CONTRIBUTIONS OF DECLARATIVE MEMORY TO ON-LINE REFERENCE RESOLUTION: FINDINGS FROM AMNESIA

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Memory and reference

Givenness hierarchy: Form of an NP signals different attentional/memorv statuses of referent

- personal pronouns— *it, he, she*—refer to items in the focus of attention
- indefinite reference— *an apple*—signals the addressee can identify the type of thing; more likely drawing on long-term/semantic knowledge

Gundel, Hedberg, & Zacharski (1993); Gundel (1998)
Memory systems and Language

- Lots of evidence for pre-frontal/ executive contributions to language: attention, working memory, executive control (Green et al., 1994; Gibson, 1998; Novick, Trueswell & Thompson-Schill, 2005; Walker, 1996; cf. MacDonald & Christiansen, 2002)

- Hippocampus/ declarative memory clearly relevant to acquisition of lexicon (Gabrieli, Cohen & Corkin, 1988; Ullman, 2004)
Hippocampal contributions online?

- fMRI evidence with healthy participants points to hippocampal involvement at even short time-lags
  - hippocampal activation during memory retrieval for all but the last item in a list (Oztekin, Davachi, & McElree, 2010; also Oztekin, Curtis, & McElree, 2008)
  - hippocampal activity during encoding and retrieval of object-location relations across short intervals (Hannula & Ranganath, 2008)
- Neuropsychological work shows deficits in behavioral performance with short delays in amnesia (Hannula et al., 2006; Warren et al., 2010)
Hippocampal contributions to language processing?

- Evidence from hippocampal amnesia points to hippocampal involvement in some aspects of language processing:
  - Disruption in production of reference (Kurczek & Duff, 2011; Duff, et al., 2011)
    - Fewer pronouns; inappropriate use of indefinites
    - More fixations to cohort-competitors
  - Failure to maintain discourse representation after delay (Rubin, Brown-Schmidt, Duff, Tranel, & Cohen, 2011)
    - 40s unrelated delay prevents interpretation of anaphoric noun
Present research

- Examine the reach of the hippocampal-declarative memory system in on-line language processing.
- Does the hippocampal system extend to brief discourses and items in discourse focus?
Amnesic patients experience difficulty with discourse interruptions...

patients mostly successful with short discourses:
- *What’s in the bottom left? [an elephant], look at the cross, look at the elephant.*
- Patients with amnesia not statistically different
Present Experiment

- Design similar to Arnold, Eisenband, Brown-Schmidt & Trueswell (2000)
- Two-sentence story introduces two characters; refers to one using a pronoun
- Measure gaze at characters during pronoun
- Task is to say whether story matches picture
  - target trials always match
Minnie is playing the violin for Daisy as the sun is shining overhead. She is wearing a yellow (green) bracelet and it looks like the song is being played well.
Example Story – Different Gender

- Minnie is playing the violin for Mickey as the sun is shining overhead. \textit{She/he} is wearing a yellow (green) bracelet and it looks like the song is being played well.

\textbf{Different-Gender:} Identifying referent (only) requires integrating pronoun & character gender
Predictions

- If maintaining representation of discourse referents independent of hippocampal-dependent declarative memory...

- In same-gender condition, patients should preferentially fixate the 1st mentioned character.

- In different-gender condition, patients should show strong preference for gender-consistent character.
Predictions

- If maintaining representation of discourse referents depends on hippocampal-dependent declarative memory...

- In same-gender condition, patients should
  - fixate both characters equally

- In different-gender condition, patients may
  - show weaker preference for gender-consistent character if integrating gender information depends on declarative memory system
Participants

- Healthy undergraduate controls (n=12)
- Amnesic patients (n=4), with MTL damage
- Healthy comparisons (n=8), matched to patients on sex, age, education

<table>
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<th>Patient</th>
<th>Sex</th>
<th>Age at testing</th>
<th>Education</th>
<th>Etiology</th>
<th>WAIS-III FSIQ</th>
<th>WMS-III GMI</th>
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<td>52</td>
<td>18</td>
<td>Anoxia</td>
<td>98</td>
<td>73</td>
</tr>
</tbody>
</table>
Two types of amnesic patients

Anoxic amnesic

Hippocampus

HSE amnesic
Design

- 2 x 2 within subject, within item
  - characters of same vs. different gender
  - pronoun refers to 1\textsuperscript{st} vs. 2\textsuperscript{nd} mentioned referent

- 32 targets + 32 fillers
  - targets rotated across 4 conditions
  - each participant completes 163 trials
    - 3 practice
    - 128 critical
    - 32 filler
Results: Undergraduates

- Different-gender/ 1\textsuperscript{st} mentioned: Minnie... Donald... \textit{She}... yellow bracelet
- Different-gender/ 2\textsuperscript{nd} mentioned: Minnie... Donald... \textit{He}... green bracelet
- Same-gender/ 1\textsuperscript{st} mentioned: Minnie... Daisy... \textit{She}... yellow bracelet
- Same-gender/ 2\textsuperscript{nd} mentioned: Minnie... Daisy... \textit{She}... green bracelet
Results: Undergraduates

ANALYSIS
- mixed models
- maximal ran effects
- 3 time regions
- DV: empirical logit of T/C fixations; calc. trial-by-trial basis

RESULTS: PRONOUN & LATE REGIONS
- Same-gender: 1st-mention preference
- Diff-gender: Mention is ns.
Preliminaries: Patients vs. Comparisons

- **Knowledge of Disney characters**
  - queried before experiment and during practice
  - accurate for both groups

- **Accuracy in identifying story-picture mismatches**
  - high for both groups
Results: Patients vs. Comparisons

- **Patients**
- **Comparisons**

![Graphs showing target advantage over time for patients and comparisons.](image-url)
By-region results: Comparisons

RESULTS: PRONOUN & LATE REGIONS

• pro: Gender*Mention ($t = -4.94$)
• Same-gender: 1\textsuperscript{st}-mention preference ($t = -4.77$)
• Diff-gender: Mention is ns ($t = .08$)

• late: Gender*Mention ($t = -4.82$)
• Same-gender: 1\textsuperscript{st}-mention preference ($t = -3.93$)
• Diff-gender: Mention is ns ($t = .29$)
By-region results: Patients

RESULTS: PRONOUN & LATE REGIONS

• **pronoun**: Gender ($t=-5.63$)
  • target preference larger when gender disambiguated the pronoun
  • no interaction with mention ($t=-.88$)

• **late**: Gender ($t=-6.17$)
  • target preference larger when gender disambiguated the pronoun
  • no interaction with mention ($t=-1.60$)
Summary

- Healthy comparison participants and undergraduates used both gender and order-of-mention information to interpret pronoun.
- Amnesic patients less successful.
  - Patients show gender effect following pronoun.
    - Demonstrates ability to link language with scene (along with Rubin, et al., 2011; Trude, et al., 2011).
  - Patients do not show gender * mention interaction.
What is the locus of patients’ deficit?

- Initial encoding of the discourse likely impaired
  - analysis of first part of story shows that patients impaired at tracking characters when named
- During integration/ retrieval of the discourse structure at pronoun interpretation?
  - providing more time to interpret the pronoun may help
  - c.f. Song & Fisher (2005) show success with mention information in 3-year-olds with extra time
Findings consistent with unitary views of working & long-term memory in which access to all but the single item in the focus of attention depends on hippocampal-mediated memory systems (Oztekin, Davachi, & McElree, 2010; also McElree, 2006; Lewis & Vasishth, 2005).

Minnie is playing the violin for Daisy as the sun is shining overhead. **She**
Findings consistent with direct-access views of referential processing (Foraker & McElree, 2007; also Foraker & Wight, today)

- 1st-mentioned character more distinct (available) in hippocampal-mediated memory
- “She” co-refers with [Minnie] because we can look up the relevant information in memory, not because she’s in the focus of attention.
These and other results (Rubin, et al., 2011; Trude, et al., 2011; Kurczek & Duff, 2011) point to the hippocampal-dependent declarative memory system as contributing to language processing.

Relevant functions may include:
- use of all but the most recent discourse information
- integrating information across discourse

Deficits in amnesia apparent when:
- integration across discourse segments necessary
- temporal order is involved
- competition between activated candidates
General Discussion

- Consistent with growing body of work pointing to hippocampal involvement on short time-scales (Oztekin, et al., 2010; Hannula & Ranganath, 2008; Ranganath & Mark D’Esposito, 2001; Olson et al., 2006; Shrager et al., 2008)

- and in language use in general (Duff & Brown-Schmidt, 2012; MacKay, Stewart, & Burke, 1998; Park et al., 2011).
Thank you!

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- Questions?
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Specificity: Frontal patients (BDCs)

- Patients with ventromedial PFC damage (n=4) and paired healthy comparisons (n=6)
Fixations during Character names

Character 1 fixations following “Minnie…”

Character 2 fixations following “…Daisy”
Distracter and Other fixations

- Patients looked slightly at non-character regions
Results split by patient

e.Logit TC ratio in Pronoun region; 4 patients
Results split by comparison participant

**elogit TC ratio in Pronoun region; 8 comparisons**
Conclusions

Why were patients successful in Rubin, et al (2011)?

“Elephant….. the elephant”

Same-Gender condition: FAIL
“Minnie… Daisy… sun she”
Conclusions

- Why were patients successful in Rubin, et al (2011), but not here?

- Competition between mentioned items may be key
  - temporal order must be computed
  - target item may still have been in focus of attention in Rubin, et al. (even though it wasn’t being fixated)