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

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Abstract

Object-centric interactions provide rich learning moments for young children, including opportunities to discover word meanings. Children's own object handling, 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, with a few notable exceptions owing to differences in object availability, child carrying practices, daily activities, along with maturational constraints. Object handling patterns are discussed in relation to their 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 learners, 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 in their visual fields (Suanda, Barnhart, Smith, & Yu, 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, Kachergis, Agrawal, & Frank, 2020). Infants' own object handling is relatively frequent: Herzberg and colleagues (2021) 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.

Concurrent with these events, children will sometimes encounter linguistic information relating to the focused-on object (e.g., its label and associated concepts). However, this critical additional ingredient for word learning 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, Amatuni, Dailey, Koorathota, & Tor, 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 maturational constraints.

Object handling across cultures

The array of objects available to children varies in type and prevalence across cultures. Objects spread via globalization (e.g., plastic bags) and objects with a basic functional role that arose 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 the 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 ("clutter"), much of which is designed specifically for children (e.g., toys and children's books: Arnold, Graesch, Ochs, & Ragazzini, 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 (2021) 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 ∼100% of infants playing with children's books and stuffed animals, and a total of 32 toy types appearing in ≥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, Schneider, Kuchirko, & Tamis-LeMonda, 2018).

Object handling across age

In early infancy, children have little ability to hold things or to control their posture, primarily experiencing objects through what 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, Kachergis, Agrawal, & Frank, 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 information relating to objects and for how long (Adolph, Karasik, & Tamis-LeMonda, 2010; Gaskins, 2000; Herzberg, Fletcher, Schatz, & Tamis-LeMonda, 2021; Kretch, Franchak, & Adolph, 2014; Sanchez, Long, Kraus, & Frank, 2018).

The current study

Overall, 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 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, Amatuni, Dailey, Koorathota, & Tor, 2019; Casillas & Elliott, 2021; Herzberg, Fletcher, Schatz, & Tamis-LeMonda, 2021).

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 sites. 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 handled 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 with confirmed child object handling in the present study.

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). One participant had no usable images (see below for exclusion information), so our analyses are based on 76 photo streams. 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,

Figure 1: Example images with object and category labels.

Fisher, Tice, & Casillas, 2022). Annotators provided labels for the handled 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 ("Food"; food, drinks, and drugs), 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), and "object category" refers to the predefined categories we used for 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 (9,223 for Rossel, 6,555 for Tseltal).

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 (Rossel: 91.9%, Tseltal: 90.6%), on average across photo streams. At the object label level, annotators agreed on 85.1% of decisions (Rossel: 86.1%, Tseltal: 84.3%).

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

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).

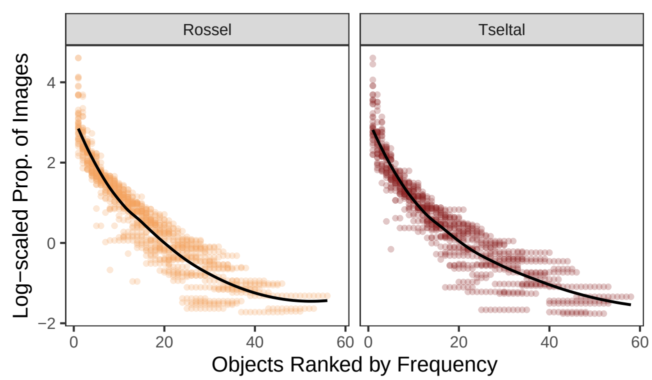

Figure 2: Zipfian distribution of objects. For each child, the top object was defined as the object appearing in the greatest number of images; thus, the identity of the top object does not match across all children. Points reflect log-transformed proportion estimates for individual children.

[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, Amatuni, Dailey, Koorathota, & Tor, 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

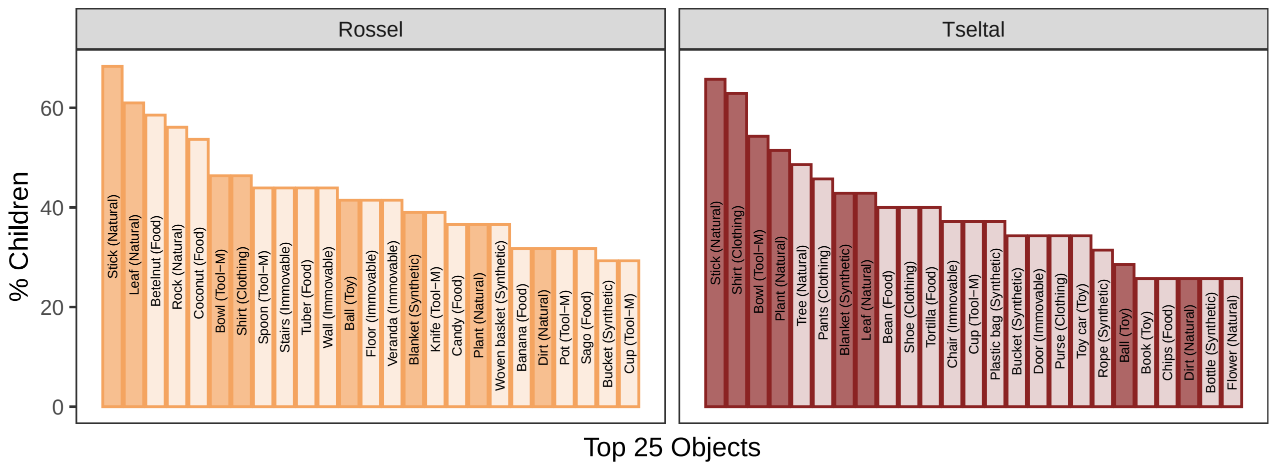

Figure 3: Non-study-related objects handled at least once by the most children in each site. Filled bars represent objects that were among the top 25 for both sites.

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 3.0 different categories, on average (median = 4.0 objects, *SD* = 4.9, range = 0–27). 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]. We excluded hours with no object handling from this analysis (and all following linear mixed-effects modeling) to avoid zero-inflation that would violate the assumptions of a Gaussian distribution. After correcting for multiple comparisons, we found a significant main effect of the synthetic object category ($\beta = 0.35$, $SE = 0.09$, $t = 4.04$, $p = 0.001$) and a marginal site-by-synthetic interaction ($\beta = 0.36$, $SE = 0.12$, $t = 2.93$, $p = 0.058$) 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 ($\beta = -0.42$, $SE = 0.13$, $t = -3.14$, $p = 0.034$), mealtime tool ($\beta = -0.35$, $SE = 0.12$, $t = -2.96$, $p = 0.056$), clothing ($\beta = -0.32$, $SE = 0.11$, $t = -3.02$, $p = 0.049$), and work tool ($\beta = -0.65$, $SE = 0.17$, $t = -3.86$, $p = 0.002$) 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 ($\beta = 0.43$, $SE = 0.11$, $t = 3.95$, $p = 0.002$) and a significant site-by-immovable interaction ($\beta = -0.76$, $SE = 0.17$, $t = -4.44$, $p < 0.001$) 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).

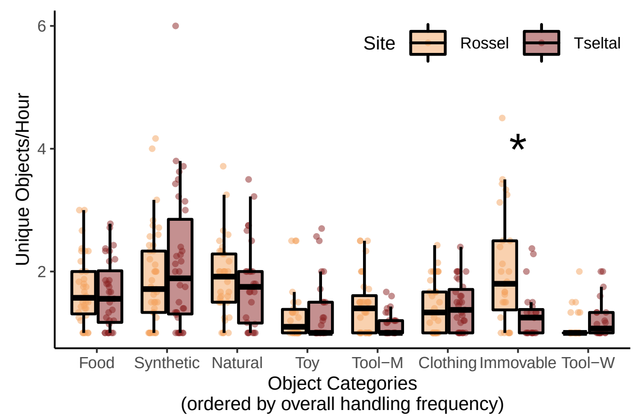

Figure 4: Count of unique objects handled per hour by object category. Points reflect means for individual children across all hours of recording. Asterisks indicate significant differences between sites after correcting for multiple comparisons.

Effects of age

Prior work with this same data set 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. 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.

[2] Model structure: lmer(unique objects/hour $\sim$ category (target/non-target; factorial) * site (Rossel/Tseltal; factorial) + (1 | child))

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), leading to a 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 *p*s $>$ 0.05). Thus, the the broad composition of handled objects remained largely stable over age (Figure 5).

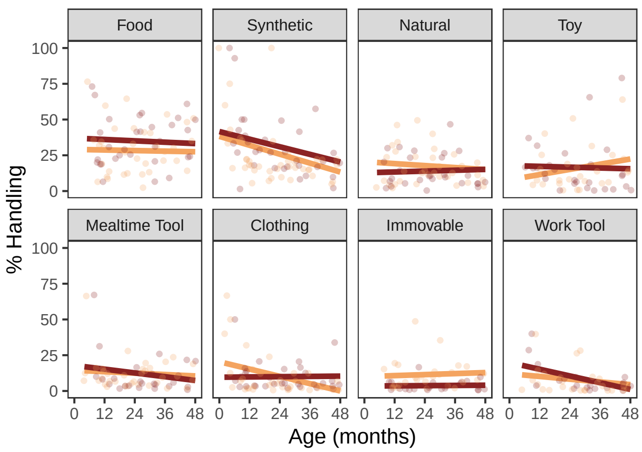

Figure 5: Frequency of handling by object category across age. Individual points show raw percentages per hour for each child, and lines reflect model-predicted percentages.

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 = 0.14, *SE* = 0.03, *t* = 4.04, *p* = 0.000; Figure 6A) and more objects from different categories per hour (β = 0.06, *SE* = 0.01, *t* = 4.45, *p* = 0.000). These effects were consistent across sites; we found no main effects of site or interactions between site and age (all *p*s $>$ 0.05).

[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)—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., Model structure: lmer(non-proportional DV $\sim$ 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 = -0.004, *SE* = 0.00, *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.

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* = 0.00, *t* = 2.19, *p* = 0.031). However, there was a significant main effect of site (β = -0.40, *SE* = 0.14, *t* = -2.81, *p* = 0.006) as well as a site-by-age interaction (β = 0.01, *SE* = 0.01, *t* = 2.12, *p* = 0.037), indicating that Tseltal children made fewer transitions between objects per hour than Rossel children but showed a steeper increase across age (Figure 6B). At the category level, we found that, children made marginally more transitions between object categories per hour with age (β = 0.02, *SE* = 0.01, *t* = 2.47, *p* = 0.016), with no detectable differences across sites.

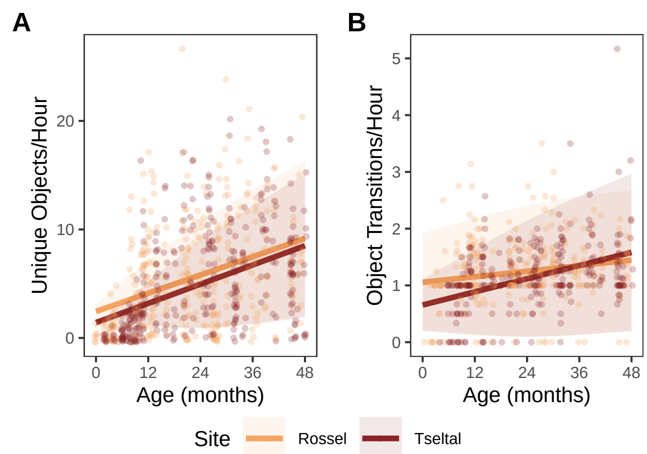

Figure 6: (A) Unique objects handled per hour and (B) relative number of transitions between objects per hour as a function of age. Points reflect raw hourly counts for each child, and lines reflect model predictions with shaded standard error regions.

Discussion

We annotated and analyzed 16,916 images of 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 time spent within categories (e.g., food vs. natural vs. immovable) 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, with only Tseltal children significantly increasing their transition rate over age. Finally, time spent with objects is Zipfian-distributed, and many of the most common objects within site were also common across the two 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

These findings, while preliminary, suggest that different measures of object handling reveal differing 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, Kachergis, Bhatt, & Frank, 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 to find more differences [e.g., more time spent with toys in US middle-class samples; Herzberg, Fletcher, Schatz, & Tamis-LeMonda (2021)], but these two rural subsistence communities show overall similar profiles despite substantial differences in their current market integration, the 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. This means more unique objects handled, from more categories, and for Tseltal children, more frequent transitions between objects. Note that this effect may be stronger for Tseltal children because they are more restricted in their movements early on, as they are often carried in a sling and 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) of 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 children handle give us insight into development. Through identification of the specific objects children engage with, we can detect age-related changes in object access along with 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 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 and 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 word learning (see Carvalho, Chen, & Yu, 2019; Clerkin, Hart, Rehg, Yu, & Smith, 2017; Long, Kachergis, Bhatt, & Frank, 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

In the current work, we grouped objects on the basis of broad semantic categories. While this categorization allows us to broadly describe the distribution of handling across different types of objects, it does not necessarily give us insight into the specific associated activity or applied function. Knowing more about how objects are being used in context could help (a) 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 also require that we further analyze the temporal characteristics of handling bouts and track unique object tokens rather than just types (Herzberg, Fletcher, Schatz, & Tamis-LeMonda, 2021) We note, however, that this will be near-impossible for some object types (e.g., leaves, twigs). Furthermore, we would like to extend our comparison to other communities, rural and urban, but this will require daylong photo collection in these other sites. We find less within-site overlap in exact objects handled by Rossel and Tseltal children compared to Herzberg, Fletcher, Schatz, & Tamis-LeMonda (2021)'s US data, but this may be as much due to recording type (e.g., two-hour videos) as to cultural difference.

Our most urgent goal is to analyze the speech surrounding bouts of object handling to derive estimates of how often the objects are talked about, what is mentioned, and by whom. By combining these daylong photo streams with 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

Children's material worlds—especially the objects they handle—tell us what they are interested in, what they do and talk about with others, what they are allowed to access, and more. Handled objects offer children 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. If indeed object-centric interactions guide word learning and other types of social learning, the present data provide some basis for kernels of similarity in experience across culture and change with developmental time. *However*, the current data equally suggest that any story along those lines must also mention the immense variation we have begun to unpack in the assemblages of unique objects handled by individual children, as well as the very *narrow* slices of time children actually spend with the vast majority of objects.

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