Dimensional Label Learning Drives the Development of Dimensional Attention

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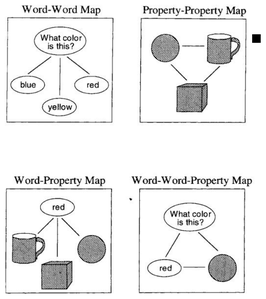
Dimensional Label Learning (DLL)

- Comprehension and production of dimensional labels develop relatively late in toddlerhood.

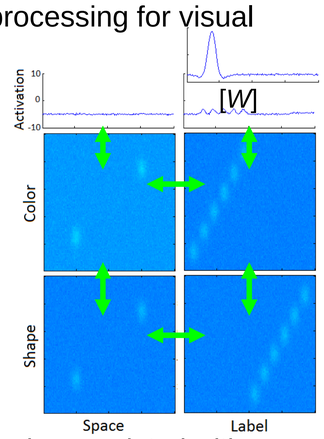


- Sandhofer & Smith (1999) demonstrated that dimensional label competence involves a system of mappings that link label with features/dimensions.

Dimensional Attention

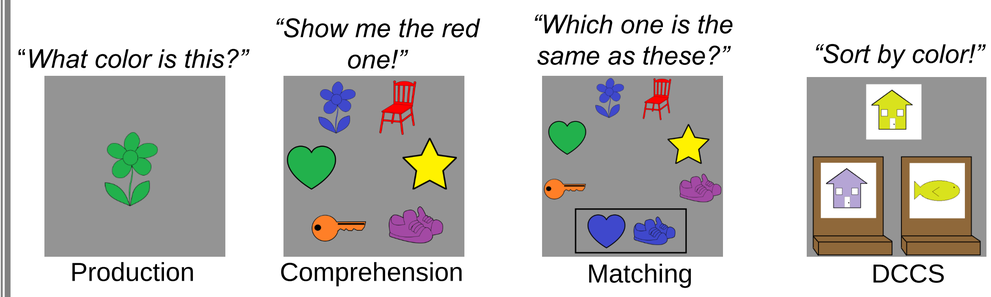
- Dimensional attention refers to selective processing of a particular color or shape.
- DLL has been proposed as a developmental mechanism that forms the basis of dimensional attention.
- In the model of Buss & Spencer (2014), DLL served as a mechanism to form associations between label representations in frontal cortex with visual feature representations in posterior cortex.
- Activation of labels in frontal cortex provides a means of biasing processing for visual features.

Dynamic neural field model that has been proposed by Buss & Spencer (2014) to explain the development of dimensional attention. Visual features are associated with spatial locations in the left column, while visual features are associated with labels in the right column. Connectivity is fully reciprocal along all dimensions.



- Dimensional attention is associated with activation across frontal, parietal, and temporal regions.
- Little is known about the neural processes involved in the comprehension and production of dimensional labels and its role in dimensional attention:
  - Do dimensional labels involve processes in neural regions that overlap with dimensional attention?
  - Does neural activation in dimensional label tasks predict performance in dimensional attention tasks?

Tasks



Dimensional Label Tasks

- The Sandhofer and Smith (1999) tasks were used to test both color and shape labels. The six stimuli for each task included the colors red, blue, green, yellow, purple, and orange and the shapes of a chair, flower, key, shoes, star, and heart.
- 26 -3 and 4-year-olds completed 24 trials of each of the Production, Comprehension, and Matching tasks. fNIRS data were collected with clusters of channels at bilateral frontal cortex regions and left temporal regions.

Dimensional Change Card Sort Task

- Children completed the NIH Toolbox version of the DCCS task.
- Children were given 5 pre- and post-switch trials and a mixed block with 20 trials corresponding to the post-switch dimension and 10 trials corresponding to the pre-switch dimension in randomized order.

fNIRS Analysis

- fNIRS data were band-pass filtered, converted to an optical density measure, trials containing motion were removed (ΔOD > .35), and outlier trials were identified and removed (> 2.5 SD above or the mean).
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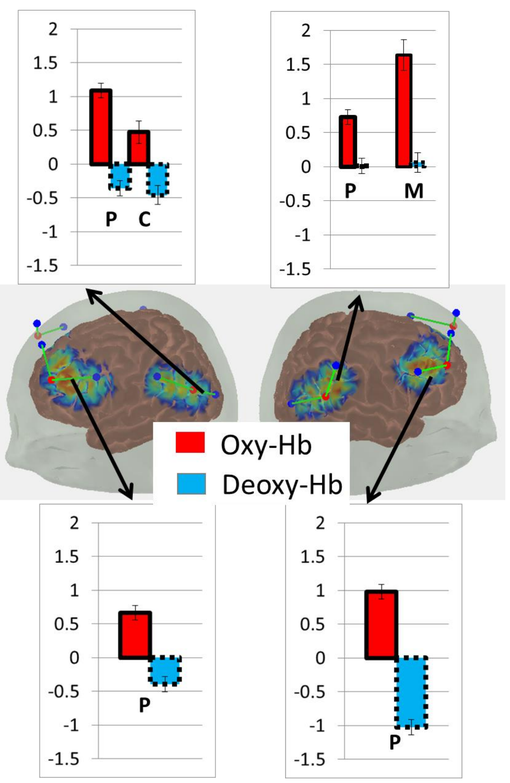
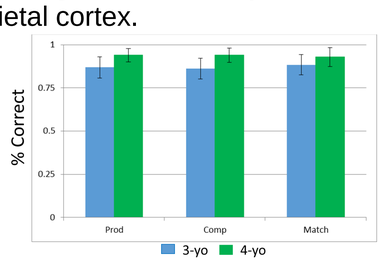


- Data were then converted to Oxy- and Deoxy-Hb measures (μM) and averaged over a time-window from 4-8 s post trial onset.
- The Oxy- and Deoxy-Hb data were compared for each channel to determine which channels showed task-related activation.

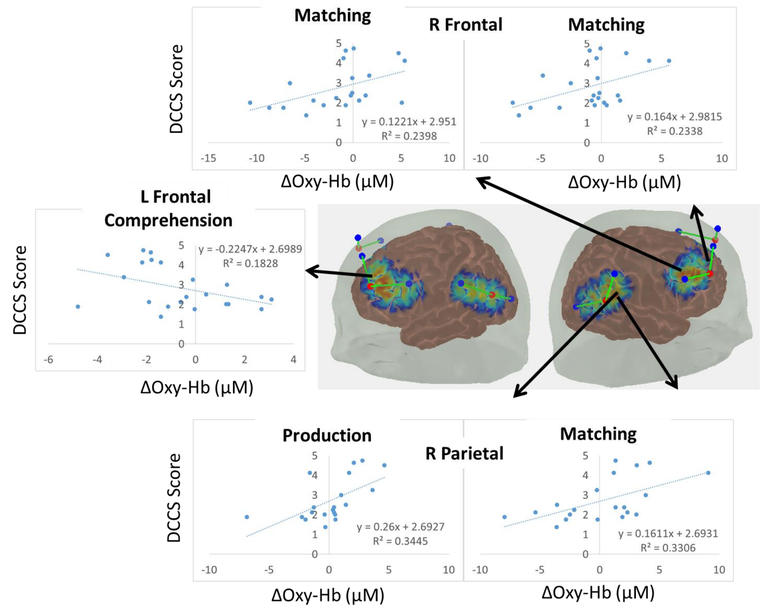
Color Task Results

- All children performed at ceiling in all three tasks
- Activation was observed in all ROI's for the production task.
- Comprehension selectively activated left temporal cortex whereas the matching task selectively activated right parietal cortex.



Associations with Task Switching

- Functional activation during the dimensional label tasks predicted switching in the DCCS
- Production was positively correlated in right parietal
- Matching was positively correlated in right frontal and right parietal
- Comprehension was negatively correlated in left frontal



Discussion

- This is the first examination of the neural dynamics involved in dimensional label comprehension and production.
- Dimensional label learning taps into a network of frontal, parietal, and temporal regions, similar to the regions involved in selective and flexible attention tasks.
- Cortical activation in the color production task was correlated with performance in the DCCS task, further supporting our hypothesis that DLL is centrally involved with dimensional attention.
- In the modeling framework of DFT, DLL provides a mechanism for associating label representations in frontal cortex with visual representations in temporal cortex.
- Future work will explore how different outcomes of DLL can facilitate the development of executive function.

References

Buss, A. T., & Spencer, J. P. (2014). The emergent executive: a dynamic neural fields model of the development of executive function. *SRCD Monographs.*

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