Cross-Linguistic Perception of Itunyoso Trique Tone

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Questions

1 **Is tone perceived categorically for native speakers of tone languages?**

2 What accounts for the differences in how well listeners of tonal and non-tonal languages discriminate tonal contrasts?

3 Do speakers of tone languages have an advantage over speakers of non-tonal languages in pitch perception?

4 How well do speakers of tonal languages identify tonal contrasts?

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④ How well do speakers of tonal languages identify tonal contrasts?

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❹ How well do speakers of tonal languages identify tonal contrasts?

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❹ How well do speakers of tonal languages identify tonal contrasts?

Roadmap

❶ Background: tone perception, Itunyoso Trique tone

❷ Experiment 1: AXB Tone Discrimination task
  • Trique and French listeners

❸ Experiment 2: AXB Tone Identification task
  • Trique listeners

❹ General Discussion

Itunyoso Trique tone (DiCanio, 2008)

- Otomanguean language spoken in Oaxaca, Mexico. 2,554 speakers (INEGI, 2005).

- 9 lexical tones: 4 level, 5 contours.

- Phonologically level tones are phonetically level with no significant pitch movements.

- Two rising tones /35/ and /13/, which only surface before a coda /h/.

- Three falling tones /43/, /32/, /31/.

Introduction   **Background**   Discrimination Exp.   Identification Exp.   Discussion   Appendix   References
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Itunyoso Trique

Trique Tone Examples

Tone	CVV	Gloss	CVʔ	Gloss	CVh	Gloss
/4/	ββe⁴	*hair*	tʃiʔ⁴	*elderly man*	βeh⁴	*beat.3sg (intr.)*
/3/	**nne**³	*plow*	nneʔ³	*mecate*	nneh³	*dream*
/2/	**nne**²	*to lie (tr.)*	nniʔ²	*smelly*	ββeh²	*cave*
/1/	**nne**¹	*naked*	ʔniʔ¹	*be.salty*	cnãh¹	*brother (voc.)*
/35/	*	*	*	*	ββeh³⁵	*petate*
/13/	*	*	*	*	keh¹³	*barely*
/43/	li⁴³	*small*	*	*	*	*
/32/	**nne**³²	*water*	*	*	kkweh³²	*quelite*
/31/	**nne**³¹	*meat*	*	*	*	*

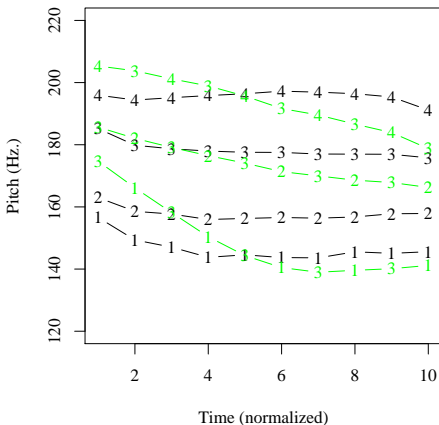Experimental Stimuli in **boldface**.

Figure: Itunyoso Trique Tones in Open Syllables

Categorical Perception of Tone

Is tone perceived categorically? Mixed findings.

- Results from a tonal identification task using a tone level continuum in Thai, Abramson (1979) found no categorical-type boundaries distinguishing the three level tones.
- Results from tonal identification tasks found categorical-type perception of Cantonese tones, but discrimination tasks did not show such strong evidence (Francis et al., 2003).
- Results from tonal discrimination and identification tasks found evidence of categorical-type perception for only a handful of speakers in Zapotec (Avelino Becerra, 2004).

| Introduction | **Background** | Discrimination Exp. | Identification Exp. | Discussion | Appendix | References |
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Tone Perception

Some positive findings

- Categorical-type perception of Mandarin contour tones (Chan et al., 1975). Mandarin listeners actively ignore irrelevant within-category tonal differences (Stagray and Downs, 1993).

- Results from both discrimination and identification tasks show more categorical boundaries around tones for speakers of Taiwanese Mandarin (Halle et al., 2004) than for French speakers.

- Results from an identification task show categorical-like perception of level tones (H vs. L) in Zapotec (Avelino, 2003).

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Tone Perception

What accounts for these mixed findings?

- Like vowels, tones have fuzzier boundaries, which means that their categorization functions will be less steep in identification tasks (Halle et al., 2004).

- Factors like natural auditory sensitivities and talker-specific speech processes based on information about the talker's pitch range play a role in tonal discrimination and identification (Francis et al., 2003).

- Certain speakers may perceive tone categorically while others may not (Avelino Becerra, 2004).

Introduction   **Background**   Discrimination Exp.   Identification Exp.   Discussion   Appendix   References
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Tone Perception

Language effects in tonal discrimination

- Speakers of tonal languages better discriminate tonal contrasts than speakers of non-tonal languages (Burnham et al., 1996; Lee et al., 1996; Halle et al., 2004; So, 2006).

- Stagray and Downs (1993) found Mandarin listeners to be worse overall at tonal discrimination, but mainly within categories.

- Does an increased ability to discriminate tone translate into a greater ability to discriminate pitch?

Method - AXB Discrimination Task (Halle et al., 2004)

- 8 tonal comparisons between 6 tones: /3/, /2/, /1/, /43/, /32/, /31/.
- Resynthesized tokens using an 8-step linear interpolation of pitch and intensity of original tones (Praat (Boersma and Weenink, 2008), Matlab). Tokens matched for duration. Two-step difference in A and B, where X = A or B.
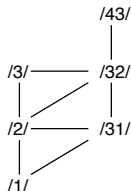
Linear Interpolation of Pitch and Intensity between tonal pairs
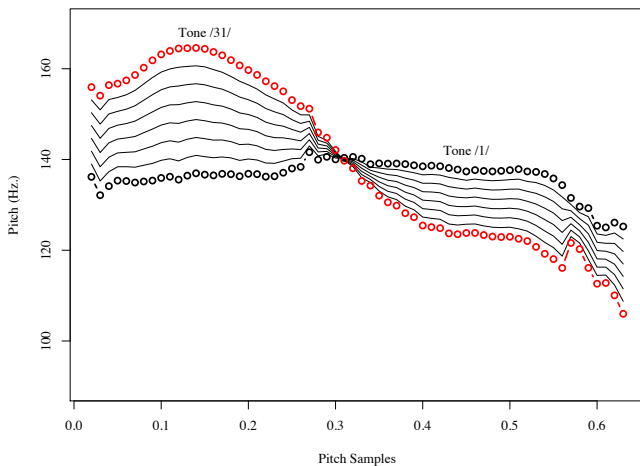
Method (cont.)

- 8 Blocks of 48 trials preceded by 1 practice block of 32 trials.

- Pseudo-randomization of block order, randomized trials.

- All tonal stimuli appeared in carrier sentence:
  ka^3tah^3 \<target\> , 'He says \<target\>.'

- Subjects: 18 native speakers of Itunyoso Trique (all bilingual Trique-Spanish), 20 native speakers of French.

- Location: Oaxaca, Mexico and Lyon, France.

- Praat experiment using Spanish and French.

- No lexical information in trial given, e.g. "Is the second phrase more similar to the first or the last?."

Results: Between Group Comparisons

- Two-factor logistic regression w/probit link for each tonal comparison, with Language and Stimulus Pair as factors.
- Both main effects were significant, with significant interactions for certain tonal comparisons.
- In general, French speakers performed better (78.0%) at tonal discrimination than Trique speakers (67.2%).
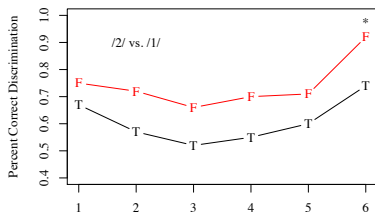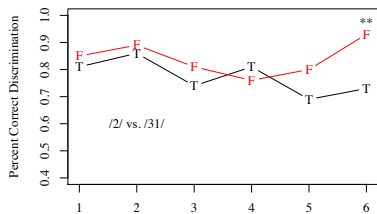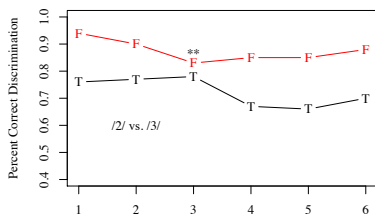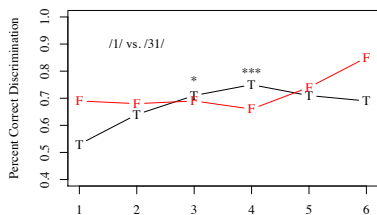
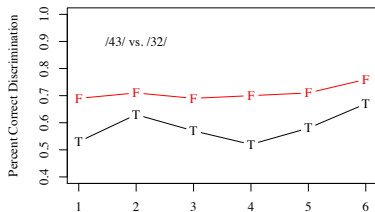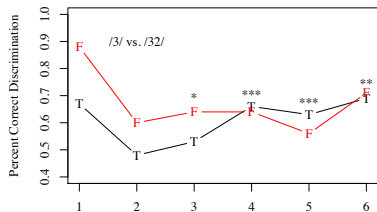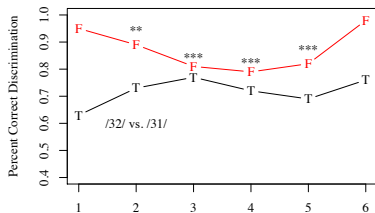| Language Effect		
Tonal Comparison		
/1/ - /31/	$G^2(1) = 5.4$	$p < .05$ *
/2/ - /31/	$G^2(1) = 12.0$	$p < .001$ ***
/2/ - /3/	$G^2(1) = 67.7$	$p < .001$ ***
/2/ - /1/	$G^2(1) = 40.0$	$p < .001$ ***
/2/ - /32/	$G^2(1) = 36.5$	$p < .001$ ***
/3/ - /32/	$G^2(1) = 8.2$	$p < .01$ **
/32/ - /31/	$G^2(1) = 71.7$	$p < .001$ ***
/43/ - /32/	$G^2(1) = 32.4$	$p < .001$ ***

Results: Between Group Comparisons

- Significant or near significant interactions between Language x Stimulus Pair for 6/8 tonal comparisons.
- For 5 of these, there was a signficant effect at a between-category peak for Trique listeners.

Language x Stimulus Pair		
Tonal Comparison		
/1/ - /31/	$G^2(5) = 19.3$	$p < .01$ **
/2/ - /31/	$G^2(5) = 18.1$	$p < .01$ **
/2/ - /3/	$G^2(5) = 9.7$	$p = 0.08$ NS
/2/ - /1/	$G^2(5) = 5.8$	$p = 0.33$
/2/ - /32/	$G^2(5) = 16.0$	$p < .01$ **
/3/ - /32/	$G^2(5) = 21.5$	$p < .001$ ***
/32/ - /31/	$G^2(5) = 39.3$	$p < .001$ ***
/43/ - /32/	$G^2(5) = 2.1$	$p = 0.83$

| Introduction | Background | Discrimination Exp. | Identification Exp. | Discussion | Appendix | References |
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Results

Introduction	Background	Discrimination Exp.	Identification Exp.	Discussion	Appendix	References
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Results

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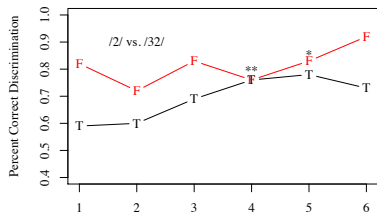
Results

Discussion

- Significant effect of continuum endpoints on tonal discrimination, resulting from stimulus pair at endpoints consisting of a resynthesized and a natural token.

- No significant categorical-type increase in discrimination accuracy found for Trique listeners for tonal pairs /2 - 1/, /43 - 32/, and /2 - 31/.

- For Trique listeners, discrimination approaches chance level within categories for tonal comparisons /1 - 31/ and /3 - 32/. It approaches chance level between categories for tonal comparisons /2 - 1/ and /43 - 32/, the worst two discriminated pairs.

Introduction   Background   **Discrimination Exp.**   Identification Exp.   Discussion   Appendix   References
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Results

Psychoacoustic Effects

- Post-hoc analyses revealed a correspondence between the raw psychoacoustic distance between each stimulus pair and the degree of discriminability by listeners.
- Psychoacoustic distance between stimuli = average difference in semitones between each stimulus pair.
- Worst discriminated tonal pairs are among those most psychoacoustically similar.

Tonal Comparison	Psychoacoustic Distance (semitones)	Discrimination Accuracy Trique	French
/32/ - /31/	1.02	71.6%	87.2%
/2/ - /3/	0.81	72.3%	87.5%
/43/ - /32/	0.75	58.5%	71.1%
/2/ - /32/	0.64	69.1%	81.1%
/2/ - /31/	0.63	77.4%	83.4%
/1/ - /31/	0.58	67.1%	72.0%
/2/ - /1/	0.46	60.6%	74.2%
/3/ - /32/	0.25	61.0%	67.2%

Introduction	Background	**Discrimination Exp.**	Identification Exp.	Discussion	Appendix	References
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Results

Speaker Differences

- Strong subject effect in discrimination for all tonal comparisons, mean $G^2(36) = 171.1$, $p < .001$ ***.
- Language effects on discrimination partly explainable by differences among individual listeners.
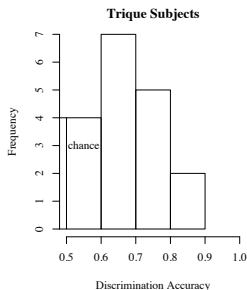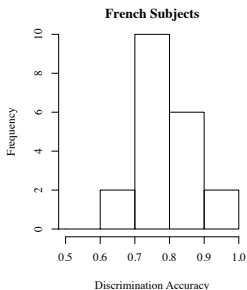
- If we remove the 4 listeners who discriminated tones at chance level, the Trique tonal discrimination accuracy increases by 4.4% to 71.6%.

- Similar to findings by Avelino Becerra (2004), some speakers simply were unable to discriminate tones in the task.

- Unfamiliarity with experimental procedures may explain some of the language differences in discrimination accuracy.

- Language effect contradicts findings by Halle et al. (2004) and Burnham et al. (1996) arguing that speakers of tone languages are better at tonal discrimination than speakers of non-tonal languages.

Introduction	Background	**Discrimination Exp.**	Identification Exp.	Discussion	Appendix	References
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Results

Summary

- Language effects on tonal discrimination: French listeners discriminate better overall than Trique listeners, but only the latter have significant categorical-type "peaks."

- For French and Trique listeners, significant increases in discrimination for endpoint stimulus pairs (Appendix: Within Group).

- Do discrimination peaks correspond to a crossover point in tonal identification?
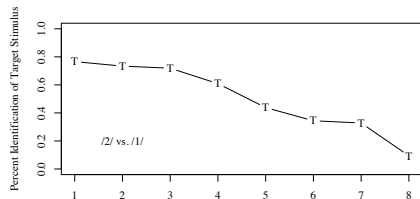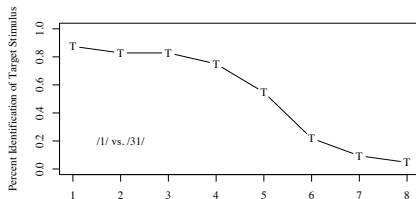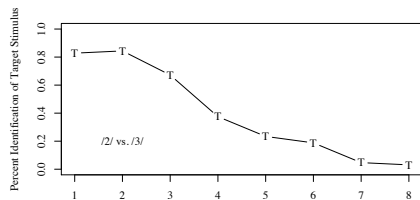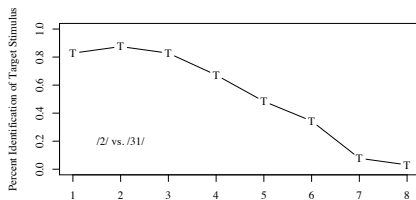
Method - AXB Identification Task

- Same resynthesized data, tonal comparisons, and block randomization as in the discrimination task.

- AXB task; A and B = continuum endpoints, X varied along entire 8-step continuum.

- 8 Blocks of 32 trials preceded by 1 practice block of 32 trials.

- Subjects: 16 native speakers of Itunyoso Trique (all bilingual Trique-Spanish).

- Location: Oaxaca, Mexico.

- Psyscope experiment using pictures corresponding to stimuli.

- Subjects instructed to identify which word was uttered by face between picture stimuli.
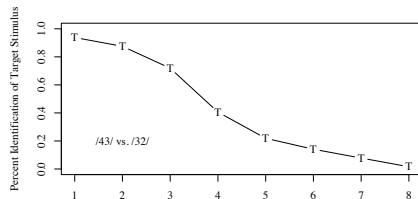
Identification Results

- The tonal comparisons with better discrimination accuracy had steeper identification curves.

- 50% crossover points in the identification data were converted to probability scores and then analyzed using a repeated measures ANOVA with Tonal Comparison as the main factor and subject as the error term. No significant differences in crossover location were found.

	/1x31/	/2x31/	/2x3/	/2x1/	/2x32/	/3x32/	/32x31/	/43x32/
Crossover:	4.93	4.60	3.94	5.16	5.38	4.85	5.13	3.91

| Introduction | Background | Discrimination Exp. | **Identification Exp.** | Discussion | Appendix | References |
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Introduction	Background	Discrimination Exp.	**Identification Exp.**	Discussion	Appendix	References
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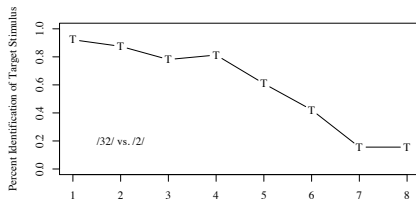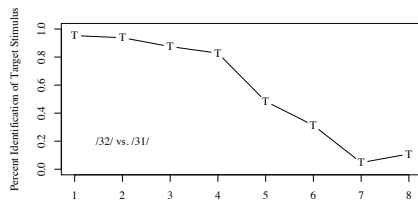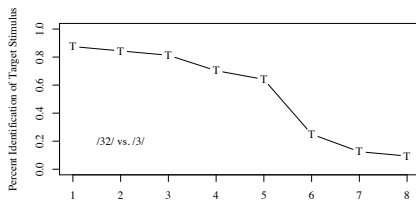
Relationship between discrimination and identification

- For 5/8 tonal comparisons, peaks in the discrimination function correspond to crossover points in the identification curve.

- Close relationship between boundaries in identification and increased sensitivity in discrimination.

Tonal Comparison	Discrimination Peak	Identification Crossover
/1 - 31/	Stimuli Pair 4-6	Between Stimuli 5-6
/2 - 3/	Stimuli Pair 3-5	Between Stimuli 3-4
/32 - 2/	Stimuli Pair 4-6, 5-7	Between Stimuli 5-6
/32 - 3/	Stimuli Pair 4-6, 5-7	Between Stimuli 5-6
/32 - 31/	Stimuli Pair 3-5, 4-6	At Stimulus 5

General Discussion I

- For 5/8 tonal comparisons, evidence of categorical-type peaks in discrimination accuracy for Trique listeners.

- These particular tonal comparisons had steeper identification functions where the crossover point corresponded to increases in discrimination sensitivity.
    - /2 - 3/, /1 - 31/, /2 - 32/, /3 - 32/, and /32 - 31/ perceived categorically in Itunyoso Trique.
    - /43 - 32/, /2 - 1/, /2 - 31/ not perceived categorically.

- Relationship between low tonal discrimination and low psychoacoustic distance.

General Discussion II

- Tone is perceived quasi-categorically by Trique listeners, but its discrimination is sensitive to individual speaker factors and psychoacoustic similarity between stimuli.

- Better discrimination of Trique tone by French listeners than by Trique listeners, even after adjusting for Trique listeners who discriminated at chance level. Why?

- Possible explanations: individual speaker differences, lack of familiarity with experimental procedures or computers.

Future Directions

- Examine sensitivity of Trique listeners to tonal contrasts and non-tonal pitch data using step intervals of varying sizes.

- Examine acoustic cues to tones in Trique using similarity rating task.

Acknowledgements

- Laboratoire Dynamique du Langage / CNRS
- François Pellegrino
- Keith Johnson
- Reiko Kataoka

ABX Discrimination Data

Statistics showing significant main effect of Stimulus Pair

Stimulus Pair Effect		
Tonal Comparison		
/1/ - /31/	$G^2(5) = 21.2$	p < .001 ***
/2/ - /31/	$G^2(5) = 21.7$	p < .001 ***
/2/ - /3/	$G^2(5) = 14.7$	p < .05 *
/2/ - /1/	$G^2(5) = 53.9$	p < .001 ***
/2/ - /32/	$G^2(5) = 30.4$	p < .001 ***
/3/ - /32/	$G^2(5) = 52.7$	p < .001 ***
/32/ - /31/	$G^2(5) = 17.6$	p < .01 **
/43/ - /32/	$G^2(5) = 10.2$	p = .07

Within Group ABX Discrimination Statistics

Trique Data: significant values where peaks in discrimination occur between categories.

Stimulus Pair Effect

Tonal Comparison	Stimulus Pair	z-value	
/1/ - /31/	3-5	3.2	p < .01 **
	4-6	3.9	p < .001 ***
	5-7	3.2	p < .01 **
	6-8	2.8	p < .01 **
/2/ - /31/	5-7	2.3	p < .05 *
/2/ - /3/	4-6	1.69	p = .09
	5-7	1.8	p = .06
/2/ - /1/	3-5	2.5	p < .05 *
	4-6	2.1	p < .05 *
/2/ - /32/	4-6	3.0	p < .01 **
	5-7	3.4	p < .001 ***
	6-8	2.5	p < .05 *
/3/ - /32/	2-4	3.3	p < .001 ***
	3-5	2.5	p < .05 *
/32/ - /31/	3-5	1.9	p < .01 **
	4-6	1.8	p = 0.08
	6-8	2.4	p < .05 *
/43/ - /32/	6-8	2.4	p < .05

Introduction   Background   Discrimination Exp.   Identification Exp.   Discussion   **Appendix**   References
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Appendix B: Within Group Data

French Data: significant values where troughs in discrimination occur between categories.

Stimulus Pair Effect			
Tonal Comparison	Stimulus Pair	z-value	
/1/ - /31/	6-8	3.3	p < .001 ***
/2/ - /31/	4-6	2.1	p < .05 *
	6-8	2.1	p < .05 *
/2/ - /3/	3-5	3.3	p < .01 **
	4-6	2.7	p < .01 **
	5-7	2.7	p < .01 **
	6-8	2.0	p < .05 *
/2/ - /1/	6-8	4.0	p < .001 ***
/2/ - /32/	2-4	2.1	p < .05 *
	6-8	2.6	p < .01 **
/3/ - /32/	2-4	5.7	p < .05 *
	3-5	5.1	p < .001 ***
	4-6	5.1	p < .001 ***
	5-7	6.3	p < .001 ***
	6-8	3.7	p < .001 ***
/32/ - /31/	2-4	2.0	p < .05 *
	3-5	3.7	p < .001 ***
	4-6	4.2	p < .001 ***
	5-7	3.6	p < .001 ***
/43/ - /32/	NSE	NSE	NSE

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Introduction	Background	Discrimination Exp.	Identification Exp.	Discussion	Appendix	**References**
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Appendix B: Within Group Data

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