

# The computational tradeoff between multiuse and multitasking in neural networks



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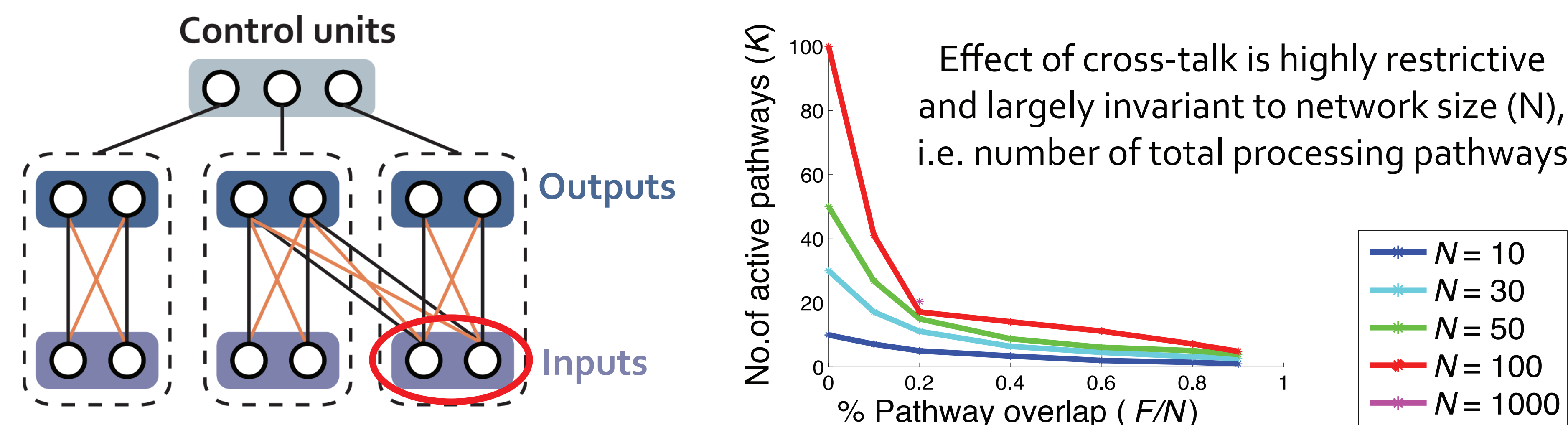
## Introduction

Capacity for controlled processing is limited (1, 2)

Feng et al. (2014)

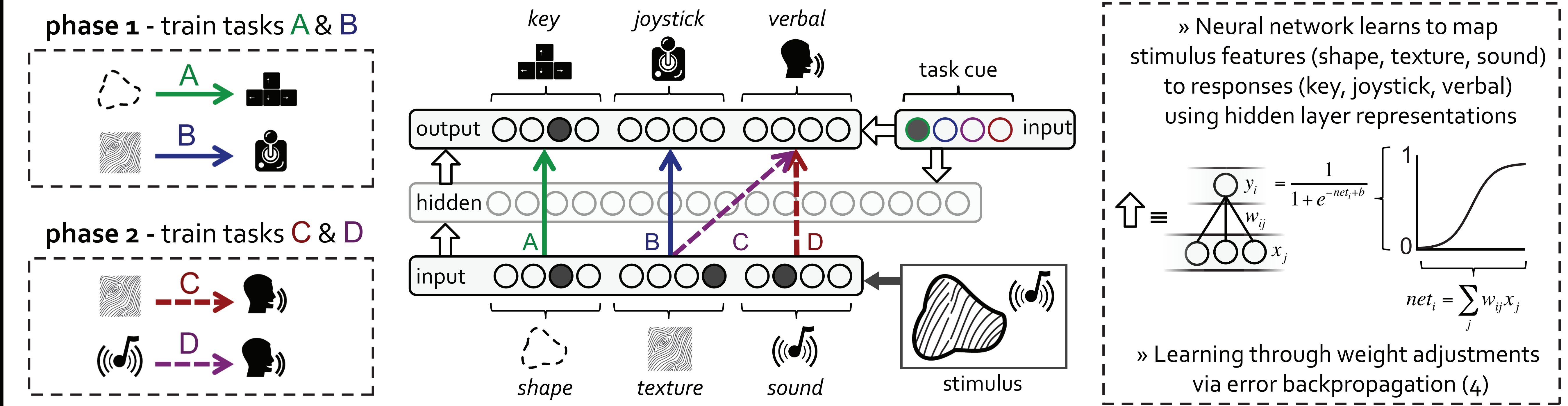
- 1) Multiuse of representations (pathway overlap) introduces cross-talk
- 2) Cross-talk limits the optimal number of active control-dependent pathways

» So why multiuse?

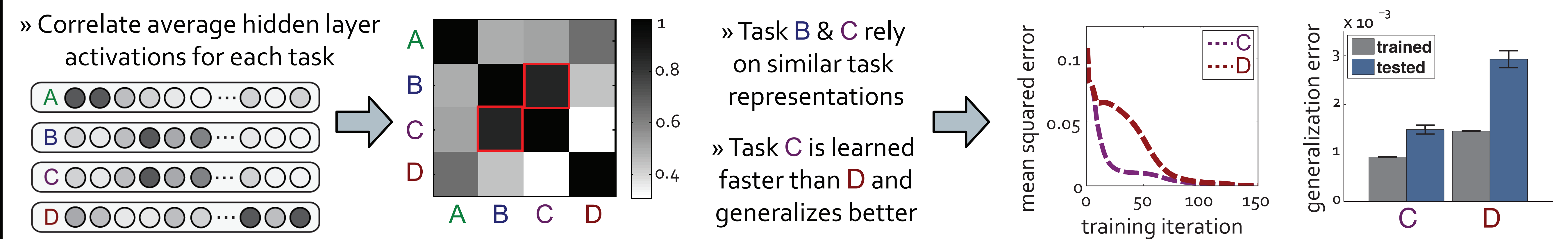


**Hypothesis:** Capacity constraints in cognitive control reflect a fundamental tradeoff between efficiency (multiuse) of representation and multitasking performance in network architectures.

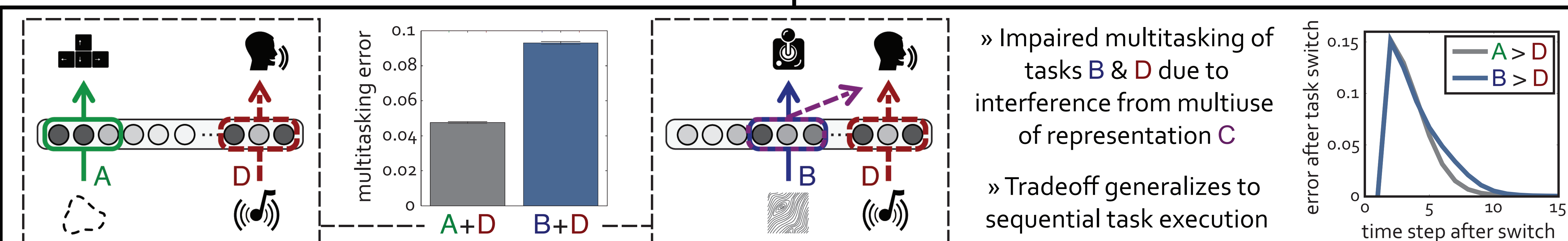
## Multiuse vs. Multitasking



Multiuse of Task Representation Facilitates Learning & Generalization (cf. 5)

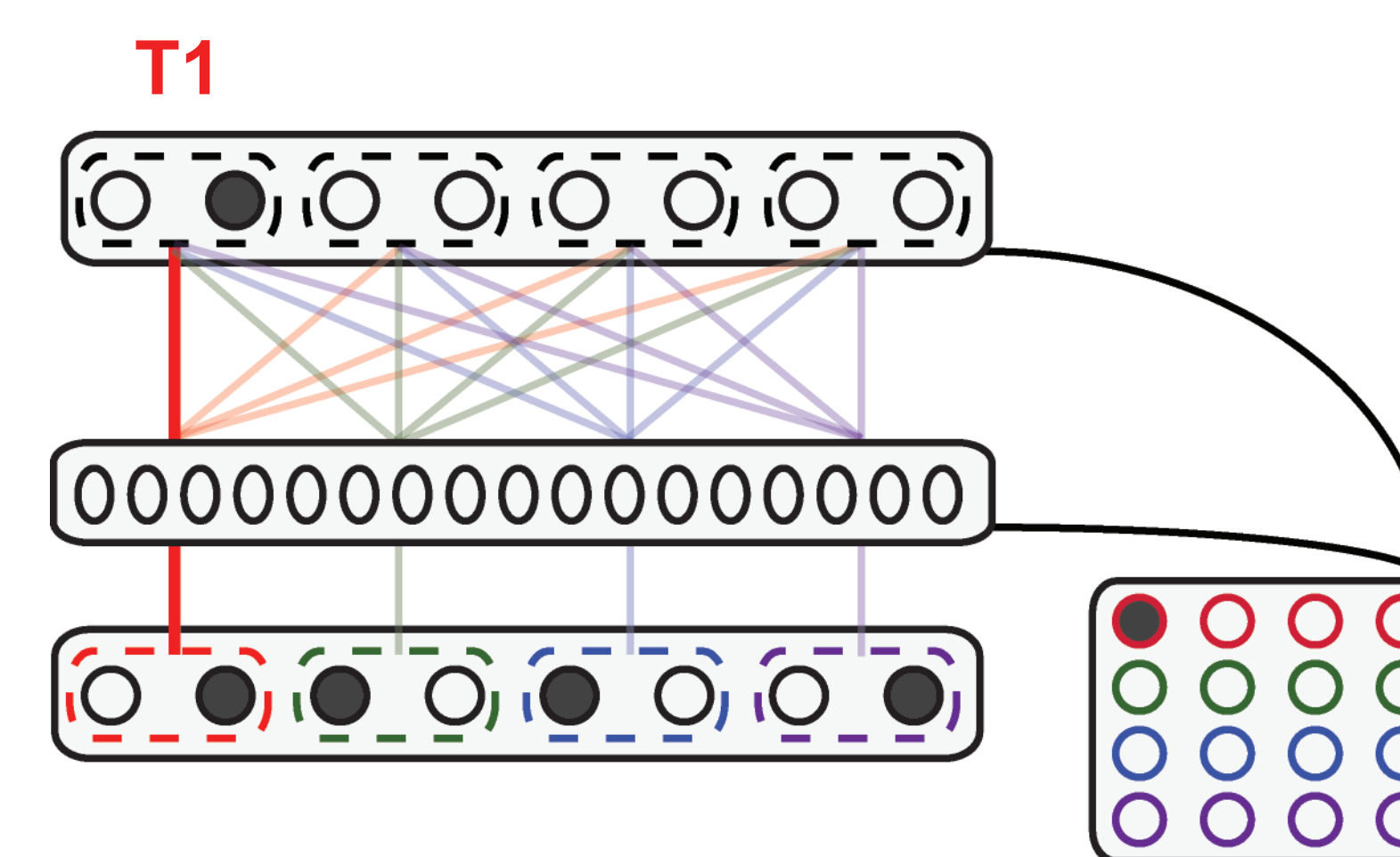


Multiused Representations Impose Limit on Multitasking Capacity

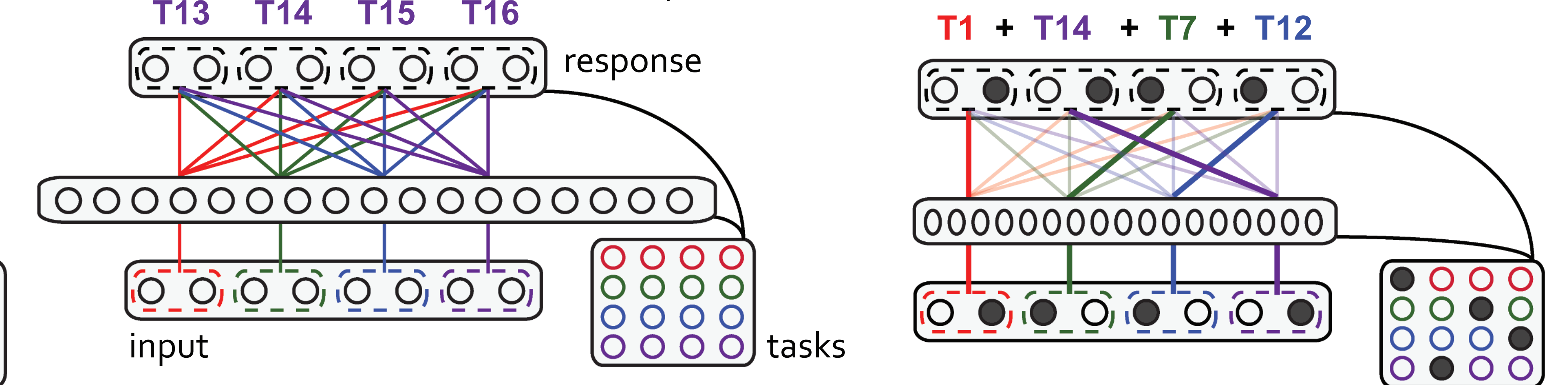


## Task Demands Shape Learned Task Representations

single task environment  
perform only one task  
at a time during training

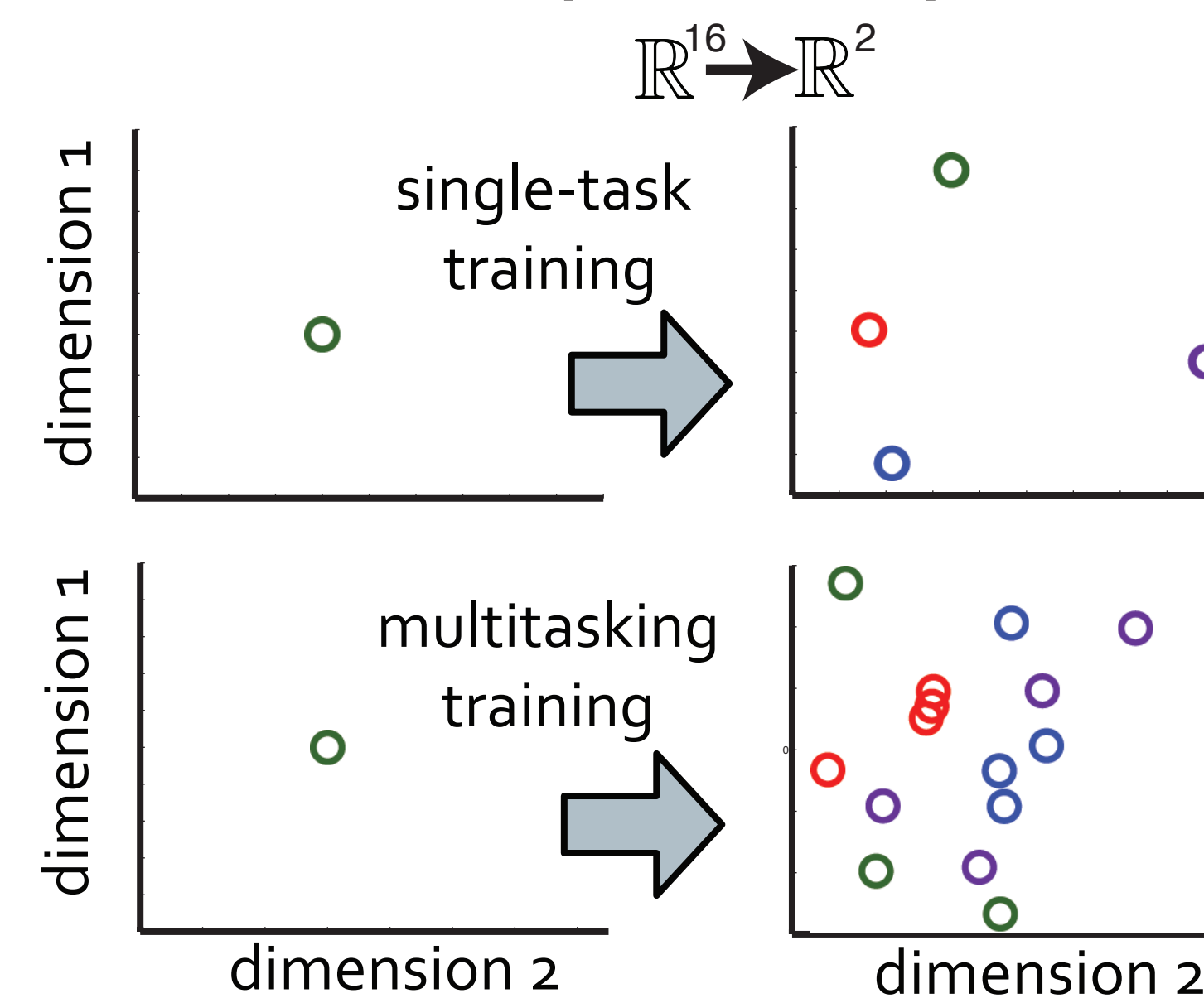


multitasking environment  
always perform 4 tasks  
simultaneously during training

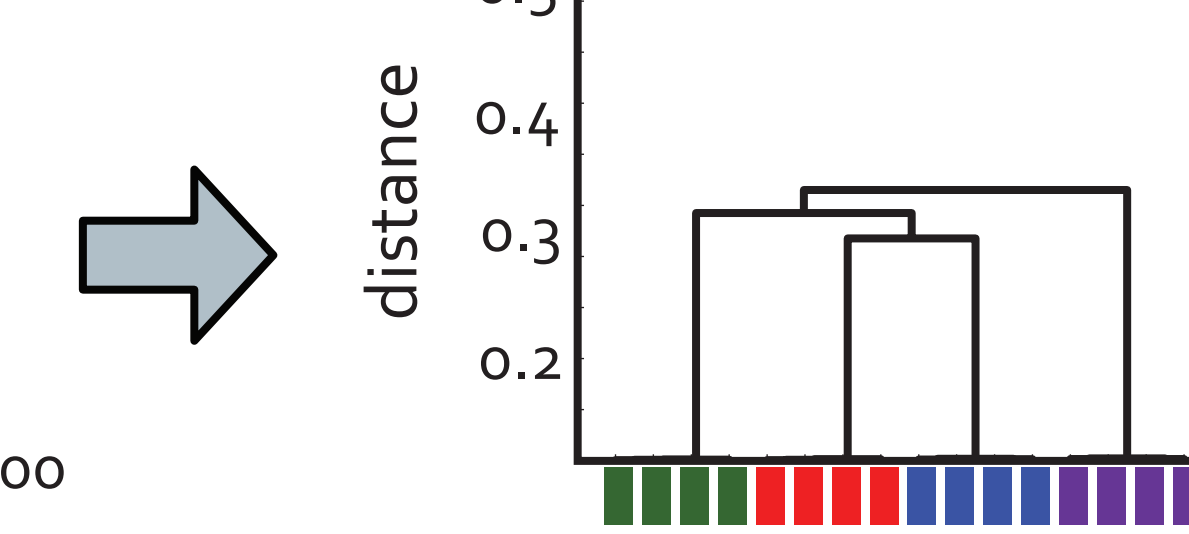
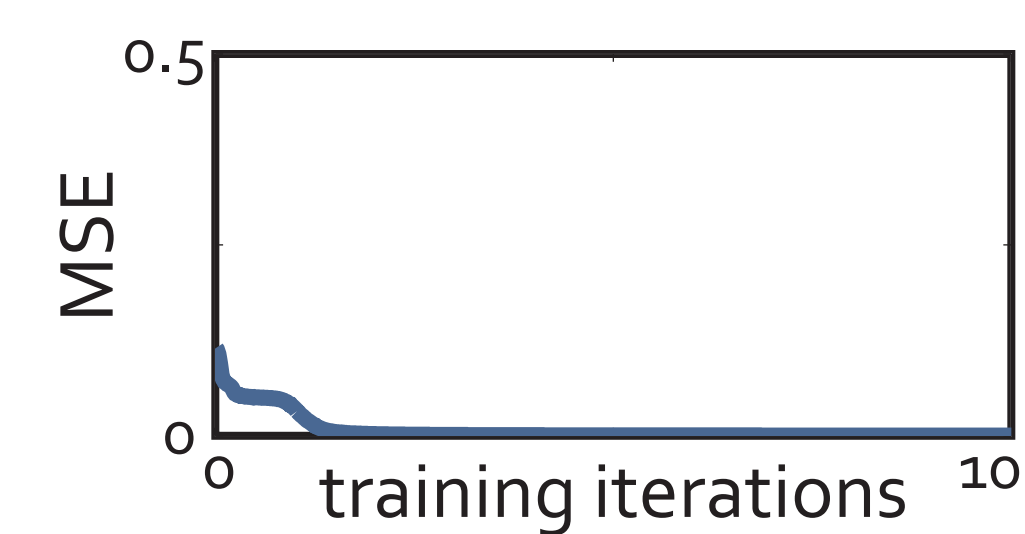


Learning Single Tasks vs. Learning to Multitask

dimensionality of task representations



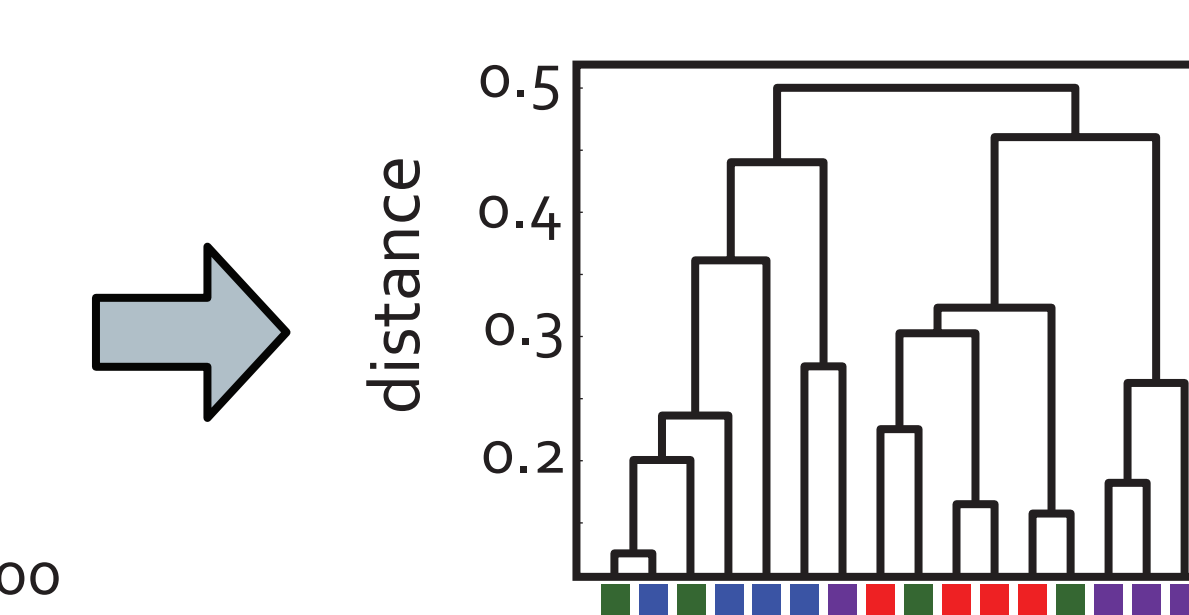
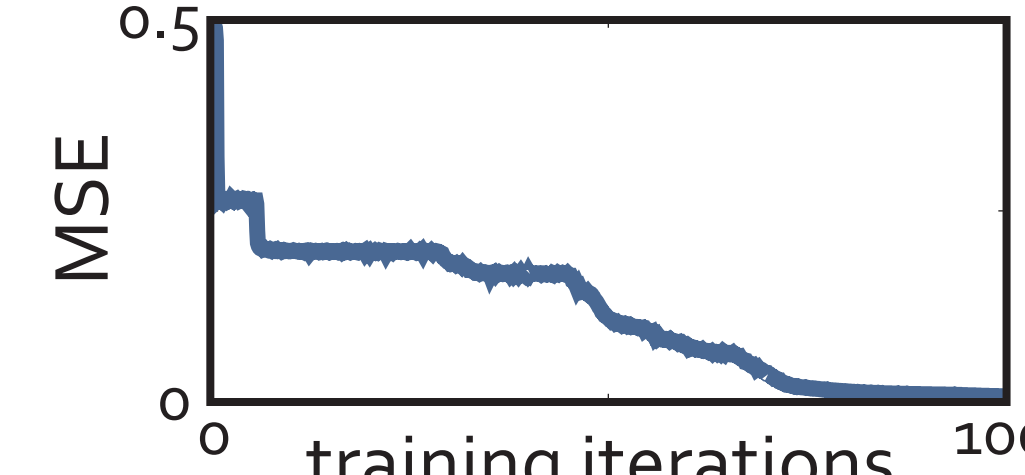
learning single tasks



hierarchical clustering

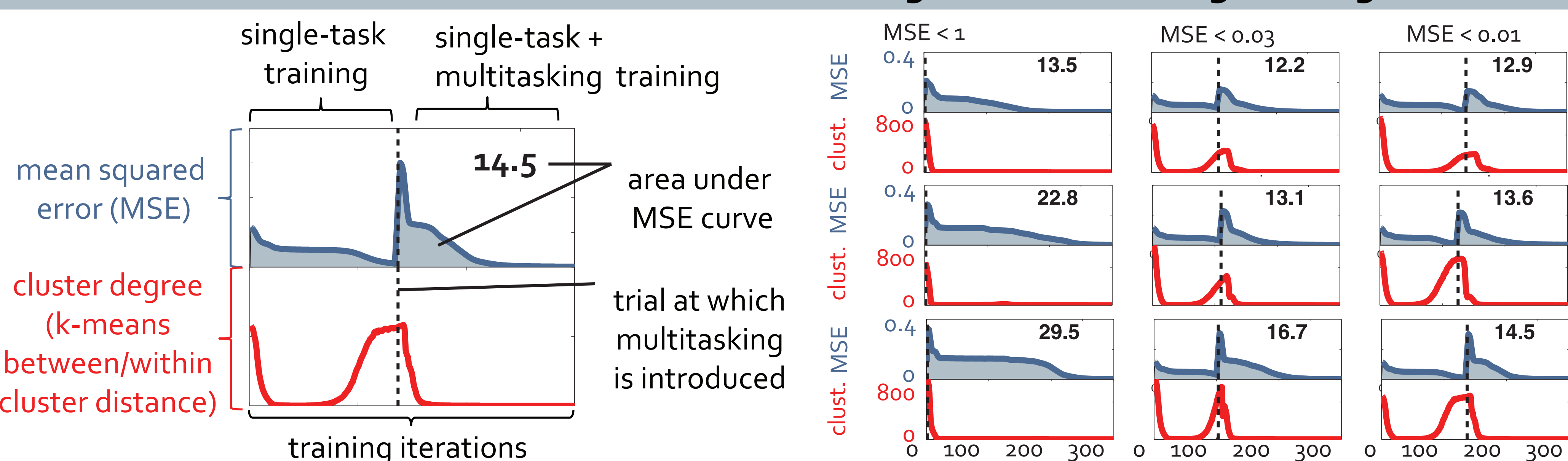
» single-task training leads to multiused task representations at hidden layer (clustered by relevant stimulus dimension)

learning multitasking



» representations separate over the course of multitasking training  
(similar pattern observed by k-means cross-validation)

Combined Single- & Multitasking Training



**Why not learning to multitask from the beginning?**  
» Preceding single-task training facilitates the acquisition of multitasking

» Demand for multitasking leads to separation of task representations, allowing for parallelization

## Future Directions

- » Validation of experimental predictions
- » Investigation of optimal balance between parallel and sequential task execution based on individual model fits

## Summary

- » Multiuse enables flexibility but limits capacity for multitasking
- » Computational analysis of the trajectory from controlled to automatic (parallel) processing and multitask performance over the course of learning

## References

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