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Daylong patterns of object-centric interaction in two subsistence societies

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A B S T R A C T

Object-centric interactions provide rich sources of multimodal input for early learning. Using daylong photo streams from child-worn cameras, we analyze > 90k images to identify the frequency and targets of object handling across the first three years of life in two small-scale subsistence farming communities on opposite sides of the globe (Tseltal Mayan and Rossel Papuan). We find that infant object handling is relatively frequent in both communities, capturing just under one-third of infants' waking time, on average, and increasing with age. In contrast, others' handling of child-relevant objects was exceptionally rare, capturing only 1–2% of infants' waking time, on average, in both communities. The distribution of infants' handled object categories (e.g., consumables, mealtime tools, natural kinds, etc.) was broadly similar across communities and relatively stable over development, likely reflecting consistent features of children's physical environments and daily routines. However, the exact objects available to infants varied substantially both within and between communities. We discuss how the objects infants handle index their early experiences and offer a window into the sociocultural contexts shaping their everyday learning.

1. Introduction

A great deal of developmental science seeks to understand how children come to internalize and reproduce the invisible structures of their social worlds (e.g., object categories, linguistic structures, social roles, politeness norms). Doing so requires capturing children's everyday sensory experiences—what they see, hear, do, and interact with. But how can such natural experiences be sampled?

Researchers have approached this question using diverse methods, depending on their theoretical aims and the tools available to them. The miniaturization of recording hardware in the last two decades has allowed researchers to capture unique insights from child-centered data—that is, recording the world from the child's perspective. In brief, growing exploration of child-centered audio (e.g., Pisani et al., 2024; Xu et al., 2009) has demonstrated the quantity of speech (and many of its features) that children hear around the world (Bergelson et al., 2019; Bergelson et al., 2023; Bunce et al., 2025; Casillas et al., 2020, 2021; Florencia et al., 2022). Head-mounted cameras and other child-centered imagery (Bergelson, 2017; Long et al., 2024; Sullivan et al., 2022) have revealed the visual statistics of early life, showing, for instance, how frequently young children see faces, hands, and objects (Fausey et al., 2016;

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Jayaraman et al., 2017; Long et al., 2022). Further, wearable inertial sensors tracking posture, locomotion, and carrying or holding allow researchers to track interactions between children's physical and social environments and their own motor capacities (Airaksinen et al., 2024; Salo et al., 2022). Lastly, child-centered studies of object play highlight the high frequency with which young children explore and engage with objects, both on their own and jointly with their caregivers (Herzberg et al., 2022; Schatz et al., 2022). Our current research builds on this last line of work, focusing specifically on object-centered interactions in the first three years of life.

Children's object-handling behaviors hint at many different facets of their experience—what they are interested in (in general), what they are focused on (momentarily), what they are intentionally exposed to (e.g., child-specific objects or restricted object access), the activities they participate in (e.g., regular routines or outings), and the roles they play in those activities (e.g., leader or follower). Indeed, as we will review below (1.1), children's experience with objects may be key to understanding development in multiple areas, including object recognition, object concepts, visual categories, vocabulary, and fine motor skills. Thus, as portholes into children's social, cultural, and material worlds, handled objects have much to tell developmental scientists.

1.1. *Objects as input for early learning*

Object handling has been a central focus of developmental psychology research because of its links to children's emerging representational capacities. Through grasping, manipulating, and exploring objects, children learn about the physical properties of objects, such as their texture and weight (e.g., Ruff, 1984), and their functions and affordances (see Gibson, 1988; Lockman & Tamis-LeMonda, 2021, for related reviews). These interactions are foundational for the continuing development of fine motor skills (e.g., Corbetta & Snapp-Childs, 2009). They also shape future patterns of object exploration (Libertus et al., 2016) and may set the stage for later instrumental use of culture-specific artifacts and tools.

Children's manual exploration of objects also provides them with close-up visual input (Suanda et al., 2019; Yurovsky et al., 2013) and the opportunity to view objects from many different angles (Pereira et al., 2010; Slone et al., 2019). Such exposure has been shown to support children's development of robust object recognition (James et al., 2014; Soska et al., 2010) and their learning of visual categories (Bornstein & Mash, 2010; Ellis & Oakes, 2006; Orhan et al., 2020). These object-centric experiences are also closely tied to early language development: many of the first words children understand and say refer to objects they frequently handle (e.g., food items and toys: Bergelson & Swingley, 2012; Frank et al., 2017). Moreover, English words referring to objects that can be handled (or physically interacted with) tend to be learned earlier (Muraki et al., 2022). In urban Western contexts, children's manual interactions with objects uniquely predict their learning of object names in both home (Suarez-Rivera et al., 2022) and laboratory settings (Seidl et al., 2024). Children's interactants—typically, their caregivers—scaffold such learning by sustaining their attention to objects, and by providing contingent, relevant linguistic input during moments of object exploration (Burling & Yoshida, 2019; Chang et al., 2016; Elmlinger et al., 2019; Schroer & Yu, 2022; Tamis-LeMonda et al., 2013; West & Iverson, 2017; Yu & Smith, 2013; Yurovsky et al., 2013).

Rich, naturalistic, and multimodal information about children's object-centered interactions is difficult to study at scale, particularly across diverse sociocultural contexts. In the present work, we zoom into everyday experiences, using daylong egocentric images to characterize children's object handling as it unfolds at home. Our goal is to understand objects not only as instruments for early learning, but also as reflections of the broader developmental, cultural, and material contexts in which learning takes place.

1.2. *Objects as windows into local environments*

The physical and social characteristics of children's home environments vary widely across the globe, shaping their material cultures. Observing children's object handling patterns in different communities—particularly on a daylong scale—can give us insight into (a) what objects are present, accessible, and prioritized for children, (b) how much of children's time and attention is allotted toward object-centric or other activities, and (c) how children's object use plays into their socialization (e.g., enacting roles in their family or community). Because prior research on children's object handling has almost exclusively focused on the US and other urban Western contexts (see exceptions: Karasik et al., 2025; Koşkulu et al., 2021), the influence of local context on object handling patterns has largely been ignored.

Cross-community variation in the rate of commercial contact with other communities shapes the types of objects that are readily available to children. In communities with limited international commercial exchange, children may have more access to natural kinds and handmade tools. In contrast, children in industrialized societies may encounter primarily manufactured goods. Objects that have spread via globalization (e.g., plastic bags) and objects with a basic functional role that has arisen similarly across many groups (e.g., spoon-like tools for eating) are likely to appear widely. By contrast, other objects may remain fairly specific to particular social groups or regions (e.g., the gourd and bombilla for drinking mate in much of South America, stemming from Indigenous Guaraní and Tupí tradition).

Children's day-to-day routines differ cross-culturally, affecting both the frequency and nature of early object-centric interactions (e.g., spending more time outside vs. inside, or with vs. without other children and adults, etc.). Early opportunities for object handling are also shaped by culture-specific practices for carrying infants. For example, children who spend much of their first year carried or tightly bound (e.g., for safety or warmth: Hayashi, 1992; Ishak et al., 2007; Karasik et al., 2023; LeVine & Lloyd, 1966; Mei, 1994) are less likely to engage in bouts of object handling.

A further driver of cross-cultural variation is the degree to which children's environments are saturated with manipulable objects, and the kinds of objects that are most prevalent (e.g., toys vs. tools vs. natural kinds). Take, for example, middle-class US family homes, which have been noted for their "clutter" or "mountains of things". They feature large quantities of possessions, many of which are designed specifically for children (e.g., toys and picture books: Arnold et al., 2012; Arnold, 2013). We might infer, based on these assemblages of home objects, that much of what US children do and talk about at home is centered around what particularly interests them. Recent work by Herzberg and colleagues (2022) underscores this point with data from US infants (13–23 months old) who spent nearly 70% of their time in object play with toys or a mix of toys and non-toys, with ~100% of infants playing with children's books and stuffed animals and 32 unique toy types appearing in ≥ 25% of infants' play. Non-toy play was also common but still predominantly included engagement with child-specific objects (e.g., sippy cups, baby spoons, high chairs, pacifiers). We would expect many of these items to be rare in other parts of the world and instead expect to find much greater overlap between objects for infants and objects for adults. Similarly, prior work also suggests cross-community differences in caregivers' use of object labels versus less object-centered language in interactions with young children (Choi & Gopnik, 1995; de León, 1999; Fernald & Morikawa, 1993; Kim et al., 2000; Lawrence & Shipley, 1996). Together, prior research highlights strong potential for variation in early experiences with objects across different sociocultural contexts.

1.3. Current studies: Daylong object handling in two subsistence societies

Prior research on object-centered interaction has been informative about how children and caregivers coordinate attention during joint play (Yu & Smith, 2013, 2017) and how children distribute their attention over different objects in multi-object play, moving between them in patterned ways (Herzberg et al., 2022; Karmazyn-Raz & Smith, 2023; Schatz et al., 2022). However, this work has, by and large, been restricted to toy play—just one type of object-centered interaction—and to US families. Young children's everyday experiences are highly heterogeneous and organized across multiple timescales, such that brief laboratory sessions or even relatively longer (e.g., 1 h), semi-structured, in-home recordings systematically miss important patterns in daily life, highlighting the value of sampling over longer timescales (e.g., full waking days) and across populations (de Barbaro & Fausey, 2022).

The present study examines infants' daylong object-handling activity at home across two unrelated cultural contexts. Building on prior research about object-centered interactions, we give a first view into how object handling varies over age and across the day, and how these patterns vary (and do not vary) in two unrelated populations. Without knowing the actual base rates of different kinds of object-centered interactions, we are in a poor position to build theories that accurately reflect how real-world learning about objects (e.g., labels, categories, etc.) occurs. Our findings ground theories of object-driven learning—which is hypothesized to operate across visual, conceptual, linguistic, and motor development—by providing basic information about how often infants actually engage with objects, what kinds of objects they handle, and what role interactants may play in their object-handling episodes. Our cross-community sample also gives initial insights into the effects of infant care practices and play demographics on children's object-handling activity.

In Study 1, we analyze the frequency of object handling in more than 92,000 child-perspective photos taken during 67 daylong recordings for infants between 0;0–3;0 in two different communities on opposite sides of the globe. In Study 2, we further explore the targets of child object handling (i.e., what objects were handled). Our studies comparatively analyze object-handling behaviors in two rural, small-scale subsistence farming populations in which children are raised in closely clustered patrilocal, and multi-generation homesteads. The first sample (collected in 2015) is based in a Tseltal (Mayan) village in central Chiapas, Mexico (see also Casillas et al., 2020). The second (collected in 2016) is based in a cluster of villages on Rossel Island, a remote island off the southeast coast of Papua New Guinea (see also Casillas et al., 2021). Our interest in comparing these two communities stems from the fact that, despite their apparent basic similarities in size, rurality, economic activities, and household demographics, a number of key differences in children's everyday experiences allows us to examine the variable ways in which children develop social knowledge. For the present study, key differences between the communities include diverging child-rearing practices (including infant carrying), children's day-to-day activities, and the nature of each community's integration with national and global industrial markets (see 2.1 below for a detailed description of the participating communities, and see also Brown & Casillas, 2025). Together, our studies reveal sources of both consistency and variability in infants' early object-centric input across the first three years and in two unrelated sociocultural contexts (see 2 below for specific hypotheses).

2. Study 1: Frequency of infant and interactant object handling

How frequently do young children engage in object-handling episodes? Egocentric recordings of interaction have revealed evidence for increasing views of hands over the first two years (Fausey et al., 2016; Jayaraman et al., 2017; but see also Long et al., 2022). This focus on active hands can lead to episodes of triadic attention between children, their interactants, and interactionally-relevant objects. While both children and their interactants can initiate these episodes, children's own holding experiences throw objects into sharp perceptual relief, thereby increasing the potential for learning about objects' perceptual properties (Slone et al., 2019), affordances and associated functions (Baumgartner & Oakes, 2011; Rachwani et al., 2020), and possible labels (Clerkin & Smith, 2022). However, the frequency and manner in which caregivers and other interactants (child and adult) jointly engage with young children vary cross-culturally (e.g., Little et al., 2016; Rochanavibhata & Marian, 2022). Even in well-studied Western contexts, we know quite little about the natural frequency of interactants' object-centric behaviors outside of lab contexts.

Rates of child object handling have primarily been estimated from short (up to 1–2 h) recordings taken either in families' homes (Herzberg et al., 2022; Swirbul et al., 2022) or in a lab setting (Yu & Smith, 2013)—almost exclusively in the US or other Western contexts (see exceptions: Karasik et al., 2025; Koşkulu et al., 2021). These studies reveal that infants typically handle objects around 60% of their time at home and up to 90% of their time in the lab. However, prior studies have characterized children's object-centric input over relatively short periods of time and primarily in caregiver- or researcher-selected activity contexts (see exceptions:

Bergelson, Amatuni, et al., 2019; Franchak et al., 2024; Long et al., 2021; Yang et al., 2025) and are therefore not necessarily representative of children's entire waking days, which span a variety of activity contexts (see Casillas, 2023, for relevant discussion). Further, existing findings are highly limited to a culturally narrow sample of populations. Cross-cultural differences in the types of objects available in children's environments as well as differences in how children are carried and socialized guarantee wide variability in object handling (Adolph et al., 2010; Gaskins, 2000).

In Study 1, we measured the frequency of child and interactant object handling across the day and early lifespan (0;0–3;0) in two non-Western subsistence societies. We predicted that the majority of object-centric input would come from infants' own object handling, not their interactants', in both communities. Additionally, we predicted that rates of child object handling would differ between communities, particularly due to differences in typical infant-carrying practices and availability of manufactured objects (see 2.1 below for further details).

We also hypothesized that children's object handling would increase with age (consistent with: Franchak et al., 2026; Herzberg et al., 2022; but see also Franchak et al., 2024). Physical constraints limit the scope and duration of infants' early object-centric interactions; young infants primarily interact with objects that others bring near them (de Barbaro et al., 2016). But significant gains in gross motor skills (e.g., sitting, crawling, walking) over the first year and beyond increasingly widen children's ability to seek out and handle a diversity of objects in their environments (Franchak, 2019; Marcinowski et al., 2019; Schneider et al., 2022; Thurman & Corbetta, 2019). Developing motor skills not only give children greater control over what objects they handle, but also how they jointly engage with others and, in turn, how they elicit social and linguistic information relating to handled objects (Adolph et al., 2010; Herzberg et al., 2022; Kretch et al., 2014; Sanchez et al., 2018).

2.1. Participating communities

We first describe the physical landscapes, typical infant-carrying practices, and social and commercial environments observed in the two communities of study. The authors are not members of the communities described. Our description is informed by experience talking to and observing families firsthand (second and last author), plus consultation with two researchers who have worked with these communities for several decades (P. Brown and S. C. Levinson). See Figure S1 for example scenes from each field site.

2.1.1. Physical landscapes

The Tseltal (Mayan) participants live in a rural, swidden horticulturalist community situated within the Chiapas highlands of Southern Mexico. This Tseltal community is located on a mountainside such that, when infants and their caregivers leave the home (e.g., to visit a relative), they must typically traverse steep dirt paths or walk on paved roads that bring the occasional taxi, truck, and motorcycle traffic. Mothers also tend to carry infants continuously while working in and out of the house, especially if the infant is sleeping. Thus, while nearly all children between 1;0 and 1;6 walk, they may still be carried for significant parts of the day, especially over longer distances or challenging terrain.

The Rossel (Papuan) participants in our study live in a collection of swidden horticulturalist hamlets on the northeastern region of Rossel Island, which is the farthest outlying atoll of the Louisiade Archipelago, off the coast of mainland Papua New Guinea. Most villages are situated near the coast, with family gardens in both lower and higher altitude areas. Daily travel for infants is primarily restricted to footpaths near the villages, as well as canoe rides (with an older family member, if the child is small). From around age 2;0,

Fig. 1. Typical infant holding positions in the studied Tseltal (left) and Rossel (right) communities.

infants move fairly freely within and nearby their hamlet, typically with a large mixed-age group of older-child relatives. These groups of children often spend their time foraging for snacks, swimming in the river, and playing games around and under their houses, which are raised above ground on posts and typically feature a raised veranda that children can easily climb onto from the ground level.

2.1.2. Carrying practices and gross motor milestones

Tseltal infants are carried in a sling on their mother's back during their first year and are rarely placed on the ground before they begin walking (Brown, 2011, 2014). While sleeping, they are entirely wrapped in the sling, and while waking, they are hitched into a sitting position with their head and torso free (Fig. 1). If infants are placed on the ground, it is usually on a woven mat or blanket, or occasionally in a cardboard box, and always under the surveillance of a nearby caregiver. Infants are sometimes put to sleep in a hammock during the daytime. For these reasons, it is rare to see Tseltal infants crawling. Mothers report that, at some point, infants begin making limb movements while tied up in the sling, indicating their readiness to begin standing, and soon after, to take their first steps. At this point, caregivers may provide standing and walking support with their bodies and household objects until the child is walking on their own.

Rossel infants are also carried for much of their first year. However, they are typically carried in the arms (i.e., on the waist, against the chest, and over the shoulder, Fig. 1, Brown, 2011; Brown & Casillas, 2025). Children are cared for by a wide network of nearby family members and neighbors (male and female, adult and child), any of whom might carry or hold the child for sustained periods. Rossel infants, like Tseltal infants, are rarely put directly on the ground. Instead, they are more often found laying, sitting, scooting, and crawling on the raised verandas that are constructed under or attached to residences. Similarly, infants are sometimes placed in hammocks for daytime sleep. Once children show signs of interest in walking, caregivers might set out a line of small posts in the ground that the infant can grasp and walk along under a caregiver's supervision.

In brief, while infants are rarely placed on the ground in both communities, young Tseltal children's movements and ability to grasp nearby objects are more restricted early in development. For this reason, we predicted that Tseltal infants would show lower rates of object handling in daylong recordings than Rossel infants before age 1;6 (i.e., around the onset of independent walking).

2.1.3. Social and commercial environments

Cross-cultural differences in carrying practices less strongly influence infants' object handling once they begin to walk, but the social landscape and available objects in each site create persistent differences between communities. While infants in both contexts spend significant time interacting with other children (e.g., older siblings and cousins/neighbors), large-group peer play is especially prominent in the Rossel community, where infants join independent child playgroups of up to around a dozen children shortly after they start to walk (Brown, 2011, 2014; Brown & Casillas, 2025). These large playgroups sometimes engage in stationary, object-centric, verbally interactive activities (e.g., pretend household play, cracking and eating foraged nuts, preparing and cooking simple food) but more often initiate mobile activities in which few objects are relevant and verbal activity is repetitive or routinized (e.g., diving games in the river, chasing games similar to 'tag'). Tseltal infants tend to participate in smaller child social groups and move within a somewhat more restricted area around their homestead grounds. Spot observations of Yucatec Mayan children suggest that play—particularly manipulative play with objects and substances—increases in frequency with age, to 40% of the child's time by ages 3;0–5;0 (Gaskins, 2000). Work activities that may involve object manipulation may also increase during this time (Gaskins, 2000).

While both communities are rural, the Tseltal community is much more commercially connected to its regional market economy—indigenous taxis run daily between the rural Tseltal community under study and the regional capital town (as well as the nearby tourist city). In contrast, Rossel Island sees only infrequent and irregular boat contact. For this reason, industrially manufactured objects that are designed specifically for children's interest (e.g., toys, crayons, etc.) are far less frequently seen in the Rossel context than in the Tseltal context.

2.2. Method

2.2.1. Recording procedure

The present data come from a subset of daylong photo-linked audio recordings collected in 2015 (Tseltal) and 2016 (Rossel) of 55 + children under age 5;0 in each site. Children were outfitted with an elastic vest that carried two devices: a lightweight Olympus audio recorder (WS-832 or WS-853) and a wearable camera with a miniature fisheye lens that provided a 180° view of the environment (Narrative Clip 1 and Photojojo Super Fisheye, see Figure S2). Some infants (typically those 0;6 and younger) could not wear both devices at once so instead wore an infant bodysuit ("onesie") with the audio recorder while their caregiver wore an adult-sized vest with the camera. This difference in perspective did not impact the procedure for manually annotating photos described below. While one might reasonably wonder whether caregiver-worn cameras captured infants' field of view, our manual review of the photo streams suggested that annotators could reliably code the infant's perspective.

The camera captured images at a fixed interval over the course of the recording day, which typically lasted around 8 (Rossel) or 9 (Tseltal) h. Timestamped images were captured every 30 s in the Tseltal data and, following a camera firmware update in late 2015, every 15 s in the Rossel data. Participants were able to cover the camera lens at their discretion using a piece of cloth attached to the underside of the camera case (see Casillas et al., 2020, for details). Recordings were conducted during daytime hours and were intended to capture primarily waking activity. However, sampled images may include times during or surrounding bouts of sleep. Because infant sleep is difficult to identify from child-perspective images and because infants in these communities do not tend to have clearly defined nap periods, we do not attempt to explicitly distinguish between sleeping and waking time in the present study. This research was performed in compliance with a protocol reviewed and approved by the Radboud University (Nijmegen, NL) Faculty of

Social Sciences Ethics Committee (Ethiek Commissie van de faculteit de Sociale Wetenschappen; ECSW2013–1811–144).

Here, we analyze daylong photo streams from 67 infants up to age 3;0, including 31 Tseltal infants (13 male, 18 female, $M_{age} = 1;4$) and 36 Rossel infants (20 male, 16 female, $M_{age} = 1;5$). Across sites, participants are imperfectly balanced in age and sex, but each sample incorporates a majority of the local population in the target age range at the time of data collection. The communities of study are small populations, and our samples represent the upper limit of consenting participants in each community (i.e., they are nearly comprehensive). The sample size for each site is comparable to US-based studies of infants' at-home object handling, which typically include 30–40 participants (e.g., Herzberg et al., 2022; Schatz et al., 2022; Suarez-Rivera et al., 2022).

2.2.2. Manual annotation

We annotated photos with IMCO (version 1.0, Casillas & Tice, 2021), an open-source program that allows for efficient tagging of images using keyboard inputs that are mapped to predefined categories. We only annotated photos between the time the researcher (the last author) left and the time she returned because caregivers tended to restrict the recorded infant's movements during researcher visits.

For each photo, we determined whether there was **infant object handling** and/or **interactant object handling** (i.e., at least one of the recorded infant's interactants—caregivers, other adults, or other children—was handling an object directly relevant to the recorded infant). Large or immovable objects were considered handled if the infant was actively engaging with them (e.g., a branch while climbing a tree, but not a table on which a hand was resting). We relied on handshape to determine whether hand-to-object contact was considered handling or resting. People were not counted as handled objects (e.g., a mother holding her baby, or a child holding a breast). Objects near but not directly in contact with a hand were coded as handled when justifiable (e.g., a hand reaching for an object). We also annotated for the number of visible adults (i.e., post-pubescents) and children in the photos.

2.2.3. Data preparation and reliability

Our full data set includes annotations of 92,243 photos (31,393 from Tseltal recordings, 60,850 from Rossel recordings). A substantial proportion of photos from each site were multiply annotated (by at least two or more annotators; Tseltal: 11.24%; Rossel: 11.93%). Photos were excluded if they were too dark, bright, blurry, or blocked for annotators to identify object handling. We analyze the photos deemed usable by at least one annotator (69,466 photos; 75.31% of the full annotated set), and for estimates of infant object handling, only those photos reported to contain at least one recorded infant hand (32,403 photos; 35.13% of the full annotated set). The average number of usable photos per infant was 483.63, but there was wide variability between infants (median = 484, range = 0–1466). Agreement between annotators was high (85.65%), with comparable scores for Tseltal (87.37%) and Rossel (83.83%) photos (see Supplementary Materials Section 1.4 for additional information).

2.3. Results

All analyses and figures were generated in R (Aust & Barth, 2020; R Core Team., 2024; Wickham et al., 2019). Anonymized data and analysis code are available on the Open Science Framework (https://osf.io/7bgtd/).

2.3.1. Child object handling

We first analyzed how often the target infant's hands were visible in the chest camera photos to determine inclusion for handling rate analyses. On average, infants' hands were visible in 46.82% of photos (median = 44.54%, range = 11.99–87.48%, Figure S4). This rate is considerably higher than what is seen for child-worn head cameras. For instance, in ~1 h recordings of 44 US children between 0;6 and 1;5 (Bergelson, 2017), infants' hands were visible in only 18.03% of photos, on average, taking into account views from two head cameras (see Supplementary Materials, including Figures S5 and S6, for more details). The frequency of visible infant hands was descriptively similar for Tseltal recordings (M = 45.29%, median = 44.89%, range = 11.99–87.48%) and Rossel recordings (M = 48.09%, median = 44.19%, range = 13.83–84.89%) despite differences in the image sampling rate. A linear regression modeling the effects of age, site, and their interaction on the rates of visible infant hands ($N = 64$; $AIC = 545.03$)[1] revealed a significant age-related increase ($\beta = 0.47$, $SE = 0.20$, $t = 2.30$, $p = 0.025$) but no main effect of site ($\beta = -2.55$, $SE = 4.10$, $t = -0.62$, $p = 0.537$). A significant age-by-site interaction ($\beta = 1.47$, $SE = 0.41$, $t = 3.61$, $p < .001$) indicated that Tseltal infants' hands were less frequently in view of the camera than Rossel infants' early on, but then appeared more frequently than Rossel infants' at later ages (see Figure S4 for visualization).

The analyses that follow are based on photos where at least one recorded infant hand was visible. Infant object handling was detected in 28.98% of photos (median = 25.63%, range = 0–71.65%). Rates of object handling were similar for Tseltal infants (M = 28.97%, median = 27.24%, range = 0–67.84%) and Rossel infants (M = 28.99%, median = 20.94%, range = 0–71.65%). A linear regression modeling the effects of age, site, and their interaction on the prevalence of infant object handling ($N = 64$; AIC = 553.08)[2] revealed a significant age-related increase ($\beta = 1.24$, $SE = 0.22$, $t = 5.73$, $p < .001$; Fig. 2), but no main effect of site ($\beta = 0.56$, $SE = 4.37$, $t = 0.13$, $p = 0.899$) or age-by-site interaction ($\beta = 0.38$, $SE = 0.43$, $t = 0.87$, $p = 0.386$). That is, infant object-handling rate increased with age in both communities: each 1-month increase in age was associated with a 1.24% increase in object-handling rate, on average for Tseltal and Rossel infants (Fig. 2). See also Figure S11 for visualization of handling rate over age for walkers versus non-

[1] glm(% Photos with visible child hand(s) ~ Age (months; mean-centered, numeric) * Site (Tseltal/Rossel; factorial))

[2] glm(% Photos with child object handling ~ Age (months; mean-centered, numeric) * Site (Tseltal/Rossel; factorial))

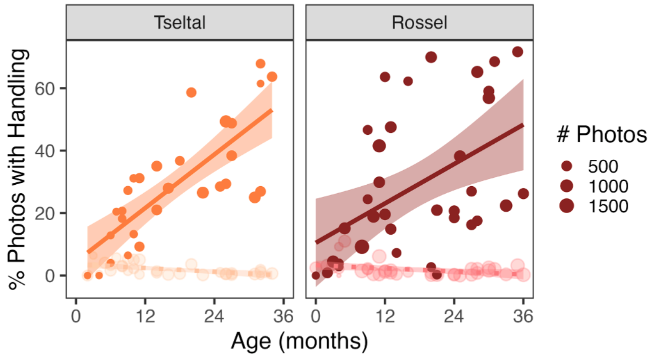

Fig. 2. Percentage of photos with one or two child hand(s) visible in which children (dark) and their interactants (light) handled objects during the Tseltal (left) and Rossel (right) daylong recordings. Points reflect estimates for individual children, and point size corresponds to the number of usable photos for each participant.

walkers.

As expected, infants' object handling was not uniformly distributed across the day. Rates of object handling for individual infants varied substantially across individual hours of recording. For any given infant, the difference in object-handling rate between their hour with the most object handling and their hour with the least object handling was an average of 22.76% of the hour (median = 6.10%, range = 0.73–66.96%). Intra-individual variability was observed in both sites and increased significantly with age (see Figure S7).

We also explored how infants' object handling was affected by the presence of interactants. At least one potential interactant—child or adult—was present in 78.46% of photos, on average per participant (Tseltal = 73.78%, Rossel = 82.21%). Rossel infants were found to be in close proximity to more other children and more adults than Tseltal infants ($M_{Rossel,child} = 1.02$, $M_{Tseltal,child} = 0.76$, $M_{Rossel,adult} = 1.01$, $M_{Tseltal,adult} = 0.74$; all *ps* for Wilcoxon tests <.001; see Figure S8). We fit a mixed-effects binomial logistic regression model[3] predicting infant object handling (1/0) from the number of visible interactants (child and adult), age, site, and their interactions, with by-child random intercepts (see Table S1 for full table of results). The presence of more interactants was associated with less object handling for Rossel infants ($\beta = -0.04$, $SE = 0.01$, $z = -5.09$, $p < .001$) and *more* object handling for Tseltal infants ($\beta = 0.21$, $SE = 0.02$, $z = 13.61$, $p < .001$). The age-related change in the effect of interactants also differed reliably between sites (interactants × age × site interaction: $\beta = -0.01$, $SE = 0.002$, $z = -5.37$, $p < .001$; see Figure S10 for visualization). Specifically, the effect of interactants increased with age for Tseltal infants; whereas, the effect of interactants was relatively small and did not reliably change across age for Rossel infants.

2.3.2. Interactant object handling

Despite the overall high presence of other people in child-perspective photos, interactant handling of child-relevant objects was only detected in 1.90% of photos, on average (median = 1.20%, range = 0–11.00%). Interactant object handling was similarly rare across sites, appearing in an average of 2.00% of photos for Tseltal infants (median = 1.10%, range = 0–6.40%) and 1.90% for Rossel infants (median = 1.30%, range = 0–11.00%). Unlike infants' own object handling, interactant object handling decreased significantly over age ($\beta = -0.09$, $SE = 0.02$, $t = -3.77$, $p < .001$; Fig. 2) and remained near-zero for the first three years. We found no evidence to support an impact of site on interactant object handling ($N = 67$, AIC = 289.82, all $ps > 0.05$). That is, while adults and other children certainly hold objects, interactant-held objects were rarely coded as child-relevant from the recorded infant's perspective, both between sites and across age. See the Supplementary Materials for a comparison with a US dataset (~1 h, in-home recordings; Figure S9) and for analyses only including photos where at least one potential interactant was visible.

2.4. Discussion

The present findings suggest that infant object handling—but not interactant object handling—is relatively frequent, particularly after age 1;0 in two non-Western subsistence societies. Both Tseltal and Rossel infants' object handling increased significantly with age. This finding is consistent with analyses of shorter video recordings in the US (Herzberg et al., 2022), with ethnographic observations in a (Yucatec) Mayan village (Gaskins, 2000), and with some evidence from sparser ecological momentary assessments in US households (Franchak et al., 2026; but see also Franchak et al., 2024). Developmental changes in object-handling rates likely reflect infants' growing motor skills and physical abilities to seek out and handle objects. Higher rates of object handling with age may also be driven by decreased amount of time infants are held by caregivers and increased permission to access certain types of objects (e.g., objects with sharp edges).

[3] glmer(Child object handling (1/0) ~ Age (in months, mean-centered; numeric) * Site (Tseltal/Rossel; factorial) * Interactants (visible children and adults, mean-centered; numeric) + (1 | Child), family = "binomial")

Interactants' child-relevant object handling was very rare—only visible in around 1–2% of photos, on average—and was similarly limited across sociocultural contexts. While in-lab and at-home studies in Western contexts highlight caregivers' scaffolding of object-centric interactions through their handling of, attention to, and talk about child-relevant objects (e.g., Schatz et al., 2022; Yu & Smith, 2013), interactant object handling appears to be an implausible driver of early learning in both Tseltal and Rossel communities.

Interactant presence (i.e., the number of visible children and adults) differentially affected infants' object-handling rate across communities. The presence of more nearby people was associated with less object handling for Rossel infants, who spend much of their day engaging in large-group, peer play, which often does not center around objects (e.g., playing 'tag': Casillas et al., 2021). In contrast, the presence of more people was associated with more object handling for Tseltal infants, which may be driven, in part, by their participation in large-group family mealtime. Moreover, the effect of nearby potential interactants became stronger with age for Tseltal children; whereas, the effect of interactants remained relatively small across age for Rossel children. These age-related changes likely reflect shifting activity contexts, though further research is needed to pinpoint the specific changes in children's social environments and daily routines that give rise to different developmental trajectories between sites.

Despite differences in typical infant-carrying practices and caregiving styles, we found no significant differences in the overall rates of infant or interactant object handling between the two communities of study. Because younger children's hands were less frequently in view of the recording camera, it is possible we were insufficiently powered to detect differential rates of object handling for Tseltal infants, whose hands are typically covered when carried in a sling on their caregivers' backs, versus Rossel infants, whose hands are likely to remain unoccluded when held in caregivers' arms. Thus, while carrying practices may lead to differences in how often infants' hands are free to engage with objects, object-handling activity—in this case, handling frequency—looks similar across sites when hands are free and visible.

Overall, Study 1 established that infant object handling is frequent in everyday life. Across the first three years and in two unrelated non-Western communities, infants' own egocentric object-handling experiences capture, on average, just under one-third of their waking time and increase significantly with age. However, overall object-handling rates provide only a coarse estimate of how much object-centered interactions may contribute to infants' early learning and socialization. What exactly infants may be able to learn from moments of object handling depends on finer-grained information, such as what types of objects they handle, what categories those objects come from, and whether they do (or do not) vary across age and different sociocultural contexts. Study 2 addresses these open questions by identifying the targets of infant object handling in the same corpus of egocentric photo streams.

3. Study 2: Targets of infant object handling

A first step in determining what infants may be able to learn from frequent first-person holding experiences is to examine what objects they handle. In Study 2, we identify the targets of infant object handling and explore how handling of specific types of objects varies across age and between communities.

3.1. Method

3.1.1. Corpus

We further annotate and analyze the subset of 12,368 photos with infant object handling from Study 1. Because three infants had no instances of object handling, Study 2 includes 64 infants up to age 3;0: 29 Tseltal infants (M_{age} = 1;5) and 35 Rossel infants (M_{age} = 1;6). Individual rates of object handling—and thus the number of photos available for annotation—varied across infants, ranging from 1 to 576 ($M_{Tseltal} = 163.30$, $M_{Rossel} = 223.50$).

3.1.2. Manual annotation

Photos were annotated with IMCO (version 2.0, Casey et al., 2022) for four pieces of information: (1) object category, (2) object type, (3) object token, and (4) child-specific token status (i.e., whether each object token was designed specifically for infants or young children). **Object categories**[4] included consumables (e.g., food, drinks, medicines), mealtime tools ("Tool-M"), toys, clothing, tools for working or cleaning ("Tool-W"), large or immovable objects (e.g., furniture and housing structures), natural objects, and miscellaneous synthetic objects (see Fig. 3 for example photos and Table 1 for example objects from each category). These categories were chosen to be somewhat consistent with prior US-based research (e.g., Herzberg et al., 2022), but were also tailored to the local contexts of study. **Object types** refer to any exemplar of a type of object (e.g., any stick), rather than a particular instance of an object (e.g., a specific stick). **Object tokens** refer to specific instances of a given object type, numbered in order of appearance (e.g., "stick1", "stick2", "stick3", indicating three distinct instances of the object type "stick"). **Child-specific objects** include items that are designed

[4] It is important to note that these are 'etic' categories—we (who are foreigners in each community) determined what kinds of category distinctions were relevant and what kinds were not. Our definitions relied on a broad consideration of typical object function, which we expected to apply comparably across sites and to be reliably identified and classified by our (Western) annotators. We imagine that, given the collection of objects we actually observed, community members might sort them into different or more fine-grained categories, and do so on the basis of features other than (or in addition to) function, e.g., material/production activity, typical location, association with social group, etc. Such 'emic' categories are likely to further inform our analyses of developmental patterns of object handling in each site, but would likely make comparison across sites less straightforward. Thus, we see benefits and drawbacks to each approach and, for now, rely on our strength in defining and reliably identifying etic categories while acknowledging the limitation of these categories' meaning in situ.

Fig. 3. Example photos with object type and object category labels.

Table 1
Number of unique object types (N) and identities of the object types handled by the greatest number of infants, for each category, across sites. Underlined object types are shared between sites.

	Tseltal		Rossel	
Object Category	**N**	**Top Object Types**	**N**	**Top Object Types**
Consumable	44	tortilla, bean, banana	33	betelnut, coconut, candy
Synthetic	64	blanket, plastic bag, bucket	62	basket, blanket, container
Natural	12	stick, plant, leaf	17	stick, leaf, rock
Toy	37	car, ball, children's book	16	ball, swing, car
Mealtime Tool	7	bowl, cup, baby bottle	20	spoon, bowl, knife
Clothing	15	shirt, purse, pants	13	shirt, pants, skirt
Immovable	15	chair, door, table	18	stairs, wall, floor
Work Tool	26	broom, mop, clothesline	13	knife, broom, machete

exclusively for use with or by children in the communities of study (e.g., toys, child-sized clothing, child-sized mealtime tools, baby blankets, baby bathtubs, children's books, etc.). Annotators provided a binary classification of object tokens as "child-specific" or "non-child-specific".

3.1.3. *Data preparation and reliability*

Photos were excluded if annotators were unable to determine the identity of the handled object(s) ($n = 722$, or 5.84% of the dataset). To avoid unnecessary data loss, all excluded photos were checked by at least one other annotator and re-included for analysis if objects were identifiable. In total, 11,646 photos were deemed usable by annotators (Tseltal: 4275; Rossel: 7371). One participant had no usable photos, so our analyses are based on 63 daylong photo streams.

For reliability purposes, 20% of photo streams were double coded. Reliability annotations were equally spread across sites and ages and included a total of 3783 photos. At the category level, annotators agreed on 90.95% of decisions, on average across photo streams (Tseltal: 92.16%, Rossel: 89.90%). At the object type level, annotators agreed on 78.56% of decisions (Tseltal: 79.64%, Rossel: 77.62%). At the object token level, annotators agreed on 79.21% of decisions for identification of the token number (Tseltal: 74.24%, Rossel: 84.19%) and on 86.32% of decisions for classification as child-specific or non-child-specific (Tseltal: 87.25%, Rossel: 85.39%). All photos with annotator disagreements were re-coded before inclusion in the final analyses.

3.2. *Results*

For the results that follow, we quantify the distribution of object categories, types, and tokens at two timescales: across the entire recorded day and across individual hours of recording. On average, each infant contributed 6.83 h of recording with at least one instance of object handling ($M_{Tseltal} = 7.32$, $M_{Rossel} = 6.34$, range = 1–11). We also test for effects of age and site at all levels of object representation.

3.2.1. *Distribution across object categories*

Across the day, infants handled objects from 5.98 different categories, on average (median = 7, $SD = 2.07$, range = 1–8), with no significant difference between sites ($M_{Tseltal} = 5.89$, $M_{Rossel} = 6.06$, $W = 469.00$, $p = 0.772$). The category-level distribution was largely stable, both over age (see Figure S12 for visualization) and between communities. Consumables ($M_{Tseltal} = 29.40\%$ of photos, $M_{Rossel} = 22.96\%$) and synthetic objects ($M_{Tseltal} = 31.30\%$ of photos, $M_{Rossel} = 27.94\%$) were the most frequently handled by infants in both sites based on total proportion of handling time.

During any given hour, infants handled objects from 2.70 different categories, on average (median = 2, $SD = 2.20$, range = 0–8). To test for differences across sites and categories, we ran individual linear mixed-effects regressions[5] for each of the eight object categories, with category membership dummy coded (i.e., objects belonging to the target category for a given model = 1, objects belonging to other categories = 0). Each regression model included fixed effects of site, category, and a site-by-category interaction as well as random intercepts for individual children.[6] Site was effect-coded so that main effects reflect averages across sites. We report all statistically significant effects after correcting for multiple comparisons; all p-values below are Holm-Bonferroni adjusted. We found significant positive main effects for the synthetic object ($\beta = 0.41$, $SE = 0.07$, $t = 5.95$, $p < .001$) and natural object categories ($\beta = 0.34$, $SE = 0.08$, $t = 4.07$, $p = 0.001$), indicating that infants handled 0.41 more unique synthetic object types and 0.34 more unique natural object types per hour, relative to all other categories. Additionally, we found significant negative main effects for mealtime tools ($\beta = -0.48$, $SE = 0.09$, $t = -5.05$, $p < .001$), work tools ($\beta = -0.54$, $SE = 0.13$, $t = -4.13$, $p < .001$), and toys ($\beta = -0.37$, $SE = 0.10$, $t = -3.57$, $p = 0.007$), indicating that infants handled fewer unique object types from these categories per hour relative to other categories. A significant site-by-immovable interaction ($\beta = -0.72$, $SE = 0.21$, $t = -3.49$, $p = 0.010$) revealed that Rossel infants handled 0.86 more unique object types from this category per hour than Tseltal infants (Fig. 4). Finally, the predicted site-by-synthetic interaction (resulting from greater market integration in Chiapas) was found to be significant before correction for multiple comparisons but not after ($\beta = 0.27$, $SE = 0.14$, $t = 1.99$, $p = 0.778$), as was the site-by-toy interaction ($\beta = 0.42$, $SE = 0.21$, $t = 2.00$, $p = 0.778$).

3.2.2. Distribution across object types

Infants handled an average of 24.29 unique identifiable object types per day (median = 24, $SD = 15.5$, range = 1–54), with no significant differences across sites ($M_{Tseltal} = 23.82$, $M_{Rossel} = 24.66$, $W = 463.50$, $p = 0.719$). A linear model predicting the total number of unique object types handled per day (within-child) from child age, site, and their interaction revealed a significant age-related increase ($\beta = 1.16$, $SE = 0.25$, $t = 4.69$, $p < .001$), indicating that older infants handled a greater diversity of object types over the recorded day.

The distribution of object types was highly right-skewed within and across infants. Each infant's distribution was skewed such that a small group of object types was handled in a majority of their photos. Each infant's top object was handled for 31.90% of their object-handling time, on average (median = 22.29%, $SD = 25.00\%$, range = 9.47–100%), and the top three objects alone captured a majority of the day, on average ($M = 55.19\%$, median = 47.37%, $SD = 25.30\%$, range = 22.44–100%). However, the vast majority of object types were handled for relatively short portions of the recorded day (Fig. 5). Across infants, common object types followed a similar right-skewed distribution—a few object types were handled by many infants, but a majority of objects (Tseltal: 63.76%; Rossel: 52.91%) were handled by only one or two infants in each site.

We found overlap in commonly-handled object types across communities. 31.20% of object types were handled by both Tseltal and Rossel infants, and several shared object types were among the most frequently handled in both sites. Among the top 25 most common object types, 9 were shared across sites (Fig. 6). The study camera was the object that was handled by the most infants in both sites (Tseltal: 92.90%, Rossel: 65.70% infants, see Bergelson, Amatuni, et al., 2019, for a similar effect) but accounted for a relatively small percentage of each infant's object-handling time, on average ($M_{Tseltal} = 7.30\%$, $M_{Rossel} = 3.70\%$ of photos). Inclusion of study-related items in the analyses did not qualitatively change any of the reported results.

During any given hour, infants handled 6.10 different object types, on average (median = 5, $SD = 4.65$, range = 1–33), with no significant difference between sites ($M_{Tseltal} = 5.71$, $M_{Rossel} = 6.45$, $W = 20{,}808.00$, $p = 0.125$).

3.2.3. Distribution across object tokens

Certain object types were near-impossible to track at the individual token level across the entire recorded day (e.g., sticks, leaves, rocks); thus, we counted unique object tokens only for individual hours of recording. Infants handled an average of 7.42 unique identifiable object tokens per hour (median = 6, $SD = 6.35$, range = 1–50). A negative binomial mixed-effects model[7] (Brooks et al., 2017) predicting the count of unique object tokens per hour from child age and site, with random intercepts for individual children, revealed that older infants handled more unique tokens per hour ($\beta = 0.01$, $SE = 0.004$, $z = 2.29$, $p = 0.022$).

For any hour with object handling, infants handled an average of 1.70 unique *child-specific* objects (median = 1, $SD = 1.10$, range = 1–6). Tseltal infants handled marginally more child-specific objects per hour ($M_{Tseltal} = 1.81$) than Rossel infants ($M_{Rossel} = 1.55$; $W = 3304.00$, $p = 0.050$). Notably, handling of child-specific manufactured items, including toys and clothing, was much more common in the Tseltal context than the Rossel context (see Figure S14 for visual comparison).

3.3. Discussion

We examined the targets of infant object handling at three levels of representation—object category, type, and token. At the

[5] We exclude from our regression models any hour in which an infant did not handle any objects, as inclusion of these hours creates a second mode at 0, violating our statistical models' assumptions of normality.

[6] lmer(Unique objects per hour ~ Category (target/non-target; factorial) * Site (Tseltal/Rossel; factorial) + (1 | Child))

[7] glmmTMB(Unique object tokens per hour ~ Age (months; numeric) + Site (Tseltal/Rossel; factorial) + (1 | Child)). Adding an age-by-site interaction term did not significantly improve model fit based on a likelihood ratio test ($\chi^2(1) = 1.94$, $p = 0.164$).

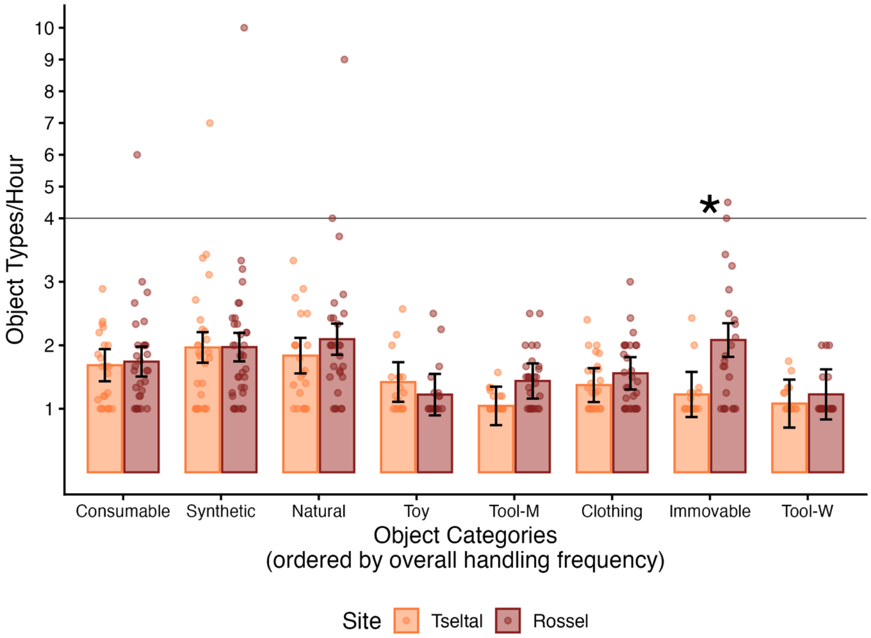

Fig. 4. Rate of unique object types handled per hour across object categories. Points reflect means for individual children. Bars show model-predicted means, with error bars depicting 95% confidence intervals. Asterisks indicate significant site-by-category interactions after Holm-Bonferroni correction. Note that the y-axis is rescaled beginning at the horizontal black line at 4 to better show differences between categories.

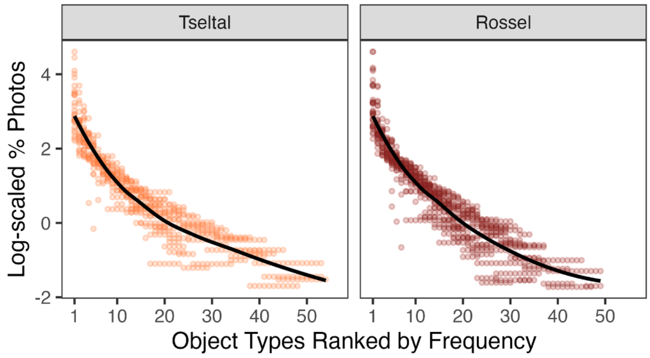

Fig. 5. Right-skewed distribution of object types. Points reflect log-transformed proportion estimates for individual children.

category level, the overall distribution of handled objects was largely stable both over age and between communities. This finding is consistent with prior work in US communities showing that the visual categories present in young children's early environments are largely stable, both over the first years of life and between households (Long et al., 2021; but see also Yang et al., 2025). That is, stability in the visually available objects is often echoed in the manually interacted-with objects, raising a parallel that may be useful in future research using vision to reason about tactile experience, or in future work investigating multimodal cues for object-centered learning. As the broadest level of object representation explored here, object categories likely reflect relatively stable properties of infants' physical environments and consistency in day-to-day routines across the first three years of life.

At the level of object types, infants' object handling followed a highly right-skewed distribution. Each infant's distribution was skewed such that a small group of object types was handled in a majority of their photos, but most objects were handled for only short periods of time throughout the day. This pattern mirrors the findings from prior studies with US-based families (Clerkin et al., 2017; Long et al., 2021; see also Yang et al., 2025 for a similar effect of visually present object types). Across infants, common object types also followed a right-skewed distribution: some objects were handled by many infants, but most objects were only handled by one or two infants in each community. Of note, many of the most frequently handled object types were shared between communities. These shared objects reflect some similarities in the structure of daily life, such as substantial time spent in a plant-dense, natural outdoor setting (e.g., sticks, rocks, and plants), as well as convergent functional demands (e.g., eating tools). However, the specific object types observed here vary substantially from the top object types observed in studies with US infants and young children (e.g., Long et al., 2021; Schatz et al., 2022; Suarez-Rivera et al., 2022). For instance, among the objects handled by at least 25% of infants in each

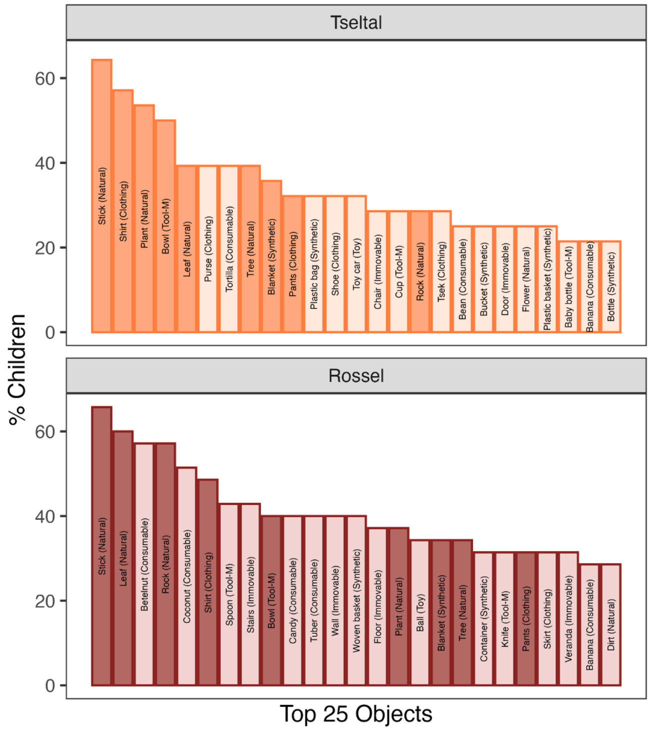

Fig. 6. Non-study-related object types handled at least once by the greatest number of children in each site. Filled bars represent object types that were among the top 25 for both sites.

sample, only a small subset of items was shared between our data and Herzberg et al. (2022)'s US (English-speaking) sample: clothing items, eating tools, bowls, baskets, bottles, and blankets. An urban US-based (Spanish-speaking) sample (Swirbul et al., 2022) shared a few additional top objects: bags, containers, doors, two toy types (balls and cars).

While much of our data speaks to consistency in the broad patterns of object handling between the Tseltal and Rossel communities of study, cross-cultural differences emerged when we examined finer-grained levels of object representation. Tseltal infants handled more child-specific manufactured items—namely, toys and clothing—than Rossel infants, while Rossel infants handled more large, immovable objects. These cross-site differences reflect the greater market integration (and hence availability of diverse, child-specific synthetic objects) in the Tseltal community and the long daily periods spent socializing around and climbing on household verandas in Rossel hamlets, as well playing outdoors in large, independent groups.

Building on object-handling frequency data from Study 1, identification of the specific objects that infants engaged with in Study 2 allowed us to detect additional age-related changes, including in object access and in some of the dynamics of object-centric interaction. With age, both Tseltal and Rossel infants spent more time with a greater diversity of objects across all levels of representation (categories, types, and tokens). Exploring finer-grained levels of object representation revealed sources of variation between communities (e.g., whether a variety of toys is available for purchase nearby, or whether daily socializing takes place on climbable surfaces). Overall, this work highlights how handled objects provide a window into infants' daily lives, reflecting their interests and momentary attention, as well as their object-centric routines, permitted object access, and the broader roles they occupy within their communities.

4. General discussion

We investigated patterns of infant and interactant object handling across the first three years of life in two non-Western communities: one Tseltal (Mayan) and one Rossel (Papuan). In Study 1, we found that infant—but not interactant—object handling was relatively frequent, comprising, on average, just under one-third of infants' waking time and increasing with age. Quantifying both infants' and interactants' object handling helps establish the sources of input that support early object-centered learning and socialization. In Study 2, we explored the common targets of infant object handling, finding evidence for both consistency and variability in the characteristics of infants' early object-centric input across communities. Providing descriptive estimates of infants' handling across object categories, types, and individual exemplars (i.e., tokens) helps specify the variability and density of young children's real-world "learning data" and, in turn, the evidence from which they are forming conceptual categories and generalizing.

4.1. Cross-cultural variation in object-centric experience

Social organization impacts the number and composition (i.e., children vs. adults) of interactants present, as well as the types of available objects and routine activities that infants engage in. The children on Rossel Island typically spend long stretches of the day with large, independent play groups that frequently participate in non-object-centric activities (e.g., playing tag, diving in the river: Casillas et al., 2021), whereas the children in the Tseltal community of study spend more of their day doing domestic-themed, object-centric activities (e.g., preparing foods, drawing, playing with toys) in smaller groups, staying nearer to the immediate area around their family homes (Casillas et al., 2020). These ethnographic observations were supported by the statistics of nearby people observed in our child-perspective photos, as Rossel infants in our sample were reliably surrounded by more children (and more adults) than Tseltal infants (Casillas et al., 2020, 2021; see also Bunce et al., 2025). Despite these differences in the structure of everyday life, including the social and interactional contexts typical for young children, the overall frequency of object handling was similar across communities.

Between the two studied sites, the Tseltal community is more commercially connected to the market economy of the region and nation in which it is located. While most families in the community rely on subsistence farming, day-to-day household necessities (e.g., cooking materials, construction materials, clothing) are often met with income generated by taxi-driving, paid farm labor, the sale of farmed goods, or other economic activities. This greater degree of market integration translates to a higher preponderance of toys and other small man-made, child-specific objects (e.g., cups, pens, plastic bottles, etc.) compared to Rossel Island (see also Padilla-Iglesias et al., 2021, for a consideration of market integration's influence on language input), though we note these objects are still less prevalent than they are in the Euro-American homes where much of the prior work on children's object-centric interaction has focused (e.g., Herzberg et al., 2022). Importantly, while Tseltal infants have access to toys and child-specific objects, we do not see these objects predominating their manual activities. This finding suggests that: (a) children are drawn toward ordinary objects in their material environments, which may be key for familiarizing them with aspects of the adult world (and their society more broadly); and (b) samples of activity from short recordings of in-lab object play capture very small slivers of children's experiences that are not fully representative of everyday life.

4.2. Limited role of interactant object handling

Interactant object handling was exceptionally rare, suggesting that in the Tseltal and Rossel communities of study, it represents, at most, a minimal source of input for early learning. Our estimates stand in stark contrast to those from in-lab, object-centric, child-caregiver interaction in the US, in which adult caregivers and one-year-olds handle objects with approximately equal prevalence (each 25% of the time on their own and 43% of the time jointly, Yu & Smith, 2013). Rates of caregiver and sibling child-relevant object handling in at-home ~1 h recordings based on our preliminary analyses of a US corpus (Bergelson, 2017, see Supplementary Materials) suggest a lower frequency (~10% of the hour). Rates of interactant object handling over the course of whole waking days may lower this estimate further, perhaps closer to the 1–2% we see in the present data. Informally, we note that interactant-held objects in the Tseltal and Rossel recordings were typically limited to a few prototypical items associated with basic care—food, clothing, and daily hygiene products, not toys, books, or other items that are more often be found in recordings with middle-class Western families. Even in the Tseltal context, where child-specific items were more abundant than in Rossel infants' environments, interactants still very rarely triadically engaged with such objects. If the present data are closer to children's true at-home experiences, in Western homes or elsewhere, theories of learning via hand-led intersubjective episodes (e.g., Yu & Smith, 2013) should focus on cases when the infant is doing the object handling, and not their interactant(s).

One caveat is that our analyses focus on interactants' handling of child-relevant objects. A recent in-lab, naturalistic study with a US sample found that infants attend to their caregivers' hands not only in highly child-centered dyadic play but also in less child-centered contexts (i.e., meal preparation: Kaplan & Yu, 2026). This finding suggests a plausible mechanism for learning through observation that is not fully captured by measures of "child-directed" object handling. Because our corpus does not include eye-tracking data (as in Kaplan & Yu, 2026), we cannot determine how Tseltal and Rossel infants allocate attention to their interactants' hands. Determining "directedness" is often highly ambiguous given that Tseltal and Rossel infants are frequently in the presence of multiple adults and other children. In these multi-party contexts, infants may act as side participants rather than direct participants (de León, 2011; see also Padilla-Iglesias et al., 2024). For these reasons, the present study focused on straightforward instances where interactants handled objects clearly relevant to the infant. This methodological choice does not imply that infants do not learn from observing interactants' handling of non-child-relevant objects. Indeed, Mayan language socialization research has long shown evidence of social learning through observation in these communities (Brown, 2011, 2014; de León, 1998, 2011; Foushee & Srinivasan, 2024; Gaskins & Paradise, 2010). Our coding of only clear instances of child-relevant object handling may have contributed to the low estimates of interactant handling. Nevertheless, consistent with previously documented low rates of child-directed speech in these and US communities at the daylong scale (Bunce et al., 2025; Casillas et al., 2020, 2021), we expect the true rate of child-directed handling to be similarly rare.

4.3. Methodological considerations and future directions

Although daylong child-perspective photos provide dense coverage of infants' natural experiences, they do not capture all aspects of object-centric interaction. The chest-worn camera position does not perfectly track children's visual attention but does afford relatively broad coverage of children's visuo-motor workspace, allowing for better detection of object handling specifically (see Casillas & Casey, 2024, for further discussion). In addition, because our analyses only included photos with at least one visible infant hand, moments when infants carried or held objects outside of the camera view (including in a non-visible hand) may have gone undetected. Thus, our estimates of child object-handling rates are likely conservative.

Using multiple camera angles (e.g., Bergelson, 2017) would provide a more comprehensive picture of children's daily environments, but with tradeoffs in feasibility: daylong recordings limit both the location and quantity of child-worn recordings, and third-person recording perspectives would be useful (Bergelson, 2017) but limit free movement in a daylong context (but see Schick & Stoll, 2025). We might learn a great deal more about the temporal properties of object handling in these two communities (e.g., Herzberg et al., 2022) by analyzing time spent with objects and sequences of object handling behavior. However, the discontinuity of visual data in our corpora—photos are taken a few times per minute—inhibits our ability to precisely track the timing or sequential properties of bouts of interaction with individual objects (e.g., an object may be handled for 2 s or 14 s, but we will not know the difference when photos are captured every 15 s; an object may be handled in two sequential photos, but the child may have briefly picked up another object between these two snapshots).

Future work combining child-perspective photos with other sources of multimodal information (e.g., audio recordings, inertial sensors) could help link children's object handling to various developmental outcomes, such as vocabulary growth and motor milestones (e.g., Babik et al., 2022; Suarez-Rivera et al., 2022). Continued comparative work across a broader range of cultural contexts will also be critical for distinguishing which features of children's early object-centered experiences are widespread versus locally contingent, helping to clarify whether object-handling patterns reflect shared aspects of early development or arise from community-specific features, such as unique material environments, daily routine activities, and caregiving practices. Such comparative, child-centered data will further ground theories of object-driven learning.

5. Conclusion

The current findings enrich our understanding of the patterns of infants' early object-centric input, including variation both within and between communities and across the first three years of life. The present work sets the stage for future comparative research on different dimensions of learning (e.g., object labels, affordances, etc.) during multimodal, object-centered interaction. The current findings also form a basis for further theory development around how object-handling episodes and early learning are influenced by children's cultural and socioeconomic milieu in concert with their own motor development. Continued work with cross-cultural collections of highly naturalistic, densely sampled egocentric data will be key to understanding how children come to learn about the world, along with how their learning processes are continually reshaped by features of both their home environment and their own developmental gains.

CRediT authorship contribution statement

Kennedy Casey: Writing – original draft, Software, Project administration, Formal analysis, Data curation. **Mary Elliott:** Writing – review & editing, Investigation, Data curation. **Elizabeth Mickiewicz:** Writing – review & editing, Data curation. **Elika Bergelson:** Writing – review & editing, Resources, Conceptualization. **Marisa Casillas:** Supervision, Software, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

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Declaration of Competing Interest

The authors declare no competing interest.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.infbeh.2026.102197.

Data availability

All anonymized data and analysis scripts are available at https://osf.io/7bgtd/.

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