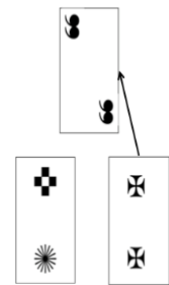


Is there a fundamental distinction between human and animal thought? This question has sparked lengthy debate in cognitive science and philosophy, at least since the time of Descartes. Researchers have suggested that a potential difference is the capacity for symbolic thought, expressed, for instance, through logical operators and abstract relations (Penn et al., 2008). My research proposal focuses on how children learn two basic yet powerful abstract relations, namely ‘same’ and ‘different’.

Psychologists test for these concepts using the relational match-to-sample (rMTS) paradigm, which involves matching either a same or different choice card to a sample card (see figure for a ‘same’ example; the arrow indicates which cards go together). Most animals fail rMTS (Premack, 1983) and children only succeed around five (Hochmann et al., 2017), remarkably late given that the words ‘same’ and ‘different’ emerge in vocabulary comprehension two years earlier (Hochmann et al., in prep). This developmental paradox asks: what is changing between the three and five, and can the answer shed light on the larger question of what may make human minds unique?



Hoyos et al. (2016) attribute preschoolers’ rMTS failure to noun learning, which encourages children to focus on individuals rather than relations: their study showed that children old enough to succeed at rMTS fail if they first complete a task labeling objects using count nouns (i.e. “That’s a ball!”). This result suggests that an emphasis on individuals impedes analogical reasoning. However, noun labels point not only to single objects, but also to objects’ membership within basic-level categories (Xu, 2007). For example, the noun “lion” highlights both the individual lion as well as the broader category that includes all lions. Noun labels provide children with the ability to construe objects both as individuals and as members of same or different categories. Hoyos et al.’s (2016) research hindered rMTS performance by exploiting the former ability, namely highlighting individuals; in contrast, I will use nouns to emphasize category membership, and hypothesize that this emphasis will facilitate relational thinking by prompting comparisons of whether objects’ category memberships are the same.

In a pilot study, I used a rMTS with same or different categories: for example, a ‘same’ card showed pictures of two lions and a ‘different’ card showed pictures of an elephant and monkey. In one condition, an experimenter emphasized the category membership of each animal using count noun labels (i.e. “That’s a lion and that’s a lion!”). In another condition, children performed the same task without hearing labels. Pilot data showed that four-year-olds succeed this task with labels but failed without labels. Thus, noun labels were beneficial when they highlighted the relevant property, namely category membership, which formed the basis of same and different relations. These results also show that noun learning does not always hinder with relational thinking, and cannot account for children’s rMTS failure.

In order to satisfactorily explain these results, I need to conduct follow-up studies. While noun labels could help by highlighting category membership, a deflationary alternative is that simple verbal repetition – hearing “lion” and “lion” while looking at pictures of two lions – emphasized the sameness between objects. Thus, an outstanding question is whether count noun labels’ psychological properties help preschoolers on rMTS, or if facilitation could occur with any repeated words. In the follow-up, children will participate in a rMTS with novel animals. The experimenter will provide novel noun labels (i.e. “This one is a dax and this one is a dax!”), novel adjectives (i.e. “This is a daxy one and this is a daxy one!”), or no verbal training. Since count noun labels highlight category membership, in this case the relevant basis of sameness and difference, I hypothesize that children will succeed in the novel noun condition but fail in the other conditions. In contrast, the deflationary alternative, namely that repetition highlights sameness, predicts that both nouns and adjectives would help. Moreover, regarding equity matters, I will collect data from groups of participants diverse in ethnicity and socio-economic status.

Investigating how noun labels impact rMTS success brings psychologists closer to finding the mechanism behind preschoolers’ developmental shift and towards a greater understanding of how humans represent abstract relations. This research will also explore how language, a uniquely human ability, shapes relational thinking. Ultimately, these studies will help psychology and comparative cognition address whether there is truly a fundamental difference between human and animal minds.

## I. Contributions to Research and Development

### a. Articles accepted or published in peer-reviewed journals

1. Thai, S., Lockwood, P., **Zhu, R.**, Li, Y., & He, C.J. (accepted). The family ties that protect: Expanded self-comparisons in parent-child relationships. *Journal of Social and Personal Relationships*. Accepted December 29, 2017, 26 pages. (Undergraduate work).
2. Tskhay, K.O., **Zhu, R.**, Zou, C., & Rule, N.O. (2018). Charisma in everyday life: Conceptualization and validation of the General Charisma Inventory. *Journal of Personality and Social Psychology*, *114*, 131-152. (Undergraduate work).
3. Hochmann, J. R., Tuerk, A., Sanborn, S., **Zhu, R.**, Long, R., Dempster, M., & Carey, S. (2017). Children's representation of abstract relations in relational/array match-to-sample tasks. *Cognitive Psychology*, *99*, 17-43. (Lab Manager work).
4. Tskhay, K.O., **Zhu, R.**, & Rule, N.O. (2017). Perceptions of charisma from thin slices of behavior predict leadership prototypicality judgments. *The Leadership Quarterly*, *28*, 555-562. (Undergraduate work).

### c. Other peer-reviewed contributions (conference posters)

1. **Zhu, R.\***, & Srinivasan, M. (2018). Children's acquisition of regular metonymy: Exploring the producer-product relation. Poster presented at the *10<sup>th</sup> Annual Dubrovnik Conference on Cognitive Science*. Dubrovnik, Croatia. (International, Doctoral work).
2. **Zhu, R.\***, Hochmann, J.R., Dempster, M., Sanborn, S., & Carey, S. (2017). Preschoolers' acquisition of the words 'same' and 'different'. Poster presented at the *Biennial Meeting of the Cognitive Development Society*. Portland, OR. (International, Lab Manager work).
3. **Zhu, R.\***, & Carey, S. (2017). Noun labels facilitate success on relational match-to-sample with same and different kinds. Poster presented at the *7<sup>th</sup> Annual Central European University Conference on Cognitive Development*. Budapest, Hungary. (International, Lab Manager work).
4. Thai, S.\*, Lockwood, P., **Zhu, R.**, He, C.J., & Li, Y. (2017). Expanded-self comparisons in parent-child relationships. Poster presented at the *18<sup>th</sup> Annual Meeting of the Society for Personality and Social Psychology*. San Antonio, TX. (International, Undergraduate work).
5. **Zhu, R.\***, Hochmann, J.R., Sanborn, S., & Carey, S. (2016). Representations of entropy and the relations same and different early in human development. Poster presented at the *38<sup>th</sup> Annual Cognitive Science Society Meeting*. Philadelphia, PA. (International, Lab Manager Work).
6. Thai, S.\*, Lockwood, P., **Zhu, R.**, & He, C. (2016). The ups and downs of comparing your child: Parents' expanded-self comparisons. Poster presented at the *International Association for Relationship Research Conference*. Toronto, ON. (International, Undergraduate work).

### d. Non-peer-reviewed contributions (invited oral presentations)

1. **Zhu, R.\***, & Srinivasan, M. (2018). Children's acquisition of regular metonymy. Talk presented at the NeuroSpin Developmental Neuroimaging Lab, Saclay, France. (Doctoral work).
2. **Zhu, R.\***, & Srinivasan, M. (2018). Children's acquisition of regular metonymy. Talk presented at the Stanford University Social Learning Lab, Palo Alto, CA. (Doctoral work).
3. **Zhu, R.\***, & Carey, S. (2017). Count noun labels facilitate relational reasoning. Talk presented at the Harvard University Workshop on Abstract Relations, Cambridge, MA. (Lab Manager work).

## II. Most Significant Contributions to Research and Development

**Zhu, R.\***, & Srinivasan, M. (2018). Children's acquisition of regular metonymy: Exploring the producer-product relation. *10<sup>th</sup> Annual Dubrovnik Conference on Cognitive Science*. Dubrovnik, Croatia.

I was responsible for study design and data collection for the three experiments in this poster. Within the past year, I created stimuli, and collected and analyzed data from over 250 child and 50 adult participants. I designed the poster and presented it at an international peer-reviewed conference. I also presented the results of this project as a PowerPoint presentation during two invited talks at Stanford University and the French neuroscience institute NeuroSpin. I will write up the results from this project and submit the article to a peer-reviewed cognitive science journal.

### III. Applicant's Statement

**Research Experience** – I possess a diverse range of research experiences in multiple subfields of psychology. In the first year of my PhD program at UC Berkeley, I worked to create and implement a study on children's acquisition of figurative language, discussed in Part II. Additionally, in my two-year position as Dr. Susan Carey's lab manager at Harvard University, I explored the interface between language and abstract thought through multiple lines of studies. For one series of studies, I collected data from over 400 adult and child participants. In the second series of studies, I personally collected data from over 150 preschoolers. Dr. Carey and I have already published one series of studies in a peer-reviewed journal and are currently writing up more experimental results.

At the University of Toronto, I managed Dr. Joan Grusec's and Dr. Nicholas Rule's labs. My work as a NSERC USRA recipient and thesis student with Dr. Rule resulted in two peer-reviewed publications and one more in preparation. My fourth-year independent project with Dr. Penelope Lockwood resulted in one peer-reviewed publication and one more in preparation. Moreover, I worked as a paid research assistant for Dr. Spike Lee on projects about metaphors. Finally, as a summer intern for Dr. Lisa Feigenson at Johns Hopkins University, I learned about children's number sense. In these positions, I gained essential research skills, such as writing ethics protocols, designing studies, creating stimuli, recruiting participants, using FileMaker Pro participant databases, running child and adult participants, administering standardized tests, collecting and analyzing data, and conducting literature reviews.

Through this extensive research training, I am confident of my ability to conduct well-designed experiments as well as report results at various peer-reviewed conferences and in manuscripts submitted for publications. Most importantly, my many mentors have fostered deep and critical thinking, helping me understand what is truly at stake when we attempt to answer questions about the human mind.

**Relevant Activities** – I have mentored undergraduate research assistants at Harvard and UC Berkeley. Thusfar, I have supervised two thesis students, two full-time summer interns, and three course-credit research assistants on my specific research projects. In these mentorship roles, I do not simply teach undergraduates how to collect data, but rather guide them through a full research cycle: reading and discussing background literature, designing stimuli, collecting and analyzing data, and disseminating results in both oral and written formats. Moreover, as a lab manager in three labs over three years, I have trained over forty undergraduate and masters-level students on the fundamentals of research.

Furthermore, I am capable of both general and specific project management. In my lab manager positions, I was responsible for overall lab functioning, including tasks such as training and supervising research assistants, purchasing lab materials, monitoring finances, overseeing lab communication, and maintaining important lab resources such as a child participant database. In terms of research projects, I oversee multiple experiments simultaneously, often from the development of the study question to manuscript preparation and submission. I have learned how to communicate effectively with both graduate and faculty-level collaborators as well as research assistants in order to ensure that my research teams produce, discuss, and disseminate research findings in an efficient and insightful fashion.

Finally, in my first year at Berkeley, I was Social Chair of the Graduate Assembly of Students in Psychology, where I organized events such as student-faculty bowling night in order to facilitate a sense of community within the department. I will be continuing in the role of Social Chair this year, eventually hoping to become Co-Chair of the Graduate Assembly.