Cognition and attentional control

Traumatic brain injury and dysexecutive syndrome

Sentence and discourse processing following TBI

Assessment and treatment for discourse impairments following TBI

Questions and answers

Learning Objectives

- Describe the role of attentional control for language
- Summarize recent studies of sentence and narrative production following TBI and how they relate to a resource model of discourse processing
- Apply research results to the assessment and treatment of discourse impairment due to TBI

Attentional Functions

- System 1 – Arousal, alerting, and vigilance
- System 2 – Selective attention
- System 3 – Executive control and supervision (intentional, goal-directed task performances; includes working memory)

System 1

- Arousal
  - General facilitation of cognitive processing for any source of information
- Alertness
  - Readiness to engage with a task – “mobilization of effort”
- Vigilance
  - Extended readiness for long periods
System 2
- Orienting to and selecting from simultaneous sources of information
- Regulating information flow
- Giving priority to the processing of material from some sources
- Enhancement
- Inhibiting information from others
- Suppression

System 3
- Most closely associated with working memory
- Multicomponent system consisting of:
  - Executive controller
  - Three buffers or short-term storage devices
    - Phonological loop
    - Visuospatial sketchpad
    - Episodic buffer (long-term working memory)
- Functional components of working memory reside in prefrontal cortex

Figure 4.6: Current architectural organization of working memory. (From Baddeley, A. D. (2000). The episodic buffer: A new component of working memory? Trends in Cognitive Sciences, 4, 421.)

Executive and Supervisory Control

- Emphasizes the concept of effort (i.e., concentration, motivation, arousal)
- Assumes a limit on the capacity of attentional resources
- Amount of resources allocated is determined by the effort or attention needed
- Central executive in this description comparable to concept of "supervisory attentional control"

Kahneman, 1973

System 1 – Arousal, alerting, and vigilance
System 2 – Selective attention
System 3 – Executive control and supervision (intentional, goal-directed performances; includes working memory)

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Executive and Supervisory Control

- Takes into account higher order aspects of attention (e.g., planning, regulation of goal-directed activity)
- Trigger conditions in the external input activate mental schemas that interpret the input and determine subsequent action
- Multiple schemas may become active simultaneously

Kahneman, 1973

System 1 – Arousal, alerting, and vigilance
System 2 – Selective attention
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Executive and Supervisory Control

- Two adaptive, top-down management functions for control of attention (inhibition of irrelevant schemas):
  - Contention scheduling (routine behavior) - automatic conflict resolution for simultaneous schemas according to priorities/environmental cues (associations in long-term memory)
  - Supervisory attentional control (non-routine situations) - voluntary modulation of the excitability of schemas (i.e., inhibition) via a strategy in working memory
- Priority assignment = selective enhancement

Prioritization and Resource Allocation

Shallice, 1982

System 1 – Arousal, alerting, and vigilance
System 2 – Selective attention
System 3 – Executive control and supervision (intentional, goal-directed performances; includes working memory)

van Zomeren & Brouwer, 1994

Language and Attentional Control

- “The (attention) invested in a task is mainly determined by the intrinsic demands of the task”
- Voluntary control over attention is quite limited
- Different tasks and situations require different types of attention depending on task demands
- Cognitive-communication disorders can be viewed as the result of impairments in attentional control for language processes

Engle et al., 1999

Magnitude depends on whether procedures are routinized or attention demanding
Language and Attentional Control

- Intentionally-guided attention: "What we intend to do influences to what we attend"¹
- Experience modifies auditory attentional allocation in a wide range of tasks²
- Executive (i.e., attentional) control required for lexical selection, biasing in bilingualism, and sustaining sentential interpretations against competing candidates³
- Effect of training with a task involving multiple executive control components is highly specific to the trained task⁴

¹ Crosson & Cohen, 2012; ² Addleman & Jiang, 2019; ³ Tran et al., 2018; ⁴ Simonet et al., 2019
Traumatic Brain Injury, Dysexecutive Syndrome, and Communication

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Central Executive

- The functional unit of the brain responsible for programming, controlling, and verifying activity
- Executive, supervisory system for managing
  - Dual task performance
  - Attentional focusing
  - Attentional switching
  - Interfacing with long-term (permanent) memory

Executive Functions

- Initiation, or activation of a cognitive system
- Goal maintenance or task persistence
- Organization of action sequences
- Awareness, or self-monitoring and modification (flexibility)

Executive Functions and Communication

- Communication is complex, goal-directed behavior for exchanging information
- Comprehension and production of discourse requires cognitive control for coordinating and organizing
  - Linguistic interpretation
  - Organizational structure
  - Pragmatic rules
- Uses frameworks (structured event complexes (SECs)) that are learned through repeated exposures to general patterns and important contextual factors

Executive Functions and Communication

- SECs are goal-oriented, sequentially structured, thematic, and rule-governed
- Conceived as distinctive memories that are activated in parallel to create the framework for an episode
- Represent thematic knowledge, morals, abstractions, concepts, social rules, features of specific events, and grammars for actions, stories, and schemas
- Memory units stored in various regions of the prefrontal cortex (PFC)
Executive Functions and Communication
- SEC knowledge is a type of pattern abstraction of prior experience
- Discourse, presented in a simple and organized pattern, reduces processing load to the point of becoming predictable and automatic
- Discourse analysis therefore provides important means for assessing SECs because of the:
  - Rich content
  - Predictable organizational structure
  - Linguistic processing demands required in discourse tasks

Dysexecutive Syndrome and Communication
- DS often associated with pathophysiology of the PFC
- Any disruption of the PFC or its related cortical/subcortical circuitry may lead to executive deficits and subsequent communication disorders
- Impacts communication by affecting organization, output, efficiency, precision, abstraction, social referencing, appropriateness, and verbal learning
- Evident during discourse (procedural, narrative, conversational) at the word, sentence, and global levels

Sentence and discourse processing following TBI

Cognition and Acquired Language Disorders Lab
- Goal 3: To understand the cognitive bases for discourse processing following TBI
- Approach: Measure language outcomes and other cognitive abilities associated with TBI
- Methods: Online and off-line analyses of discourse focusing on the microlinguistic, inter-sentential, and global levels of discourse production
  - Sentence pausing
  - Maze production
  - Local sentence cohesion
  - Story grammar

Sentence planning following traumatic brain injury

Abstract: Contextualization of the language problems following traumatic brain injury (TBI) grant the emphasis on planning discourse production and evaluating the observed outcomes in terms of disruptions in executive processes. These disruptions produce qualitative impairments in the sentence level that have not generally been ignored. To respond to this issue, we examined sentence planning in 10 TBI patients with amnesia and 10 age-matched controls with amnesia. The 10 TBI participants were selected for a level of oral and written abilities that was the same. All patients were patients with amnesia during language planning, such as sentence level. Maltreatment of the patients with amnesia during language planning was found to be more severe than that in patients with amnesia during language planning. TBI patients exhibited impairment in sentence planning. The evidence suggests that the language profile of TBI may be one of both disruptions and non-disruptions.
Purpose

- Describe sentence planning in individuals with TBI and 
  "confused language."
- Examine planning processes in well-formed sentences 
  using online analyses of pauses and initiation times.
- Evaluate effects of different response conditions (reading 
  and repetition) in sentences varying in complexity.

Findings

- TBI participants paused significantly more than control 
  participants in well-formed sentences for both reading and 
  repetition.
- Sentence complexity exerted a significant influence on 
  sentence pausing for TBI participants but not for control 
  participants.
- Increased initiation time for TBI participants on Object-
  Subject Relative sentences compared to controls.

Experimental Questions:

- Do speakers with and without TBI show different patterns of:
  - Sentence planning for simple discourse as evidenced by an online 
    index of sentence planning (i.e., pause time)?
  - Sentence planning for discourse as evidenced by off-line measures of 
    sentence planning (i.e., length of narrative and utterances, maze 
    production, syntactic errors, and abandoned utterances)?
- What cognitive skills predict patterns of:
  - Pausing during sentence planning following TBI?
  - Productivity, mazes, errors, and abandoned utterances following TBI?
Analyses for Pause Time, Maze Production, and Syntactic Errors

Findings:
- Microlinguistic impairments of individuals with TBI are associated with variations in the organization and monitoring of language representations in working memory.
- Among the fundamental operations of the central executive, a multicomponent attentional system is responsible for facilitation of language processing and inhibition of undesired representations.
- Suggests that microlinguistic deficits are due to deficits in the recruitment and control of attention for sentence planning.

Purpose:
- Investigated relationship between inter-sentential cohesion and intra-sentential planning in the discourse of speakers with severe TBI.
- Tested the hypothesis that impairments in inter-sentential cohesion and intra-sentential planning are the result of executive deficits that support microlinguistic processing.
- Variable but coincident breakdowns in inter-sentential cohesion and sentence planning during the production of narratives would be expected if such impairments are the result of executive dysfunction.
Analysis of Inter-sentential Cohesion

- Local Cohesion – Linking of sentences in a text by cohesive ties (various types of meaning relations)
  - Words that require a listener to search for information outside the sentence (e.g., using a pronoun following a more specific identity).
  - Correct when the information referred to by the tie is easily found
  - Erroneous when it guides the listener to ambiguous information

Analysis for Sentence Cohesion

Analyses for Cohesive Ties and Pause Time, Maze Production, and Syntactic Errors

Findings:

- Moderate-to-strong association between cohesive ties and intra-sentential deficits.
- Pattern of intra-sentential deficits, primarily increased pausing followed by mazes and occasional errors, was similar for both complete and error ties.
- Results support hypothesis that executive deficits influence both the intra-sentential and inter-sentential levels of microlinguistic processing for discourse.
- Suggest that the utilization of processing resources required for establishing adequate cohesion in discourse following TBI negatively affects intra-sentential processing.
Purpose:
- To test the resource model of discourse processing by examining the relationships among inter-sentential cohesion, intra-sentential planning, and macrolinguistic organization, e.g., the completeness of the episodic structure of discourse.

Questions:
- Does the accuracy of the cohesive ties produced in narratives by speakers with TBI (i.e., inter-sentential cohesion) predict the completeness of the story grammar for those narratives?
- Do frequent pauses and mazes produced in narratives by speakers with TBI (i.e., intra-sentential planning) predict the completeness of the story grammar for those narratives?

Hanna & Peach, 2018

Story Grammar – The supposed regularities in the internal structure of stories; measured by the number of complete episodes consisting of:
- An initiating event that prompts a character to act
- An attempt related to the initiating event
- A direct consequence of the attempt

Completeness – An inventory of key components (events and characters)
- Based on normative sampling, e.g., components named by 80% of a comparison group

Table 2. Descriptive statistics for group results on each study measure.

<table>
<thead>
<tr>
<th>Measures per Story</th>
<th>Complete Stories</th>
<th>Incomplete Stories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>F-Units</td>
<td>9.15</td>
<td>7.42</td>
</tr>
<tr>
<td>Corrected Ties</td>
<td>20.0</td>
<td>15.6</td>
</tr>
<tr>
<td>Errorless Ties</td>
<td>0.21</td>
<td>0.41</td>
</tr>
<tr>
<td>Pauses</td>
<td>3.88</td>
<td>4.70</td>
</tr>
<tr>
<td>Mazes</td>
<td>4.17</td>
<td>4.08</td>
</tr>
</tbody>
</table>

Table 5. Classification table for complete and incomplete stories using logistical regression.

<table>
<thead>
<tr>
<th>Observed Story</th>
<th>Predicted Complete</th>
<th>Percentage Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incomplete</td>
<td>22</td>
<td>91.7</td>
</tr>
<tr>
<td>Complete</td>
<td>25</td>
<td>95.8</td>
</tr>
<tr>
<td>Overall</td>
<td>47</td>
<td>93.8</td>
</tr>
</tbody>
</table>
Hanna & Peach, 2018

- Findings:
  - More complete episodes (or at least a number equal to the number of their incomplete episodes) associated with large numbers of pauses and impaired cohesion.
  - More incomplete than complete episodes also associated with greater numbers of pauses but relatively more preserved cohesion.
  - Findings support impaired control for attentional resources
    - When more resources are expended to generate complete narratives, fewer are allocated for producing correct cohesive ties and/or for sentence planning
  - Results in a variable pattern of co-occurring disturbances at two or more levels of discourse processing during narrative production.

**Assessment**

- Consider standardized testing “within broader framework” that considers...
  - Evaluation of the person’s pre-injury characteristics
  - Stage of development and recovery
  - Communication-related demands of personally meaningful everyday activities
  - Life and communication contexts
  - Core deficits inherent in executive functioning (e.g., establishing a functional framework to complete an operation, starting, stopping, tracking and switching) may be circumvented by the controlled nature of standardized assessment tasks
  - Include standardized and non-standardized assessments of executive functioning that are associated with communication skills in everyday contexts

**Functional Assessment of Verbal Reasoning and Executive Strategies (FAVRES)**

- Assesses executive functioning within everyday communication contexts
- Uses functional tasks to simulate real-life contexts

**Standardized Tests for Cognitive and Communication Disorders After TBI**

- DEX Questionnaire
  - Assesses executive functioning within everyday communication contexts
  - Uses functional tasks to simulate real-life contexts

**DEX Questionnaire**

<table>
<thead>
<tr>
<th>Item</th>
<th>Behavioral Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Has problems understanding what other people mean unless they keep things simple and straightforward</td>
<td>Abstract thinking problems</td>
</tr>
<tr>
<td>2. Acts without thinking, doing the first thing that comes to mind</td>
<td>Impulsivity</td>
</tr>
<tr>
<td>3. Sometimes talks about events or details that never actually happened, but the listener did happen</td>
<td>Confabulation</td>
</tr>
<tr>
<td>4. Has difficulty thinking ahead or planning for the future</td>
<td>Planning problems</td>
</tr>
<tr>
<td>5. Sometimes gets over-excited about things and can be a bit over the top at these times</td>
<td>Exhilaration</td>
</tr>
<tr>
<td>6. Gets事件 mixed up with each other, and gets confused about the correct order of events</td>
<td>Temporal sequencing deficits</td>
</tr>
<tr>
<td>7. Has difficulty realizing the extent of his/her problems and is unrealistic about the future</td>
<td>Lack of insight and social awareness</td>
</tr>
<tr>
<td>8. Seems lethargic or unenthusiastic about things</td>
<td>Alzheimers and lack of drive</td>
</tr>
<tr>
<td>9. Does or says embarrassing things when in the company of others</td>
<td>Disinhibition</td>
</tr>
<tr>
<td>10. Sometimes wants to do something one minute, but wouldn’t care less about it the next</td>
<td>Variable evaluation</td>
</tr>
</tbody>
</table>
DEX Questionnaire

<table>
<thead>
<tr>
<th>Item</th>
<th>Behavioral Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>Has difficulty choosing emotions</td>
</tr>
<tr>
<td>12.</td>
<td>Loses his/her temper at the slightest thing</td>
</tr>
<tr>
<td>13.</td>
<td>Seems uninterested in how s/he should behave in certain situations</td>
</tr>
<tr>
<td>14.</td>
<td>Has difficulty repeating things once started</td>
</tr>
<tr>
<td>15.</td>
<td>Tends to be very restless, and can't sit still for any length of time</td>
</tr>
<tr>
<td>16.</td>
<td>Has difficulty stopping something even if s/he knows it's not what s/he should do</td>
</tr>
<tr>
<td>17.</td>
<td>Will say one thing, but will do something different</td>
</tr>
<tr>
<td>18.</td>
<td>Has difficulty keeping his/her mind on something and is easily distracted</td>
</tr>
<tr>
<td>19.</td>
<td>Has difficulty making decisions, or deciding what s/he wants to do</td>
</tr>
<tr>
<td>20.</td>
<td>Is unaware of, or unconcerned about, how others feel about his/her behavior</td>
</tr>
</tbody>
</table>

Burgess et al., 1998

Discourse Genres

- Procedural (e.g., explaining how to make a sandwich)
- Descriptive (e.g., describing a memorable vacation)
- Story narratives
  - Generating an original story (e.g., picture description, picture sequences, story stems, wordless books, soundless film strips)
  - Retelling a previously presented story
- Conversation

Norman Rockwell Paintings
Implications for treatment

- Executive control training improves performance for trained tasks
- Extensive executive training with a complex task involving multiple control components has effects highly specific to the trained tasks
- Very limited, if any, transfer effects of broad interventions, e.g., ‘brain training’
- Questions the utility of such approaches to improve general cognition and daily functioning

Specificity of cognitive training

- Skill for coordinating multiple linguistic processes can be developed and modified; should be done within the language domain to the extent possible
- Discourse training offers opportunity to analyze speaker’s attentional abilities under conditions that capture everyday potential for distraction and demands for coordination of multiple resources
- To the extent automatic processes and skills for discourse are impaired, goal should be to re-establish automatically those processes
Metacognitive strategy instruction

- Training to solve problems, plan, or be better organized by teaching step-by-step procedures
- Direct instruction used to teach individuals to regulate their own behavior by breaking complex tasks into steps (e.g., story grammar episode components) while thinking strategically
- Requires ability to:
  - Identify appropriate goal and predict performance in advance of an activity
  - Identify possible solutions based on one’s general predictions
  - Self-monitor performance and change behavior if determined through self-assessment that the goal has not been met

Kennedy et al., 2008
Tate et al., 2014
Togher et al., 2014