# Auditory perception of timing in adolescents with ASD

A. Bhatara[1,2,3], E. Laugeson[2], T. Babikian[4], R.Tachdjian[5], & Y. Sininger[1]

1. Division of Head & Neck Surgery, David Geffen School of Medicine at UCLA 2. The Help Group – UCLA Autism Research Alliance 3. Laboratoire Psychologie de la Perception, Université Paris Descartes, CNRS, Paris 4. Psychiatry and Biobehavioral Sciences, David Geffen School of Medicine at UCLA 5. Departments of Medicine and Pediatrics, David Geffen School of Medicine at UCLA

## Background

Numerous studies have shown preserved or enhanced frequency perception in individuals with autism spectrum disorders (ASD; e.g. Bonnel et al., 2003; Heaton, 2003, Järvinen-Pasley & Heaton, 2007). For perception of auditory timing, however, there is evidence of impairment (Alcantara et al., 2003; Groen et al., 2009) and Boucher (2001) proposed that impaired time perception may underlie many of the impairments in autism. Spectral information (as is used in pitch perception) is preferentially processed in the right hemisphere, and temporal information is preferentially processed in the left hemisphere (Zatorre & Gandour, 2008; Zatorre & Belin, 2001). Differences in abilities between these two domains implies that there is a lateralization difference in auditory processing in individuals with ASD.

### How can psychophysical methods help us measure this?

As in many sensory systems, the pathways from peripheral (ear) to central (brain) regions are crossed, so processing of stimuli from one ear is processed primarily by the opposite hemisphere. This has been demonstrated by dichotic listening studies with both adults and children showing a right ear advantage for speech stimuli and a left ear advantage for tonal stimuli (e.g. Kimura 1961, 1963, 1964). Other studies using dichotic listening techniques have provided further support for this, but also have found variability in the consistency of the lateralization (Sidtis, 1982) or in the amount of time that the lateralization persists during the task (Kallman & Corballis, 1975).

Sininger & de Bode (2008) found a right ear advantage for a gap detection task (explained in methods, this poster) using wide band noise, and a left ear advantage for the same task using tonal stimuli. Using the same stimuli and tasks as the present study, we found a left ear advantage for tonal stimuli for typical adults, but no right ear advantage for any of the stimuli (Sininger & Bhatara, in press). The present study investigates typically developing (TD) children and children with ASD with two questions: 1) Do children with ASD have a specific deficit in perception of timing (as measured by gap detection) relative to a pitch perception task? 2) Do school-aged children show the same type of laterality as adults, and is this different in children with ASD?

### Measures

Child questionnaires (with parent's help if needed):
- Handedness (modified version of Edinburgh Handedness Inventory)
- Sensory Profile

Parent questionnaires:
- Social Responsiveness Scale (Constantino, 2002)
- Gilliam Autism Rating Scale – 2nd Ed. (Gilliam, 2006)
- Autism-Spectrum Quotient (Baron-Cohen et al., 2001)
- Ear health & Musical experience questionnaire
- Demographic questionnaire

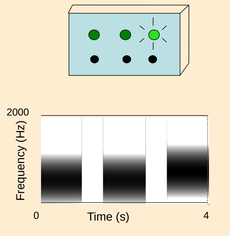
Tests/Instruments:
- WASI
- Audiogram, Tympanogram, Otoacoustic emissions
- Words-in-Noise test

## Methods

### Procedure

Participants sat in a sound-isolated booth. They performed two tasks.

1.Frequency difference limens
- 3AFC procedures – 3 sounds, 500 ms apart – task is to press button corresponding to sound that differs from other two
- Frequency difference starts large (200 Hz) and decreases until threshold is reached after 2 large-step [1/3 change in frequency difference] and 5 small-step [1/10 change] reversals
- Tested at three base frequencies: 500 Hz, 1000 Hz and 4000 Hz, so 3 frequency levels x 2 ears = 6 thresholds of discrimination determined




2. Gap detection
- Same task; press button corresponding to sound with gap of silence
- Size of gap decreases from 100 ms in same fashion as frequency task, but with only 4 small-step reversals
- Tested at four base frequencies: 500 Hz, 1000 Hz, and 4000 Hz plus wide band noise (WBN) x 2 ears = 8 thresholds of detection determined

### Participants

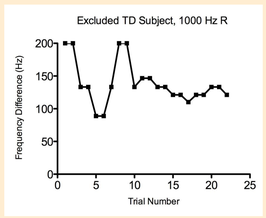
Children with ASD ages 10-14 and chronologically age-matched controls (group matched). All participants' IQ scores were above 70, and they all scored within normal levels on the audiogram, tympanogram and OAEs and reported no hearing difficulties or ear pain.

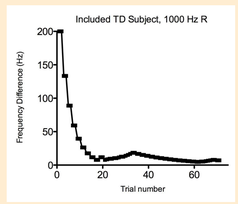
Exclusion criteria: One participant was excluded from TD group because he scored in the ASD range on two of the measures (SRS and GARS) and one was excluded from ASD group because he did not score in the ASD range on any of the measures. Additionally, one participant was excluded from the ASD group because of low IQ scores, and two others because they were unable to complete the task.

Individual results: Statistical outliers ( + or – 2 SD from mean) were further examined. If the participants' trajectory of responses on the psychophysical tasks indicated that he/she was not paying attention or not following task instructions (see below), those threshold results were excluded. One participant's results were excluded from the frequency task but not from the gap detection task; thus there were 12 participants with ASD in the gap task and only 11 in the frequency task.

| | N | Age in months | Years of musical experience | Number of instruments | Handedness (laterality score)[2] | Verbal IQ | Performance IQ | Full Scale IQ | Autism Quotient score | SRS[3] overall t-score |
|---|---|---|---|---|---|---|---|---|---|---|
| **TD** | 16 (7 F, 9 M) | 152(6) | 3.77(.83) | 1.62(.30) | 69(16.4) | 109(4) | 105(3.7) | 107(3.7) | 12.7(1.7) | 45.4(1.4) |
| **ASD** | 12 (1 F, 11 M) | 152(7) | 2.23(.94) | 1.08(.26) | 54(17) | 93(4.6) | 99(4.5) | 96(4.6) | 37(1.6) | 81.5(3.9) |
| ***t*(26)** | | 0.05 | 1.36 | 1.22 | 0.61 | 2.62* | 1.08 | 1.86 | -10.5** | -8.3** |

1) Numbers in parentheses are standard errors
2) Laterality scores are defined as -100 = Left handed, 0 = ambidextrous, +100 = Right handed
3) SRS = Social Responsiveness Scale
*p<.05; **p<.01




## Results

Mixed models analyses were run on each task with Group, Ear (L vs R), Frequency as predictors and and VIQ as a covariate. Ear was not a significant factor, nor did it interact with any other factors, so it was removed from subsequent analyses.

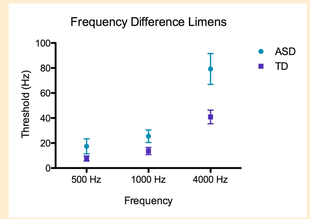
**Frequency difference limens analysis**

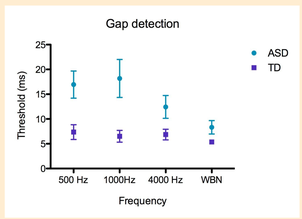
| Factor | significance |
|---|---|
| Group (ASD or TD) | ns |
| Frequency (500, 1000, or 4000 Hz) | p < .001 |
| VIQ | p < .001 |
| Subject (random) | |

**Gap detection analysis**

| Factor | significance |
|---|---|
| Group (ASD or TD) | p < .001 |
| Frequency (500, 1000, 4000 Hz or WBN) | p = .02 |
| Group x VIQ* | p = .03 |
| VIQ | ns |
| Subject (random) | |

*Other interactions ns




### Discussion & Conclusions

The results from this study show an impairment in the group with ASD relative to the TD group in the gap detection task but not in the frequency discrimination task, thus supporting previous research proposing a specific deficit in timing.

Frequency task
- Main effect of frequency; the task is more difficult at higher frequencies
- VIQ is a significant covariate, and when included in the model eliminates any differences between the TD and the ASD group

Gap detection task
- Main effect of group; after accounting for VIQ, the ASD group is impaired relative to the TD group in gap detection
- Main effect of frequency; task seems easiest for WBN, but post-hoc Tukey tests showed no significantly different pairs
- Interaction between Group & VIQ: Linear regressions showed that, for the TD group, threshold was negatively correlated with VIQ. No relationship in ASD group.
- [Supplementary analysis with only boys included (N = 11 ASD and 9 TD): Group was the only significant factor $p$ = .04]

Our predictions of laterality differences were not supported; however, this could be due to lack of power or to individual differences in handedness, as three of our participants were left-handed and one was ambidextrous.

We are currently analyzing ERP data from these same participants. In that task, they listened to frequency changes or gaps in sounds presented to one ear at a time. Stay tuned…

**Acknowledgements**

Thanks to Elias Ballat, Sophie Kaye, the Help Group, the Children's Music Fund, and all of the parents and children who participated in the study.
This study was funded in part by a grant from the American Association of University Women.

Contact: bhatara@gmail.com