retention trials utilized in this experiment to assess infants' novel word learning ability involved encoding, retaining, and retrieving the novel word-object mappings, which has been found to result in significant variability among infants of this age group (Bion et al., 2013).

This is in line with previous research on task difficulty and individual differences. Task difficulty has been found to play a crucial role in revealing individual differences in cognitive abilities (Dodonova & Dodonov, 2013; Lohman, 2000; Robinson, 2001). For instance, research has demonstrated that high-ability individuals and low-ability individuals tend to show a greater difference in accuracy rates in complex tasks that require higher cognitive demand (Dodonova & Dodonov, 2013). It is therefore plausible to suggest that tasks with increased difficulty levels can provide valuable insights into understanding individual differences in language development during infancy as well. As such, our findings indicate that this real-time language measure with a high level of task difficulty may be able to detect more nuanced variations in infant's language development relating to maternal factors.

Extending from previous research, our findings revealed that for two-year-olds whose mothers stayed at home, the ability to learn novel words was positively associated with maternal education, while the association between maternal education and novel word learning was not evident in infants with part-time and full-time working moms – when mothers were working either part-time or full-time, there was no salient connection between maternal education and infant's language learning performance in the challenging task. This finding goes against the “rich get richer” framework of language development, though the source of differences (or the lack thereof) in infants' novel word learning ability remains to be identified. One possible explanation is that working mothers may have to seek nonmaternal care for their child when they are not available due to work. Nonmaternal care, such as child care centers, or other family member's care, may be an equalizer for infants' language development across families with varying levels of maternal education when mothers are working, which merits further exploration in future studies. Another potential factor to consider is the possibility of shared genetic propensity between mothers and infants, which could be linked to their language learning skills. It is plausible that genetic factors play a role in shaping the language abilities of both mothers and infants (e.g., Dale et al., 2015; Plomin et al., 1977). Future studies investigating maternal factors' impact on infant language learning should consider the shared genetic propensity.

Ample research demonstrated that parent education is a positive factor associated with the diversity and sophistication of vocabulary used by parents when interacting with infants (Dailey & Bergelson, 2022; Rowe, 2012; Rowe & Snow, 2012), and that the variability of language input is strongly associated with infants' language development (Anderson et al., 2021; Pancsofar & Vernon-Feagans, 2006). It is also important to note that even in SES-homogeneous samples, there is large variability in the language input parents provided (Hirsh-Pasek et al., 2015; Rowe, 2018). This suggests that there are additional factors, beyond parental education or SES, that contribute to the quantity and

quality of language input provided to infants, which in turn relate to infant's language skills. Maternal work status could be one of such contributing factors. While there is limited research directly examining the link between different work statuses in mothers and their language input toward infants, studies have shown that working mothers are more likely to utilize center-based child care services (Brooks-Gunn et al., 2010). Moreover, children whose mothers were employed and utilized non-maternal care resources may benefit from increased language input, which ultimately leads to enhanced language abilities (Milne et al., 1986; Yoshikawa, 1999).

Implications, limitations, and future directions

This study holds important practical implications for families concerning infants' language development, especially those who are economically disadvantaged. Mothers who work in infants' early years often experience feelings of guilt about leaving their child while they are at work, and worry that limited maternal care during infancy could lead to negative child outcomes (Westervelt, 2018). However, our findings provide evidence that infants who have working mothers with limited education attainment may experience benefits in their language development. Mothers going back to work often leads to higher income, which increases the likelihood of having access to more learning resources at home and being able to afford high-quality nonmaternal care for the child (Nobel, 2015). Access to high-quality nonmaternal care may provide children with diverse and enriching language environments, which could compensate for limited home language environments. More enriched language environments may thus facilitate infant's language development.

While the study has important implications, it is necessary to acknowledge its limitations as an initial exploration of the interaction between maternal employment and education, and its correlations with infant's language skills. Firstly, while we have discussed the mechanisms that could potentially explain the associations between maternal factors and infants' language abilities, the study did not include measures to capture variations in maternal language input, the amount of time spent by mothers with their children, or other environmental factors within the family that may be associated with maternal work status or education. Similarly, the study did not assess the specific types of care or the quality of care that the participating families utilized. This makes it difficult to draw conclusions about the effect of child care attendance on infant language development based solely on maternal employment status. Future studies should incorporate measures to capture and evaluate childcare-related variables to pinpoint the compensatory effect that nonmaternal care may bring. In addition, future studies may collect information about shared genetic propensities between mothers and infants and investigate how the shared genetic propensities could account for the relations between maternal factors and infant's language learning abilities.

Another limitation of our study is that we did not screen or control for maternal mental health, such as depression and anxiety symptoms. These factors have been shown to have a significant impact on the home language environment and language outcomes of infants (Brookman et al., 2020). Future studies should consider maternal mental health, especially during the postnatal period, when examining the association between maternal factors and infant language learning. Additionally, it is important to note that maternal work status was only reported when the infants were around 24-month-old, and we do not have information on when mothers started to work postpartum. Previous studies have

suggested that the timing of maternal work status can have varying effects on child developmental outcomes (Baum, 2003; Brooks-Gunn et al., 2010). Specifically, mothers who return to work in the first year after childbirth may lead to more negative outcomes for their children compared to those who return to work at a later stage (Baum, 2003; Hill et al., 2005). Therefore, it would be valuable for future studies to examine the history of maternal employment and investigate the concurrent and longitudinal effects of timing differences of maternal employment on infant's novel word learning.

Conclusion

The present study provides valuable insight into the associations between interactive maternal factors (maternal education and work status) and infants' language abilities, as assessed by both offline and online language measures. Our research findings suggest that maternal backgrounds may be associated with differences in infants' language development, which can be better captured using more demanding real-time language tasks. This highlights the potential of utilizing high-demand tasks beyond the widely used MacArthur-Bates Communicative Development Inventories (MCDIs) even for infants as young as 24 months old. Additionally, this study shares practical implications with mothers in the labor force.

Supplementary material. The supplementary material for this article can be found at <http://doi.org/10.1017/S0305000924000011>.

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Competing interest. The authors declare none.

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