

**INTRODUCTION**

Little is known about the full impact of early CVA on cognitive and language development. "Full recovery" is typically reported by 2 years post-onset focal lesion (e.g., Feldman et al., 1992), but the development of higher-level language and cognitive processes in later stages is not well-understood. More complex language tasks such as discourse are thought to rely more heavily on an available supply of processing resources, including sustained attention. Discourse and sustained attention have been found to be impaired after pediatric TBI. Sustained attention interference on the Starry Night task may serve as an index of linguistic complexity in a dual-task paradigm.

**Background—Chapman et al. (in press)**

Children post childhood stroke are particularly impaired in the higher-level information structure dimension of discourse, relative to the more basic linguistic level. This impairment was more characteristic of early age-at-stroke (<1 year), as the late age-at-stroke (>1 year) subjects performed more similar to controls.

No group differences in verbal short-term memory (CVLT) were found.

The poorer performance of the early age-at-stroke relative to the late age-at-stroke group could not be attributed to age-at-test, lesion volume, or lesion laterality (except MLU) effects.

**POSE**

- To further document the attentional impairments in children/adolescents who have suffered CVA
- To explore the relationship between sustained attention and discourse impairments in this population

**METHOD**

- Participants**
  - Two groups (age 6-16 years):
    - Early age-at-stroke (EAS) (n=9) CVA occurred before age 1.
    - Late age-at-stroke (LAS) (n=8) CVA occurred after age 1.
  - Orthopedic controls (OC) (n=17) age-matched with stroke participants
- Post-CVA interval was at least 2 years in this sample

**Subject Criteria**

| Inclusion | Stroke group  | Exclusion  | Inclusion | Control group   | Exclusion |
|-----------|---|--|-----------|---|-----------|
|           | <ul style="list-style-type: none"> <li>Neonatal bleeds (e.g. intraventricular hemorrhages, germinal matrix hemorrhages) which might be associated with prematurity</li> </ul> | <ul style="list-style-type: none"> <li>Neonatal watershed infarcts associated with hypoxia</li> <li>Hemoglobinopathies</li> <li>Progressive neurometabolic disorders</li> <li>Down's syndrome and other major chromosomal abnormalities</li> <li>Malignancy</li> <li>Congenital hydrocephalus</li> <li>Clotting factor deficiency</li> <li>Stroke in a pregnant minor</li> <li>Previous organ or bone marrow transplant</li> <li>Cerebral cysts</li> <li>trauma</li> <li>Transient ischemic attack</li> <li>Moya Moya</li> <li>Severe and profound mental retardation</li> <li>Quadriplegia, triplegia, or diplegia diagnoses</li> <li>Syndromic vascular malformations</li> <li>Systemic lupus erythematosus</li> <li>Multiple lesions (unless in close proximity)</li> </ul> |           | <ul style="list-style-type: none"> <li>Congenital clubfoot or scoliosis</li> <li>Evidence of congenital or acquired CNS injury</li> </ul> |           |

**Subject Characteristics**

| Lesion onset          | Stroke N=17           |                    | Controls N=17       |      |
|-----------------------|-----------------------|--------------------|---------------------|------|
|                       | Early (<1 year)       | N=9                | Congenital clubfoot | N=9  |
| Late (>1 year)        | N=8                   | Acquired Scoliosis | N=8                 |      |
| Gender                | Male                  | N=9                | Male                | N=9  |
|                       | Female                | N=8                | Female              | N=8  |
| Mechanism of stroke   | Occlusive             | N=11               |                     |      |
|                       | Hemorrhagic           | N=6                |                     |      |
| Lesion location/onset | Right/early           | N=4                |                     |      |
|                       | Right/late            | N=5                |                     |      |
|                       | Left/early            | N=5                |                     |      |
|                       | Left/late             | N=3                |                     |      |
| Handedness            | Right                 | N=11               | Right               | N=17 |
|                       | Left                  | N=5                | Left                | N=0  |
|                       | Ambidextrous          | N=1                | Ambidextrous        | N=0  |
|                       | Mean (SD) Age at Test | Early 12.56 (2.24) | Late 14.13 (3.23)   |      |

**Starry Night Task (Robin & Rizzo, 1990, 1996)**

- Computer monitor displayed 250 white dots ('stars') on a black background
- Subjects pressed a button whenever they observed a star appear or disappear ('event')
- 200 events occurred in the 7-12 minute task
  - "hit" = response made 100-2000 ms after event
  - "miss" = no response 100-2000 ms after event
  - "false positive" = response when no event had occurred
- Dependent variables:
  - d' (accuracy)
  - B (response criterion)
  - RT (reaction time)

**Discourse Task (Chapman et al. In Press)**

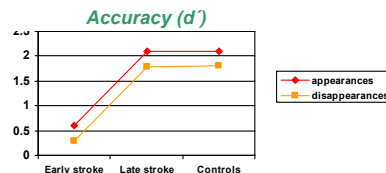
- Story retell task
  - 1) listen to 235 word story over 2 episodes
  - 2) retell story
  - 3) provide interpretation (overall point)
- Three dimensions analyzed:
  - Linguistic structure (amount and length of utterances)
  - Information structure (selecting and coding content in an organized manner)
  - Macrolevel Interpretation (lesson)

**Discourse Measures used to characterize deficits in the stroke population compared to controls**

| Domain                    | Measure  | Description  |
|---------------------------|--|--|
| Language Structure        | Number of unedited words   | The total number of words in the story was calculated by including all revisions and whole word repetitions but excluding extraneous verbalizations such as "um" or "uh."  |
|                           | Mean Length of Utterance   | MLU is calculated by dividing the total number of edited words by the number of t-units, and indicates the average length of a child's oral expression based on a representative sample of his language.   |
| Information Structure     | Core Propositions  | Propositions are units of information that were established a priori. The story contained 30 propositions, and these abstract info units were defined by meaning rather than tied to specific wording.   |
|                           | Gist Propositions  | Global story content is analogous to a skeletal outline of the most important information and is commonly referred to as the "gist" of the text (van Dijk, 1985). A set of 6 propositions, identified from the original 30 core propositions, were established a priori based on the semantic organization of the story, and provide a way to examine the selective nature of information reduction. |
| Episodic structure        | Episodic structure defines the organization of information as defined by the essential components of setting, complicating action, and resolution (Labov, 1972). |  |
| Macrolevel Interpretation | Lesson   | The lesson requires making inferences across the entire story content and real world knowledge based on actions and social consequences.   |

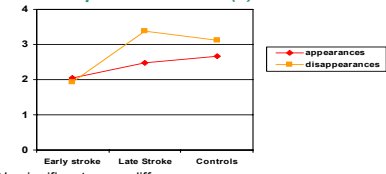
**RESULTS**

**Sustained Attention**



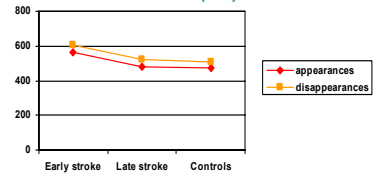
- Significant main effect of group for appearances [F(2,52)=8.497; p=.0005] and disappearances [F(2,52)=9.631; p=.0003]
- EAS less accurate than LAS and OC for appearances and disappearances.

**Response Criterion (B)**



- No significant group differences
- The sustained attention differences between groups are not due to a different performance bias.

**Reaction Time (ms)**



- Significant main effect of group for appearances [F(2,54)=3.073; p=.035] and disappearances [F(2,54)=3.073; p=.05]
- EAS more slow for appearances and disappearances than LAS and controls.

**Relationship between Discourse and Sustained Attention Accuracy (d')**

| Group        | Correlations (Spearman's rho) between Discourse variables and Attention variables (d' and B) | P value      |
|--------------|--|--------------|
| Early Stroke | .68-.9   | p<.0011-.048 |
| Late Stroke  | .73-.92  | p<.0011-.039 |
| Control      | -  | n.s.         |

**CONCLUSIONS**

- 1. Early age-at-stroke children/adolescents were most impaired on sustained attention and discourse (Chapman, et al. in press) tasks, compared to late age-at-stroke and control children/adolescents.
  - The "full recovery" assumption of the past (e.g., Feldman et al., 1992), may hold for challenging integrative and sustained tasks in children/adolescents.
  - Opposes the notion of youth-based plasticity (better outcome v. earlier injuries), suggesting that higher pre-morbid skill development may serve to promote recovery, or may be protective against permanent loss in the LAS group.
- 2. Participants' performance on the inference revision Performance on attention and discourse tasks are more strongly correlated in children/adolescents post-CVA than in non-brain-damaged controls.
  - Supports hypothesis that children/adolescents post-CVA have greater demand placed on their linguistic system during discourse than non-brain damaged children, thereby using more of the available resource pool.
  - In other words, perhaps the non-brain-damaged controls evince a correlation between the two measures because the two tasks are less heavily on a common skill or resource; or neither task sufficiently taxed the resource supply. The results suggest that in children/adolescents post-CVA, underlying skills for the discourse tasks may be inefficient, thus resulting in the need for these two to rely more heavily on the pool of resources.
- 3. Late age-at-stroke children/adolescents are similar to controls on attention and discourse measures, but dissimilar in the correlation between these characteristics.
  - Suggests late age-at-stroke children/adolescents may have an underlying deficit that is not detected by discourse or sustained attention measures alone. Alternatively, it may be that discourse creates a greater demand than it does in the non-brain injured subjects, thereby resulting in a different allocation strategy.

**IMPLICATIONS**

- Evaluation of sustained attention skills should be considered an important component of a diagnostic battery for children/adolescents post-stroke.
- Children/adolescents with stroke who appear to have "recovered" basic language and cognitive functions should be considered for evaluation of other more subtle deficits that may only become apparent in more complex integrative or sustained tasks.
  - Since only the correlation between the two tasks, and not the task or the story retell task alone differentiated the late age-at-stroke subjects from the control subjects, a more precise measure, beyond the putatively shared features of the two tasks, may be useful to detect the subtle impairments of individuals following childhood stroke.
- Although this study cannot directly address this issue, these findings potentially inform models of the development of sustained attention networks.
- Future research should address whether the improved performance of the LAS group (relative to EAS) is attributable to a) more highly-developed neural attention networks being more resistant to loss; b) compensation; or c) a combination of the two.

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