On the Nature of Numerosity and the Role of Language in Developing Number Concepts

A Reply to Everett

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In response to Everett, our article (Coolidge and Overmann 2012) was not “based in large measure on paleoanthropological data” (Everett 2013:81); 60% of our 53 references were “relevant experimental findings on numerical cognition” (81). Two of the references cited by Everett—Everett (2013a) and Everett and Madora (2012)—we did not include, indeed due to their recency. While the former remains unavailable, we have reviewed the latter and disagree with Everett’s interpretation of his data. Further, we would share his discomfort that “reconcilability with experimental data is surely a sine qua non of any treatise on the genesis of symbolic thought” (81), were it the case that this description could truly be said to characterize our paper—but it cannot. Finally, we take exception to two of Everett’s claims in particular: first, that we “errantly” (81) assume basic numerical cognition to be uniform in extant Homo sapiens, and second, that we underestimate the degree to which human numerosity is shaped by language.

Everett’s questioning of whether basic numerical cognition is uniform across humanity demonstrates the crux of his misunderstanding: The essence of basic numerosity (hereafter referred to simply as numerosity) in humans and in other species is subitization, the ability to rapidly and unambiguously recognize small quantities (up to three or four), and magnitude appreciation, the ability to appreciate quantity differentials above a threshold of just-noticeable differences. Everett fails to demonstrate a lack of uniform numerosity in humans; rather, he himself notes that the Pirahã can subitize, and of his six references, three demonstrate subitization in extant Homo sapiens without conventional language for numbers (e.g., Nicaraguan homesigners). Thus, the idea that some humans lack numerosity is dispelled by Everett’s own work and references. Notably, the presence of numerosity in peoples whose languages contain limited numbers is well documented (e.g., Butterworth et al. 2008; Gordon 2004; Pica et al. 2004).

Regarding Everett’s second exceptional claim, our purported underestimation of just how much language shapes numerosity in humans, we note that providing such an estimation was not the intent of our article. Rather, we intended to demonstrate, through a large number of experimental findings on numerical cognition, that the lower level of abstraction involved in numerosity may serve as a feral cognitive basis for higher-level symbolic thinking, including higher number recognition, letter symbolism, and sequencing. Further, we based our suggestion that numerosity and language are largely independent on the presence of numerosity in prelinguistic 9-month-old human infants and many ailinguistic species: monkeys can subitize (Cantlon and Brannon 2006), and even fish can recognize quantity differentials (Agrillo, Dadda, and Bisazza 2007).

Everett declares that language has a “fundamental role ... in shaping basic human numerosity” (2013b:81, emphasis ours), a curious claim given that the numerosity in humans is merely the same ability to recognize small and differential quantity shared by many species; the difference, as we explained in our article, is that human numerosity is functionally integrated with abilities for the precise manipulation of fingers and objects and additional dimensionality in vision (Orban 2011; Orban et al. 2006). Everett also cites Hurford’s claim, “Without language, no numeracy” (Hurford 1987:305), finding it “prescient” (Everett 2013b:81). However, Everett has failed to recognize that Hurford has since softened his stance, claiming more recently, “Without using language, we still can’t go [higher than the subitizing range of about four]” (Hurford 2007:91–92). Hurford’s revision admits the possibility of apprehending some quantities—those at least in the subitizing range—without establishing vocabulary for them first.

Nor did we argue that language cannot shape higher number concepts, since it most obviously does. Exact higher quantities are readily learned through language: number words not only help modern children learn to count, they enable the apprehension and communication of quantities for which material scaffolds may be inaccessible (e.g., millions), and as Everett himself notes, even Pirahã can learn higher-quantity numbers through linguistic exposure. Acquiring number concepts through linguistic exposure, however, is a different mechanism than the one we proposed; moreover, we suggest the linguistic-exposure mechanism entails that someone else has already developed the numerical concepts and labeled them with words that enable their communication. We are addressing a more fundamental question, which is this: Given subitization and magnitude appreciation, how do discrete quantities like “seven,” “eight,” or “nine” emerge out of the undifferentiated many, the universal term for quantities higher than the subitizing range? In our article, we suggested that this happens through the interaction of numerosity with material culture, which acts to scaffold quantities beyond the subitizing range, enabling their “crystallization” as distinct visual and tactile entities (Pica et al. 2004:503). Indeed, were it true that meaningful higher-number words were a necessary prerequisite for developing higher-number concepts, it would be surprising if any society ever developed any.
Let us return to Everett’s idea that language is somehow responsible for originating concepts of exact higher quantities, by which we assume he means quantities exceeding the subitizing range. Everett cites Spaepen et al. (2011), who argue that “exact quantities to which words like ’seven,’ ’eight,’ and ’nine’ refer seem so basic it is hard to imagine that we might need the word ’seven’ to have the concept seven” (3163). We counterargue that it is difficult to imagine because it is not true. The number “5,” for example, which falls outside the range of anyone’s definition of subitization, may perhaps be so readily understood because it combines “3” and “2,” both of which are subitizable and might act as memory chunks (e.g., Gobet et al. 2001). We find it implausible that the number “9” would first require the word “nine” in order to have the concept nine, as Spaepen et al. (2011) would argue. In a linguistically informed environment (i.e., one with preexisting concepts of number imparted through language), when children first acquire a word like “nine,” it is meaningless until they have mapped its semantic content onto their nonverbal representations of quantity (Cantlon et al. 2006; Dehaene 2007). In an environment lacking preexisting numbers, a concept such as nine might be gained by recognizing an idea or three sets of “3” acquired from subitization in interaction with material scaffolding.

There is the ethnographic evidence to support the view that subitized and higher-quantity concepts develop before their associated vocabulary and that they develop through interaction with material culture (e.g., Overmann 2012). Accordingly, our model assumes that number words indicate the presence of number concepts but do not necessarily exhaust them. We argue that numerosity is largely independent of language and that exact higher-quantity recognition is built upon numerosity in interaction with material culture. Absent the indigenous development of numeric concepts, we do not deny that exact higher-quantity concepts can also be acquired through the shortcut of linguistic exposure to cultures that have previously developed them.

References Cited

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Without Language, No Distinctly Human Numerosity

A Reply to Coolidge and Overmann

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Coolidge and Overmann (2012) offer a fascinating perspective on the origin of human symbolic thought, suggesting that it may owe itself in part to the development of numerosity and concomitant neurological reconfigurations, particularly in the intraparietal sulcus. Yet their intriguing account, based in large measure on paleoanthropological data, is not informed by relevant experimental findings on numerical cognition (perhaps due to the recency of the findings). This is discomforting since reconcilability with experimental data is surely a sine qua non of any treatise on the genesis of symbolic thought. The findings in question suggest that Coolidge and Overmann’s account, while proffering valuable insights, nevertheless (a) underestimates the extent to which language shapes typical human numerosity and (b) errantly assumes a uniformity among extant homo sapiens vis-à-vis fundamental numerical cognition.

Coolidge and Overmann rely on the strong possibility that “number concepts may be independent of language” (2012:207), noting that populations such as the Piraha speak an anumeric language. The Piraha do lack precise number terms or morphosyntactic instantiations of number such as nominal plurality. Yet, theirs is the only experimentally verified case in which an autochthonous language lacks precise number terminology, it has played a central role in discussions of the language-numerosity nexus. Significantly, though, the most recent results obtained among the Piraha (Everett and Madora 2012) demonstrate that the people struggle with merely differentiating quantities greater than three. Such results indicate that much of human numerosity is not dissociable from language, since most exact quantity recognition is dependent on numerical language and is not phylogenetically homologous. This pivotal aspect of human numerosity is largely absent in other species and among the Piraha, excepting those Piraha who have been familiarized with neologisms for precise numerosities (Everett and Madora 2012). Other recent research also demonstrates that much of the numerosity generally associated with our species relies predominantly on language. Spaepen et al. (2011) present experimental data gathered among anumeric adult Nicaraguan “homesigners,” an urban group of people with elaborate material technologies. Cудually, the performance of the Piraha and Nicaraguan homesigners is remarkably similar on the same experimental task testing for the mere differentiation of simple quantities. For both groups, quantity recognition is perfect for quantities of three or less, with a precipitous decline in accuracy for remaining quantities (Everett 2013). These strikingly convergent yet independently obtained results, based on the only two tested wholly anumeric adult populations, reflect the fundamental role of language in shaping basic human numerosity. Humans without access to the appropriate linguistic tools apparently “do not spontaneously develop representations of large exact numerosities” (Spaepen et al. 2011:3163).

This suggests a crucial caveat to Coolidge and Overmann’s claim that it is possible to have number concepts without terms for them. While Coolidge and Overmann discuss the two genetically endowed number senses (magnitude appreciation and small-quantity differentiation), the pivotal role of language in the uniquely human unification of these senses is unacknowledged. This unifying role is also evidenced by ontogenetic and neuroimaging data (Condry and Spelke 2008).

Putatively basic human numerosity, including the differentiation of most quantities, is not actually homogeneous across our species, and innate human numerosity does not seem to differ appreciably from that in several other species. Conceptual tools such as cardinal number terms, which are not universal, apparently do more than “improve mathematical competence” such as the material feedback mechanisms highlighted by Coolidge and Overmann and several commentators. Instead, they enable mathematical thought via the modulation of our largely unremarkable innate numerosity. Furthermore, humans can have language without exhibiting typically human numerosity, if their language is anumeric. Hurford’s (1987) claim “Without language, no numeracy” actually seems prescient in the light of the evidence from anumeric speakers (contra Coolidge and Overmann 2012:212).

Given that language appears to serve as ground-floor conceptual scaffolding for much of human numerosity, some may be more reluctant to accept that numerosity served as an important precursor to abstraction, symbolic reasoning, and language in the fashion tentatively posited by Coolidge and Overmann. At the least, their interesting approach could benefit from a clearer delineation of the relationship between language and numerosity—in particular, the numerosity typically associated with our species, via the incorporation of synchronic experimental findings.

References Cited


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