Simultaneous Localization and Size Discrimination Modeling via Convolutional Neural Network

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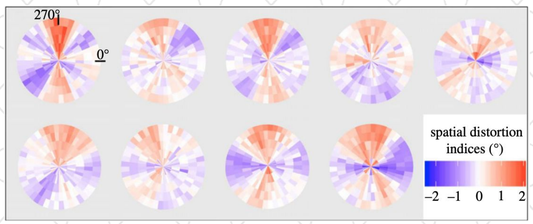
Introduction

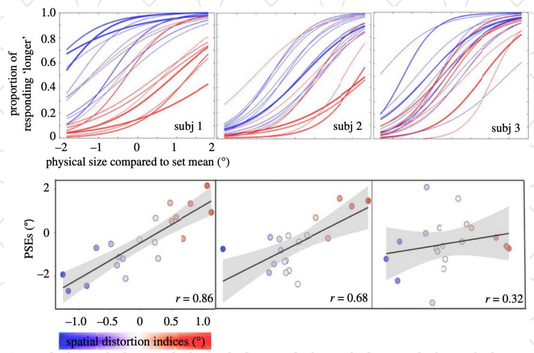
Among the many models of perception that have been proposed, most visual tasks are treated independently [1][3]. However, the human visual system is an interconnected hierarchical network, with many neurons in the visual cortex shared to process various visual features, which are then utilized by downstream processes. Inspired by this characteristic of the human visual system, we propose a novel way to simplify models that can be generalized across different visual tasks: by sharing the feature encoder. We tested this new model framework based on the findings of some recent work in psychophysics showing that localization biases (disortions) and perceived size biases are highly correlated [2]. In this study, we used a Convolutional Neural Network to model localization and size perception tasks simultaneously.

Individual Biases in Localization and Size Perception

Idiosyncratic biases in perceived position and size [2]. Different color and shade coding indicate different distortion type and magnitude. It is found that the distortions in localization and size perception tasks are highly correlated.

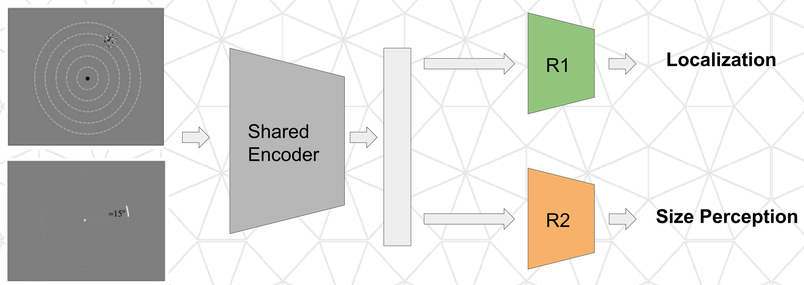


a) Individual Bias in Localization



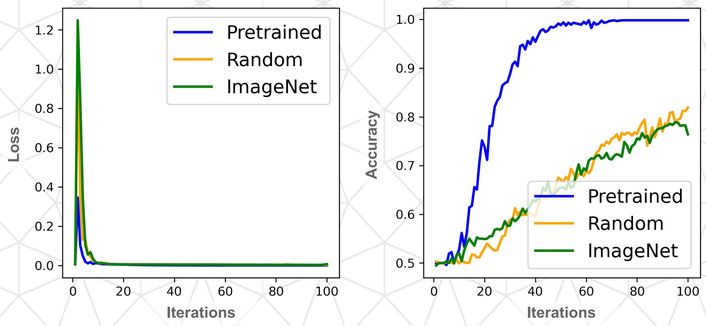
b) Individual Bias in Size Perception

Model Structure

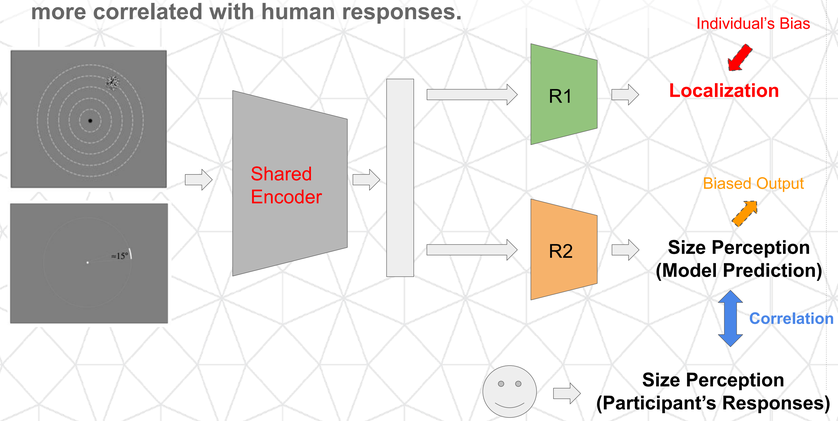


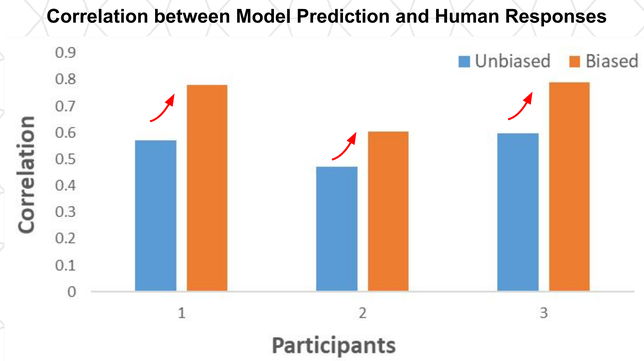
Experiments

1. **Pretraining on correlated tasks converges faster.**



2. **Bias in certain task will make the model prediction on other tasks more correlated with human responses.**





Localization bias improves the model's prediction of size perception bias.

Conclusion

1. For multitasking, pretraining on similar tasks first is better.
2. Biased annotations in one domain can have knock-on consequences in other domains (for better or worse).
3. Perceptual biases trained into a multitasking model may predict individual observer misperceptions in other domains.

Future Works

- Predict individual's perception in novel tasks
- Utilize individuals' responses for identification
- Test the influence in Robotics, such as robotic arm control
- Alleviate the negative impacts of annotation bias

References

1. *Riesenhuber, M., Poggio, T. Models of object recognition. Nat Neurosci 3, 1199–1204 (2000).*
2. *Wang, Z., Murai, Y., & Whitney, D. (2020). Idiosyncratic perception: a link between acuity, perceived position and apparent size. Proceedings of the Royal Society B, 287(1930), 20200825.*
3. *Zhou, Quan, et al. "AGLNet: Towards real-time semantic segmentation of self-driving images via attention-guided lightweight network." applied soft computing 96 (2020): 106682.*

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