

VISION FOR ACTION VS. PERCEPTION IN WILLIAMS SYNDROME: EVIDENCE FOR DEVELOPMENTAL DELAY IN THE DORSAL STREAM



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ABSTRACT

Evidence suggests that visual processing is divided into two pathways: the ventral stream that is specialized for object recognition ("What"), and the dorsal stream that is specialized for visual guidance of action ("How"). It has been suggested that the dorsal stream may develop more slowly than the ventral stream, and it may also be more vulnerable to perinatal brain damage^{3,4,9}. To investigate these claims, we examined a group of children with Williams syndrome (WS) – who have severely impaired spatial capacities, and possibly dorsal stream deficits – and two groups of normally developing children (3 and 7 year-olds). Following Milner & Goodale (1995), the relation between dorsal and ventral function was tested by comparing performance in an Action task to that in a Perception task. Results suggest that the system responsible for carrying out the Action task may mature more slowly than the system responsible for carrying out the Perception task, consistent with the claim that the dorsal stream may develop more slowly than the ventral stream. Additionally, the evidence suggests that WS may be viewed as a normal division of labor between the two streams combined with a persisting immaturity of visual spatial processing done by the dorsal stream.

PROPERTIES OF VENTRAL AND DORSAL STREAMS...

Ventral stream responsible for representing the enduring aspects of objects^{3,4,9}

- Important for *perceiving* objects
- Uses *non-egocentric* coordinate system
- May mature more *quickly* than the dorsal stream

Dorsal stream responsible for on-line visual action^{2,4,8,9}

- Important for *reaching and grasping*
- Uses *egocentric* coordinate system
- May mature more *slowly* than the ventral stream, and may be more *vulnerable* to perinatal brain damage

WILLIAMS SYNDROME (WS)

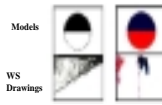
PHENOTYPIC CHARACTERISTICS^{1,2}



- Facial morphology
- Small stature
- Defects of organ especially the heart
- Brain volume reduced overall
- Mild to moderate mental retardation
- **Unusual cognitive profile**
- Relatively spared language
- Impaired spatial ability

SPECIALIZATION OF SPATIAL COGNITION IN WS

Deficits are observed in *visual construction tasks*^{1,2} (e.g., drawing and block construction) and tasks thought to involve the dorsal stream such as *visually guided action tasks*^{3,4}.



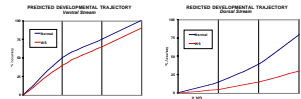
However, other aspects of spatial cognition that are assumed to reflect ventral stream function may be spared (e.g., *object identification*⁵, *biological motion*⁶, and *face recognition*⁷).

Thus, it has been suggested that this selective impairment may correspond to damage specific to the dorsal stream^{3,4}.

RESEARCH QUESTIONS

Does the dorsal stream mature more slowly than the ventral stream?

Is it more vulnerable to damage during development (e.g., Williams syndrome)?



METHOD

PARTICIPANTS

- 12 children with WS between the ages of 8;3 and 16;2 (Mean = 12;0)
- 12 normally developing mental-age matched children between the ages of 4;9 and 9;7 (Mean = 6;6)
- 12 normally developing children between the ages of 3;4 and 4;8 (Mean = 3;8)

PROCEDURE Following Milner & Goodale's method, children faced a box with a slot that was oriented to 0 degrees, 90 degrees, 45 degrees left or right of 0 degrees.

• In the "posting" or Action task, they were instructed to pick up a plexiglass dollar bill and "put it quickly into the slot of the piggy bank".

• In the "matching" or Perception task, children viewed a mannequin hand (holding the dollar bill) that rotated. The child was instructed to say "stop" when "Mr. Hand" would be "just ready to put the dollar bill into the slot in the piggy bank".

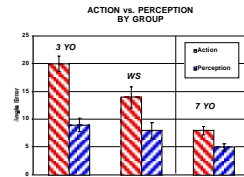


Action task

Perception task

IS THERE A DIFFERENCE BETWEEN ACTION & PERCEPTION? YES

Group Analysis by Amount of Error:



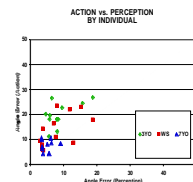
FINDINGS

ANOVA on Amount of Error revealed:

- 1) Group Effect ($p < .000$)
Regardless of task, 3 YO & WS exhibited significantly more error than 7 YO (Tukey HSD post hoc analyses; $p < .000$, $p < .03$, respectively).
- 2) Task Effect ($p < .000$)
All groups exhibited significantly more error on the Action task than the Perception task.
- 3) Group x Task Interaction ($p < .000$)

There is a significantly larger difference between the Action and Perception tasks among 3 YO than WS, as well as a significantly larger difference between the two tasks among WS than 7 YO (Tukey HSD; $p < .005$; $p < .0005$, respectively).

Individual Analysis by Amount of Error:



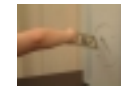
FINDINGS

- 1) Individual subject plots show roughly equal degrees of error for the two tasks for 7 YO, while revealing more error for the Action task than the Perception task among the WS & 3 YO groups.

IS THE WS PERFORMANCE QUALITATIVELY DIFFERENT FROM NORMALLY DEVELOPING CHILDREN? NO

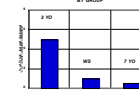
Awkward Trials Analysis:

Example:



'Overextending' the elbow

FINDINGS



3 YO made significantly more awkward trials than either WS or 7 YO ($p < .05$).

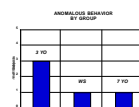
Anomalous Trials Analysis:

Example:



Putting dollar bill in 'lengthwise'

FINDINGS



The same number of WS and 7 YO exhibited anomalous behavior.

CONCLUSIONS

• For all groups, the Action task elicited worse performance than the Perception task
These results suggest that the Action system may be different from the Perception system.

• The difference in performance between tasks was significantly greater for 3 YO than 7 YO normally developing children
This suggests that the Action system matures more slowly than the Perception system, consistent with the proposal that the dorsal stream may mature more slowly than the ventral stream.

• Considering WS, the difference in performance between tasks was significantly smaller than 3 YO, but greater than 7 YO
This suggests that WS may be viewed as a normal division of labor between the two streams combined with a persisting immaturity of visual spatial processing done by the dorsal stream.

Future Research/Questions

• If the dorsal stream matures more slowly than the ventral stream, then we should see similar developmental curves for other tasks that putatively rely on the two streams.

• What happens in adults with WS? Does immaturity of visual spatial processing persist (i.e., arrested) or does it somewhat 'catch-up' or become closer to normal development (i.e., delayed)?

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