From Subitizing to Approximation:
Numeral Processing Effects on Noun-Number Word Order

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In roughly 64% of the world's languages, Nouns appear before Adjectives within the Noun Phrase, while only 27% use the reverse Adjective-Noun order [1, 2]. Interestingly, although numerals often function adjectivally in both signed and spoken languages [3], they do not conform to the broader typological Noun-Adjective pattern: 52% of languages follow the NounNumb order, 42% use NumbNoun, and 6% allow both [4, 5]. Given prior work showing that different numeral ranges involve different cognitive processes [6] and the fact that some languages (e.g., Egyptian Arabic) use different word orders for lower versus higher magnitude numbers [4], we ask whether typological word order differences can stem from differences in how people conceptually process numbers of different magnitudes. Specifically, we test the hypothesis that participants will predominantly use the NumbNoun order to describe numbers in the subitizing range (e.g., 2 & 3) because these values can be ascertained quickly and accurately even without explicit counting [7]. But, larger quantities that require explicit counting (e.g., 5 & 6) or which lend themselves to approximation (e.g., 12 & 16) will primarily be described using the NounNumb order [8]. We test this using the silent gesture paradigm – in which hearing participants describe simple scenes or objects using only manual gesture (no words or props) – because it allows us to examine participants' underlying preferences while minimizing influence from their native languages [9, 10].

Design: We manipulated Number Type (Subitizing, Counting, Approximation) within subjects, who were randomly assigned to two different lists. Participants, recruited online, were shown images of simple objects (Fig1) and told to describe the images using only manual gestures. Participants were shown a total of 6 target items and 12 fillers. Data from 48 participants were transcribed and coded for order (NounNumb vs. NumbNoun).

Results: We failed to detect a clear preference for either the NounNumb (48%) or NumbNoun (52%) order when results were collapsed across all three Number Type conditions (p > .9). But, when examining differences across Number Type conditions, a more nuanced picture emerged. Logistic regressions revealed that participants were significantly more likely to produce NounNumb in Subitizing versus Count and Approximation conditions, combined (β = 1.26, SE = 0.63, |z| = 2.01, p < .05; Fig2). This was surprising given prior work pointing to the conceptual and lexical accessibility of numbers in the subitizing range. In the Count and Approximation conditions, NumbNoun was produced more frequently, though not at statistically different levels between conditions (p > .1). Thus, the order of Nouns and Numerals in the Subitizing conditions did, indeed, differ from that in the Counting or Approximation conditions - but crucially, not in the way that we expected: Instead of mentioning more accessible elements first, participants preferred to mention more complex information earlier. It is possible that in non-subitizing conditions, participants anticipated the additional effort required to ascertain the number of items in the image, so choice of word order was made in the service of fluency [11].

Implications: Our results show that differences in the way that people conceptually process smaller (i.e., Subitizing) versus larger (i.e., Counting & Approximation) numbers may affect people's choice of Noun-Numeral word order. Overall, our work adds to the growing body of work pointing to the ways that non-linguistic conceptual processes influence linguistic ones [9, 10, 12]. At the same time, they highlight one way in which pressures arising from real-time production may affect the historical development of a language. Methodologically, our results also provide evidence against the idea that silent gesture is strictly reducible to lexical access.
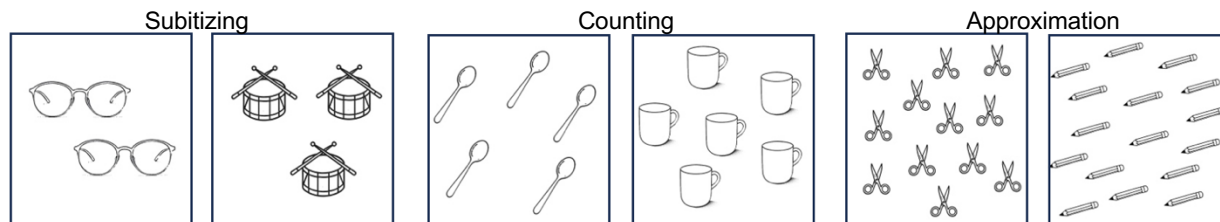
Figure 1: Stimuli across conditions: The subitizing set shows 2 glasses and 3 drums; the counting set shows 5 spoons and 6 cups; the approximating set shows 12 scissors and 16 pencils.
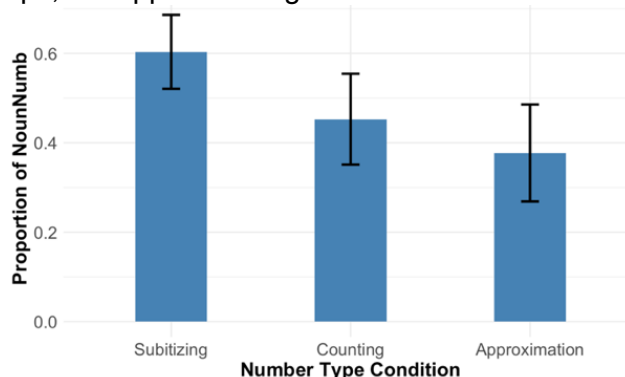

Figure 2: Proportion of NounNumb utterances produced in each of the three Number Type conditions. Errors bars indicate +/- 1 standard error.

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