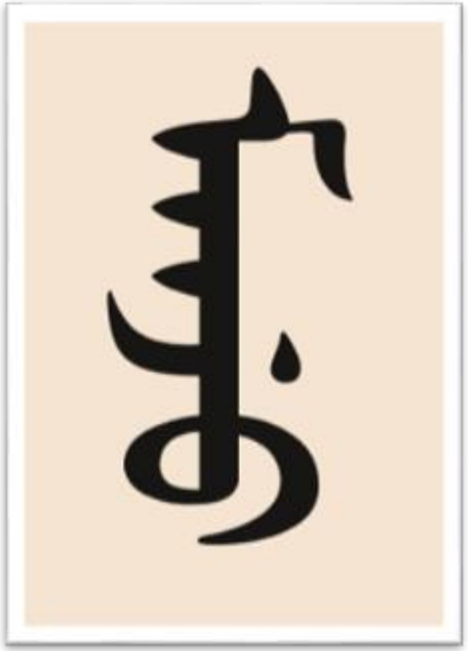
Addressing Complexity in Learning to Read the Manchu Writing System



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Outline

1. Basics of the Manchu language
2. Symbol visual complexity (Expt. 1)
3. Symbol–sound mapping complexity (Expt. 2)
4. Intra-symbol processing in reading
5. Q&A

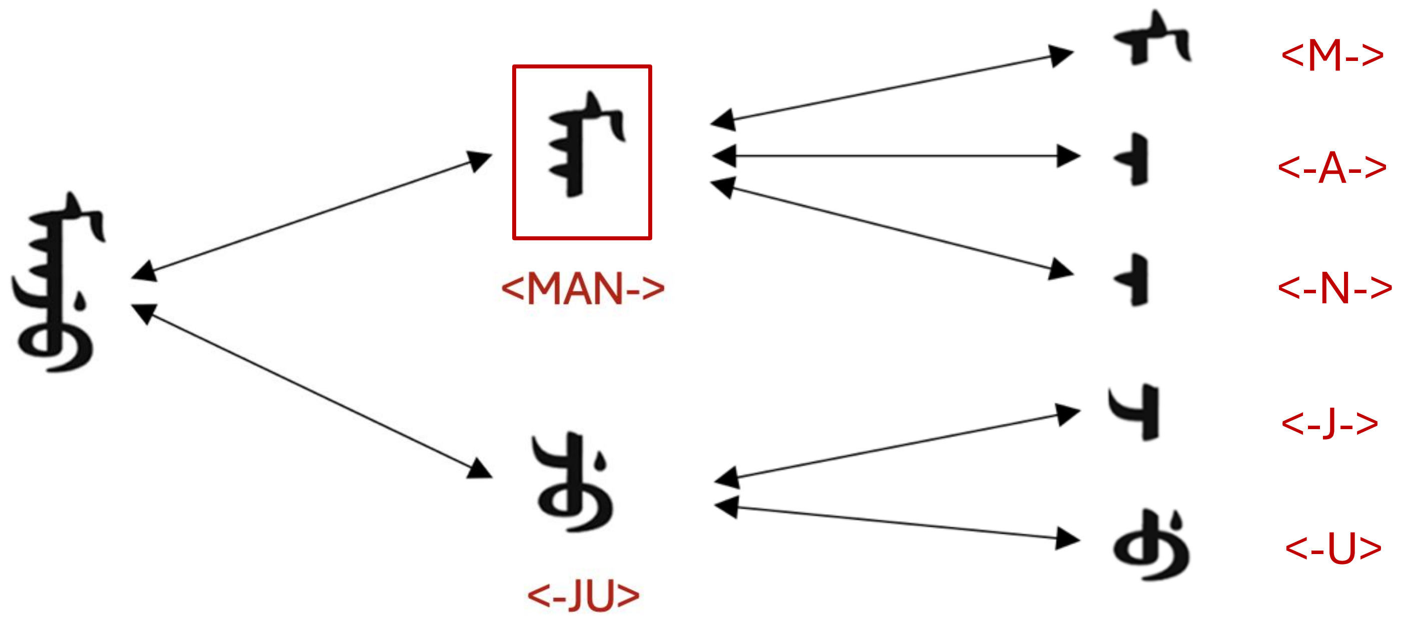
1
Basics of the Manchu language

1.1 The Manchu language

- Belongs to the Tungusic family
- Historically used by the Manchu people in northeast China
- The "national language" during the Qing China (1644–1911)
- Currently "critically endangered" with around **100** native speakers (UNESCO, 2025)

1.2 Basic symbols

- **Uju hergen:** symbol blocks for V, VV, VC, CV, CVV, and CVC
- **Manchu phomeme markers:** sub-syllabic symbols (Li & Nag, in press)



1.3 Symbol–sound mapping

Uju hergen

n = 1,400 (5,600)

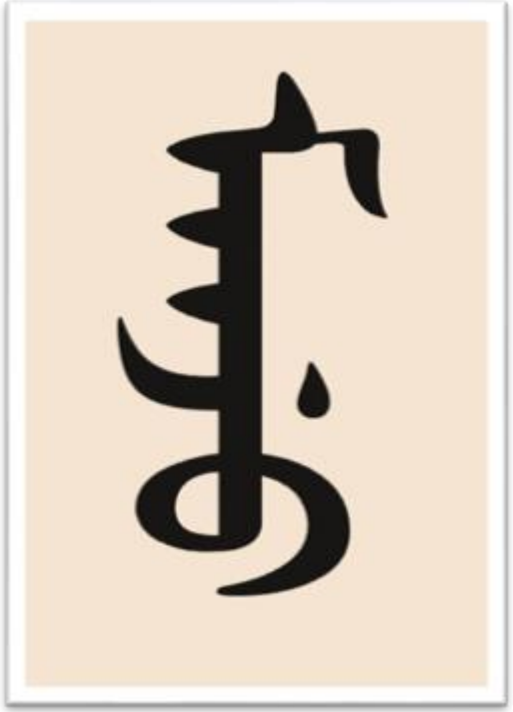
4-to-1

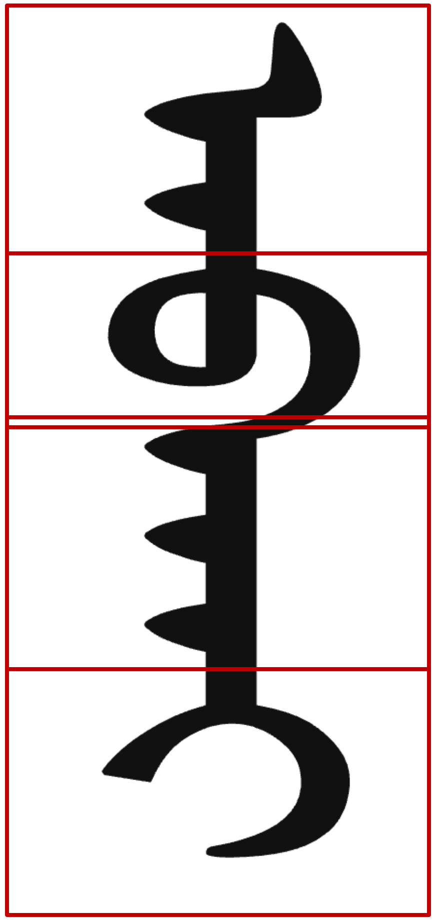
phoneme markers

n = 83

1-to-1 (75)
1-to-2 (6)
1-to-3 (2)

Symbol visual complexity





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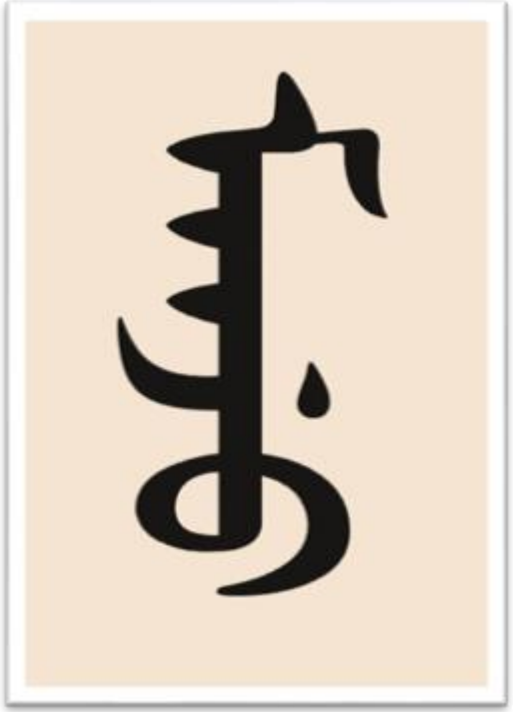
Symbol visual complexity



Symbol–sound mapping complexity

2

Symbol visual complexity

(Expt. 1)

2.1 Visual complexity and reading

- Visual complexity is an important factor influencing reading accuracy and speed among beginning and skilled readers (Arabic vs. Hebrew, Abdelhadi et al., 2011; Kannada, Nag et al., 2014; Simplified Chinese, Yu et al., 2018).
- However, studies have only been conducted on (a) a limited number of orthographies (b) which are laid out on a horizontal rather than vertical axis.

2.2 Dimensions of visual complexity

Five dimensions measuring visual complexity (Chang et al., 2018; Nag et al., 2014).

Pixel count **(PX)**	Perimetric complexity **(PC)**	Simple features **(SF)**	Connected points **(CP)**	Disconnected components **(DC)**

2.2 Dimensions of visual complexity

Five dimensions measuring visual complexity (Chang et al., 2018; Nag et al., 2014).

Pixel count (PX)	Perimetric complexity (PC)	Simple features (SF)	Connected points (CP)	Disconnected components (DC)
9933	**8.69**	**6**	**4**	**1**

2.3 RQs on visual complexity

RQ1a: What is the association between the visual complexity of uju hergen and recognition errors among novice Manchu learners?

RQ1b: What are the dimensions of visual complexity of uju hergen that predict recognition errors among novice learners?

2.4 Experiment 1

Participants

- 196 Mandarin-speaking university students (89.8% female, M_{age} = 18.79)
- They completed 10 sessions of 45 minutes instruction on orthography.

Naming task

- 18 Manchu symbol blocks (V = 5, CV = 8, CVC = 5)
- Manipulated for visual complexity

Measures

- Symbol-level: item visual complexity (PX, PC, SF, CP, and DC)
- Outcome–level: item reading error rate (= incorrect / all attempted responses)

2.5 Experiment 1 (Results)

RQ1a: Correlation test (frequency based on classroom observation)

Measures	Symbol-level				
	PX	PC	SF	CP	DC
Outcome-level (error rate)					
Item freq. not controlled	.588*	.533*	.688**	.777***	.141
Item freq. controlled	.274	.173	.427	.688**	–.115

*$p < .05$, **$p < .01$, ***$p < .001$.

2.5 Experiment 1 (Results)

RQ1b: Multiple linear regression

Models	Predictors	Estimate	*SE*	95% *CI*		*p*
				LL	*UL*	
	Constant	.322	.072	.180	.485	<.001
	CP	.078	.016	.044	.111	<.001

CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

3

Symbol–sound mapping complexity

(Expt. 2)

3.1 Relevant theories in reading

Psycholinguistic grain size theory (Ziegler & Goswami, 2005)

- Decoding is linked with granularity of symbols mapped onto sounds.

Orthographic depth hypothesis (Frost et al., 1987; Katz & Frost, 1992)

- Deep orthography is more challenging to read than the shallow ones.

Orthographic breadth hypothesis (Nag, 2007, 2017)

- Inventory sizes may trade off with cognitive demand.

Intra-symbol processing (Nag, 2022)

- Design principles such as decomposability of symbols and visuo-spatial features such as diacritics drive decoding.

3.2 RQs on mapping complexity

RQ2a: Is there a difference in novice learners' performance in uju hergen reading for lists with one-to-one compared to one-to-many mapping?

RQ2b: Is there a switching cost for novice learners when the two lists are presented in blocked order compared to mixed order?

3.3 Experiment 2

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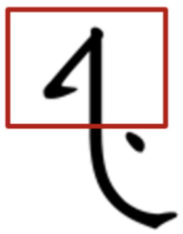

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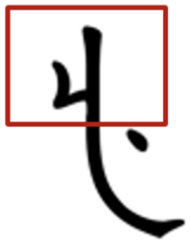
Naming task

- Two lists of 8 symbol blocks (CV = 6, CVC = 2 each) to 196 subjects
- Pair-matched for visual complexity, syllabic structures, and frequency

Measures

- Symbol-level: target phoneme marker 1-to-1 vs. 1-to-2 or 3 with sound, all non-target markers 1-to-1
- Outcome–level: item reading error rate

3.3 Experiment 2 *cont.*



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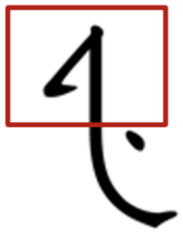

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Manipulation

- Mapping characteristics (target marker 1-to-1 vs. 1-to-many)
- Presentation order (Blocked: List 1 → List 2 vs. Mixed: Lists 1 & 2 mixed up and randomized)
- Counterbalance of Lists 1 and 2 within and across mapping and presentation conditions

3.4 Experiment 2 (Results)

RQ2a & RQ2b: Two-way repeated measures ANOVA

- **Main effect** of mapping characteristics on error rate ($F(1, 7) = 18.312$, $p = .004$, $\eta^2 = .723$). Low error rate for one-to-one mapping ($M_1 = 0.629$, $M_2 = 0.786$)
- **No main effect** of item presentation order on error rate ($F(1, 7) = 1.510$, $p = .259$, $\eta^2 = .177$).
- **No interaction effect** between mapping * presentation ($F(1, 7) = .005$, $p = .946$, $\eta^2 = .001$).

4

Intra-symbol processing in reading

4.1 Findings

This study examined the effects of visual complexity and symbol–sound mapping complexity on uju symbol blocks reading.

We found that…

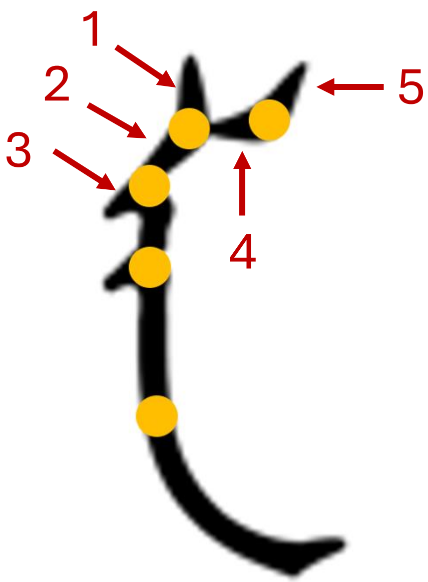
1. Connected points predict uju symbol blocks recognition.
2. Novice readers made more errors when reading uju symbol blocks with one-to-many phoneme-to-sound mapping.
3. However, their performance on the same uju symbol block remained unchanged across blocked (low-switching-demand) and mixed (high-switching-demand) orders.

4.2 The dual-function connected points

Finding 1: Connected points predicts uju symbol blocks reading.

Decomposition

- As visual cues guiding segmentation of uju hergen into simple features (SF).
- Changes in orientation, lengths, and shapes of SF at CP increase demands of perceptual parsing.



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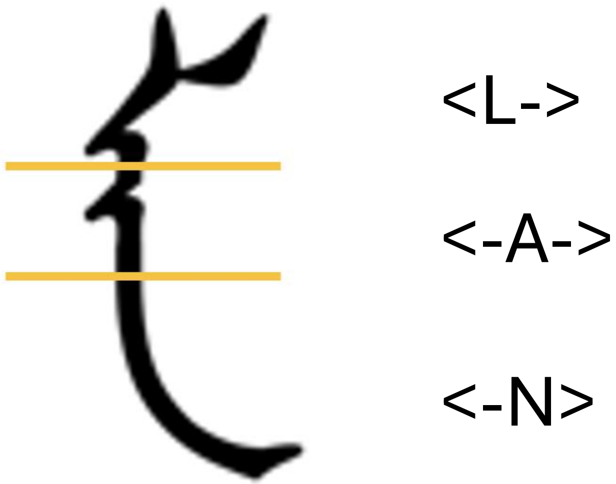
Recomposition

- As nexus visually combining simple features into phoneme markers.
- Recompose identified features into recognisable phoneme markers and further into uju hergen.

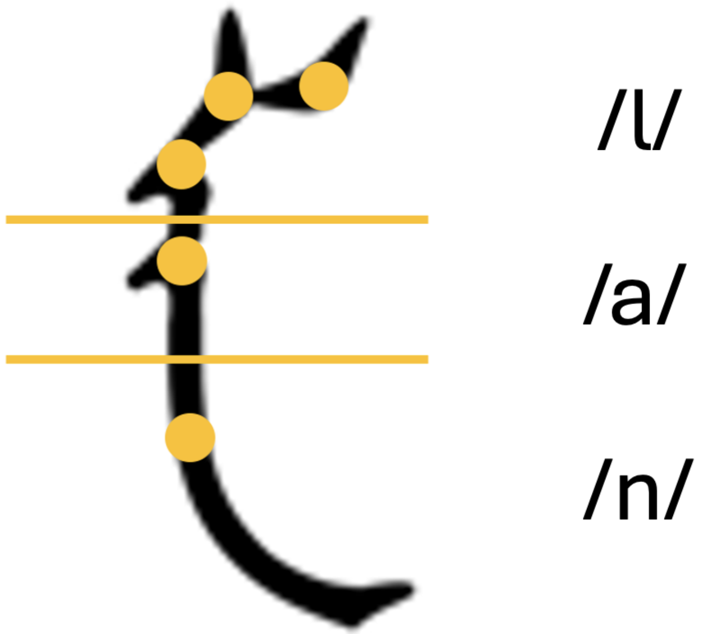
4.3 Use of phoneme markers in decoding

- **Finding 2:** The inhibitory effect of symbol–sound mapping can be attributed to learners' reliance on phoneme markers in decoding (also see Li, Murphy, & Nag, 2025 for instruction strategies).
- **Finding 3:** The absence of switching cost between the low- and high-switching-demand orders further supports this interpretation.



4.4 Intra-symbol processing in reading

- At the **sub-symbolic** level, readers recognise simple features and mentally organise them into phoneme markers, a cognitive process supported by connected points as visual cues.
- At the **symbolic** level, readers convert the resultant phoneme markers into sounds by appropriately applying their knowledge of symbol-to-sound mapping (after Coltheart, 2005).



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Limitations & Contributions

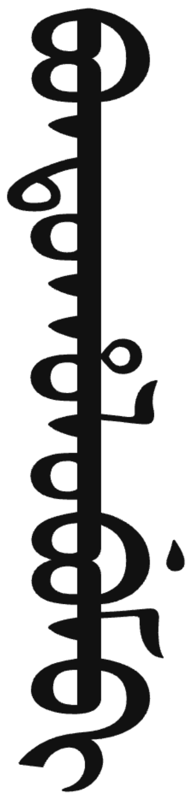
5.1 Limitation

Syllabic structures

- Experiment items only in V, CV and CVC
- Grain size(s) employed for more complex words?

Participants

- Novice learners of Manchu
- Flexible decoding strategies for advanced readers?



5.2 Contributions

- The first empirical study on Manchu orthography acquisition.
- Intra-symbol processing is central to uju symbol blocks reading.
- Additional evidence to theories grounded in a few orthographies that fall short of a universal account of reading acquisition (Share, 2025).

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Grazie.

谢谢!

Thank you.

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