UNIVERSITÄT OSNABRÜCK

Grounding Psychological Shape Space in Convolutional Neural Networks

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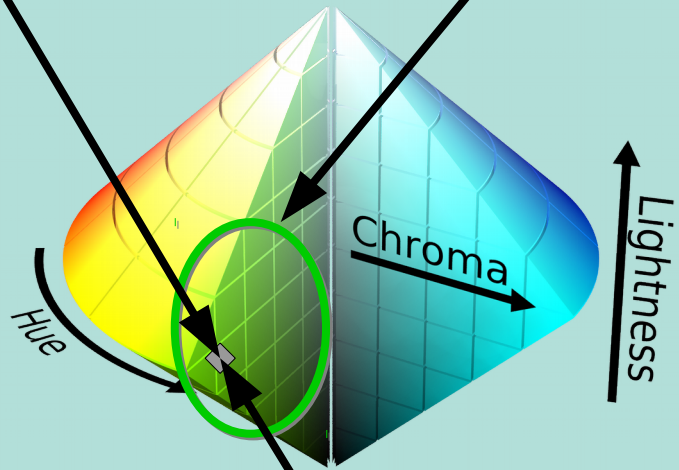
Conceptual Spaces

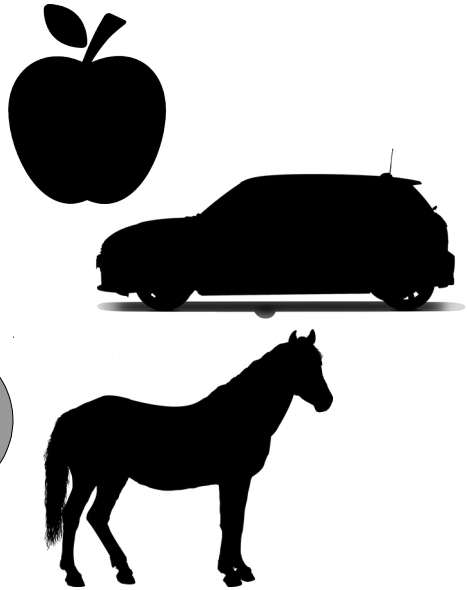
Symbolic Layer $\forall x : \text{apple}(x) \wedge \text{sour}(x) \Rightarrow \text{green}(x)$

Conceptual Layer



https://en.wikipedia.org/wiki/HSL_and_HSV#/media/File:HSL_color_solid_dblcone_chroma_gray.png

Subsymbolic Layer [0.42; -1.337, 1.95583; ...]

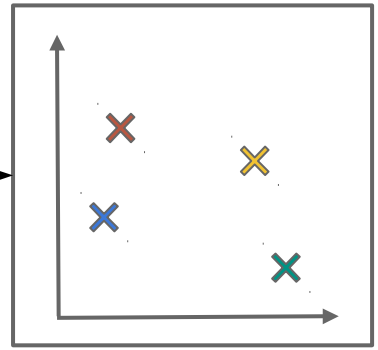


Multidimensional Scaling on Psychological Data

Psychological Experiment

0	1	2	1
1	0	4	3
2	4	0	2
1	3	2	0

Multidimensional Scaling

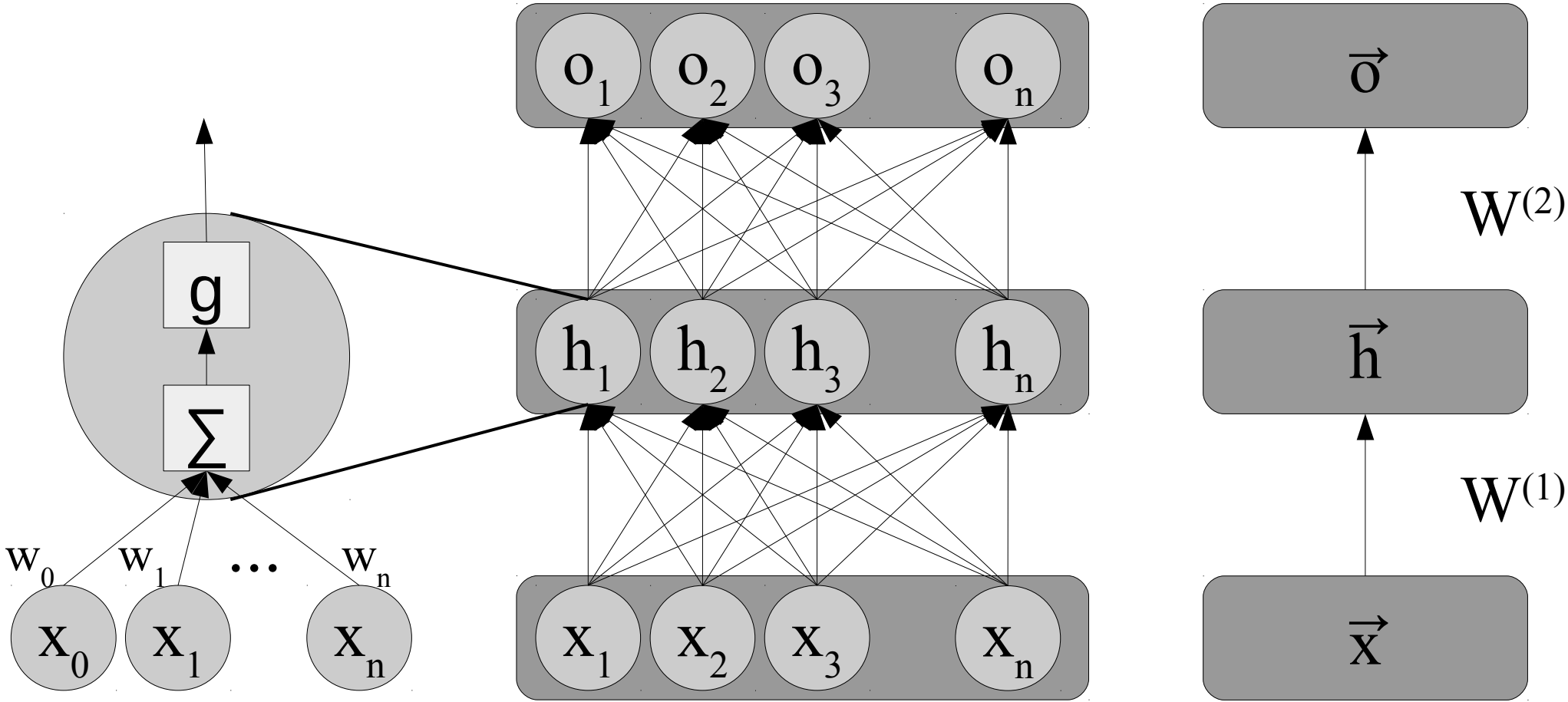


Psychological grounding

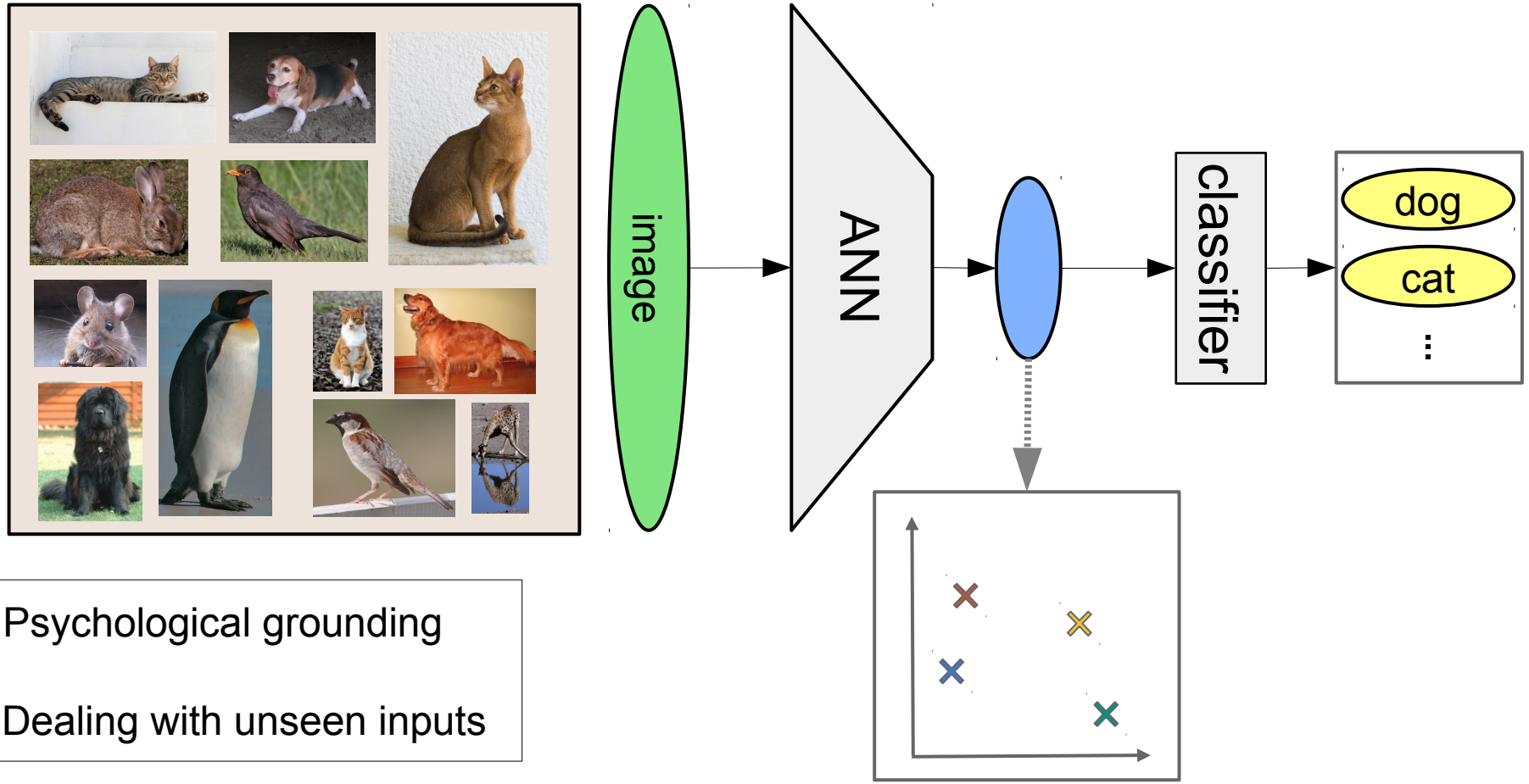
Dealing with unseen inputs

Borg, I. & Groenen, J. F. Modern Multidimensional Scaling: Theory and Applications Springer-Verlag New York, 2005

Representation Learning with Neural Networks

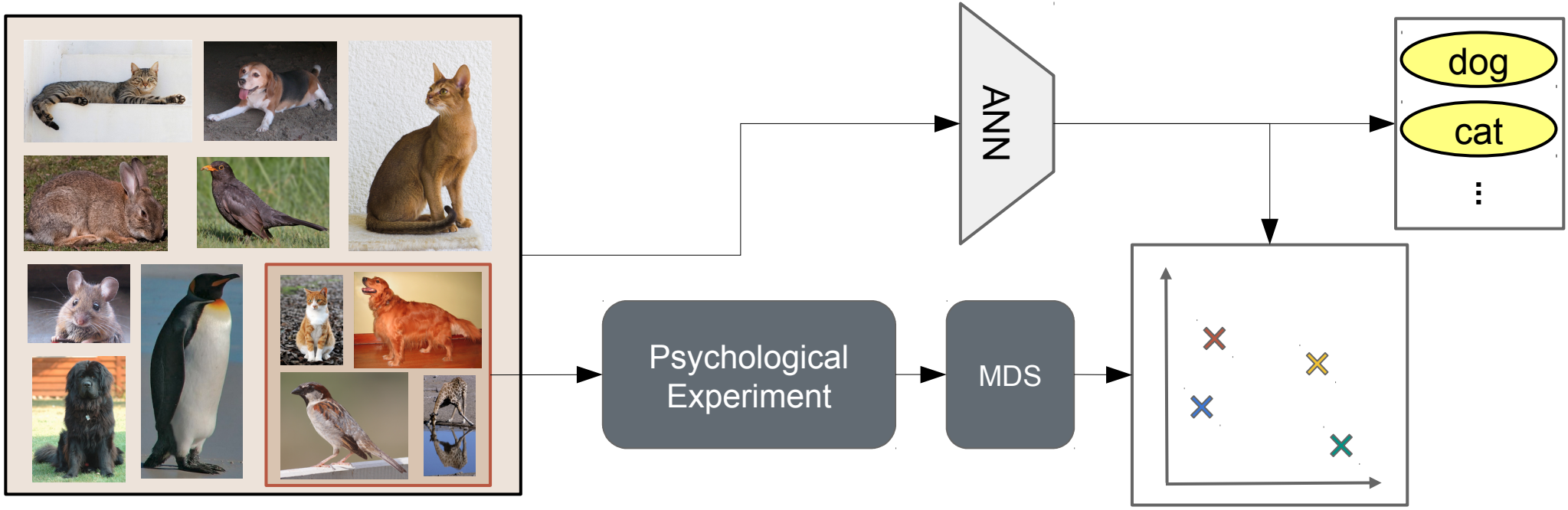


Representation Learning with Neural Networks



Bengio, Y.; Courville, A. & Vincent, P. Representation Learning: A Review and New Perspectives IEEE Transactions on Pattern Analysis and Machine Intelligence, Institute of Electrical and Electronics Engineers (IEEE), 2013, 35, 1798-1828

A Hybrid Approach



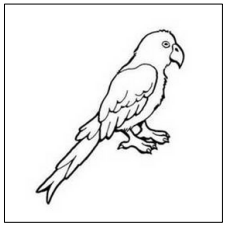
- ✚ Psychological grounding
- ✚ Dealing with unseen inputs

Bechberger, L. & Kypridemou, E. Mapping Images to Psychological Similarity Spaces Using Neural Networks. AIC 2018

Sanders, C. A. & Nosofsy, R.M. Using Deep-Learning Representations of Complex Natural Stimuli as Input to Psychological Models of Classification. CogSci 2018

Bechberger, L. & Kühnberger, K.-U. Generalizing Psychological Similarity Spaces to Unseen Stimuli. In: Concepts in Action: Representation, Learning, and Application, Springer International Publishing, 2021, 11-36

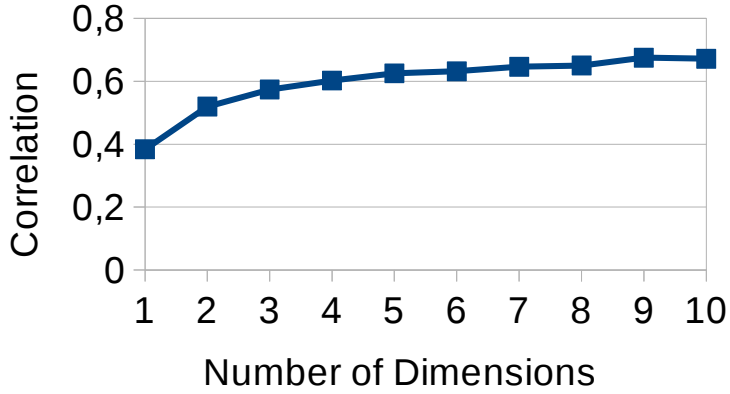
The Similarity Spaces

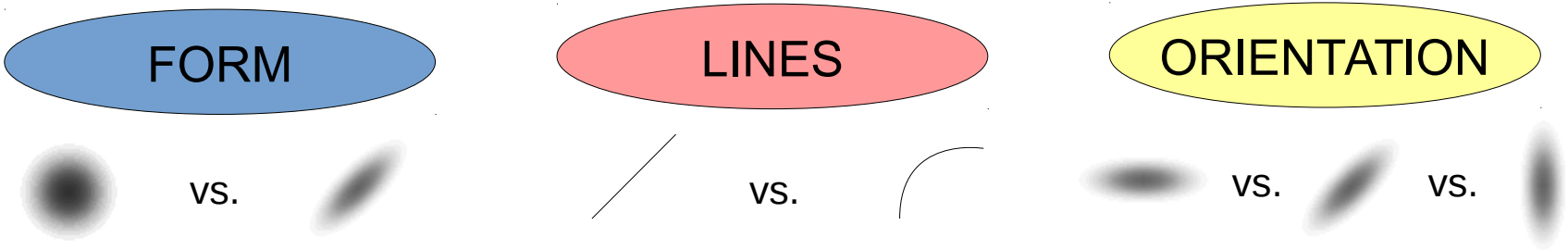


Bechberger, L. & Scheibel, M. Alam, M.; Braun, T. & Yun, B. (Ed.) Analyzing Psychological Similarity Spaces for Shapes Ontologies and Concepts in Mind and Machine, Springer International Publishing, 2020, 204-207

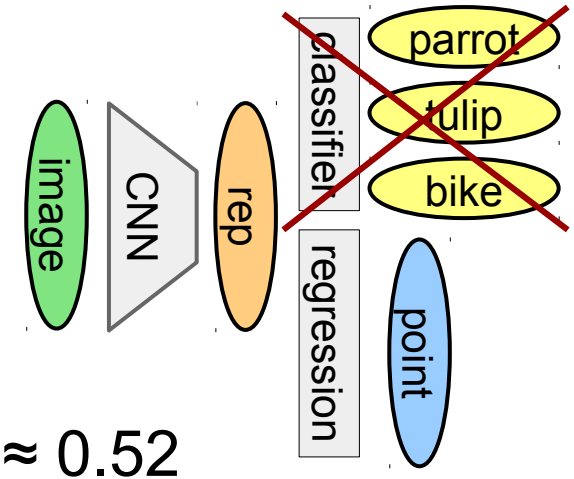
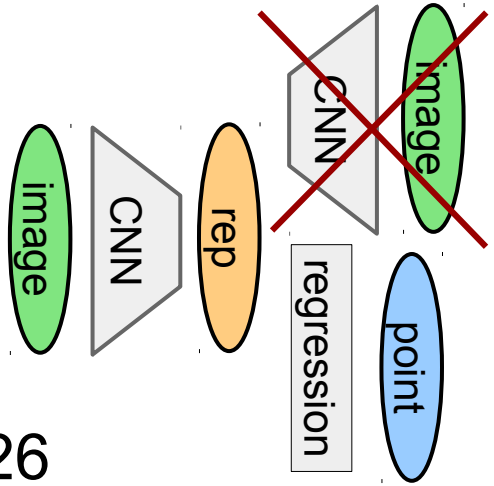
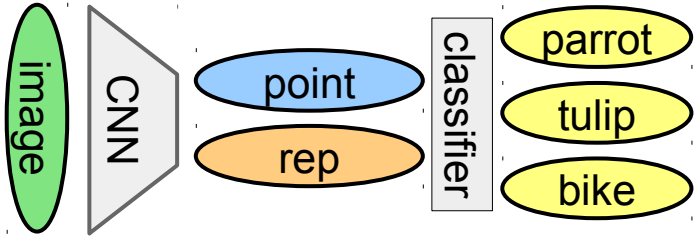
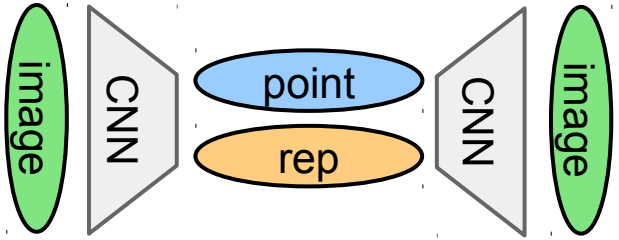
Bechberger, L. & Scheibel, M. Modeling the Holistic Perception of Everyday Object Shapes with Conceptual Spaces. In preparation

- Dissimilarity = Distance ✓
- Small Convex Regions ✓
- Interpretable Directions ✓





Learning a Mapping From Images Into Shape Space

	Classification	Autoencoder
Transfer Learning	 $R^2 \approx 0.52$	 $R^2 \approx 0.26$
Multi-Task Learning	 $R^2 \approx 0.58$	 $R^2 \approx 0.42$

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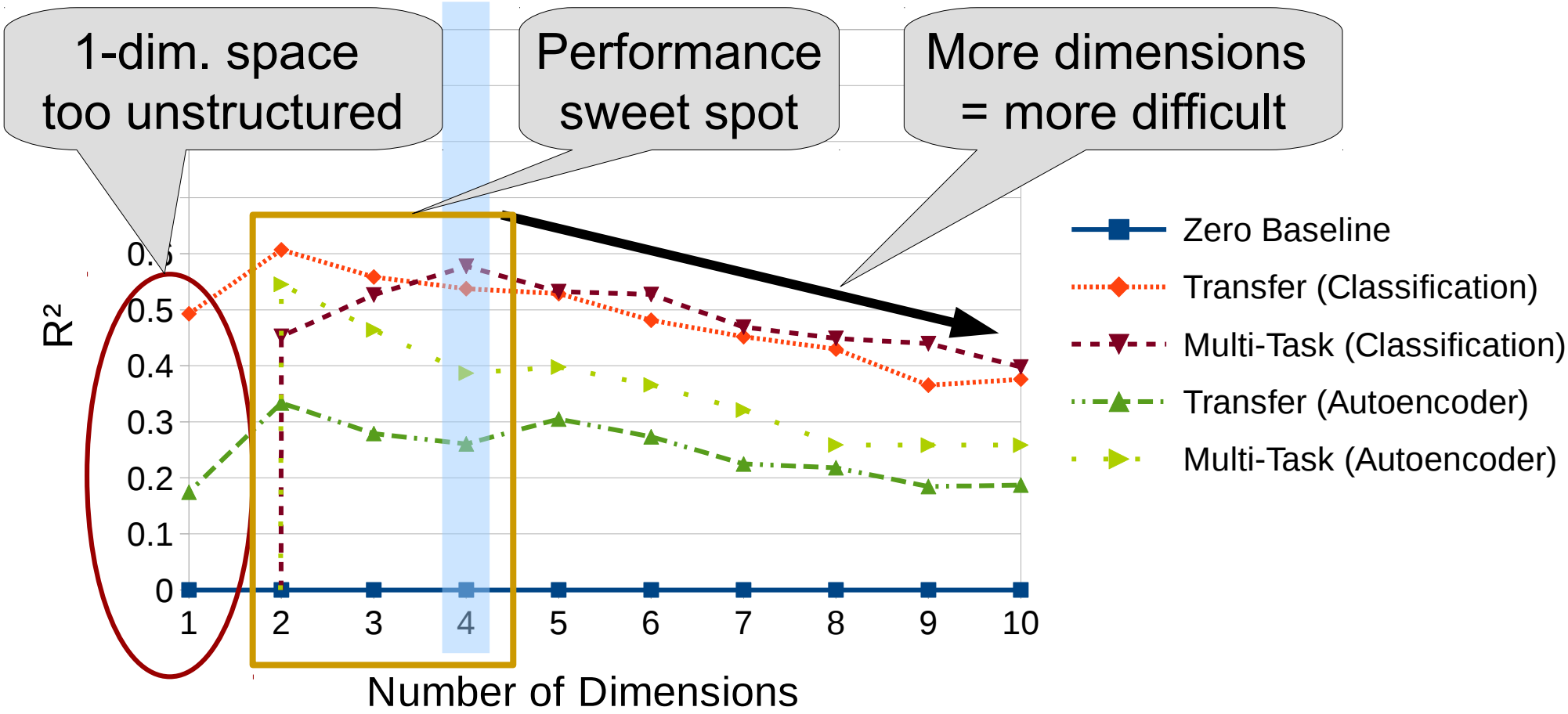

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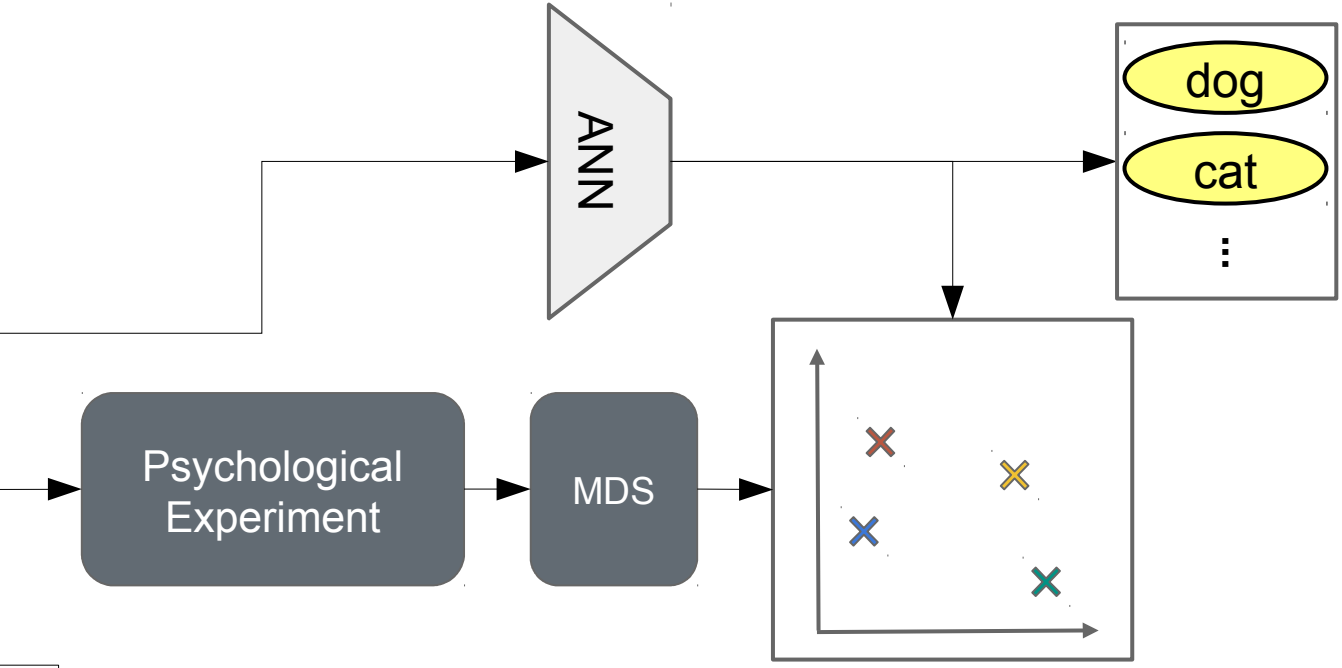

- ✓ It works in principle
- ✓ Experimental setup matters
- ? Performance still limited

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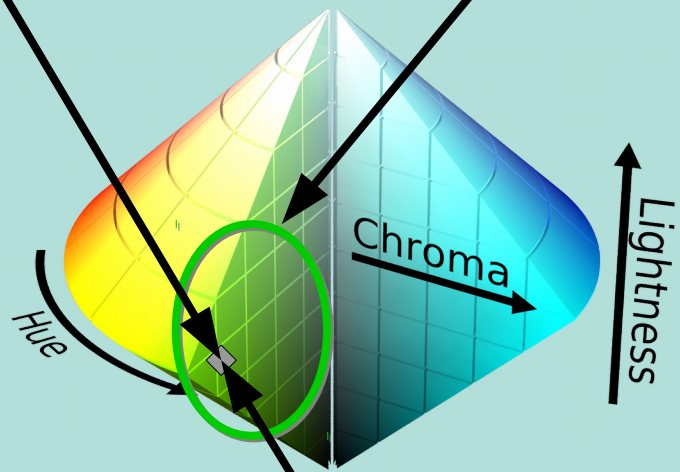

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? Reasoning on top of this

? Apply to other domains