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Infants' Daily Routines Shape Opportunities for Perceptual-Motor Exploration

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Abstract

How infants spend time in everyday life is an important source of day-to-day, infant-to-infant, and age-related variability in development. Here, we measured the frequency of macro-level activity categories—playing, eating and drinking, napping, going on errands, bathing and dressing, watching media, book reading, and being comforted—in infants aged 4-7 and 10-13 months recruited from across the United States (55% female assigned at birth; 40% male assigned at birth; 5% unknown). Unlike past work that used retrospective estimates, we used an ecological momentary assessment sampling method to obtain direct reports of activities from infants' caregivers via text-message surveys. The resulting data illustrate that play is the most frequent activity within the first year, accounting for half of infants' waking time. Other frequent activities, such as mealtimes and errands, contribute significantly to how infants spend their time. Older infants spend more time playing and eating/drinking and less time napping and being comforted compared with younger infants. Importantly, different macro-level activities facilitate and constrain what infants do from moment to moment, such as hold objects, sit, and stand, suggesting that the composition of infants' daily routines shapes opportunities for perceptual-motor learning.

Keywords: play, motor development, objects, sleep, reading

Infants' Daily Routines Shape Opportunities for Perceptual-Motor Exploration

Characterizing the structure and content of infants' everyday experiences has become a prominent focus of developmental research (de Barbaro & Fausey, 2022; Lancaster & Wass, 2025). Spurred to improve ecological validity by documenting infants' actual, lived experiences, researchers have measured how many steps infants take (Adolph et al., 2012), the rate they touch objects (Herzberg et al., 2021), how often they see hands and faces (Fausey et al., 2016; Jayaraman et al., 2015), how frequently they share objects with caregivers (Karasik et al., 2011), and how many words they hear (Bergelson et al., 2019; Weisleder & Fernald, 2013). These *micro-level activities* comprise the input for learning and development. The goal of the current investigation is to measure *macro-level activities*, which we define as periods of behavior unified by a common functional task or goal, such as playing, eating a meal, or reading a book. Whereas micro-level activities might span a few seconds or less (i.e., taking a step, hearing an utterance, making eye contact, holding an object), macro-level activities span minutes to hours of behavior (i.e., watching an episode of *Bluey*, eating lunch, going to the park). Macro-level activities are important to measure for three reasons. First, they facilitate or constrain which micro-level activities will occur within a period of time. An infant may be more likely to take steps, hold objects, and hear a parent talk while playing compared to while watching television. Second, macro-level activities comprise an understudied source of within-day, across-age, and between-family variability. Even activities that are human necessities (e.g., sleeping and eating) may vary in daily frequency from family to family. Leisure activities, such as reading books and watching media, might differ substantially due to caregiving practices. Third, the ecological validity of observational research depends on how well the activities researchers choose to study correspond to infants' actual macro-level activities in daily life. Studies of "free play" in the lab (Adolph et

al., 2012; Franchak et al., 2018; Thurman & Corbetta, 2017) might generalize to play in the home but not generalize to riding in the car to the doctor's office.

Hofferth and Sandberg's (2001b) foundational investigation of macro-level activities analyzed 24-hour time diaries from a large sample of US children (birth to 12 years). Time use diaries, which ask children (or their caregivers) to log activities across an entire day, are more accurate compared with simple retrospective surveys (e.g., how much time did you play yesterday), which tend to underestimate infrequent activities and suffer from social desirability bias. Hofferth and Sandberg's (2001b) analysis revealed differences in time use over childhood and how individual differences in time use relate to cognitive achievement and behavioral problems, grouping children into four age ranges—0-2, 3-5, 6-8, and 9-12 years. Infants and toddlers (less than 2 years) spent more time playing (~30% of awake time) and eating (~14% of awake time) compared with older children. However, grouping all children under the age of 2 together precluded answering questions about how activities differ over the first year of life. Soderstrom and Wittebolle (2013) scored macro-level activities from full-day audio recordings in a sample of Canadian 12- to 29-month-olds, but a small sample of eleven children obscured potential age differences. Baxter (2009) collected time use diaries from mothers of 3- to 14-month-old Australian children; cross-sectional comparisons showed that older versus younger infants spent more time playing and eating but less time napping and being comforted. However, their use of non-mutually-exclusive categories makes it difficult to estimate the relative amount of everyday time spent in each activity.

Beyond these studies, most prior investigations of infants' macro-level activities focused on the prevalence of single activities in isolation (e.g., book reading alone or media viewing alone) (Brushe et al., 2023; Patel et al., 2024). The goal of the current investigation was to

improve on past research by simultaneously measuring the relative frequency of multiple macro-level activities—playing, napping, eating/drinking, going on errands, being comforted, book reading, watching media, and bathing—while also measuring how frequency differs with age in the first year. Furthermore, the current study is novel in assessing how micro-level motor activities—sitting, standing upright, and holding objects—differ according to macro-level activities in everyday life. In the following sections, we review past work about each activity category.

Sleep

The sleep/wake cycle defines infants' "waking day"—the period of time excluding nighttime sleep. Furthermore, naps define which parts of the waking day can contain other macro-level activities. Beyond this, sleep is crucial for infant development because it plays an important role in early brain growth, cognitive function, and emotion regulation (Chaput et al., 2017; Tarullo et al., 2011). Getting ample sleep allows infants to engage in processes like memory consolidation (Seehagen et al., 2015). Because infant sleep is emphasized in public health guidance (Hirshkowitz et al., 2015) and is a frequent concern for caregivers, rates of sleep are widely studied using both caregiver report and actigraphy methods (Armstrong et al., 2019; Galland et al., 2012).

Sleep patterns change as infants age (Camerota et al., 2019; Galland et al., 2012; Sadeh et al., 2009; Williams et al., 2013). Newborns typically spend the majority of the day asleep (16 to 18 hours) and take 3-4 daytime naps. At 6 months, total sleep declines to 12.9 hours per day with ~2 naps; at 12 months, total sleep averages 12.6 hours per day with ~1 nap. Sleep is an important source of individual differences in infants' days. For example, 6-month-olds might sleep as little as 9 hours per day with 1 nap and as much as 17 hours per day with 4 naps. These variations

dramatically alter the amount and distribution of awake time in which other activities might occur. However, sleep is usually studied in isolation rather than measured along with other macro-level activity categories.

Play

Play is a fundamental component of early development because it provides opportunities for motor and cognitive development, particularly through object exploration (Herzberg et al., 2021; Lockman & Tamis-LeMonda, 2021; Ruff, 1984). For infants who can crawl or walk, playtime might also allow exploration of distant places and objects (Karasik et al., 2011); accordingly, play is studied in public health research because it provides opportunities for exercise (Hesketh et al., 2015). Play can be solitary, or play can be social. Play with caregivers facilitates linguistic and social development (Ginsburg et al., 2007; Quinn & Kidd, 2019; Tamis-LeMonda et al., 2004; Tamis-LeMonda & Bornstein, 1994). Finally, play creates opportunities for infants to learn culturally-relevant skills and practices (Lockman & Tamis-LeMonda, 2021). Thus, play is widely studied both in laboratory and home contexts. But to know how well studies of play generalize to infants' daily lives, we must measure the frequency of play compared with other macro-level activities.

It is difficult to compare rates of play time compared with other activities because there is little consistency in how play is defined (Zosh et al., 2018). For Pellegrini and Smith (1998), play must include a dimension of "physical vigor", but other definitions include sedentary activities as play. For example, Soderstrom and Wittebolle (2013) defined playtime for infants aged 12 to 29 months as any activity involving toys or social interactions, categorizing it into outside playtime, organized playtime, and general playtime. Hofferth and Sandberg (2001b) included toy play, board games or other social games (e.g., hopscotch), digital games, pretend play, and other

"unspecified indoor and outdoor play" in their definition, but separated some recreation activities (hobbies, sports, art, outdoor activities) into stand-alone categories. Thus, by measuring play versus other activities simultaneously using mutually-exclusive categories, the current study can address the relative amount of time infants spend playing compared with other macro-level activities.

Nursing, eating, and drinking

Nursing, eating, and drinking are macro-level activities that must occur each day, but take relatively less time compared with play (Hofferth & Sandberg, 2001b). For newborns, nursing and/or bottle feeding make up most of their daily nutrition, with a bout of nursing/bottle feeding needed every 2-4 hours. From 6-12 months, intake of solid food becomes more frequent and accounts for more of infants' calories. Among breastfed infants, 3-month-olds spend about 3.5 hours/day nursing compared with 2 hours/day for 12-month-olds (Baxter, 2009). However, it is unknown how total feeding time—combining nursing, bottle feeding, and solid food consumption—differs across the first year. Moreover, prior work has not addressed how mealtime activities might facilitate versus constrain micro-level activities such as sitting, standing, and object holding.

Mealtimes likely provide different learning experiences compared with play. Whether nursing or eating solid food, mealtimes for US infants are expected to be relatively stationary and contain different social exchanges compared with play. Mealtimes constitute a predictable context in which certain objects are likely to be seen (e.g., spoons, bottles, cups, and plates) and labelled, contributing to early vocabulary development (Clerkin et al., 2017). Joint attention between toddlers and their caregivers during mealtimes increases the child's attention to the naming of objects (Schroer et al., 2024). Mealtimes also change social interactions: Mothers

respond less sensitively to infants during mealtime compared with during free play (Vliet et al., 2022). The micro-level activities contained within eating/drinking times may also differ with age after infants are weaned and begin to eat solid foods. For example, breastfed infants experience more physical contact and verbal interactions, such as being held, cuddled, read to, and talked to, compared to bottle-fed infants (Baxter, 2009). The transition from breastfeeding to the introduction of solid foods provides new opportunities for sensory exploration, fine motor skill development, and family interactions (Schwartz et al., 2011).

Book reading

Book reading is frequently studied for its positive impacts on infant cognitive development, since it facilitates language development and provides a head start to later literacy and school readiness (Braid & Bernstein, 2015; Bus et al., 1995; Karrass & Braungart-Rieker, 2005; Murray & Egan, 2014). In particular, book reading increases the diversity of words that infants hear (Montag et al., 2015), since the vocabulary used in books differs from normal day-to-day adult conversation. Most US caregivers report reading to infants at least several times per week, estimating an average of 16 minutes of reading time in each bout of reading (Patel et al., 2024; Taaffe Young et al., 1998). Although reading frequency is reported to increase modestly with infants' age, most preverbal infants (< 9 months) are read to on a regular basis. Book reading may shape micro-level activities in a different way compared to general playtime. For example, Soderstrom and Wittebolle (2013) found higher adult vocalization rates during reading time compared to other macro-level activities. Book reading may also restrict infants' movement and access to objects compared with play.

Media viewing

The frequency of screen media viewing, such as watching television or using touchscreen devices, is widely studied because of the potential detrimental effects (e.g., physical health). In 1999, the American Academy of Pediatrics released a statement discouraging television viewing for children under 2 (American Academy of Pediatrics. Committee on Public Education, 1999). Despite this, 68% of infants and toddlers are exposed to screen media on a daily basis with an average duration of approximately 2 hours (Rideout & Robb, 2020). Screen time increases with age: Brushe et al. (2023) measured ~1.25 hours of screen time for Australian families at 6 months rising to ~2.5 hours by 24 months. However, screen time varies widely between families according to caregivers' attitudes and routines. Whereas 80% Australian infants met physical activity and sleep guidelines, only 30% met screen time guidelines (Rivera et al., 2024). Sociodemographic factors account for some of the variation: screen exposure for 6-month-olds was 50 minutes/day versus 150 minutes/day depending on maternal education level (Brushe et al., 2023). Variations in media viewing time between infants can encroach on/free up time to spend in other macro-level activities. Xu et al. (2016) found that children with greater screen exposure spent less time sleeping. Like book reading and mealtimes, media viewing is likely to be a sedentary activity (Downing et al., 2015). Most likely, some micro-level activities, such as standing upright and object holding, decrease in frequency while viewing media compared with general playtime.

Other macro-level activities: Bathing/dressing, comforting, and errands

Beyond sleep, play, eating/drinking, book reading, and screen time, we considered three additional macro-level activities that reflect everyday necessities: bathing/dressing, comforting, and going on errands. Hofferth and Sandberg (2001a) estimated 11% of awake time for children

under the age of 2 was spent in personal care, which includes hygiene activities like bathing, toileting, and changing clothes. Time spent comforting infants is likely to appear on a daily basis. In a diary study, caregivers reported that 3-month-olds spent 97 minutes/day fussing/crying which decreased to 50 minutes/day by 10 months (St James-Roberts & Plewis, 1996); the age-decreasing trend has been replicated in audio-detection studies of crying (Micheletti et al., 2020). Individual differences in infant fussiness (e.g., colic) could mean that some infants spend more time needing to be comforted (St James-Roberts et al., 1993). Finally, errands out of the house, such as shopping trips, doctor's visits, and other visits likely account for significant time. Transportation, such as in car seats, strollers, and shopping carts, should increase the likelihood that infants are both sitting and restrained when out of the house.

Micro-level activities represent everyday opportunities for learning

A novel aim of the current study is to investigate how the rates of micro-level activities vary according to macro-level activity categories. For example, do infants hold objects more frequently while playing or while eating? Do infants sit more often while on an errand versus while playing at home? We focused the investigation of micro-level activities on four gross motor behaviors—object holding, sitting, upright position, and restraint—because they are easily observed by caregivers (Franchak, 2019; Franchak et al., 2024) and widely studied in both laboratory and home observation research (Franchak et al., 2018; Herzberg et al., 2021; Karasik et al., 2012, 2022; Kretch et al., 2023). Moreover, these four behaviors are of particular interest because they mark everyday opportunities for learning. Infants learn about object properties and words for everyday objects while holding them in their hands and exploring them (Herzberg et al., 2022; Soska et al., 2010). Sitting is an important motor context because it frees up the hands for manual exploration (Soska & Adolph, 2014). Both sitting and upright positions provide

advantageous opportunities for visual exploration of the environment compared to when infants lie prone on their stomachs (Franchak et al., 2018; Kretch et al., 2014; Luo & Franchak, 2020). Infants' time spent restrained, such as in seating devices or held in caregivers' arms, limits opportunities for movement that may hinder motor development (Abbott & Bartlett, 2001; Karasik et al., 2023). Finally, caregivers provide different learning inputs depending on infant's motor behavior: Caregiver's speech varies based on object holding (Custode & Tamis-LeMonda, 2020), sitting (Kretch et al., 2025), upright locomotion (West & Iverson, 2021), and restraint (Malachowski et al., 2023). Although everyday rates of these micro-level activities have been previously reported (Franchak, 2019; Franchak et al., 2024), it is unknown how they vary in frequency according to differences in macro-level activity.

Current Study

Time variation in macro-level activities likely shapes the inputs for early learning and development. However, measuring infant activity presents numerous challenges due to inconsistent categorization schemes (Zosh et al., 2018) and diverse methods of time measurement (e.g., surveys, diaries, observations). Accordingly, the goal of the current study is to measure age differences in infants' macro-level activities using the same set of categories. Drawing on existing work (Baxter, 2009; Hofferth & Sandberg, 2001b; Soderstrom & Wittebolle, 2013), we devised a set of eight activity categories (napping, play, eating/drinking, book reading, media viewing, bathing/dressing, comforting, and transportation) that could be easily observed by caregiver respondents and that should appear in most infants' daily lives.

We aimed to improve on past research by eliminating retrospective caregiver reports, which can suffer from inaccurate memory and/or social desirability bias (Ben-Arieh & Ofir, 2002). Most prior work on infant activity has employed coarse survey estimates, such as asking

how frequently (e.g., number of times per day or per week) an activity occurred (Patel et al., 2024) or asking caregivers to retrospectively estimate the duration of an activity in minutes or hours (St James-Roberts & Plewis, 1996). Some investigations used time diaries that require caregivers to record activities in a log (Hofferth & Sandberg, 2001b). Although time diaries can be more accurate than simple retrospective reports, they are labor-intensive for respondents who need to record all daily activities. Finally, neither survey reports nor time diaries are appropriate for asking how micro-level activities, such as sitting, co-occur with macro-level activities, such as mealtimes.

Instead, we employed ecological momentary assessment (EMA) to send caregivers text message prompts at random intervals throughout the day over four days to report infants' macro-level and micro-level activities at the moment (Ben-Arieh & Ofir, 2002; Franchak, 2019; Shiffman et al., 2008). Unlike retrospective reports, EMA survey responses reflect caregivers' direct observations of behavior. Moreover, gathering responses at random intervals across several days means that time samples of activity are unbiased, allowing us to infer the overall frequency of activities. Finally, because caregivers respond to survey prompts on their smartphones, EMA can capture activities both in the home and on the go, allowing us to study categories that might be missed through direct observation in the home or in the lab, such as errands.

The first aim was to determine which macro-level activities were most frequent in the days of US infants. Instead of 24-hour time diaries (Hofferth & Sandberg, 2001b), we aimed to characterize daytime activity and awake activity. Accordingly, we report activity frequency as a percentage of daytime (excluding nighttime sleep, including daytime naps as an activity) and as a percentage of awake time (excluding naps and nighttime sleep). Based on Hofferth and Sandberg

(2001b), we expect that play will be the most frequent awake activity. Of key interest, however, is what percentage of time infants spend engaged in non-play activities (i.e., errands, mealtimes, bathing/dressing) that are rarely captured in laboratory and home observation studies. Understanding the relative frequency of those macro-level activities will help identify gaps in our understanding of infants' experiences in the first year of life.

The second aim was to determine whether the frequency of activities varies according to age. Based on past work, we expect that sleep and comforting will decrease (Galland et al., 2012; St James-Roberts & Plewis, 1996) and book reading and media viewing will increase (Brushe et al., 2023; Patel et al., 2024). For other categories—play, eating/drinking, and errands—age differences have not been reported. By measuring the same mutually-exclusive set of activity categories in two age groups, we can be more certain that age differences are related to age differences in activity rates, not differences in category definitions/methods across investigations. We compared activity rates in two age groups that completed up to 4 monthly sessions: younger infants who completed sessions between 4-7 months and older infants who completed sessions between 10-13 months. We focused on those age groups because they comprise periods of substantial motor development—many infants learn to sit between 4-7 months and many infants learn to walk between 10-13 months.

The third aim of the study is to test whether micro-level behaviors—object holding, sitting, standing upright, and restraint—differed according to macro-level activities. Since EMA prompts ask caregivers to make direct reports of what is happening in the moment, EMA is ideally suited for studying how micro-level and macro-level activities co-occur. We predict that play will differ from other macro-level activities, such as times spent eating/drinking. For example, we predict that infants will be restrained less often and sit less often while playing

compared with when eating/drinking. Moreover, we expect that infants' age will moderate some effects of macro-level activity type on some micro-level activities. For example, we expect that older infants will stand upright more often while playing compared to while eating/drinking. Differences in standing time according to macro-level activity may not emerge within younger infants for whom standing is rare.

Method

Transparency and Open Science

The full, anonymized survey dataset is openly shared via the Open Science Foundation (https://doi.org/10.17605/OSF.IO/2EHCG). For computational reproducibility, this entire manuscript is written in R (R Core Team, 2023) and Quarto (Allaire et al., 2022) using the *apaquarto* template (https://wjschne.github.io/apaquarto/). All code to reproduce the manuscript, including the analyses, tables, and figures, is shared in the OSF repository along with the necessary data. The manuscript and analyses were created using R version 4.3.2, Quarto 1.6.32, and the following R packages: *tidyverse* (Wickham, 2023), *lme4* (Bates et al., 2024), *rstatix* (Kassambara, 2023), *interactions* (Long, 2021), *patchwork* (Pedersen, 2023), and *flextable* (Gohel & Skintzos, 2023). The study was not pre-registered. The sample size was determined by resource constraints: We recruited as many participants as possible over 2.5 years during which funding was available for advertising, staffing, and participant payments.

Participants and Design

Participants were infant-caregiver dyads recruited via Facebook advertisements across the United States. The cohort-sequential design of the current study consisted of two cohorts that were followed longitudinally over four months. One cohort (n = 58) commenced the study when the infant was 4 months old and continued longitudinally until reaching 7 months old. The other

cohort (n = 62) initiated the study when the infant was 10 months old and continued longitudinally until reaching 13 months old. Data from the older cohort has been previously published (Franchak et al., 20204), however, macro-level activity data were not reported. All legal guardians were eligible to participate in the study; nannies or other caregivers were not eligible to participate. All respondents identified as female and as the primary caregiver of the infant. Table 1 shows family demographics across the two cohorts.

The longitudinal study design involved four monthly sessions of ecological momentary assessment (EMA) within 1 week of the focal ages: 4, 5, 6, and 7 months for the younger cohort, and 10, 11, 12, and 13 months for the older cohort. For each EMA session, caregivers selected three weekdays and one weekend day that would be representative of their infant's typical daily routines to receive survey notifications. Participants were compensated 45 USD for the completion of the study in its entirety. We excluded sessions if they contained fewer than 15 of 40 EMA responses, and we excluded participants if they contributed fewer than 2 sessions. An additional 19 younger participants and 13 older participants were recruited, but did not contribute data to the final sample due to these data quality criteria. In total, the final sample includes 432 sessions with an average of 26.7 completed responses per session.

Procedure

Introduction Call

Following past work that used EMA to obtain data about infants' daily experiences (Franchak, 2019), an experimenter completed a 30-minute introductory phone call with the caregiver to explain the study, obtain informed consent, and discuss survey questions and response options. Caregivers were sent an instruction manual prior to this phone call to follow

during the phone call. After reviewing the instruction manual, the experimenter conducted a brief comprehension quiz to ensure understanding of the macro- and micro-level activity categories.

EMA Survey Notifications

Caregivers chose 3 weekdays and 1 weekend day +/- 1 week of their infant's focal age for each monthly session (i.e., 4/5/6/7 months for the younger cohort, 10/11/12/13 months for the older cohort). Experimenters advised caregivers to avoid picking atypical days (e.g., family vacations) or days when the caregiver would not plan to spend most of their time with the infant. They were also asked to indicate the time they would like to begin receiving messages, typically beginning in the morning when their infant wakes up. Automated survey notifications were sent at random each hour for 10 consecutive hours through the "formr" survey framework (Arslan et al., 2019). Notifications started at an hour the caregiver indicated that the infant typically wakes for the day. To keep survey prompts from being predictable, the survey distribution code randomly selected a time between the 15th and 45th minute of every hour, making sure the messages did not arrive within a few minutes of each other. If participants did not respond within 15 minutes, the survey prompt expired.

Survey Items

EMA text messages contained a link to a 6-item survey that took around a minute to complete. Caregivers were asked to complete the survey as soon as it was safe and possible to do so by looking at their infant at the moment they received the alert and answering all questions based on that momentary observation of their infant.

The first item of the survey asked, "Are you with your child? Is your child awake?" The answer options were "child awake", "child sleeping", or "not with child." The subsequent questions were only asked if the caregiver responded "child awake".

The second item asked, "Is your child…" and caregivers could select one item from the following options: "restrained by device/furniture", "restrained by caregiver", "locomoting", or "neither". Depending on the answer to the second question, the caregiver would be asked a follow-up question about either the type of device or furniture, caregiver restraint type, or body position ("supine", "prone", "sitting", or "upright") during unrestrained activity. These follow-up questions included the option to write-in their child's behavior if it did not fall into the offered categories, to document the study child's position.

The next item asked, "Select the activity that your child is engaged in." Caregivers could select one item from the following options: "napping", "feeding", "bathing/dressing", "reading", "media viewing", "errands or transportation", "comforting", "play", or "other" with a write-in option to document the study child's activity context. Responding "other" was rare, accounting for only 330 of 11531 responses (2.9%). Of those, 217 could be recoded into the existing categories based on the free responses (i.e., "Going for a walk" would be rescored as "Errands/Transportation"). The remaining 113 were left as "other", which included responses such as "swimming", "blowing spit bubbles", and "making faces".

The last item asked, "Is your child holding an object?" Caregivers could respond "Yes" or "No", allowing us to calculate the proportion of time the child was holding an object.

Results

How do infants in the United States spend their time? The present study leveraged 11531 total caregiver reports of infants' everyday experiences to characterize their macro-level activities. We report three sets of results. First, we reveal how infants spend their time by analyzing activity frequencies averaged across age. Second, we examined which activities differed in frequency comparing younger versus older infants. Third, we report how infants'

micro-level activities—holding objects, sitting, upright position, and restraint—vary according to infants' current activity and age to demonstrate how activity sets the stage for perceptual-motor exploration.

Frequency of Everyday Activities

Our first analysis focused on the relative difference in frequency between activity categories, collapsing across infants' age (Figure 1). We report the prevalence of activities in two ways: including napping as an activity with activity frequency expressed as a percentage of **daytime** (Figure 1 A), and excluding times that infants napped with activity frequency expressed as a percentage of **awake time** (Figure 1 B). In each case, the number of caregiver reports of each activity were summed for each infant across monthly sessions and divided by the appropriate denominator. For frequency including naps, the denominator was the total of available samples for that infant across sessions (excluding times that the caregiver was not with the infant). For frequency excluding naps, the denominator was the total of awake samples in which the caregiver was with the infant across sessions. Figure 1 shows the mean percentage for each activity averaged across infants with 95% confidence intervals. Since activity categories are necessarily dependent—if an infant is in one activity, they cannot be in another—it would not be appropriate to compare activity frequencies directly using a GLM. Instead, we provide 95% confidence intervals as a guide to interpret the relative frequency of activities.

Activity as a Percentage of Daytime

As Figure 1 A indicates, infants spent most of their daytime playing (M = 33.13%, 95% CI [31.41, 34.85]) and napping (M = 32.23%, 95% CI [30.34, 34.13]). Overlapping confidence intervals between playing and napping suggests that playing was not significantly more frequent. Eating/drinking was the next most frequent category (M = 15.03%, 95% CI [14.05, 16.00]),

occurring about half as often as either playing or napping and with no overlap in confidence intervals. Errands were less frequent (*M* = 8.13%, 95% CI [7.25, 9.00]) than eating/drinking, but still more frequent than the remaining categories: media time (*M* = 3.92%, 95% CI [2.94, 4.89]), comforting (*M* = 3.17%, 95% CI [2.38, 3.96]), bathing and dressing (*M* = 1.96%, 95% CI [1.60, 2.32]), reading (*M* = 1.40%, 95% CI [1.00, 1.79]), and other (*M* = 1.03%, 95% CI [0.74, 1.33]). Media time and comforting appeared to be more frequent than bathing/dressing, reading, and other; however, we are cautious to avoid making a strong claim about differences in the least frequent five categories given the low base rates and possible floor effects. Although the five least frequent categories each amount to a small portion of infants' daytime, in combination they comprise a total of 11.48%, highlighting the diversity of experiences that occur beyond the predominant categories of playing, napping, and eating/drinking.

Activity as a Percentage of Awake Time

Although the rank order of activities is identical when analyzing activity prevalence as a percentage of awake time excluding naps, we report those statistics since they might be relevant for researchers studying everyday learning and social interaction. As Figure 1 B shows, the four most frequent activities were play (*M* = 48.39%, 95% CI [46.34, 50.43]), eating/drinking (*M* = 22.04%, 95% CI [20.71, 23.37]), errands (*M* = 11.95%, 95% CI [10.70, 13.19]), and media time (*M* = 6.19%, 95% CI [4.42, 7.96]). Play accounted for nearly half of infants' awake time. Going up from media to play, each category approximately doubled the previous category in frequency. None of the confidence intervals overlapped, lending high confidence that the top four categories were distinct in frequency from one another. Low base rates among the least frequent categories, comforting (*M* = 4.83%, 95% CI [3.62, 6.04]), bathing and dressing (*M* = 2.99%, 95% CI [2.42,

3.56]), reading (*M* = 2.13%, 95% CI [1.51, 2.76]), and other (*M* = 1.49%, 95% CI [1.08, 1.90]), make it difficult to discern whether there are reliable differences in frequency.

Activity Frequencies Differ between Younger and Older Infants

Our second analysis identified whether the frequency of each activity type differed according to age group. Here, we treated each activity as a separate dependent variable modeled in a generalized linear mixed-effect model (GLMM) with a binomial link function to identify whether the likelihood of an activity differed between age groups (with younger infants as the reference category). For each GLMM, the focal activity was coded as a "1" for each observation if it was present and a "0" if the infant was reported to be in any other activity, using all samples in which the caregiver was able to observe the infant. Random intercepts were included for each unique participant to account for the repeated testing over monthly sessions. Random slopes were modeled according to age group. Table 2 shows the result of each GLMM, with the odds ratio (OR) indicating the difference in likelihood of an activity occurring for being an older versus a younger infant. For example, an odds ratio of 1.32 for play indicated that older infants were 1.32 times as likely to be reported as playing compared to younger infants.

As Figure 2 indicates, play and eating/drinking time were significantly greater among older infants compared with younger infants (ORs > 1), whereas time spent napping and being comforted were significantly less frequent for older infants compared with younger infants (ORs < 1). No differences were observed for time spent bathing/dressing, going on errands, reading, or watching media. The most salient age difference was play. Younger infants played *M* = 29.8% of the day, whereas older infants played *M* = 36.3%. Younger infants spent *M* = 13.6% of the day eating/drinking, significantly less compared to older infants (*M* = 16.4%). Decreases in time spent napping and being comforted freed up time for the increases in playing and

eating/drinking. For the younger cohort, infants napped $M = 35.2\%$ of the day compared with $M = 29.5\%$ for older infants. Caregivers reported more time spent comforting younger infants: $M = 6\%$ for younger infants versus $M = 0.5\%$ for older infants.

Activity Moderates Opportunities for Perceptual-Motor Exploration

In our third set of analyses, we asked how the frequency of micro-level motor activities varied according to macro-activity context and age. We focused on the likelihood of object holding, sitting (independent and/or with support), upright position (standing, walking), and restraint (placed in a device or held by a caregiver), conditioned on infants' current macro-level activity. Because of the large number of macro-level activity categories and low base rates of the least frequent categories, we chose to analyze the three most frequent awake categories: play, eating/drinking, and errands. For each analysis, we used a GLMM modeling approach that used the binary micro-level activity as the dependent measure (e.g., 1 = holding an object, 0 = not holding an object) with fixed effects of age group (centered), activity category (play, eating/drinking, errand), and their interaction. Random intercepts were modeled by participant, and random slopes were modeled according to age group. We used a model comparison approach to add fixed effects and interactions sequentially from a random-effects-only model; in all cases, the fit was improved by including both fixed effects and their interaction. In all analyses, play was the reference category. The final models are described in Table 4; Table 5 contains the full descriptive statistics for the frequency of each micro-level activity occurring within each macro-level activity for each age group.

Overall, results revealed that all four micro-level activities varied in frequency comparing between play, eating/drinking, and errand activities, suggesting that opportunities for perceptual-motor learning differ according to macro-level activities. Moreover, significant interactions with

age indicate that macro-level activities provide varying opportunities for perceptual-motor exploration to younger versus older infants.

Object Holding

Both age and activity type moderated infants' object holding behavior. As seen in Figure 3, object holding was greater overall for older versus younger infants. However, the significant interactions (Table 4) indicate that age differences in object holding depended on the type of activity. Follow-up Holm-Bonferroni corrected pairwise comparisons between age groups within each activity revealed age differences within play ($p = 0.01$) and eating/drinking activities ($p < .01$), but not within errand times ($p = 0.41$). Across ages, infants held objects for M = 27.8% of errand time. In contrast, older infants spent double the amount of eating/drinking time holding objects (M = 51.1%) compared with younger infants (M = 23.5%). Older infants also held objects more often during play (M = 44.5%) compared with younger infants (M = 36.2%), but the age difference was not as large as during eating/drinking times. Thus, infants' opportunities to manually explore objects differ between playtime, eating/drinking time, and errand time, with older infants receiving more opportunities for object holding during play and mealtimes.

Sitting Position

How often infants sat varied both by age and by activity type (Figure 3). Replicating past work (Franchak, 2019), sitting frequency significantly increased with age (Table 4). The current research is novel in showing that overall rates of sitting varied greatly between daily activities: Sitting was most frequent while on errands (M = 97.5% of errand time), followed by while eating/drinking (M = 77.3% of eating/drinking time) but was least frequent during play time (M = 35.2%). Significant interactions and follow-up pairwise comparisons revealed that age

moderated sitting time within play ($p < .01$) and within eating/drinking ($p < .01$), however, no significant age effect was found for sitting within errand times ($p = 0.11$).

Upright Position

As expected, younger infants spent less time upright compared with older infants, and upright time varied according to activity (Figure 3). Table 4 shows significant parameters for eating/drinking and errands that indicate the relatively lower base rates of upright among those activities compared with the reference category of play (ORs < 1). Furthermore, follow-up Holm-Bonferroni corrected pairwise comparisons indicate that age significantly moderated upright time during play ($p < .01$) but not during eating/drinking ($p = 0.25$) or errand times ($p = 0.20$). For older infants, upright accounted for $M = 42.9\%$ of play time compared with $M = 15.3\%$ of play time for younger infants.

Restraint

Younger infants spent more time restrained compared with older infants, and restraint varied greatly between activities (Figure 3). Across age groups, infants were almost always restrained during errand times ($M = 96.8\%$) and were frequently restrained when eating/drinking ($M = 83.5\%$), but restraint was less common during play ($M = 29.2\%$). Age differences were the largest for play, with younger infants spending $M = 45.6\%$ of play time restrained compared to only $M = 17.1\%$ for older infants. Significant interaction terms (Table 4) and follow-up comparisons confirmed age differences in restraint within play time ($p < .01$) and eating/drinking ($p < .01$), but not during errand time ($p = 0.17$).

Discussion

Development depends on time spent in both micro-level activities—bouts of standing, holding objects, seeing faces, and hearing speech—and macro-level activities—playing, eating

meals, and going on errands. Infants' days were filled with a variety of macro-level activities that varied by age and between individuals. Our findings, collected using a novel EMA method, converge with past work that used time diaries (Hofferth & Sandberg, 2001b) by showing that play was the most frequent category for US infants and confirming that eating/drinking, going on errands, and watching media were moderately frequent. Play was the most frequent macro-level activity, accounting for half of infants' awake time. Non-play activities, which are rarely studied in laboratory and observational research, comprise the other half of infants' early experiences.

This matters for understanding perceptual-motor exploration because rates of micro-level activities varied according to macro-level activity category. While playing, infants sat less, stood upright more, and were restrained less often compared to when on errands and while eating/drinking. Modest age differences in macro-level activity frequencies mean that experiences accumulate at different rates. Furthermore, how macro-level activities co-occurred with some micro-level activities also depended on age. During play, older infants held objects more, sat more, were upright more, and were restrained less than younger infants. But age differences were absent during errand times, when infants were likely to be sitting and restrained and unlikely to be upright or holding objects. Thus, macro-level activities provide different opportunities for learning by facilitating/constraining the kinds of perceptual-motor exploration that infants (depending on age) can experience within activity types (see also Montag et al., 2018; Tamis-LeMonda et al., 2019 for related theoretical priorities in the domain of early word learning). Visual inspection of Figure 3 also shows that there is considerable individual variability in micro-level activity rates even within a given age group and macro-level activity type. For example, some older infants were restrained 0% of their playtime whereas others were restrained for 50%, and infants on errands held objects between 0-100% of errand time. More

work is needed to identify the source of these individual differences, which could be due to caregiving styles (e.g., decisions about restraint, providing objects, cultural beliefs about parenting), infant factors (e.g., motor skills, fussiness about being restrained, interest in objects), and the physical culture (e.g., availability of objects and furniture).

The distribution of macro-level activities showed a striking, long-tailed distribution: A few activities (e.g., play, eating/drinking) comprise most of US infants' time, with numerous activities taking a small share. This creates dramatic differences in the accumulated time spent in different activity types. Figure 4 illustrates how daily rates of activity translate to differences in accumulated experiences with exemplar younger and older infants who represent the 25th and 75th percentile rates for playtime. The left panel shows the distribution of their awake activity converted to hours of behavior based on an 11.1-hour waking day (Galland et al., 2012). Whereas the younger infant was estimated to play 4.7 hours a day, eat/drink for 2.2 hours/day, and spend 0.4 hours being read to, the older infant played 6.2 hours, spent 2.9 hours eating/drinking, and experienced 0.6 hours of reading. The right panel shows how those daily rates might accumulate over a month (based on linear extrapolation). Even though the daily activity differences are modest, they could amount to large differences in experiences over just 30 days. The older infant is estimated to total 44 more hours playing, 21 more hours eating/drinking, and 8 more hours in book reading compared to the younger infant.

Comparing accumulated experiences between activities within an infant exemplifies how relative base rates matter. Looking at the older infant's experiences in Figure 4 (solid lines), 2.9 hours of eating/drinking time accumulates to 86 hours of experience, whereas 0.6 hours of reading time accumulates to only 19 hours of experience over 30 days. Characterizing the relative accumulation of learning experiences helps contextualize past research. Mealtimes are a

consistent context for early noun learning (Clerkin et al., 2017), and here we show that those experiences take substantial time each day and provide ample opportunities for object holding and object naming when amassed over a month. Book reading predicts later developmental outcomes despite its low frequency (Braid & Bernstein, 2015; Bus et al., 1995; Karrass & Braungart-Rieker, 2005; Montag et al., 2015; Murray & Egan, 2014), suggesting that it is a high impact (or highly efficient) learning activity. Even small individual differences in daily reading time (i.e., 0.4 versus 0.6 daily hours) accumulate to large differences in reading experiences (19 versus 11 hours over a month). Moreover, this highlights the potential impact of making small daily modifications to caregiving practices through interventions.

Although we focused on activity frequency—the overall time spent in each activity—we stress that frequency is only one aspect of temporal structure (Abney et al., 2025). For example, infants' daily experiences hearing music are brief and bursty, meaning that infants are most likely to hear music in repeated episodes during some portions of the day with other portions containing no music experience at all (Mendoza & Fausey, 2022). How macro-level activities are clustered in time and whether activities are repeated in multiple bouts might be relevant for learning outcomes (Cychosz et al., 2025; Nencheva et al., 2024; Slone et al., 2023). Clustering might be optimal for learning because it provides epochs of blocked practice—hearing the same novel word or attempting the same difficult motor skill—interspersed with periods of downtime for rest and reconsolidation (Lee & Fisher, 2019; Newell et al., 2001; Shea et al., 2000). Cyclical needs for rest and nourishment mean that naps and mealtimes will be distributed across the day. Lower-frequency activities, such as book reading, might occur in a few bouts at predictable times (i.e., reading before naps and bedtime). Because we estimated frequency from moments sampled randomly throughout the day, it is impossible to know how often activities switched—did infants

experience long bouts of play, or was play frequently interrupted by meals, naps, and errands? Potentially, hybrid approaches that blend EMA sampling with time diary reports (and/or continuous audio recording) could help identify the event structure of macro-level activities to address questions about how activities are spaced, sequenced, and organized (Abney et al., 2025).

It is important to note that the current study cannot address causality—why did activities occur in the observed distribution? Of course, we expect that daily routines depend on caregiving decisions. Caring for infants means choosing when infants eat, when they sleep, when their clothes need to be changed, and how to spend the remaining discretionary time. But those decisions do not happen in isolation—caregivers have to contend with various demands on their time, such as other children, remote work, and household chores. And, caregiving must be responsive—the planned outing to the park might be nixed after the infant misses a nap; added screen time and comforting fill the gap on the fly. That activities differed according to age shows one way in which caregivers responded to changes in infants' needs and abilities—older infants need less sleep and comfort, so they can instead spend more time playing and eating as they contend with solid food.

Individual differences in families likely impact how different infants spend their time. Time use is dependent—spending longer in one activity means less time in the day for other activities. The distributions of individual data in Figure 2 suggest that between-participant differences in activity time within an age are greater in magnitude than the age differences. Individual differences in certain activities, such as sleep and screen time (Brushe et al., 2023; Galland et al., 2012; Xu et al., 2016), are well-established in prior work. We expect that there are other, more mundane factors that create differences in time use. For example, daily errand time

might depend on a caregiver's willingness to take an infant out of the house, access to a car versus public transportation, their infant's tolerance for sitting in the car seat or stroller, and/or the availability of a partner or delivery service to pick up the groceries. Individual differences in macro-level activity time will likely create corresponding individual differences in micro-level activity rates. For example, errand time was distinct from other activities in that infants were mostly sitting restrained, and they rarely held objects or stood upright. Between participant or day-to-day variations in spending time on errands, thus, should create different opportunities for everyday perceptual-motor exploration.

Strengths, Limitations, and Future Directions

One goal of the present study was to improve ecological validity through accurate measurements of infants' macro-level activities. The current method was advantageous for representatively sampling time by scheduling EMA prompts throughout the day over several days. Remote, smartphone-based data collection helped gather a more representative participant sample than could be achieved through a local, observational study. Some demographic categories closely matched 2020 US Census levels (19.2% Hispanic/Latino in the current sample compared to 18.7% in the US Census) and others were within 10% of those US Census levels (e.g., the current sample identified as 61.0% White, 15.3% Two or More Races, and 8.5% Black compared to 61.0% White, 10.2% Two or More Races, and 12.4% Black in the US Census). In the current sample, 25.8% of people identified as living in a town, village, or rural area, which tracks US 2020 Census estimates of 20% of people living in a rural (vs. urban) area. A much larger sample using a quota sampling strategy and/or recruitment avenues beyond Facebook advertisements would be needed to even more closely represent the US population. However, an advantage of the EMA method for future work is that it is possible to scale in order to model

even larger samples across large geographic areas. Collecting more detailed demographic data using standardized protocols (e.g., Singh et al., 2024) would also help characterize future samples and identify potential sources of individual variability in activities at the family level.

One particular sampling limitation of the current study was that the demanding protocol meant that we only included families who had a caregiver with the infant throughout the day. This means that families with infants in full-time daycare were unlikely to participate, and our data exclude any times during the day that infants spent in a daycare setting. Although our findings are representative of many US infants' experiences, they are unlikely to generalize to infants who spend significant portions of time in daycare. Soderstrom and Wittebolle (2013) compared home care and daycare settings in their analysis of infant activity, and although there were similar times for many categories, others differed: In daycare, infants rarely watched TV and spent more time in outdoor play. In future work, a dual-respondent design that includes both the infants' caregiver and daycare provider could be used to gather EMA reports of infants' activities across care settings.

High demand on participants—responding to 10 hourly notifications per day—likely accounts for why response rates in the current study (66.8%) were lower than in some past research (e.g., exceeding 95% in Franchak, 2019). Potentially, participants' responsiveness might have depended in part on the current macro-level activity, which could have biased rates of responding to some activity categories. For example, caregivers might have found it easier to respond while infants were napping or watching media, but harder to respond when changing a diaper or comforting a fussy infant. Consequently, we took a cautious approach in comparing the relative rates of activities, and in particular, activities with lower base rates. It seems safe to conclude that infants spent more time playing and sleeping than eating/drinking since the former

categories were reported twice as frequently. However, lower base rates and the potential for reporting bias among less frequent categories, such as bathing versus watching media, mean that rates should be interpreted cautiously.

Another limitation is in the particular definitions we used for macro-level activity categories. This is not unique to the present study; all investigations of macro-level activities need to choose a set of categories (Baxter, 2009; Casillas, 2023; Hofferth & Sandberg, 2001b; Soderstrom & Wittebolle, 2013), and researchers select categories that make sense given their focal age and study design. For example, we did not include sports and homework as categories for a study that focused solely on infants, although those activities were relevant for Hofferth and Sandberg (2001b) who studied activities across childhood. Whereas Baxter (2009) focused on the role of breastfeeding and differentiated nursing from eating solid foods, we combined all types of nourishment into a single category. Our method depended on caregivers to score each activity, so we opted for a smaller set of activities that were easily distinguished from each other.

Perhaps the most difficult decision was how to define "play". As we reviewed, researchers disagree about what constitutes play (Zosh et al., 2018). We made play a "catch-all" category and instructed caregivers to use play to include general "hanging out" and times with no particular focus. Accordingly, play in the current study collapses across many sub-types of play that are of interest to researchers in different fields, such as outdoor play, toy play, and social play. We also chose to use mutually-exclusive categories, forcing caregivers to select only one activity for a given moment. This is an oversimplification because it is possible to eat a meal while watching TV or to play while on an errand. However, since our goal was to understand the relative frequency of activities and how they shaped micro-level behavior, choosing a mutually-

exclusive scheme fit our purpose. Real-world activities might not be so rigid and may be better represented as continua rather than true categories (Zosh et al., 2018).

Conclusion

The current study highlights an understudied aspect of infants' daily experiences—the daily distribution of macro-level activities that form a day. Quantifying daily activity rates means that researchers no longer need to make assumptions about how infants spend their time. Models of early learning should account for these distributions because activities vary day to day, between infants, and across age. Importantly, daily activities offer different opportunities for learning by constraining micro-level activities. In future work, our EMA method for simultaneously measuring macro- and micro-level activity can be extended to test infants in multiple contexts (e.g., daycare) and cultures.

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Table 1

Participant demographics for the younger cohort, older cohort, and overall sample.

		Younger		Older		Overall	
		N	%	N	%	N	%
Infant's Sex Assigned at Birth	Female	32	55.20	34	54.80	66	55.00
	Male	23	39.70	28	45.20	51	42.50
	Unknown	3	5.20	0	0.00	3	2.50
Infant's Race	Asian	2	3.40	1	1.60	3	2.50
	Black Or African American	9	15.50	1	1.60	10	8.30
	More Than One Race	8	13.80	10	16.10	18	15.00
	Other Race Not Listed	1	1.70	5	8.10	6	5.00
	White	36	62.10	45	72.60	81	67.50
	Unknown	2	3.40	0	0.00	2	1.70
Infant's Ethnicity	Hispanic Or Latino	12	20.70	11	17.70	23	19.20
	Not Hispanic Or Latino	44	75.90	51	82.30	95	79.20
	Unknown	2	3.40	0	0.00	2	1.70
Community Type	Rural Area	10	17.20	5	8.10	15	12.50
	Town Or Village	5	8.60	11	17.70	16	13.30
	Suburbs Of A Large City	18	31.00	17	27.40	35	29.20
	Small City	15	25.90	14	22.60	29	24.20
	Large City	8	13.80	15	24.20	23	19.20
	Unknown	2	3.40	0	0.00	2	1.70
Annual Family Income	<$25,000	7	12.10	5	8.10	12	10.00
	$25,000-$50,000	10	17.20	15	24.20	25	20.80
	$50,000-$75,000	18	31.00	10	16.10	28	23.30
	$75,000-$100,000	9	15.50	7	11.30	16	13.30
	$100,000-$125,000	3	5.20	11	17.70	14	11.70
	$125,000-$150,000	1	1.70	1	1.60	2	1.70
	$150,000-$175,000	2	3.40	2	3.20	4	3.30
	$175,000-$200,000	0	0.00	4	6.50	4	3.30
	>$200,000	0	0.00	1	1.60	1	0.80
	Unknown	8	13.80	6	9.70	14	11.70
Mother's Education	Partial High School	0	0.00	2	3.20	2	1.70
	High School Graduate/GED	2	3.40	5	8.10	7	5.80
	Partial College	13	22.40	17	27.40	30	25.00
	Standard College Graduation	27	46.60	21	33.90	48	40.00
	Graduate/Professional Training	14	24.10	17	27.40	31	25.80
	Unknown	2	3.40	0	0.00	2	1.70

Table 2

Generalized linear mixed-effect model results of activity frequency as a function of age group

Activity	Term	Odds Ratio	Conf. Int.	p
Play	Intercept	0.43	[0.38 0.48]	<.001
	Older Infant	1.32	[1.14 1.52]	<.001
Nap	Intercept	0.52	[0.46 0.6]	<.001
	Older Infant	0.79	[0.67 0.93]	.005
EatDrink	Intercept	0.16	[0.14 0.17]	<.001
	Older Infant	1.26	[1.09 1.45]	.002
Errand	Intercept	0.08	[0.06 0.09]	<.001
	Older Infant	1.13	[0.89 1.44]	.308
Media	Intercept	0.02	[0.01 0.03]	<.001
	Older Infant	1.57	[0.83 2.98]	.167
Comforting	Intercept	0.06	[0.04 0.07]	<.001
	Older Infant	0.05	[0.03 0.1]	<.001
BathDress	Intercept	0.02	[0.02 0.03]	<.001
	Older Infant	0.89	[0.62 1.27]	.516
Read	Intercept	0.01	[0 0.01]	<.001
	Older Infant	1.72	[0.95 3.11]	.075

Each activity was modeled separately as a function of age group (younger infants were the reference category) with random intercepts for unique participant and random slopes by age group. Odds ratios indicate the change in activity likelihood between the younger and older age groups; ratios greater than 1 indicate the activity was more likely for older infants whereas ratios less than 1 indicate the activity was less likely for older infants.

Table 3

Mean activity frequency for younger versus older infants.

Activity	Younger	Older
Play	29.8 (9.7)	36.3 (8.3)
Nap	35.2 (12.2)	29.5 (7.7)
EatDrink	13.6 (5.5)	16.4 (4.9)
Errand	7.7 (5.0)	8.6 (4.7)
Media	3.5 (5.3)	4.3 (5.5)
Comforting	6.0 (4.7)	0.5 (1.3)
BathDress	2.2 (2.2)	1.8 (1.7)
Read	1.0 (1.9)	1.7 (2.4)
Other	1.1 (1.8)	1.0 (1.5)

Units are percentage of daytime. Standard deviation is shown in parentheses following each mean.

Table 4

Generalized linear mixed-effect model results showing that each micro-level activity differed according to macro-level activity and age group

Behavior	Term	Odds Ratio	Conf. Int.	p
Holding	Intercept	0.70	[0.61 0.8]	<.001
	Age Group	1.48	[1.12 1.94]	.005
	EatDrink	0.87	[0.77 0.99]	.032
	Errand	0.54	[0.46 0.64]	<.001
	Age×EatDrink	2.78	[2.14 3.61]	<.001
	Age×Errand	0.58	[0.41 0.81]	.001
Sitting	Intercept	0.50	[0.43 0.58]	<.001
	Age Group	1.71	[1.27 2.31]	<.001
	EatDrink	6.08	[5.02 7.37]	<.001
	Errand	90.79	[55.69 148.01]	<.001
	Age×EatDrink	1.62	[1.08 2.44]	.019
	Age×Errand	0.25	[0.09 0.7]	.009
Upright	Intercept	0.37	[0.3 0.45]	<.001
	Age Group	4.65	[3.11 6.96]	<.001
	EatDrink	0.20	[0.15 0.27]	<.001
	Errand	0.02	[0.01 0.05]	<.001
	Age×EatDrink	0.32	[0.17 0.6]	<.001
	Age×Errand	1.26	[0.15 10.28]	.83
Restraint	Intercept	0.34	[0.29 0.4]	<.001
	Age Group	0.25	[0.18 0.35]	<.001
	EatDrink	17.08	[14.52 20.09]	<.001
	Errand	102.69	[69.37 152.01]	<.001
	Age×EatDrink	1.94	[1.39 2.72]	<.001
	Age×Errand	2.19	[0.96 5]	.061

Each micro-level activity was modeled separately with fixed effects for macro-level activity (play, eating/drinking, errands), mean-centered age group, and age by activity interactions. Random intercepts were modeled by participant. Play was the reference category. Odds ratios > 1 indicate that the likelihood of an activity increased relative to play and/or among older infants.

Table 5

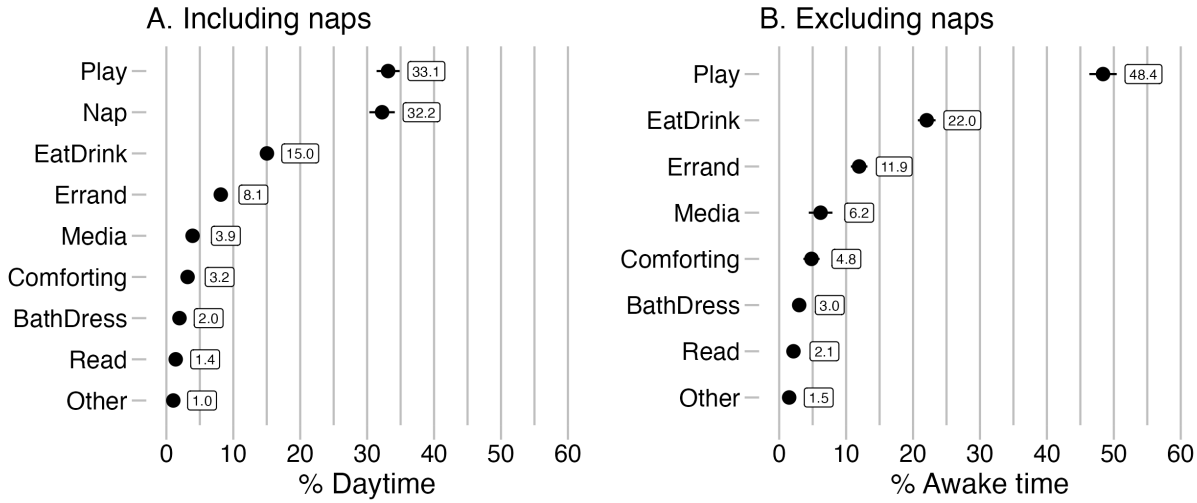
Percent of time holding objects, sitting, upright, and restraint within each macro-level activity category for younger versus older infants.

Behavior	Activity	Younger	Older
Holding	Play	36.2 (48.1)	44.5 (49.7)
	EatDrink	23.5 (42.4)	51.1 (50.0)
	Errand	29.9 (45.8)	26.2 (44.0)
Sitting	Play	29.1 (45.5)	39.0 (48.8)
	EatDrink	61.1 (48.9)	81.7 (38.7)
	Errand	98.5 (12.1)	96.8 (17.6)
Upright	Play	15.3 (36.0)	42.9 (49.5)
	EatDrink	8.8 (28.4)	9.6 (29.4)
	Errand	0.3 (5.4)	1.7 (13.0)
Restraint	Play	45.6 (49.8)	17.1 (37.7)
	EatDrink	88.6 (31.8)	79.9 (40.1)
	Errand	97.8 (14.6)	96.0 (19.6)

Units are percentage of macro-level activity time. Standard deviation is shown in parentheses after each mean.

Figure 1

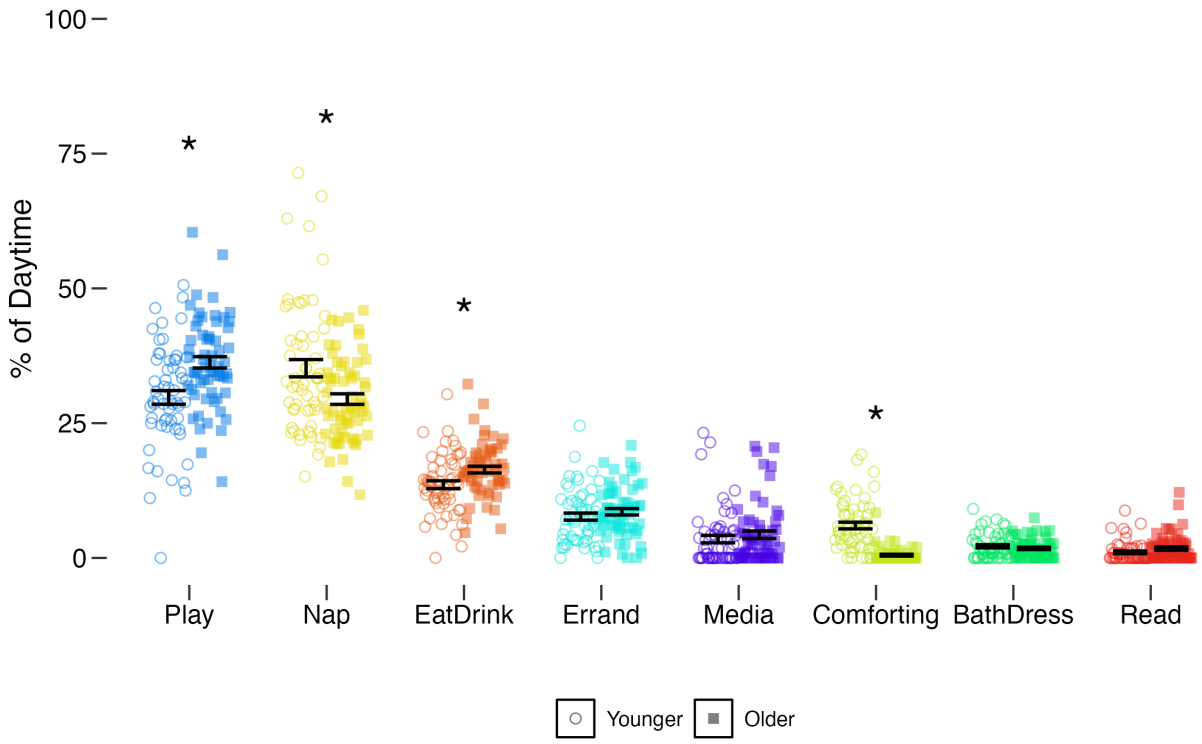
Macro-level activity frequencies averaged across age as a percentage of (A) daytime (including naps) and (B) awake time (excluding naps)



Horizontal error bars show 95% confidence intervals

Figure 2

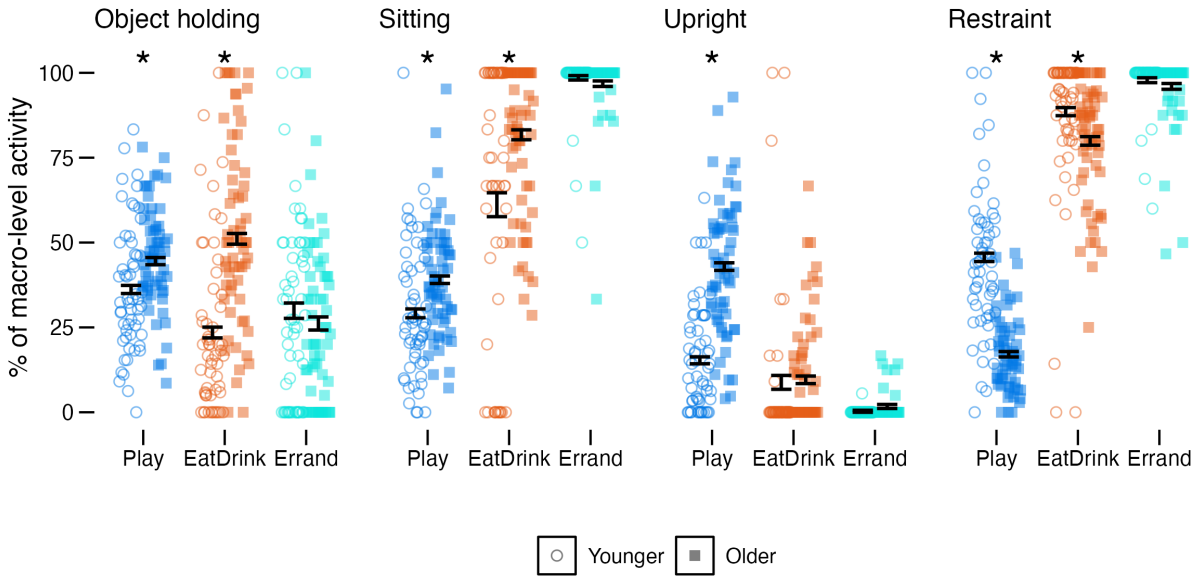
Macro-level activity frequencies according to infant age group



Each circular point shows the individual frequency for one infant collapsed across sessions within the age group. Error bars are centered on the mean and indicate 1 SE. Asterisks indicate significant effects of age.

Figure 3

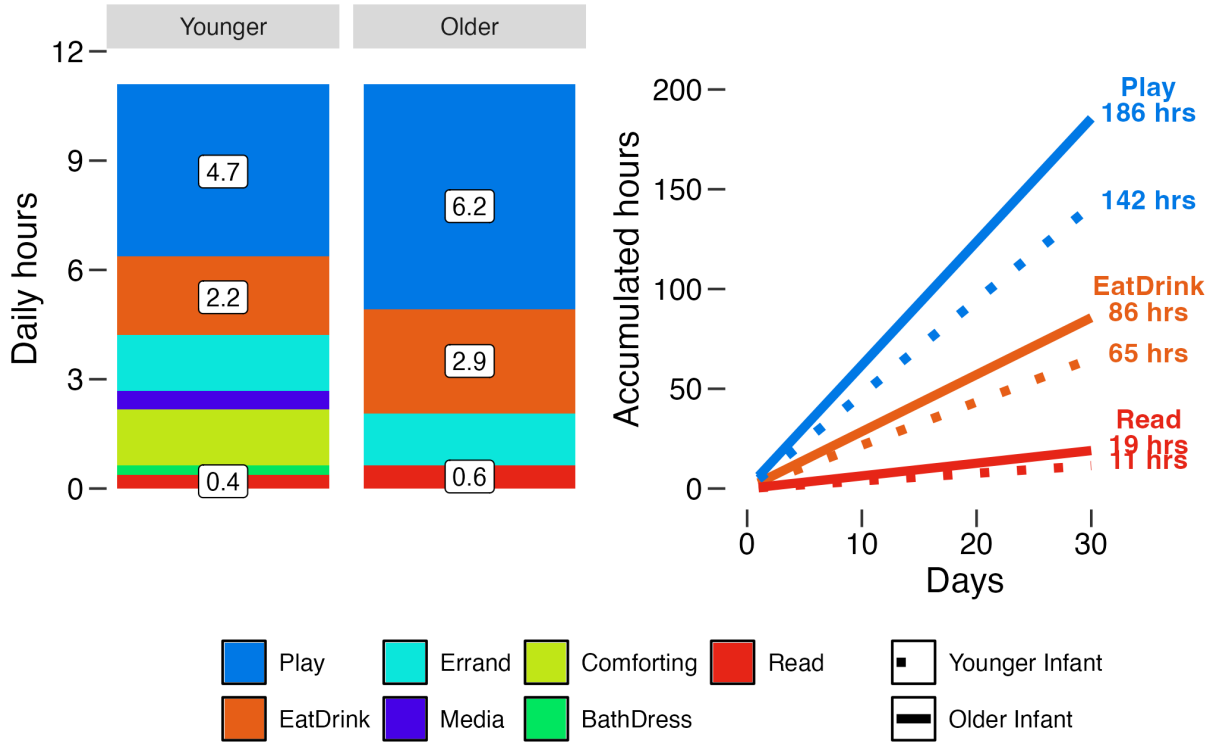
Likelihood of holding, sitting, upright, and restraint within each of the three most frequent macro-level activities according to age



Each circular point shows one infant's data collapsed across sessions and indicates the percent of samples within each macro-level activity that the infant was reported to be holding, sitting, upright, or restrained. Error bars are centered on the mean and indicate 1 SE. Asterisks indicate significant Holm-corrected pairwise age comparisons within each activity category.

Figure 4

Individual exemplars illustrate how a younger infant's versus an older infant's daily activity time could accumulate to large monthly differences in experience



Left panel shows the daily distribution of macro-level activities for two exemplar infants, one younger and one older. The younger infant represents the 25th percentile for play time and the older infant represents the 75th percentile for play time. Right panel shows the predicted accumulation of hours of experience for play, eating/drinking, and reading, linearly extrapolated from the daily activity rates, with separate lines for the younger infant (dotted lines) and older infant (solid lines).