Monkeys See Snakes Like Humans Do? 
A comparative analysis of internal noise and efficiency of contour integration
A. Zhang¹, P. Khayat¹,², H. Akhavien¹, A. Baldwin¹, R. Hess¹, R. Farivar¹
¹Ophthalmology, McGill University Health Center, Montreal, QC, Canada, ²School of Optometry, University of Montreal, Montreal, QC, Canada

Introduction

Animal models are used ubiquitously in the study of visual perception, such as the detection of contours in the presence of discontinuities. Past studies found that monkeys perform equally well in contour detection tasks, but do not equate the underlying neuronal processes involved. We designed a novel task that non-invasively probes internal processes of contour integration through internal noise and efficiency.

Internal noise reflects noise in the computation by the brain (i.e., due to noise in neural circuits or cells) while efficiency is how well the brain uses that information to perform a task.

Methods

Rhesus monkeys (n=3, male, 7-8kg) were trained on a 2AFC Good Continuation discrimination task. In Exp 1, 21 humans (21-50y old, 11 females) completed an adaptive staircase version of the task, while in Exp 2, 5 human subjects (21-25y old, 2 females) completed the identical task as monkeys, responding with gaze direction instead of button presses. We measured the threshold of contour amplitude needed to discriminate between contours with good vs bad continuation, and measured these thresholds across three levels of orientation noise added: 0, 8, 16°. We then fitted the thresholds across noise levels with the linear amplifier model to estimate internal noise and efficiency.

Results

Figure 3. (A) Individual monkey psychometric functions from Good Continuation discrimination task. Increases in external noise decreased performance in each monkey. (B) Mean psychometric function for monkeys at 3 noise levels calculated by averaging the 4 parameters of the psychometric function. Dotted lines represent the threshold at which performance was above 75%.

Figure 4. (A) Linear amplifier models fitted to psychometric data of each monkey as a function of noise level. Dotted lines represent internal noise. (B) Comparison of median internal noise (upper) and efficiency (lower) between monkeys and humans on a quick-version task (n=21). Internal noise was significantly different between humans and monkeys (Mann–Whitney U Test, p=0.05). Error bars represent 95% confidence interval.

Figure 6. Median internal noise (left) and efficiency (right) between monkeys and humans pooled from both tasks. Monkeys have significantly higher internal noise than humans but not significantly different efficiency (Mann–Whitney U Test, p=0.07). Error bars represent 95% confidence interval.

Conclusion

Monkeys and humans process contours differently. The results show that monkeys have higher internal noise and the same efficiency during contour integration compared to humans. Increased internal noise may arise from any step in the processing of contours, from detection at the level of the retina to integrating the elements of the contour in the visual cortex. The current study only indicates that increased noise exists at any of these steps and future studies may aim to identify where it occurs.

Since detecting contours is one of the first steps towards object recognition, monkeys also perceive objects differently from humans, contrary to many previous assumptions. In light of this, we should hesitate to use monkeys as a model for the mechanisms of contour integration or even object recognition.

Acknowledgements

This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs, through the Psychological Health and Traumatic Brain Injury Research Program under Award No. W81XWH-14-1-0320.