Sticks, leaves, buckets, and bowls: Distributional patterns of children's at-home object handling in two subsistence societies

Kennedy Casey
University of Chicago
kbcasey@uchicago.edu

Mary Elliott
University of Texas at Dallas
maryle18@gmail.com

Elizabeth Mickiewicz
University of Chicago
lizmick9@uchicago.edu

Anapaula Silva Mandujano
University of Chicago
anapaula@uchicago.edu

Kimberly Shorter
University of Chicago
klshorter@uchicago.edu

Mara Duquette
University of Chicago
duquettemara@uchicago.edu

Elika Bergelson
Duke University
elika.bergelson@duke.edu

Marisa Casillas
University of Chicago
mcasillas@uchicago.edu

Abstract

Object-centric interactions provide rich learning moments for young children, including opportunities to discover word meanings. Children's first-person object handling experience, in particular, forms a key source of input—one that varies across cultures and across development. Using daylong photo streams from child-worn cameras, we analyze >16k images to identify the frequency and targets of child object handling across the first four years in two small-scale subsistence farming communities on opposite sides of the globe (Papuan and Mayan). Overall, we see a general consistency in the broad composition of handled objects across cultures and age, likely reflecting stable properties of children's physical environments and day-to-day routines. However, the exact objects available to children vary both within and across communities and also diversify with age. These various distributions of handling patterns are discussed in their relation to potential consequences for word learning.

Keywords: culture; object play; word learning; daylong recording; egocentric images

Introduction

The objects that we regularly pick up and handle—a coffee cup, a laptop, a baby bottle—offer a window into the physical, social, and cultural contexts that shape our understanding of the world. In this paper, we take a glimpse into everyday life at its beginnings by exploring children's at-home object handling from early infancy until age four.

Object handling and word learning

We contextualize our study with respect to the effects of object-centric interaction on word learning. For young children, objects—along with their associated activities and surrounding language—form a critical source of input. Caregivers' tendency to use nouns referring to objects in the here-and-now positively predicts children's early word comprehension (Bergelson & Aslin, 2017; see also Slone, Smith, & Yu, 2019) by helping learners map word forms onto their meanings in and across real-time interaction (e.g., Yu & Smith, 2013; Yurovsky, Smith, & Yu, 2013). Children also actively shape their own input via the objects that they choose to pick up and handle. Children's own object handling influences not only which objects dominate their visual fields (Suanda et al., 2019) but sometimes also the language that they hear about those objects (e.g., Chang, Barbaro, & Deák, 2016).

How frequently do children engage in object-centric interactions? First, hands—others' and their own—are in good supply in young children's view of the world, especially after early infancy (Fausey, Jayaraman, & Smith, 2016; Jayaraman, Fausey, & Smith, 2017; Long et al., 2020). Infants' own object handling is relatively frequent: Herzberg and colleagues (2022) find that US infants handle objects ∼60% of the time during at-home play, Yu and colleagues (2013) find ∼70% when including joint handling with adults in US in-lab object play, and Casillas and Elliott (2021) find ∼15 and 17% object handling in daylong photo streams in a Papuan and a Mayan community, respectively.

A first step in determining what children may be able to learn from these frequent first-person holding experiences is to examine *what* objects are being held. From there, we can explore the second critical ingredient for word learning—how often children are also encountering linguistic information relating to handled objects (e.g., their labels and associated concepts). This labeling piece may only occur during a small subset of total object handling time. We do not yet know how often objects in the here-and-now are typically talked about over the course of children's whole waking days at home, but we do know that such talk fluctuates across high and low activity periods (Bergelson et al., 2019). We also know that children's object handling varies enormously across the first few years due to cross-cultural differences in available objects and caregiving practices, as well as age-related maturational constraints.

Object handling across cultures

The array of objects available to children varies in type and prevalence across cultures. 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, while other objects remain specific to people and places (e.g., the gourd and bombilla for drinking mate in much of South America, stemming from Indigenous Guaraní and Tupí tradition).

Early access to objects is also shaped by culture-specific practices for carrying children, keeping them safe and warm, and scaffolding their development of locally-valued capacities (e.g., word learning in many US families, walking in Kenyan Kipsigis families: Super, 1976; see Adolph, Karasik, & Tamis-LeMonda, 2010, for an overview). Take, for example, middle-class US family homes, which have been noted for their large quantities of possessions, or "clutter"—much of which designed specifically for children (e.g., toys and picture books: Arnold et al., 2012). We might infer, based on these assemblages of home objects, that much of what 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 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 $\sim$100% of infants playing with children's books and stuffed animals, and a total of 32 toy types appearing in $\geq$25% of infants' play. Non-toy play was also common but still appeared to predominantly include infant-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, with much greater overlap between objects for infants and objects for adults (e.g., Karasik et al., 2018).

Object handling across age

In early infancy, children have little ability to hold things or to control their posture, so they primarily interact with the objects that others bring near to them. Faces, rather than objects, may make up a much greater proportion of their social and visual input early on (Fausey, Jayaraman, & Smith, 2016; Jayaraman, Fausey, & Smith, 2017; but see also Long et al., 2020). However, later gains in manual dexterity and gross motor skill (e.g., sitting, crawling, walking) increasingly widen children's ability to seek, reach, and grab a diversity of objects in their environments. Increasing motor development not only gives children greater control over what objects they handle, but also how they elicit social and linguistic information relating to objects and for how long (Adolph, Karasik, & Tamis-LeMonda, 2010; Gaskins, 2000; Herzberg et al., 2022; Kretch, Franchak, & Adolph, 2014; Sanchez et al., 2018).

The current study

While prior work makes a strong case for the impact of children's object-centric interactions on their word learning, the findings: (a) are limited to a culturally narrow sample of populations, (b) have tended to rely on short recordings that limit the scope of the object-centered interactions analyzed, and (c) have rarely examined in detail the distributions of individual objects that children typically interact with at home (exceptions include Bergelson et al., 2019; Casillas & Elliott, 2021; Herzberg et al., 2022).

In the current work, we use daylong photo streams from child-worn cameras to analyze object handling by children under age four in two rural, small-scale subsistence farming communities on opposite sides of the globe: Rossel Island ("Rossel"; Milne Bay Province, Papua New Guinea) and Tenejapa ("Tseltal"; Chiapas, Mexico). While these communities are comparable in many ways (e.g., rural, swidden horticulturalist, housed in multi-generation family complexes), prior work has established substantial differences in the organization of young children's daily lives, child carrying practices, and each community's level of market integration (i.e., greater availability of synthetic materials in Tenejapa), leading us to expect differences in the objects that children handle across the day and early lifespan (Brown & Casillas, 2021; Casillas, Brown, & Levinson, 2020, 2021; Casillas & Elliott, 2021).

Using these manually annotated photo streams, we first establish how often children handle objects from different categories (e.g., food vs. tools), both by the total amount of handling and by number of unique objects per hour in each category across sites. We explore the top individual objects in each site along with the overlap that exists between communities. We then investigate how the rate and characteristics of object handling change with age.

Our findings reveal relative consistency in the broad composition of objects handled by children, both between sites and across age, with a few important exceptions: a greater diversity of synthetic objects handled by Tseltal children (e.g., relating to greater market integration), more time spent with immovable objects for Rossel children (e.g., relating to socializing time on/near household verandas), and a greater diversity of held objects and greater number of transitions between objects across age. While we focus here on describing the distributional patterns of children's object handling, we do this with an eye toward the cognitive and linguistic implications of these experiences—namely, consequences for word learning.

Method

Corpus

Daylong photo streams consisted of images captured approximately every 15 (Rossel) to 30 (Tseltal) seconds over the course of 8 (Rossel) to 9 (Tseltal) waking hours at home. Children wore a recording vest equipped with a camera (Narrative Clip 1) and miniature fisheye lens (Photojojo Super Fisheye) that provided a 180° view of the environment. For younger infants who were not yet walking, the camera was instead worn by the primary caregiver.

Previously, 83 daylong photo streams (113,668 photos) had been comprehensively manually annotated for the presence or absence of child object handling (Casillas & Elliott, 2021). Here, we further annotate and analyze the subset of 16,916 photos with confirmed child object handling.

We included one randomly selected daylong photo stream from each of 77 children with object handling in the original data set (Rossel: 41, Tseltal: 36). Children ranged in age from 0 to 48 months (M_{Rossel} = 21.9, $M_{Tseltal}$ = 22.7). The amount of object handling and thus the number of photos available to be annotated varied across children, ranging from 1 to 631 (M_{Rossel} = 238.2, $M_{Tseltal}$ = 198.6).

Manual annotation

Photos were annotated with IMCO, an open-source Python program adapted for efficient coding of photo streams (Casey et al., 2022). Annotators provided labels for the handled

Figure 1: Example images with object and category labels.

object(s) in each photo (e.g., "stick") and selected among a set of predefined categories to characterize each type of object (e.g., "Natural"). Categories included consumables (e.g., food, drinks, and drugs: "Food"), 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 Figure 1 for example images and Table 1 for example objects from each category). In the reported findings, **object** refers 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 category** refers to the predefined categories used to classify each object type (e.g., "Natural," "Toy," "Immovable").

Data preparation and reliability

Images were excluded if they were too dark, bright, blurry, or covered for annotators to identify handled objects, if annotators were otherwise unsure about what objects were being handled, if there was no handled object, or if the researcher was still present when the image was captured (n = 1,138, or 6.7% of the data set). 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, 15,778 images were deemed usable by annotators (Rossel: 9,223, Tseltal: 6,555). One participant had no usable images, so our analyses are based on 76 photo streams.

To confirm sufficient reliability, 20% of photo streams were double coded. Reliability annotations were equally spread across sites and ages and included a total of 8,288 images. At the category level, annotators agreed on 91.2% of decisions, on average across photo streams (Rossel: 91.9%, Tseltal: 90.6%). At the object label level, annotators agreed on 85.1% of decisions (Rossel: 86.1%, Tseltal: 84.3%).

Results

Overall frequency statistics

Children handled an average of 26.7 unique objects per day (median = 27.0, SD = 16.0, range = 1–58), with no significant differences across sites (M_{Rossel} = 26.3, $M_{Tseltal}$ = 27.2, W = 700.50, p = 0.863). The distribution of handled objects was highly right-skewed within and across children. Each child's distribution was skewed such that a small group of objects was handled in a majority of their images, but most objects were handled for only short periods of time (Figure 2). Across children, common objects followed a similar Zipfian distribution: some objects were handled by many children, but most objects were only handled by 1–2 children in each site (Rossel: 55.7%, Tseltal: 60.9%).

Comparing across sites, 34.8% of objects were handled by both Rossel and Tseltal children, and several shared objects were among the most frequently handled in both sites. In fact, among the top 25 most common objects[1], 10 were shared across sites (Figure 3).

Table 1: Number of unique objects (N) and objects handled by the most children, for each category, across sites.

	Rossel		Tseltal	
Object Category	**N**	**Top Objects**	**N**	**Top Objects**
Food	38	betelnut, coconut, tuber	54	bean, tortilla, chips
Synthetic	68	blanket, woven basket, bucket	68	blanket, plastic bag, bucket
Natural	21	stick, leaf, rock	13	stick, plant, tree
Toy	21	ball, book, swing	42	toy car, ball, book
Mealtime Tool	21	bowl, spoon, knife	11	bowl, cup, baby bottle
Clothing	16	shirt, skirt, purse	21	shirt, pants, shoe
Immovable	20	stairs, wall, floor	19	chair, door, fence
Work Tool	16	knife, broom, baby bathtub	30	broom, clothesline, embroidery ring

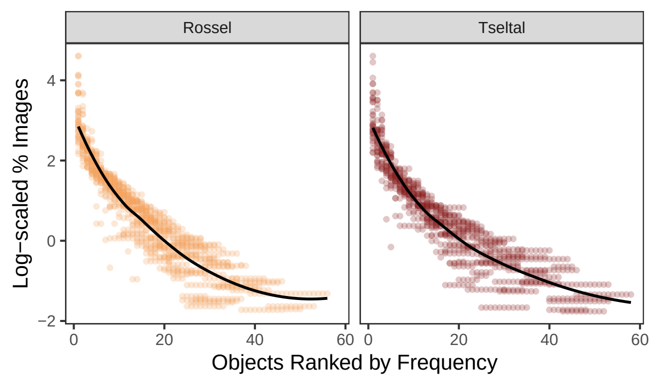

Figure 2: Zipfian distribution of objects. Points reflect log-transformed proportion estimates for individual children.

Effects of object category

We quantified the distribution of object categories at two timescales: across the whole waking day (i.e., overall % handling for different object categories across all images) and across individual hours (i.e., number of unique objects from different object categories per hour).

During any given hour, children handled 5.3 objects from

[1]The study camera was the object that was handled by the most children in both sites (Rossel: 68.3%, Tseltal: 91.4% of children; see Bergelson et al., 2019, for a similar effect) but accounted for a relatively small percentage of each child's object handling time, on average (M_{Rossel} = 3.6%, $M_{Tseltal}$ = 6.5% of images). Inclusion of study-related items did not qualitatively change any of the reported results, unless otherwise noted.

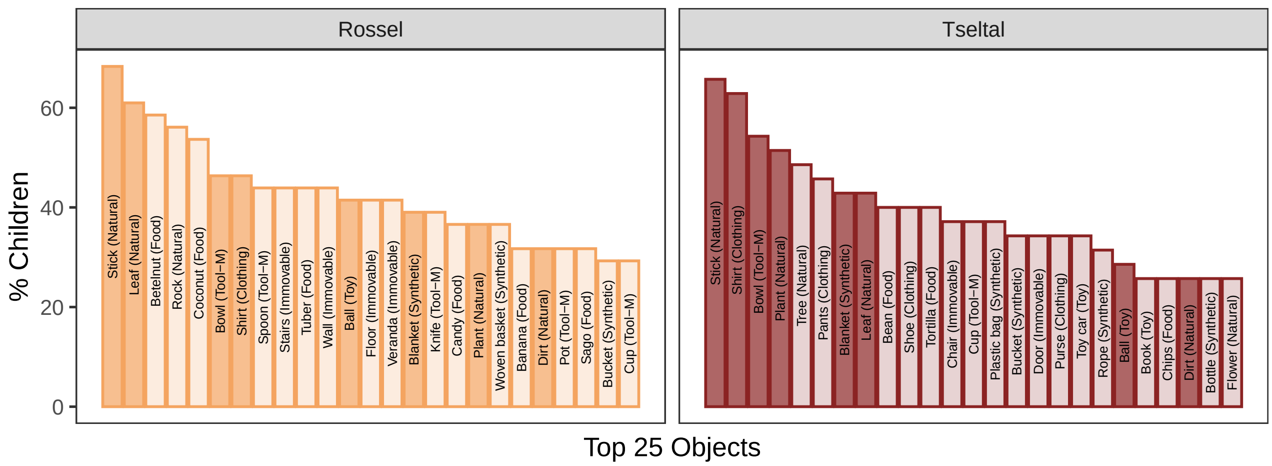

Figure 3: Non-study-related objects handled at least once by the most children in each site. Filled bars represent objects that were among the top 25 for both sites.

3.0 different categories, on average (median = 4.0 objects, *SD* = 4.9, range = 0–27). We exclude from the following analyses, any hour in which a child did not handle any objects; inclusion of these hours creates a second mode at 0, violating our statistical models' assumptions of normality.

To test for differences across sites and categories, we ran individual linear mixed-effects regressions 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[2]. After correcting for multiple comparisons, we found a significant main effect of the synthetic object category (β = 0.35, *SE* = 0.09, t = 4.04, p = 0.001) and a marginal site-by-synthetic interaction (β = 0.36, *SE* = 0.12, t = 2.93, p = 0.058) such that children handled more unique synthetic objects per hour than objects from other categories, and this effect was stronger for Tseltal children than for Rossel children. Additionally, we found negative main effects for the toy (β = -0.42, *SE* = 0.13, t = -3.14, p = 0.034), mealtime tool (β = -0.35, *SE* = 0.12, t = -2.96, p = 0.056), clothing (β = -0.32, *SE* = 0.11, t = -3.02, p = 0.049), and work tool (β = -0.65, *SE* = 0.17, t = -3.86, p = 0.002) categories, indicating that children handled fewer unique objects from these categories per hour relative to other categories. Finally, a significant main effect of the immovable object category (β = 0.43, *SE* = 0.11, t = 3.95, p = 0.002) and a significant site-by-immovable interaction (β = -0.76, *SE* = 0.17, t = -4.44, $p < 0.001$) revealed that children handled more unique immovable objects per hour than objects from other categories, and this effect was stronger for Rossel children than for Tseltal children (Figure 4).

[2]lmer(unique objects per hour ∼ category (target/non-target; factorial) * site (Rossel/Tseltal; factorial) + (1 | child))

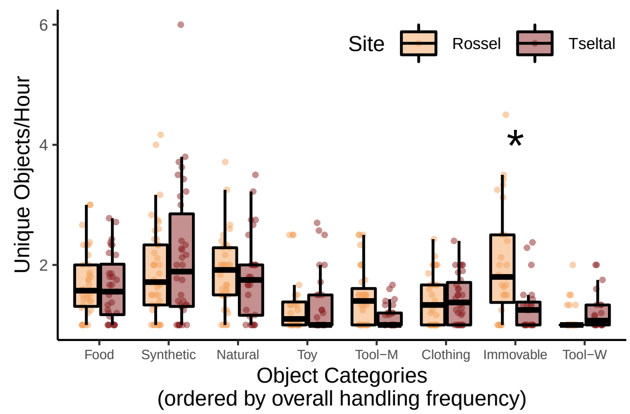

Figure 4: Rate of unique objects handled per hour across object categories. Points reflect means for individual children. Asterisks indicate significant site-by-category interactions after correcting for multiple comparisons.

Effects of age

Prior work with this same corpus indicated a significant increase in object handling across the first four years (Casillas & Elliott, 2021). By adding information about *what* objects children are handling, we can now explore finer-grained characteristics of age-related change in object handling behaviors. We investigate changes in (a) the distribution of object categories, (b) the number of unique objects and categories handled per hour, and (c) transitions between objects and categories per hour.

Do children handle different types of objects with age? We fit individual linear regressions predicting the proportion of handling time for each category as a function of age (in months), site, and their interaction. We included number of images as an additional fixed effect to account for the wide range in total available images for each child (range = 1–631) and the resulting greater likelihood of detecting proportions near 0 or 1 when there were only a handful of images[3]. This analysis revealed no significant age-related changes in the frequency of handling of different object categories[4] and no significant site-by-age interaction effects (all adjusted ps > 0.05). Thus, the the broad composition of handled objects remained largely stable over age.

Does object handling diversify with age? In addition to the overall age-related increase in handling found by Casillas and Elliott (2021), we see that, with increasing age, children handled more unique objects per hour (β = 0.12, SE = 0.03, t = 3.60, p = 0.001; Figure 5A) and more objects from different categories per hour (β = 0.06, SE = 0.01, t = 4.45, $p < 0.001$; Figure 5B). These effects were consistent across sites; we found no main effects of site or interactions between site and age (all ps > 0.05).

Does object handling become more complex with age? Analysis of children's relative rate of transition between objects per hour (i.e., the number of transitions from one object to another divided by the number of available objects for that hour) did not reveal an overall age-related increase (β = 0.01, SE = 0.003, t = 1.59, p = 0.116). However, there was a significant main effect of site (β = -0.30, SE = 0.13, t = -2.37, p = 0.020; Figure 6C), indicating that Tseltal children made fewer transitions between objects per hour than Rossel children. While the site-by-age interaction term did not reach statistical significance (β = 0.01, SE = 0.005, t = 1.54, p = 0.128), descriptively, this difference appears to be more pronounced for younger children. At the category level, we found that children made marginally more transitions between object categories per hour with age (β = 0.01, SE = 0.01, t = 1.69, p = 0.095), in addition to a marginal main effect of site (β = -0.53, SE = 0.31, t = -1.70, p = 0.092; Figure 6D) that mirrors the finding for object transitions: Tseltal children made fewer category transitions per hour than Rossel children.

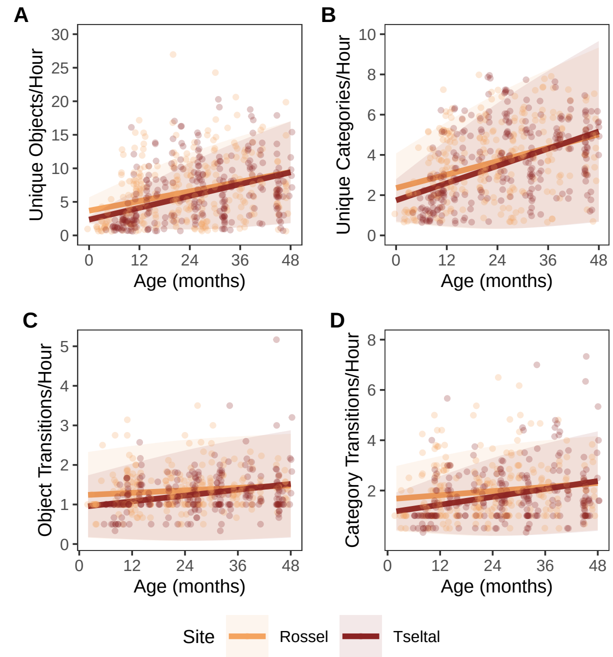

Figure 5: (A) Unique objects and (B) object categories handled per hour as a function of age. (C) Relative number of transitions between objects and (D) object categories per hour as a function of age. Points reflect raw hourly counts for each child, and lines reflect model predictions with shaded standard error regions.

Discussion

In the current descriptive work, we annotated and analyzed 16,916 images featuring at-home child object handling from children under age four in two subsistence communities from opposite sides of the globe. Our main findings are as follows: Children's overall handling of different object categories (e.g., food vs. toys vs. natural objects) appears stable across age and cultural context. In contrast, when it comes to the number of unique objects per hour, children handled a greater diversity of synthetic and immovable objects, relative to the other categories, and did so to different extents across sites. The rate of transition between objects also varied between sites. Finally, time spent with objects is Zipfian-distributed, and many of the most common objects within sites were also common across sites. We discuss this rich set of findings with respect to (a) object handling as a window into children's worlds in general, and (b) the implications of object handling patterns for word learning.

Objects as insight into children's worlds

Our findings, while preliminary, suggest that different measures of object handling reveal unique aspects of children's worlds. The total time children spend handling objects of different types (e.g., natural, immovable, synthetic, etc.) appears stable across age and sites (consistent with Long et al., 2021, for visually present categories). Specifically, food and synthetic objects are most prevalent. We suggest that this measure of **total time spent within categories** may reflect stable properties of children's physical environments and their routine activities, across age and across diverse contexts. If we were to sample in other communities, we would expect

[3] As expected, number of handling images was correlated with age (r = 0.50 [0.31, 0.65], $p < 0.001$), which we attribute to changes in motor development and permitted object access over the first four years (Casillas & Elliott, 2021). That is, the correlation is an artifactual outcome of development. Including both variables as fixed effects in a regression poses no technical issue in estimating R^2, but does limit the total variance attributed independently to either variable (Wurm & Fisicaro, 2014). Thus, for models of non-proportional measures, we rely solely on age to capture this variance (i.e., lmer(non-proportional DV ∼ age (months; numeric) * site (Rossel/Tseltal; factorial) + (1 | child)).

[4] The only exception was an initial finding of a decrease in handling of clothing over age (β < 0.001, SE = 0.001, t = -2.88, p = 0.005). However, after removing study-related clothing (i.e., the vest containing the camera), this effect was no longer significant.

to find more differences (e.g., more time spent with toys in US middle-class samples: Herzberg et al., 2022), but these two rural subsistence communities show overall similar profiles despite substantial differences in their current level of market integration, organization of daily life, infant carrying practices, and other aspects of their cultural milieux (Brown & Casillas, 2021; Casillas, Brown, & Levinson, 2020, 2021; Casillas & Elliott, 2021).

In contrast, the **number of individual objects** children handle reveals strong age-related change, as well as some differences between sites. Children's object handling diversifies within and across categories as they get older, which means more unique objects handled from more categories. We see that Rossel children transition between objects more frequently than Tseltal children. This difference can likely be attributed to culture-specific child carrying practices—Tseltal children are often carried in a sling during their early years and are therefore less freely able to seek out and handle new objects (Casillas & Elliott, 2021). Compared to other categories, children handle a greater diversity of synthetic objects (stronger for Tseltal) and immovable objects (stronger for Rossel) per hour. These cross-site differences reflect the greater market integration (and hence availability of diverse synthetic objects) in the Tseltal community and the long daily periods of socializing around and climbing on family verandas in the Rossel community.

We suggest that the individual objects that children handle give us insight into development. Through identification of the specific objects that children engage with, we can detect age-related changes, both in object access and in the dynamics of object-centric interaction (e.g., rate of transition between objects). Moreover, knowing what objects children handle can reveal many facets of everyday life that vary across economic and cultural contexts (e.g., whether a variety of toys is available for purchase nearby, or whether daily socializing takes place on climbable surfaces).

Implications for word learning

Our data indicate that children are exposed to a stable and wide variety of object categories in the first four years of life. Children also have increasing access to a diversity of objects within categories as they get older. Similarity in the distribution of categories across sites suggests some basis for expecting similarity in early object label knowledge and other associated word knowledge by children in these two sites. Individual objects also show a Zipfian distribution in how they are handled, with some handled frequently and most handled infrequently. This distribution may help support children's word learning (see Carvalho, Chen, & Yu, 2019; Clerkin et al., 2017; Long et al., 2021; Montag, Jones, & Smith, 2018), and in tandem with other observed effects across age and cultural context, may indicate which words (i.e., object names or other object-relevant words) children are likely to learn first and how their semantic networks grow within and across categories.

Future directions

Here, we grouped objects on the basis of broad semantic categories. While this categorization allows us to describe the overall distribution of handling across different types of objects, it does not necessarily give us insight into the specific associated activities or applied functions of objects. Knowing more about *how* objects are being used in context could help (a) further indicate links between social and linguistic behavior, and (b) reveal more changes over developmental time (e.g., a spoon as a teething toy, musical instrument, and ultimately, a utensil).

To more directly compare to existing data from other cultural contexts, we will need to further analyze the temporal characteristics of handling bouts and track unique object tokens rather than just types (Herzberg et al., 2022). We note, however, that this second task will be near-impossible for some object types in the Rossel and Tseltal context (e.g., leaves, twigs). As of now, we find less within-site overlap in the exact objects handled by Rossel and Tseltal children compared to Herzberg et al. (2022)'s US data, but this could be as much due to recording type (e.g., two-hour videos vs. daylong photos) as to cultural difference. Thus, future cross-community investigations with parallel—ideally daylong—recording methods are needed to more fully understand the influence of culture on children's typical object handling experience.

Relating to direct implications for word learning, our most urgent goal is to analyze the speech surrounding bouts of object handling to derive estimates of (a) how often objects are talked about, (b) what type of information is mentioned, and (c) by whom. By combining our existing annotations of daylong photo streams with time-linked daylong audio data in two unrelated cultural contexts, our aim is to develop a benchmark against which models and mechanisms of word learning via object-centric interaction can be tested.

Conclusion

Analyzing the types of objects that children handle gives us a window into what they are interested in, what they do and talk about with others, what they are allowed to access, and more. Handled objects offer learners a range of sensory experiences that could be paired with the social, linguistic, and physical information around them. In the present study, we examined coarse patterns in young children's at-home object handling in two unrelated subsistence communities, finding many striking similarities despite differences in the communities' market integration and ways of life. Our data provide some basis for kernels of similarity in experience across culture and change with developmental time. However, our findings also point to immense variation in the assemblages of unique objects handled by individual children and indicate that children actually spend only narrow slices of time with a vast majority of objects. Determining if and how these distributional patterns, plus language input, coalesce to give rise to word learning is a crucial next step.

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