**36863 – Number and Natural Language (Working Syllabus)**

**Instructor:** David Barner

**Office Hours:** By appointment

This class will explore the development of numerical cognition and mathematical concepts, especially as they relate to language acquisition. The class will begin with a discussion of philosophical foundations, focusing on Kant, Mill, and Frege’s early psychological proposals, as well as the efforts to describe a logical foundation for arithmetic, by Peano, Dedekind, Frege, and Hume. Our goal here will be to articulate the content that must be acquired by human children in order to learn the positive integers, and ultimately higher order mathematical knowledge. We will then read papers that describe candidate non-verbal origins of mathematical concepts, including experimental work in humans and non-human animals on numerical discrimination and object tracking. Next, we will review evidence that non-verbal systems are related to mathematical representations in human adults and children. We will then turn to what is known about the acquisition of the positive integers, and the relation of this ability to non-verbal systems, as well as to natural language. The final section of the class will focus on comparing individuals with profoundly different numerical capacities, including brain-damaged patients, bilingual learners, members of innumerate groups, speakers of morphologically rich number languages, etc.

**Reading:** Each class there will be 1 target reading and 2 recommended readings. The recommended readings are optional but will be helpful for following the narrative of the lectures. I have also listed supplemental readings – readings that can be explored at another moment when reading more deeply into a particular topic. These will also be covered in lecture.

**Evaluation:**

***1. Lead Discussion (20%)***

Each enrolled student will choose a paper from the supplemental reading list and prepare a 30 minute discussion of the paper. To do so, the student should begin with an overview of the article, sketch out the argument of the paper, and then present questions, points of confusion, or criticisms. The student should should prepare an outline (a couple pages) to hand out as a structure for your discussion. Powerpoint is also acceptable as an alternative.

***2. Response Papers x 10 (30%)***

Each class each student should write a one-page response to an idea encountered in the readings. Do not use any of the space to summarize the readings. Instead, use all of the space to state your original ideas, comments, questions, or criticisms. Papers must be handed in as **hard copies** before the beginning of each class (times new roman, 12 pt font, 1” margins, 1 page max, title & name in header).

***3. Class Participation (10%)***

Each class 3% of the participation grade will be assigned, based on active participation. Every student should speak in class each week and should come prepared with questions / comments on each of the readings.

***4. Final Paper (40%)***

The Final Paper should describe a question or problem that arose in the class, describe different alternative accounts, and then propose an experiment that could test these accounts. The paper should include a literature review to frame the problem, a Method section, an Analysis section and a General Discussion. Please make a meeting with Dr. Barner to discuss the structure of the paper. It should be between 25 and 30 pages in length maximum (double spaced, 12 pt Times New Roman, APA format).

**CLASS 1. The Explananda of a Theory of Numerical Development**

This lecture will describe the goals of the class, which will center on explaining how humans acquire numerical representations in language, and especially what the role of language might be in the development of the positive integers. The explananda of the class include a simple description of number word learning, a history of human numerical symbol use, and a brief characterization of linguistic diversity.

TARGET: Ifrah, G., (2000). *The universal history of computing: From the abacus to quantum computing*. John Wiley & Sons, Inc. (Ch.1 & Ch.2)

RECOMMENDED:

Corbett, G. G. (2000). Number. Cambridge textbooks in linguistics. *Cambridge: CUP*. pp. 9-53

Epps, P. (2006). Growing a numeral system: The historical development of numerals in an Amazonian language family. *Diachronica*, *23*(2), 259-288.

SUPPLEMENTAL:

Shapiro, S. (2000). Thinking about mathematics: The philosophy of mathematics. pp. 49-103

Frege, G. (1980). *The Foundations of Arithmetic: A logico-mathematical enquiry into the concept of number*. Northwestern University Press. Pp. 1-39; 67-104

**CLASS 2. Non-verbal “Number” Systems**

This lecture will describe two “core” systems that may contribute numerical content to cognition: The “object file” system and the “approximate number” system. We will focus on the develop of these capacities in human children.

TARGET: Feigenson, L., Dehaene, S., & Spelke, E. (2004). Core systems of number.*Trends in cognitive sciences*, *8*(7), 307-314.

RECOMMENDED:

Dehaene, S. (2001). Précis of the number sense. *Mind & language*, *16*(1), 16-36.

Dehaene, S., Spelke, E., Pinel, P., Stanescu, R., & Tsivkin, S. (1999). Sources of mathematical thinking: Behavioral and brain-imaging evidence. *Science*,*284*(5416), 970-974.

SUPPLEMENTAL:

Dehaene, S., Molko, N., Cohen, L., & Wilson, A. J. (2004). Arithmetic and the brain. *Current opinion in neurobiology*, *14*(2), 218-224.

Kahneman, D., Treisman, A., & Gibbs, B. J. (1992). The reviewing of object files: Object-specific integration of information. *Cognitive psychology*, *24*(2), 175-219.

**CLASS 3. Language and Countability**

This lecture will focus on the problem of countability in natural language, with a special focus on the mass-count distinction in language acquisition.

TARGET: Barner, D., & Snedeker, J. (2005). Quantity judgments and individuation: Evidence that mass nouns count. *Cognition, 97*, 41-66

RECOMMENDED:

Barner, D., & Wagner, L., & Snedeker, J. (2008). Events and the ontology of individuals: Verbs as a source of individuating mass and count nouns. *Cognition, 106,* 805-832.

Barner, D., & Snedeker, J. (2006). Children's early understanding of mass-count syntax: Individuation, lexical content, and the number asymmetry hypothesis. *Language Learning and Development, 2,* 163-194

SUPPLEMENTAL:

Bale, A. & Barner, D. (2009). The interpretation of functional heads: Using comparatives to explore the mass/count distinction. *Journal of Semantics, 26,* 217-252.

Srinivasan, M., Chestnut, E., & Barner, D. (2013). Sortal concepts and pragmatic inference in children's early quantification of objects. *Cognitive Psychology*, *6,*302-326.

**CLASS 4. Number Morphology and Learning 1, 2, 3**

This lecture will describe how children acquire the meanings of the words “one”, “two”, and “three”, and the role that language might play in bootstrapping these meanings.

TARGET: Carey (2004)

RECOMMENDED:

Almoammer, A., Sullivan, J., Donlan, C., Marušič, F., O’Donnell, T., & Barner, D. (2013). Grammatical morphology as a source of early number word meanings. *Proceedings of the National Academy of Sciences*, *110*(46), 18448-18453.

Wynn, K. (1990). Children's understanding of counting. *Cognition*, *36*(2), 155-193.

SUPPLEMENTAL:

Bloom, P., & Wynn, K. (1997). Linguistic cues in the acquisition of number words. *Journal of Child Language*, *24*(03), 511-533.

Sarnecka, B. W., Kamenskaya, V. G., Yamana, Y., Ogura, T., & Yudovina, Y. B. (2007). From grammatical number to exact numbers: Early meanings of ‘one’,‘two’, and ‘three’ in English, Russian, and Japanese. *Cognitive psychology*,*55*(2), 136-168.

**CLASS 5. Acquiring the Logic of Counting**

This lecture will address the problem of how children discover the logic of the counting procedure, with a focus on how they acquire knowledge of the successor function. We will ask whether this knowledge might be acquired from core non-verbal systems.

TARGET: Sarnecka, B. W., & Carey, S. (2008). How counting represents number: What children must learn and when they learn it. *Cognition*, *108*(3), 662-674.

RECOMMENDED:

Gallistel, C. R., & Gelman, R. (1992). Preverbal and verbal counting and computation. *Cognition*, *44*(1), 43-74.

Davidson, K., Eng, K., & Barner, D. (2012). Does learning to count involve a semantic induction? *Cognition*, *123*(1), 162-173.

SUPPLEMENTAL:

Le Corre, M., & Carey, S. (2007). One, two, three, four, nothing more: An investigation of the conceptual sources of the verbal counting principles. *Cognition*, *105*(2), 395-438.

Laurence, S., & Margolis, E. (2005). Number and Natural. *The innate mind: Structure and contents*, *1*, 216.

**CLASS 6. Number & Pragmatic Inference in Language Acquisition**

This lecture will describe the role that pragmatic inference might play in acquiring exact number word meanings. In doing so, we will review the problem of conversational implicature, and possible accounts of why children have difficulty computing scalar implicatures.

TARGET: Barner, D., & Bachrach, A. (2010). Inference and exact numerical representation in early language development. *Cognitive psychology*, *60*(1), 40-62.

RECOMMENDED**:**

Barner, D., Brooks, N., & Bale, A. (2011). Accessing the unsaid: The role of scalar alternatives in children's pragmatic inference. *Cognition, 188,* 87-96*.*

Condry, K. F., & Spelke, E. S. (2008). The development of language and abstract concepts: the case of natural number. *Journal of Experimental Psychology: General*, *137*(1), 22.

SUPPLEMENTAL:

Hochstein, L., Bale, A., Fox, D., & Barner, D. (2014). Ignorance and inference: Do problems with Gricean epistemic reasoning explain children's difficulty with scalar implicature? *Journal of Semantics, 0,*1-29.

Hochstein, L., Bale, A., & Barner, D. (under review). Pragmatic inference in children with autism spectrum disorder.