Processing Head-Final Relative Clauses without Garden Paths

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Head-final RCs

- Mandarin Chinese:
  
  抓到 強盜 的 那位 警長
  `catch robber Rel that sheriff`
  ‘the sheriff who caught the robber’
Head-final RCs

- Japanese:

\[
[\_i \text{新任の} \quad \text{議員を} \quad \text{非難した}] \quad \text{記者が} \quad \text{過ちを} \quad \text{認めた。}
\]

‘The reporter [who ___ attacked the new senator] admitted the error.’

Ueno & Garnsey (2007)
Head-final RCs

• Korean:

\[
\text{[RC – naitun pwuin-ui bes cenkecang-kkaci tonghayngha]-n sonye}
\]

\[
\begin{array}{c}
\text{elderly lady-acc bus stop-to} \\
\text{accompany-rel} \\
\text{girl}
\end{array}
\]

‘the girl that accompanied the elderly woman to the bus stop’

Kwon (p.c.)
Properties of head-final RCs

- Mandarin Chinese:

  [ S-GAP ]rc S-GAP catch robber of the sheriff

  ‘the sheriff who caught the robber’

  The RC precedes the head.

  - The gap precedes the filler.
  - The relativizer/head appears late, so garden paths (i.e. main-clause misanalyses) may occur.
  - They demonstrate a reverse pattern of filler-gap distances in subject versus object RCs than head-initial RCs.
Filler-gap **distances** of subject and object RCs in head-initial and head-final languages (with SVO or SOV as the basic word orders):

- **head-initial RC:**
  - src:
    - the sheriff that S-GAP caught the robber
  - orc:
    - the sheriff that the robber shot O-GAP

- **head-final RC:**
  - src:
    - S-GAP caught the robber REL the sheriff
  - orc:
    - the robber shot O-GAP REL the sheriff
Issues in processing head-final RCs

• The gap precedes the filler; do filler-gap and gap-filler relations involve the same processes? (Aoshima, Phillips, & Weinberg, 2004; Lin, Fong, & Bever, 2005)

• The RC precedes the head. Is there a main-clause garden path? How do we avoid such garden path in experimentation?

• Can we find the same extraction effects as head-initial relative clauses? (Hsiao & Gibson, 2003; Lin & Bever, 2006)
Main issues in this talk

• The gap precedes the filler; do filler-gap and gap-filler relations involve the same processes? (Aoshima, Phillips, & Weinberg, 2004; Lin, Fong, & Bever, 2005)

• The RC precedes the head. Is there a main-clause garden path? How do we avoid such garden path in experimentation?

• Can we find the same extraction effects as head-initial relative clauses? (Mandarin: Hsiao & Gibson, 2003; Lin & Bever, 2006; among others)
Garden path effects in head-final RCs (Mandarin)

- Garden path seems to exist; at least, it helps identify ORCs in Mandarin. (Hsu et al., in preparation)

Mandarin ORCs with and without SUO

sheriff caught O-GAP REL thief

sheriff SUO caught O-GAP REL thief
Garden path effects in head-final RCs (Korean)

- Garden path seems to exist (Kwon et al., 2006):

  pro vs. trace in Korean

  trace Tom-acc met REL teacher-nom

  pro Tom-acc met REL fact-nom

  Difficulty appeared earlier (right on the relativizer).
Does this potential garden-path matter?

• Maybe. (However, SRCs and ORCs can both be misread.)

**src:**

S-GAP pro / trace

caught the robber

V N

infrequent

RC analysis

**orc:**

the robber shot

O-GAP

REL the sheriff

N V

main clause?

may be harder due to reanalysis
Does this potential garden-path matter?

- This makes ORCs in Mandarin potentially more likely to be mis-read as main clauses than SRCs. Thus, ORCs can be harder in comprehension because reanalysis needs to take place.

N.B. With SRCs, readers also face the difficulty of dealing with unusual VN structures with the subject pro missing.
A quick survey of how the garden path in ORCs was treated previously

<table>
<thead>
<tr>
<th>Language</th>
<th>Study</th>
<th>Preference</th>
<th>GP?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japanese</td>
<td>Ishizuka &amp; Gibson (2006)</td>
<td>ORC</td>
<td>context</td>
</tr>
<tr>
<td>Korean</td>
<td>Kwon, Polinsky, &amp; Kluender (2005)</td>
<td>SRC</td>
<td>pro vs. trace</td>
</tr>
<tr>
<td>Mandarin</td>
<td>Hsiao &amp; Gibson (2003)</td>
<td>ORC</td>
<td>--</td>
</tr>
<tr>
<td>Mandarin</td>
<td>Lin &amp; Bever (2006)</td>
<td>SRC</td>
<td>--</td>
</tr>
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</table>
How to avoid the garden path?

- SUO in Mandarin ORCs (Hsu et al., ms)
- classifier-mismatch (Hsu et al., ms; Yoshida et al., 2004)
- RC-inducing contexts (Ishizuka et al., 2006; Hsu & Chen, 2007)
- Comparison b/w traces and pro (Kwon et al., 2006)
How to solve the garden-path problem?

- The participants need to know as early as possible that what they are reading are RCs, not main clauses.
The rationale

• We decreased the possibility of garden paths in two enhanced experiments of self-paced reading.

• Self-paced reading tasks induced garden path more easily because it encourages incremental parsing at each window frame.
To solve the garden-path problem, 2 experiments will be reported.

- Self-paced reading: RC regions presented at once
- Self-paced reading (with instructions on the existence and location of the RCs)

• We asked the same question:

IS SUBJECT OR OBJECT RELATIVE CLAUSE EASIER TO PROCESS?
(processing-resource vs. structural accounts, etc.)

• We gave different answers:

H&G: ORCs (for linear-distance, WM accounts)
L&B: SRCs (for structural parsing accounts)
Evidence on each side (focus on the relativizer and head nouns):

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Single RCs:</strong></td>
<td><strong>Single RCs</strong></td>
</tr>
<tr>
<td>n.s.</td>
<td>SRCs &lt; ORCs</td>
</tr>
<tr>
<td><strong>Double RCs</strong></td>
<td></td>
</tr>
<tr>
<td>doubled SRCs &gt; doubled ORCs</td>
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</tbody>
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src: S-GAP caught the robber

orc: the robber shot O-GAP

REL the sheriff

REL the sheriff
Problems on each side:

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<td><strong>Single RCs:</strong></td>
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<tr>
<td>potential garden-path</td>
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</tr>
<tr>
<td><strong>Double RCs</strong></td>
<td></td>
</tr>
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<td>potential garden-path &amp;</td>
<td></td>
</tr>
<tr>
<td>confounded by dependency types (nested vs. serial)</td>
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Hsiao & Gibson’s (2003) double RCs

Subject RC embedded in Subject RC (Nested-SRC)

- GAP1 v1: zhuisui follow
- GAP2 v2: xiahuai liumang scare rascal
- DE2 rel: qiangfei robber
- Head_Noun2 de yaofan criminal

‘the criminal that followed the robber that scared the rascals’

Object RC embedded in Object RC (Serial-ORC)

- N2 v2: liumang xiahuai de rascal scare rel
- GAP2 de qiangfei robber
- Head_Noun2 de yaofan criminal
- V1 gap1 de zhuisui follow rel

‘the criminal that the robber that the rascals scared followed’

easier =>

dependency?

easier =>

extraction?
Problems on each side:

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GP confound
The studies reported today

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<th>Dependency type (serial vs. nested dep)</th>
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<td>GAP1 V1 zhuisui follow</td>
<td>GAP2 V2 N2 DE2 Head_Noun2 de qiangfei scare rascal Rel robber DE1 Head_Noun1 de yaofan Rel criminal</td>
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<td>'the criminal that followed the robber that scared the rascals'</td>
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<td><strong>(b) Object RC embedded in Subject RC (Nested-ORC)</strong></td>
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<td><strong>(c) Subject RC embedded in Object RC (Serial-SRC)</strong></td>
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<tr>
<td>GAP2 V2 N2 DE2 Head_Noun2 de qiangfei scare rascal Rel</td>
<td>V1 GAP1 DE1 Head_Noun1 zhuisui de yaofan follow Rel criminal</td>
</tr>
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<td><strong>Object RC embedded in Object RC (Serial-ORC)</strong></td>
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### terminology

#### lower RCs vs. higher RCs

(a) **Subject RC embedded in Subject RC (Nested-SRC)**

<table>
<thead>
<tr>
<th>GAP1</th>
<th>V1</th>
<th>zhuisui</th>
<th>follow</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAP2</td>
<td>V2</td>
<td>xiahui</td>
<td>liumang</td>
</tr>
</tbody>
</table>

'**the criminal that followed the robber that scared the rascals**'

(b) **Object RC embedded in Subject RC (Nested-ORC)**

<table>
<thead>
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<th>V1</th>
<th>zhuisui</th>
<th>follow</th>
</tr>
</thead>
<tbody>
<tr>
<td>N2</td>
<td>V2</td>
<td>liumang</td>
<td>xiahui</td>
</tr>
<tr>
<td>GAP2</td>
<td>DE2</td>
<td>rascal</td>
<td>scare</td>
</tr>
</tbody>
</table>

'**the criminal that followed the robber that the rascals scared**'

(c) **Subject RC embedded in Object RC (Serial-SRC)**

<table>
<thead>
<tr>
<th>GAP2</th>
<th>V2</th>
<th>xiahui</th>
<th>liumang</th>
<th>de</th>
<th>qiangfei</th>
<th>robber</th>
</tr>
</thead>
<tbody>
<tr>
<td>N2</td>
<td>DE2</td>
<td>rascal</td>
<td>scare</td>
<td>Rel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head_Noun2</td>
<td>V1</td>
<td>zhuisui</td>
<td>de</td>
<td>yaofan</td>
<td>follow</td>
<td>Rel</td>
</tr>
</tbody>
</table>

'**the criminal that the robber that scared the rascals followed**'

(d) **Object RC embedded in Object RC (Serial-ORC)**

<table>
<thead>
<tr>
<th>N2</th>
<th>V2</th>
<th>liumang</th>
<th>xiahui</th>
<th>de</th>
<th>qiangfei</th>
<th>robber</th>
</tr>
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<tbody>
<tr>
<td>GAP2</td>
<td>DE2</td>
<td>rascal</td>
<td>scare</td>
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<td></td>
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</tr>
<tr>
<td>Head_Noun2</td>
<td>V1</td>
<td>zhuisui</td>
<td>de</td>
<td>yaofan</td>
<td>follow</td>
<td>Rel</td>
</tr>
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</table>
In the studies reported today

- We will show that Hsiao & Gibson’s (2003) effect was an effect of dependency type. It had nothing to do with subject versus object extractions per se.

- We will also show that the extraction effect in Mandarin favors subject-extracted RCs even with the garden-path confound removed.
Experiment 1: Self-paced readings with RC as one region

- 48 Ss
- Self-paced reading tasks
- Materials:
  - The same as those in Lin & Bever (2006) plus doubly-embedded RCs, with 24 sentences across conditions, and filler sentences.
Experiment 1: Self-paced readings with RC as one region

• Participants read RC-REL-Head_Noun as one region.
Experiment 1: Self-paced readings with RC as one region

• Participants read RC-REL-Head_Noun as one region.

責怪縣長的居民－－－－－－

blame mayor REL resident
Experiment 1: Self-paced readings with RC as one region

- Participants read RC-REL-Head_Noun as one region.

问问著——
greeted
Experiment 1: Self-paced readings with RC as one region

- Participants read RC-REL-Head_Noun as one region.

立委

legislator
Experiment 1: Self-paced readings with RC as one region

- Participants read RC-REL-Head_Noun as one region.
Experiment 1: Self-paced readings with RC as one region

- Results--Single-level RCs

Comprehension accuracy

n.s. though numerically SRCs > ORCs
Experiment 1: Self-paced readings with RC as one region

- Results--Single-level RCs

RTs of the RC-Rel-Head_noun region

\[ *\text{mod: } F(1, 47) = 61.45, p < 0.001; F(1, 23) = 56.88, p < 0.001 \]

n.s. for RC extraction

- SRC
- ORC
Experiment 1: Self-paced readings with RC as one region

• Results--Double-level RCs

Comprehension accuracy

*SRC-high < ORC-high: F1(1, 47)=42.46, p < 0.001; F2(1,23)=16.25, p < 0.01
(also found in the RTs answering comprehension questions)
Experiment 1: Self-paced readings with RC as one region

• Results--Double-level RCs

RTs of the RC-Rel-Head_noun region

*SRC-high > ORC-high: F1(1, 47)=18.70, p < 0.001; F2 (1,23)=13.58, p < 0.01
SRC-low < ORC-low: F1(1, 47)=1.92, p = 0.172; F2 (1,23)=1.23, p = 0.280
Experiment 1: Self-paced readings with RC as one region

Discussion

• Within single RCs, RCs that modified subjects had shorter RTs than those that modified objects.

• Numerically, SRCs had shorter RTs and were comprehended better than ORCs.
Experiment 1: Self-paced readings with RC as one region

Discussion

• Within double RCs, serial RCs (i.e. ORCs at the higher level) had shorter RTs and better comprehension than nested RCs (i.e. SRCs at the higher level).

• This shows that the ORC advantage in Hsiao & Gibson (2003) was not an effect of extraction but an effect of dependency types.
Hsiao & Gibson (2003)

(a) Subject RC embedded in Subject RC (Nested-SRC)

- GAP1: zhuisui (follow)
- GAP2: xiahuai liumang de scare rascal Rel
- DE2: qiangfei robber
- Head_Noun1: de yaofan criminal

"the criminal that followed the robber that scared the rascals"

(b) Object RC embedded in Subject RC (Nested-ORC)

- GAP1: zhuisui follow
- N2: liumang xiahuai de scare rascal Rel
- GAP2: qiangfei robber
- DE1: Head_Noun1: de yaofan criminal

"the criminal that followed the robber that the rascals scared"

(c) Subject RC embedded in Object RC (Serial-SRC)

- GAP2: xiahuai liumang de scare rascal Rel
- DE2: qiangfei robber
- V1: zhuisui follow
- GAP1: Head_Noun1: de yaofan criminal

"the criminal that the robber that scared the rascals followed"

(d) Object RC embedded in Object RC (Serial-ORC)

- N2: liumang xiahuai de rascal scare Rel
- GAP2: qiangfei robber
- DE1: V1: zhuisui follow
- DE1: Head_Noun1: de yaofan criminal

"the criminal that the robber that the rascals scared followed"
The studies reported today

(a) Subject RC embedded in Subject RC (Nested-SRC)

(b) Object RC embedded in Subject RC (Nested-ORC)

(c) Subject RC embedded in Object RC (Serial-SRC)

(d) Object RC embedded in Object RC (Serial-ORC)
Experiment 1: Self-paced readings with RC as one region

Discussion

• Within *double RCs*, SRCs at the lower level had shorter RTs than ORCs numerically.
Experiment 2: Self-paced readings with specific instructions about the RCs

- 48 Ss
- Self-paced reading tasks
- Materials:
  - The same as those in Lin & Bever (2006), with 24 sentences across conditions, and filler sentences.
Experiment 2: Self-paced readings with specific instructions about the RCs

Procedure

• Participants were instructed about what RCs look like, where they will see the RCs (sentence-initial or close the end of the sentences) and whether the RCs will be of single or double levels. (Each condition was read separately as a block.)

• All sentences contained RCs.
Experiment 2: Self-paced readings with specific instructions about the RCs

- Results--Single-level RCs

Comprehension accuracy

![Bar chart showing comprehension accuracy for S-mod and O-mod with specific results indicated by FIs < 2.59]
Experiment 2: Self-paced readings with specific instructions about the RCs

- **RT Results--Single-level RCs**

  RTs of DE (the relativizer)

<table>
<thead>
<tr>
<th>src: S-GAP caught the robber REL the sheriff</th>
</tr>
</thead>
<tbody>
<tr>
<td>orc: the robber shot O-GAP REL the sheriff</td>
</tr>
</tbody>
</table>
Experiment 2: Self-paced readings with specific instructions about the RCs

• RT Results--Single-level RCs

RTs of the head noun

msec

| src: S-GAP caught the robber REL the sheriff |
| orc: the robber shot O-GAP REL the sheriff |

*S-mod: p < 0.001
Experiment 2: Self-paced readings with specific instructions about the RCs

- Results--Double-level RCs

Comprehension accuracy

*SRC-high > ORC-high: F1(1, 47)=25.81, p < 0.001; F2 (1,23)=13.58, p < 0.01
Experiment 2: Self-paced readings with specific instructions about the RCs

Dependency type (serial vs. nested dep) × Extraction type (subject vs. object RC in the lower RC)

(a) Subject RC embedded in Subject RC (Nested-SRC)
(b) Object RC embedded in Subject RC (Nested-ORC)
(c) Subject RC embedded in Object RC (Serial-SRC)
(d) Object RC embedded in Object RC (Serial-ORC)

The criminal that followed the robber that scared the rascals followed

The criminal that followed the robber that scared the rascals followed

The criminal that followed the robber that scared the rascals followed

The criminal that followed the robber that scared the rascals followed
Experiment 2: Self-paced readings with specific instructions about the RCs

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<td></td>
<td>GAP1 V1 zhuisui follow</td>
</tr>
<tr>
<td></td>
<td>GAP2 V2 N2 xiahuai liumang scare rascal</td>
</tr>
<tr>
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<td>DE2 Head_Noun2 de qiangfei Rel robber</td>
</tr>
<tr>
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<td>DE1 Head_Noun1 de yaofan Rel criminal</td>
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</tr>
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</tr>
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<td>V1 GAP1 DE1 Head_Noun1</td>
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RTs of the lower RC regions (the shaded regions)

- Nested-SRC
- Nested-ORC
- Serial-SRC
- Serial-ORC
Experiment 2: Self-paced readings with specific instructions about the RCs

Dependency type (serial vs. nested dep) × Extraction type (subject vs. object RC in the lower RC)

(a) Subject RC embedded in Subject RC (Nested-SRC)
- GAP1: zhuisui
- V1: follow
- GAP2: xiahuai liuman
- N2: scare
- DE2: rascal
- Head_Noun2: giangfei
- DE1: yaofan
- Head_Noun1: robber

‘the criminal that followed the robber that scared the rascals’

(b) Object RC embedded in Subject RC (Nested-ORC)
- GAP1: zhuisui
- V1: follow
- GAP2: liuman xiahuai
- N2: scare
- DE2: rascal
- Head_Noun2: giangfei
- DE1: yaofan
- Head_Noun1: robber

‘the criminal that followed the robber that the rascals scared’

(c) Subject RC embedded in Object RC (Serial-SRC)
- GAP2: xiahuai liuman
- V2: scare
- N2: rascal
- DE2: giangfei
- Head_Noun2: yaofan
- V1: zhuisui
- GAP1: follow
- DE1: yaofan
- Head_Noun1: criminal

‘the criminal that the robber that scared the rascals followed’

(d) Object RC embedded in Object RC (Serial-ORC)
- N2: liuman xiahuai
- V2: scare
- GAP: rascal
- DE2: giangfei
- Head_Noun2: yaofan
- V1: zhuisui
- GAP1: follow
- DE1: yaofan
- Head_Noun1: criminal

‘the criminal that the robber that the rascals scared followed’
Experiment 2: Self-paced readings with specific instructions about the RCs

• RT Results--Double-level RCs

RTs of lower Rel

\* SRC-low > ORC-low \( (p < 0.01, F1 (1, 47) = 11.92; p < 0.01, F2 (1, 23) = 9.25) \)

\* SRC-High > ORC-High \( (p < 0.01, F1 (1, 47) = 11.92; p < 0.01, F2 (1, 23) = 9.25) \)
Experiment 2: Self-paced readings with specific instructions about the RCs

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<tr>
<th>Dependency type (serial vs. nested dep)</th>
<th>Extraction type (subject vs. object RC in the lower RC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td></td>
</tr>
<tr>
<td>(a) Subject RC embedded in Subject RC (Nested-SRC)</td>
<td></td>
</tr>
<tr>
<td>GAP1 V1 zhu suǐ follow</td>
<td>GAP2 V2 xiao huái liú man scare rascal</td>
</tr>
<tr>
<td></td>
<td>DE2 Head_Noun2 de qiăng fēi robber</td>
</tr>
<tr>
<td></td>
<td>DE1 Head_Noun1 de ya ō fān Rel criminal</td>
</tr>
<tr>
<td>‘the criminal that followed the robber’</td>
<td>that scared the rascals</td>
</tr>
<tr>
<td>(b) Object RC embedded in Subject RC (Nested-ORC)</td>
<td></td>
</tr>
<tr>
<td>GAP1 V1 zhu suǐ follow</td>
<td>N2 V2 liú man xiao huái scare rascal</td>
</tr>
<tr>
<td></td>
<td>DE2 Head_Noun2 de qiăng fēi robber</td>
</tr>
<tr>
<td></td>
<td>DE1 Head_Noun1 de ya ō fān Rel criminal</td>
</tr>
<tr>
<td>‘the criminal that followed the robber’</td>
<td>that the rascals scared</td>
</tr>
<tr>
<td>(c) Subject RC embedded in Object RC (Serial-SRC)</td>
<td></td>
</tr>
<tr>
<td>GAP2 V2 xiao huái liú man scare rascal</td>
<td>DE2 Head_Noun2 de qiăng fēi robber</td>
</tr>
<tr>
<td></td>
<td>V1 GAP1 DE1 Head_Noun1 de ya ō fān follow</td>
</tr>
<tr>
<td></td>
<td>Rel criminal</td>
</tr>
<tr>
<td>‘the criminal that the robber that scared the rascals followed’</td>
<td></td>
</tr>
<tr>
<td>(d) Object RC embedded in Object RC (Serial-ORC)</td>
<td></td>
</tr>
<tr>
<td>N2 V2 liú man xiao huái scare rascal</td>
<td>DE2 Head_Noun2 de qiăng fēi robber</td>
</tr>
<tr>
<td></td>
<td>V1 GAP1 DE1 Head_Noun1 de ya ō fān follow</td>
</tr>
<tr>
<td></td>
<td>Rel criminal</td>
</tr>
<tr>
<td>‘the criminal that the robber that the rascals scared followed’</td>
<td></td>
</tr>
</tbody>
</table>
Experiment 2: Self-paced readings with specific instructions about the RCs

- RT Results--Double-level RCs

RTs of the doubly embedded Relativizer plus Head Noun (DE2 + HN2)

* SRC-High > ORC-High (p < 0.001, F1 (1, 47) = 27.58; p < 0.001, F2 (1, 23) = 22.94)

* Extraction X Dependency (p < 0.05, F1 (1, 47) = 6.19; p < 0.05, F2 (1, 23) = 4.56)
Experiment 2: Self-paced readings with specific instructions about the RCs

Discussion

• The effect of extraction type was not obvious in single RCs. It is best observed where processing is more difficult (e.g. object-modifying RCs and nested RCs).
Experiment 2: Self-paced readings with specific instructions about the RCs

Discussion

• Nested dependencies were consistently harder than serial dependencies. This was found with SRCs at the higher level taking longer to process than ORCs at the higher level. This underlay the effect the ORC advantage that Hsiao & Gibson (2003) found, though they thought it was an extraction effect.
Experiment 2: Self-paced readings with specific instructions about the RCs

Discussion

- Extraction effect does exist. Subject extractions were easier than object extractions. This was found on the relativizer and the head noun of the nested RCs, where processing was burdened.
General discussion

- The RC precedes the head. Is there a main-clause garden path? How do we avoid such garden path in experimentation?

- Can we find the same extraction effects as head-initial relative clauses? (Hsiao & Gibson, 2003; Lin & Bever, 2006)
General discussion

• Without the new manipulations, RT patterns for single RCs were like this in Lin & Bever (2006):
General discussion

- With the new manipulations, RT patterns for single RCs are:
General discussion

- Garden path may have existed since the RT differences are now reduced.
General discussion

• The RC precedes the head. Is there a main-clause garden path? How do we avoid such garden path in experimentation?

• Can we find the same extraction effects as head-initial relative clauses? (Hsiao & Gibson, 2003; Lin & Bever, 2006) Yes

dependency: nested > serial

extraction: SRCs < ORCs
methodological implications

• The garden-path effect has to be considered in studying the processing of head-final RCs.

• Extraction effects regarding SRCs versus ORCs are most likely to be found when the processor is burdened (e.g. in the nested filler-gap conditions, not in the single level conditions).
Acknowledgments

• Funding from the National Science Council of Taiwan (NSC 95-2411-H-003-056), National Taiwan Normal University 2006 research grant

• RAs who helped collecting data: Li-Hsin Ning, Larry Li

• Inputs from Natalie Hsu