Psychology 453: Origins of Numbers
Winter 2012

Course Location : EV3 3408
Meeting Times: Tuesdays, 12:30 to 2:20pm

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COURSE DESCRIPTION

This course will take a multi-disciplinary approach to the study of the nature and acquisition of knowledge of the natural numbers and arithmetic. We will be reading and discussing both seminal and state-of-the-art research on: the nature of numerical representations in human infants and in non-human animals, the neural substrates of basic numerical representations, and on the construction of new numerical knowledge.

COURSE OBJECTIVES

My primary goals are two-fold. First, readings and discussions of research on the acquisition of numerical knowledge and concepts will be used as a means of engaging you in learning about the central questions that arise in the study of cognitive development and about the multiple methodological approaches that can be used to answer these questions.

Second, I hope to help you improve your skill at decomposing, synthesizing and appraising scientific arguments. The course will provide two major "playing fields" for working on these skills: group discussions and written reports. In all of these exercises, I will invite you to find not only what's wrong with the papers you read, but also what contribution the authors have made to their field, whether it be a new piece of knowledge – however small – or even just a new way of looking at a problem.

GRADING

Participation. Participation in class discussions is highly valued and encouraged. It will be graded out of **10%**.

Final paper

Overview. This assignment has three parts: a first draft (**20%**), a commentary on a peer's first draft (**20%**), and a final paper (**50%**).

Topic and format. The final paper will consist of a **review paper** on any topic that is related to **the acquisition/development of some form of mathematical knowledge** in some way. You will review, compare, contrast, and synthesize ideas and research on the topic of your choice from 6 to 8 different sources. The final paper should have 12 to 15

pages, double-spaced in Times size 12 font. We will talk about how to write a review paper in class on **March 6th.**

Choosing your topic. You will start off by coming up with a few big questions concerning the acquisition of the form of mathematical knowledge of your choice. Then, **between February 27th and March 6th**, you will have an individual meeting with me, and I will help you narrow down your questions and get a bibliography together.

First draft (**20%**). **On March 20th**, you will turn in a complete first draft of your final paper. This draft will be read and commented upon by one of your peers (assigned in class).

Comment on peer's first draft (**20%**). **On March 26th**, you will turn in a short commentary on a peer's first draft. For your commentary, you will (1) summarize the paper you read in 300 words, (2) state what you found most interesting about the paper in a few sentences, (3) point out one major point that needs improvement, and (4) make one suggestion as to how to make this improvement. **On March 27th**, you and your commentator will discuss your paper together (and vice-versa).

Final paper (**50%**). Your final paper will be due on **MONDAY, APRIL 9th by 5pm. THERE WILL BE A PENALTY FOR LATE PAPERS: 5%** will be taken off the grade for your paper for each day between the deadline and the time you turned it in.

POLICY ON ACADEMIC INTEGRITY

In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility

Grievance: A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70 - Student Petitions and Grievances, Section 4, http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm

Discipline: A student is expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about 'rules' for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. When misconduct has been found to have occurred, disciplinary penalties will be imposed under Policy 71 - Student Discipline. For information on categories of offenses and types of penalties, students should refer to Policy 71 - Student Discipline, http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm

Appeals: A student may appeal the finding and/or penalty in a decision made under Policy 70 - Student Petitions and Grievances (other than regarding a petition) or Policy 71 - Student Discipline if a ground for an appeal can be established. Read Policy 72 - Student Appeals, http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm

POLICY ON ABSENCES

Students who are requesting accommodation for course requirements (assignments, midterm tests, final exams, etc.) due to illness should do the following:

- seek medical treatment as soon as possible and obtain a completed UW Verification of Illness Form: http://www.healthservices.uwaterloo.ca/Health_Services/verification.html
- submit that form to the instructor within 48 hours.
- (preferably) inform the instructor by the due date for the course requirement that you will be unable to meet the deadline and that documentation will be forthcoming.

In the case of a missed assignment deadline or midterm test, the instructor will either
a) waive the course component and re-weight remaining term work as he/she deems fit according to circumstances and the goals of the course, or
b) provide an extension.

SCHEDULE OF TOPICS AND READINGS.

Week 1 (Jan. 3). Introduction.

PART 1: NUMERICAL KNOWLEDGE IN NON-VERBAL ORGANISMS

- ➔ What kind of numerical knowledge do non-linguistic organisms have?
- ➔ Does numerical knowledge in babies, adults, and non-human animals have any common features?

Week 2 (Jan. 10). A sense of quantity.

Read first. Brannon, E. M. (2006). The representation of numerical magnitude. *Current Opinion in Neurobiology*, 16, 222-229.

Lipton, J. S., & Spelke, E. S. (2003). Origins of number sense. Large-number discrimination in human infants. *Psychological Science*, *14*(5), 396-401.

Moyer, R., & Landauer, T. (1967). Time required for judgments of numerical inequality. *Nature, 215*, 1519-1520

Week 3 (Jan. 17). One, another, and another.

Wynn, K. (1992). Addition and subtraction by human infants. *Nature*, *358*, 749-750.

Feigenson, L. & Carey, S. (2005). On the limits of infants' quantification of small object arrays. *Cognition, 97,* 295-313.

Hyde, D. C., & Spelke, Elizabeth S. (2011). Neural signatures of number processing in human infants: evidence for two core systems underlying numerical cognition. *Developmental science, 14*(2), 360-371.

PART 2: DOES LANGUAGE CHANGE THE WAY WE THINK ABOUT NUMBERS?

- ➔ Does language provide us with number concepts that babies and non-human animals do not have?
- ➔ How do we acquire numerical language? Do we use the numerical representations that were available to use as infants?
- ➔ Do all cultures have the same numerical language? If not, do cultures with different languages think about numbers differently?

Week 4 (Jan. 24). Theoretical background: Fodor's Puzzle.

Fodor, J. (1983). On the Impossibility of Acquiring More Powerful Structures. In Piatelli-Palmarini, M. (Ed.), *The Debate between Jean Piaget and Noam Chomsky* (pp. 142-162).

Laurence, S., & Margolis, E. (2002). Radical concept nativism. *Cognition, 86*(1), 25-55

Week 5 (Jan. 31). Number in humans with limited numerical language.

Frank, M.C., Everett, D.L., Fedorenko, E., & Gibson, E. (2008). Number as a cognitive technology: evidence from Piraha language and cognition. *Cognition, 108,* 819-824.

Spaepen, E., Coppola, M., Spelke, Elizabeth S, Carey, S. E., & Goldin-Meadow, S. (2011). Number without a language model. *Proceedings of the National Academy of Sciences of the United States of America, 108*(8), 3163-8

Week 6 (Feb. 7). Do children form new number concepts when they learn how counting works? (Part 1)

Read 1st

Gelman, R. (1982). Basic numerical abilities. In R. J. Sternberg (Ed.), *Advances in the psychology of human intelligence.* Hillsdale, N. J.: Erlbaum. Vol. 1., (4) 181-205.

Read 2nd

Le Corre, M., Van de Walle, G., Brannon, E.M. & Carey, S. (2006). Re-visiting the

Performance/Competence Debate in the Acquisition of the Counting Principles. *Cogntive Psychology.*

WEEK 7 (Feb 14).Do children form new number concepts when they learn how counting works? (Part 2)

Carey, S. (2009). Beyond Core Cognition: Natural Number. In *The Origin of Concepts* (pp. 287-334).

Week 8 (Feb 28). Does language provide us with number concepts that babies and non-human animals don't have?

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

Spelke, E.S., & Tsivkin, S. (2001). Language and number: a bilingual training study. *Cognition, 78*(1), 45-88. (YOU ONLY NEED TO READ THE INTRO, EXPERIMENT 2, AND THE GENERAL DISCUSSION)

Week 9 (March 6). How to write a review paper.

Bem, D. J. (1995). Writing a review article for Psychological Bulletin. *Psychological Bulletin, 118*(2), 172-177.

Dehaene, S. (2009). Origins of mathematical intuitions: the case of arithmetic. *Annals of the New York Academy of Sciences, 1156*, 232-59 (ONLY READ PAGES 232 to 242 up to "Multiple Codes for Number")

PART 3: NUMBER IN SCHOOL AND SOCIETY.

Week 10 (March 13). Learning number symbols.

Hughes, M. (1986). *Children and Number: Difficulties in Learning Mathematics.*

- Chapter 5. Children's invention of written arithmetic (pp. 53-78).

Nunes, T., Schliemann, A-.T, Caraher, D. (1993). *Street Mathematics and School Mathematics.* Chapter 2. Arithmetic in the street and in schools (pp. 13-27).

WEEK 11 (March 20). Why there are so few women academics in the natural sciences & in math: some ideas from former Harvard president Larry Summers, from the press, and from a few empirical studies.

The president

Summers, L. (2005, January 14). Remarks at the NBER Conference on Diversifying the Science & Engineering Workforce.

The science

Hyde, J. S., & Mertz, J. E. (2009). Gender, culture, and mathematics performance. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(22), 8801-7.

Optional (but highly recommended!!!): Read or watch the "Science of Gender and Science" debate between Harvard psychology professors Steven Pinker and Liz Spelke at: *www.edge.org/3rd_culture/debate05/debate05_index.html*

Week 12 (March 27). Group discussions of final paper.