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BICA and sex differences: We need to understand potential sex differences when developing computational models of human behavior

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Abstract

Validating computational models of human behavior typically involves statistically comparing human data collected during an experiment to predictions made by the model. However, these models very rarely attempt to represent sex, despite the growing indication that there are sex-based differences in neural and behavioral responses to some external stimuli. We make a case for a stronger presence of male and female models of behavior in biologically inspired cognitive architectures, an area of research that is especially susceptible to physiological differences that can cause bottom-up behavioral differences. We conclude with discussion of previous data collected that highlight the importance of providing more focus on sex-based differences.

Keywords: ACT-R/Φ, Cognitive Architectures, Sex Differences, Physiology, Decision-making

Validating computational models of human behavior typically involves statistically comparing human data collected during an experiment to predictions made by the model. However, these models very rarely attempt to represent sex, despite the growing indication that there are sex-based differences in neural and behavioral responses to some external stimuli (e.g., Hamann et al., 2004) and more generally in learning and memory (Andreano & Cahill, 2009). This shortage of biologically inspired computational behavioral process models that represent some type of sex-based difference likely has several causes, but nonetheless is problematic for a true model of human behavior. This is especially apparent when one *biologically inspired* models and architectures, where physiological and cyclic sex-based differences may come into play.

Andreano and Cahill (2009) provide a useful historical perspective on the issue of ignoring potential sex-based differences in neural and cognitive processes. Past inconsistent results contributed to the lack of deference for these possible variations by many psychology and neuroscience researchers. AI and cognitive science researchers whose work has had an impact on some current efforts in biologically inspired cognitive architectures have also historically paid less attention to sex-based differences. This lack of attention to potential differences between males and females is partially a representation of the temporal context of the research: less data existed that explicitly contrasted psychological behavior in difference sexes. The increase in dual collection of psychological *and*

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physiological data has led a better understanding of the processes underlying human behavior and those that may mediate sex-based differences.

As we continue to explore human behavior through modeling and simulation in biologically inspired cognitive architectures, an increased effort should be made to develop more representative models of males and females. This shift in thinking needs to be more explicit at two stages: the designing of experiments, and the modeling and simulation of the physiological, cognitive, and social processes. We ran an experiment that showed interesting interactions between sex and experiment conditions, and we've developed a hybrid architecture that includes physiological representations for both males and females (Dancy, 2013; Dancy et al., 2015).

We ran an experiment that studied the effects of subliminal affective stimuli on decision-making. Participants were exposed to positive, neutral, or negative subliminal images during the Iowa Gambling Task (IGT). We had the hypothesis that positive and negative images would affect participant performance on the task and physiological behavior.

When those data were analyzed, we found that participant sex interacted with the image group variable. Female participants showed a performance trend across groups opposite of the males in the study (where performance is represented as the cumulative IGT score). Female participants, who were shown negative images after selecting from disadvantageous decks, had a higher average score (4.5) than those who were shown neutral (3.1) or positive (-2.4) images. However, among male participants, those in the positive group had the highest average cumulative score (11.9), followed by males in the neutral (0.8) and negative (-3.4) groups. This and other data collected during the task indicated that women a better ability to integrate the negative signals from the stimuli to make more advantageous decisions than the men. This sensitivity to the subliminal stimuli meant that the men more resilient to the negative effects of the positive stimuli on task-performance.

When we originally designed and ran this experiment, we did not consider or expect any sex-based differences. Not surprisingly, the computational process model that we initially developed to run within the ACT-R/Φ architecture (Dancy et al., 2015) before getting those data did not match those data well. We developed the model without expectation that sex would play a major role in the results.

This and existing research (Andreano & Cahill, 2009; van den Bos et al., 2013) indicates that we need to consider how differences between males and females may affect participant behavior. This is especially important as we attempt to model and simulate physiological and cognitive process, and their interactions, in biologically inspired cognitive architectures. Future architectures and models will need to take into account hormonal differences between males and females (e.g., testosterone and estrogen) and how the periodicity of these hormones may affect behavior at different times of the day and over-time. Differences in metabolism of neurotransmitters important for memory processes (e.g., dopamine) will also need to be taken into account. Several physiological processes contribute to differences in behavior between males and females, biologically inspired cognitive architectures should more explicitly consider these modulating processes.

References

Andreano, J. M., & Cahill, L. (2009). Sex influences on the neurobiology of learning and memory. *Learning & Memory, 16*(4), 248-266.

Dancy, C. L. (2013). ACT-RΦ: A cognitive architecture with physiology and affect. *Biologically Inspired Cognitive Architectures, 6*(1), 40–45.

Dancy, C. L., Ritter, F. E., Berry, K. A., & Klein, L. C. (2015). Using a cognitive architecture with a physiological substrate to represent effects of a psychological stressor on cognition. *Computational and Mathematical Organization Theory, 21*(1), 90-114.

Hamann, S., Herman, R. A., Nolan, C. L., & Wallen, K. (2004). Men and women differ in amygdala response to visual sexual stimuli. *Nat Neurosci, 7*(4), 411-416.

van den Bos, R., Homberg, J., & De Visser, L. (2013). A critical review of sex differences in decision-making tasks: Focus on the Iowa Gambling Task. *Behavioural Brain Research, 238*(0), 95-108.