

# The Investigation of Mandarin Tone Perception and Production in Taiwanese Children with Tourette Syndrome



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## Introduction

Tourette syndrome (TS) is a common neuropsychiatric disorder among children. Prior research indicated TS children often recognize syllables faster than normal control (NC) children. We aimed to explore the tone perception and production abilities of Taiwanese children with TS.

## Objectives

The main objectives of this study are to understand (1) the tone perception abilities of Mandarin-speaking children with Tourette syndrome and (2) the tone production abilities of Mandarin-speaking children with Tourette syndrome.

## Materials & Methods

- Participants:** Participants were recruited from Pediatric Department of Taipei City Hospital, with informed consent obtained from their legal guardians. Total 32 elementary-aged children (8-12 years) with basic Chinese literacy and phonological awareness were included. The TS group had 18 children (M/F=14/4), and the NC group had 14 ones (M/F=11/3), with no significant age or gender differences between the two groups. All underwent intelligence and hearing tests to confirm normal function. TS diagnoses followed DSM-5 criteria, and tic severity was assessed using the Yale Global Tic Severity Scale (YGTSS). Additionally, the SNAP-IV scale screened for Attention-deficit hyperactivity disorder (ADHD) and comorbidities.
- Materials:** The experiments used audio stimuli recorded by two native Mandarin speakers, using the Paradigm software for tone perception and production tasks. The stimuli for tone perception included monosyllabic words across four tones (e.g., 'da' with tones da1 to da4) and disyllabic words in 16 tone combinations (e.g., 1-1,1-2...,4-4). For tone production, participants were asked to recite disyllabic words, a short passage, or describe a picture/story.

- Procedures:** This study explored the linguistic capabilities and developmental progress in children with TS by assessing their Mandarin tone perception and production. The study consisted of three tasks using the software *Paradigm* :
  - Tone Discrimination:** Participants discerned different Mandarin lexical tones in disyllabic words.
  - Tone Identification:** For monosyllabic tones, children clicked on the corresponding tone for a given word. In disyllabic words, they identified the correct tone for each character.
  - Tone Production:** Children read aloud disyllabic words and passages, with their speech analyzed for tone accuracy, tone sandhi occurrences, and the presence of tics during pronunciation.

Experiments took place in a consultation room, lasting about 30 minutes per session. The children's responses to audio prompts were recorded and sent to National Chengchi University for further analysis.

## Results

There was no significant difference between the TS group and the NC group in age and gender.(Table 1)

Table 1: Characteristics of participants in both groups.

	Tourette's Group	Control Group	p-value
Number of Participants	18	14	
Age	10.1±2.1 yr	10.3±1.8 yr	ns
Gender Ratio (M/F)	14/4	11/3	ns
Comorbidities			
ADHD	12 (66.7%)	0 (0%)	-
OCD	2 (11.1%)	0 (0%)	-
Allergic Conditions	9 (50.0%)	4 (28.6%)	ns
Abnormal EEG	7 (38.9%)	0 (0%)	-
Medications			
Vitamin B6 (50mg)	15 (83.3%)	0 (0%)	-
Aripiprazole (5mg)	7 (38.9%)	0 (0%)	-
Methyphanidate (Ritalin, Concerta, Methylur)	7 (38.9%)	0 (0%)	-

\*ns: non-significant  
(Note: ADHD = Attention-deficit hyperactivity disorder; OCD = Obsessive-compulsive disorder.)

All participants had completed the three tasks. Preliminary analysis showed that the TS group had slightly lower accuracy rates in tone discrimination (72.7±19.5% vs. 76.6±23.6%) and disyllabic tone identification (83.4±18.7% vs. 88.9±9.6%) compared to the NC group.

However, those differences were not statistically significant. Regarding tone production, although the accuracy rates were similar between the two groups, the TS group had a higher incidence of pronunciation errors (27.8% vs. 7.1%). (Table 2)

Table 2: Comparison of the results between the two groups.

	Tourette Group (mean±SD)	Control Group (mean±SD)	p-value*
Tone discrimination	72.7±19.5%	76.6±23.6%	0.37
Tone identification			
Monosyllabic tones	52.8±22.9%	52.8±20.1%	0.88
Disyllabic tones	83.4±18.7%	88.9±9.6%	0.49
First syllable	90.9±10.4%	94.2±9.2%	0.14
Second syllable	88.4±16.3%	92.9±5.8%	0.79
Tone production	99.7±0.8%	99.8±0.0%	>0.99
First syllable	99.9±0.0%	99.8±0.6%	>0.99
Second syllable	99.9±0.0%	100±0.0%	>0.99
Error rates	27.8%	7.1%	0.19#

\*Mann-Whitney U test # Fisher's exact test

In children with TS, a marked negative correlation was found between the precision of tone production and the severity of their vocal tics, better tone production was associated with less severe tics ( $r=-0.53$ ,  $p=0.02$ ). Likewise, the ability to correctly identify the second syllable in disyllabic words was significantly related to lower impairment scores on the YGTSS ( $r=-0.48$ , $p=0.04$ ).Notably, the SNAP-IV scale scores, provided by parents or teachers, showed no significant correlation to these test outcomes. (Table 3)

Table 3: Correlation between YGTSS scores of Tourette group and test results.

	YGTSS Motor Score	YGTSS Vocal Score	YGTSS Impairment Score	YGTSS Total Score
Tone discrimination	$r=0.34$ , $p=0.17$	$r=0.17$ , $p=0.50$	$r=-0.24$ , $p=0.34$	$r=-0.03$ , $p=0.90$
Tone identification				
Monosyllabic tones	$r=0.11$ , $p=0.68$	$r=0.46$ , $p=0.07$	$r=-0.28$ , $p=0.27$	$r=0.12$ , $p=0.63$
Disyllabic tones	$r=0.27$ , $p=0.28$	$r=0.20$ , $p=0.43$	$r=-0.39$ , $p=0.11$	$r=-0.11$ , $p=0.65$
First syllable	$r=0.15$ , $p=0.54$	$r=0.18$ , $p=0.48$	$r=-0.37$ , $p=0.13$	$r=-0.16$ , $p=0.53$
Second syllable	$r=0.19$ , $p=0.46$	$r=0.24$ , $p=0.33$	<b><math>r=-0.48</math></b> , <b><math>p=0.04</math></b>	$r=-0.17$ , $p=0.49$
Tone production	$r=0.15$ , $p=0.54$	<b><math>r=-0.53</math></b> , <b><math>p=0.02</math></b>	$r=-0.18$ , $p=0.47$	$r=-0.39$ , $p=0.11$
First syllable	$r=-0.16$ , $p=0.51$	$r=-0.33$ , $p=0.18$	$r=-0.30$ , $p=0.22$	$r=-0.40$ , $p=0.10$
Second syllable	$r=0.38$ , $p=0.12$	$r=-0.40$ , $p=0.10$	$r=0.05$ , $p=0.84$	$r=-0.14$ , $p=0.58$

r: Spearman's rank correlation

## Discussion & Conclusion

The study investigated how Tourette syndrome (TS) affects language tasks like tone discrimination, identification, and production. Children with TS had slightly lower but not significantly different accuracy in tone discrimination and identification than controls. This suggests TS doesn't greatly affect basic auditory tone processing. Age improved performance in these areas but wasn't a factor in disyllabic tone identification, hinting at other complexities.

For tone production, while accuracy was similar, the TS group had more pronunciation errors, indicating TS might interfere with precise spoken language, an issue especially for those with severe vocal tics. There were significant negative correlations between tone production accuracy and vocal tic severity, according to the Yale Global Tic Severity Scale (YGTSS), highlighting how severity of tic symptoms could compromise complex language tasks. Notably, ADHD symptoms measured by the SNAP-IV scale did not significantly impact tone processing, suggesting ADHD does not directly affect these language abilities in children with TS.

Overall, TS may not impede basic tone processing but could affect tone production, particularly in those with intense vocal tics. For the children with more severe vocal tic symptoms, special attention should be paid to whether there are any abnormalities in the verbal expression abilities.

## References

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