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Variations in the perception of lexical pitch accents and the correlations with individuals' autistic traits*

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Abstract

The present study examined if individual listeners' perceptual variations were associated with their cognitive characteristics indexed by the Autistic Spectrum Quotient (AQ). This study first investigated the perception of the lexical pitch accent contrast in the Kyungsang Korean currently undergoing a sound change, and then tested if listeners' perceptual variations were correlated with their AQ scores. Eighteen Kyungsang listeners in their 20s participated in the perception experiment where they identified two contrastive accent words for auditory stimuli systematically varying F0 scaling and timing properties; the participants then completed the AQ questionnaire. In the results, the acoustic parameters reporting reduced phonetic differences across accent contrasts for younger Kyungsang generation played a reliable role in perceiving the HH word from HL, suggesting the discrepancy between the perception and the production in the context of sound change. This study also observed that individuals' perceptual variations were negatively correlated with their AQ sub scores. The present findings suggested that the sound change might appear differently between production and perception with a different time course, and deviant percepts could be explained by individuals' cognitive measure.

Keywords: sound change, lexical pitch accent, individual difference, autistic traits, Kyungsang Korean

1. Introduction

Careful observation of synchronic variation and individuals' speech variation is important to understand diachronic variation. It would not only allow us to see the current stage of the sound change, but also predict the direction of the change by identifying individuals with the most and least progressive speech patterns.

Although recent studies have empathized with previous research for the importance of observing individual differences in understanding sound change mechanism, the approach between earlier and recent research is quite different. Specifically, while previous research on individual differences examined speech patterns mainly by the sub-group speakers or listeners, recent studies (pioneeringly done by Alan C. L. Yu and his research team) investigated how individual language users differ from each other even within the sub-group and attempted to find factors explaining the variabilities considering speakers' cognitive characteristics as well as social factors. For example, according to the previous research focusing on sub-groups' speech processing pattern, gender, ethnicity, and socioeconomic class are well-known social factors related to individual differences in speech (e.g., Eckert, 1988; Labov, 1990; Min, 1997; Labov, 2001; Stuart-Smith, 2007). That is, this line of research defined the individuals' speech characteristics based on the sub-group pattern, assuming that an individual language user may have identical speech patterns with others within the same (sub-) group of the language. This means that individuals showing an abnormal pattern were merely considered outliers, and accordingly serious discussion about the abnormal pattern often

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But recent individual difference studies have focused on the nature of the outliers' variability as well as the source of the variability, and have tried to find the social and cognitive characteristics of the outliers. The emphasis on such individual variation was motivated by Ohala's proposal that widespread speech errors or new phonetic variants generated from an individual language user may affect the rest of the language community, which eventually leads a sound change (Ohala, 1993). This line of research suggests that addressing the factor explaining a certain individual variation would eventually shed light on understanding the initiation or actuation of a sound change (Stevens & Harrington, 2014). To demonstrate the nature of individuals' speech variation, recent studies took into account individuals' socio-cognitive processing styles (e.g., executive functions, personality traits, etc.) as well as social factors (e.g., gender, socioeconomic class, etc.), which would provide an answer for what types of language users have the most deviated phonetic form from the norm.

While relating the individual phonetic variants with their cognitive factors has been increasingly examined in the English language (e.g., Yu, 2011; Yu *et al.*, 2013; Yu, 2016; Kong & Edwards, 2016), only a few attempts have been made in Korean (Kang *et al.*, 2015; Lee & Kong, 2016). Therefore, the present study aims to examine the relationship between individual differences in speech processing and their socio-cognitive processing styles, namely the Autism Spectrum Quotient (AQ) based on the Korean language. The present attempt not only examines the nature of the individuals' speech variations, but also enables further testing the cross-linguistic validity of the effect of the socio-cognitive factor. For the present aim, this study investigated the perception of the lexical pitch accent words of the Kyungsang dialect of Korean, which has been undergoing a sound change (Lee *et al.*, 2016). By exploring the effect of the AQ as an explanatory tool for individual differences, it is hoped to explain the source of the on-going sound change.

1.1. Autistic traits as an individual-difference dimension and its relationship with speech processing

There have been several attempts to test if and how cognitive parameters such as executive function and memory resources are correlated with individuals' language processing (e.g., Janes & Jesse, 2014; Yu, 2010; Yu *et al*., 2011; Kong & Edwards, 2016). For example, using behavioral speech identification, Kong & Edwards (2016) explored how individual differences in cue-weighting in the perception of the English voicing contrast were correlated with individuals' executive functions such as attention-switching control and inhibition. Yu *et al.* (2011) showed that individuals with greater working memory capacity tended to compensate less for vocalic coarticulation and to be less influenced by talker gender.

Along with the cognitive measures related to executive functions, researchers examined the relationship between speech processing and *autistic traits* as an index of individuals' cognitive processing styles (e.g., Yu, 2010; Bonnel *et al.*, 2003; Mottron *et al.*, 2006; Robinson *et al.*, 2011). The fact that adults with normal intelligence as well as those with autistic disorder can be characterized by autistic-like traits led these studies to explored the linguistic inquiry. Baron-Cohen *et al.* (2001) introduced an instrument easy to use for assessing one's autistic traits, namely the Autism-Spectrum Quotient (AQ), and demonstrated that normal intelligence individuals were also associated with the autistic-like traits. AQ is a self-administered paper-and-pencil task consisting of 50 questions, and these are classified into 5 sub-categories: Social Skill, Attention Switching, Attention to detail, Communication, and Imagination. The higher the AQ score is, the more autistic-like or abnormal an individual is (i.e., poor social skill, poor communication skill, etc.). Baron-Cohen *et al.* (2001) reported that among the adults who were not critically diagnosed as autistic patients males' AQ scores were higher than females', and scientists, especially mathematicians, scored higher than ordinary college students in Cambridge University. Wakabayashi *et al.* (2006) further replicated the UK results with Japanese adults, indicating the AQ as an reliable instrument for measuring the individuals' autistic traits across cultures and languages.

Notably, recent studies have demonstrated that individual differences in speech processing are associated with the AQ scores (Yu, 2010; Yu *et al*., 2013; Yu, 2016). Yu (2010) found that less autistic-like female listeners tended not to normalize for coarticulation as much as males did, pointing out that those would be more likely to introduce new phonetic forms to others. Yu and his colleagues (2013) also revealed that the magnitude of phonetic imitation (i.e., VOT imitation in the English stop production) was modulated by individuals' autistic-like trait associated with attention switching, a sub score of AQ, showing that individuals with high scores in attention switching were more likely to imitate VOT properties from exposure speech. Kong *et al*. (2014) found that affricates produced by young Seoul Korean speakers had more fronted articulatory properties relative to fricatives, and the research team (2015) further demonstrated that the acoustic characteristic was correlated with AQ scores within male speakers; males with low AQ scores had more fronted production patterns of affricates. The findings of the previous studies that explained speech variabilities in a relation to individuals' socio-cognitive processing styles are particularly important in understanding the initiation of sound change in that it would allow us to define linguistic innovators or conservatives.

1.2. Sound change of lexical pitch accent in regional dialects of Korean

To observe the relationship between individuals' speech processing pattern and their AQ scores, the present study explored the perception of the lexical pitch accent of South Kyungsang Korean. This study tested if individual Kyungsang listeners' perceptual differences are correlated with their AQ total and sub-category scores. Recent acoustic findings where a sound change for the prosodic feature of the language were demonstrated (Lee & Jongman, 2015; Lee *et al.*, 2016) motivated the present observation given that a language undergoing a change tends to have more phonetic variants.

South Kyungsang Korean is well-known for its preservation of the lexical pitch accent from Middle Korean (Lee & Ramsey, 2011) [c.f., HL (káci, 'type'), HH (kácí, 'branch'), and LH (kací, 'eggplant')]. In the South Kyungsang dialect of Korean, there are three accent classes in monosyllabic words: H(H), Rising and H(L) (the accent realization in the parentheses is an accent under suffixation). There are four classes in disyllabic words: HL, HH, LH(H), LH(L). According to the formal analysis by Lee & Zhang (2014), Kyungsang words belong to four underlying accent classes:

penult H, initial spreading H, peninitial spreading H, and *toneless* (default) *H*. The phonetic properties of Kyungsang words are well distinguished across the four underlying accent classes in terms of F0 scaling (Hz) and F0 timing (ms) properties. The representative acoustic measures for F0 scaling properties are F0 peak and onset pitch values. F0 peak value is greatest for HL, intermediate for HH and lowest for LH(H)/LH(L); the F0 onset value also varies in the same order as the F0 peak value. For the F0 timing properties, the representative acoustic correlate is F0 peak duration, that is, the point where the F0 peak is realized; the F0 peak duration is longest for the LH(H)/LH(L), intermediate for HH, and shortest for HL words (Kenstowicz & Park, 2006; Chang, 2007; Lee, 2008).

However, recent acoustic studies (Lee & Jongman, 2015) have demonstrated that these phonetic properties of the pitch accent words were realized differently between younger and older generations. While older generation exhibited clear separation of the accent words based on the reported acoustic patterns, younger speakers' accent production was less clear relative to those by older speakers. Specifically, while older speakers clearly differentiated the accent words showing the reported F0 peak pattern, the F0 peak values for younger speakers were not different across contrastive accent words. A notable age variation was also seen for the F0 peak duration; younger Kyungsang speakers showed considerable peak delay across all accent words, resulting in F0 peaks on the second syllable for all accent words. To summarize the age variation in the production pattern, both F0 scaling and timing properties across the accent words are modulated by the age groups in that the acoustic distinction across the accent contrasts became smaller for the younger speakers.

Importantly, there were substantial individual variation in the younger Kyungsang speakers' pitch realization (Lee *et al*., 2016). Although there was an averaged group tendency within each age group, individual speakers also varied from each other even within their age group. The general patterns of the observed individual differences were that even within the (innovative) younger speaker group some individuals presented conservative pitch realization similar to older speakers'; likewise even within the (conservative) older speaker group some individuals showed innovative patterns. The presence of such individual variation in the pitch accent realization might not be surprising given that the language is now undergoing the sound change under which new phonetic variants are introduced. However, what remains unanswered is the characteristics of those individuals who exhibited abnormal phonetic patterns within their homeogenous group. That is, we merely know that some individuals are more innovative than others in the context of sound change, but we do not know the source of the individual variation and the characteristics of the linguistic innovator.

1.3. Current study

The purpose of the present study is two fold. This study first aims to examine if the on-going sound change observed in the production pattern is consistently seen in the perception pattern. Then, it is aimed to relate observed individual differences in the perception with individuals' autistic-like traits (i.e., AQ), a potential factor explaining individuals' cognitive processing styles.

While the sound change of the lexical pitch accent of South Kyungsang Korean has been demonstrated in the production pattern, few studies explored the change in the perception. Therefore, the first purpose of the present study is to examine how the lexical pitch accent of the language is perceived by young generations in their 20s. This study specifically examines if the acoustic parameters reported as significant cues in contrasting HH and HL accent words are meaningfully used by the young Kyungsang listeners in the perception of the pitch accent words. The tested acoustic parameters that considered both F0 scaling and timing properties were (i) pitch onset values, (ii) pitch peak values and (iii) the location of the peak point. By using auditory stimuli for which the three acoustic parameters were manipulated, this study tested if the acoustic properties were still useful for younger Kyungsang listeners in identifying HH from HL words. A further examination is to observe the individual differences in the perception, and to see if individual Kyungsang listeners can be grouped as innovators and conservatives based on their perceptual patterns. To avoid the geographical variation of pitch accent patterns between North and South Kyungsang dialects of Korean, the present study focused on South Kyungsang Korean used near the Pusan city.

The second purpose of this study is to examine the relationship between individuals' utilization of the acoustic parameters in perceiving HH and HL accent words and their autistic-like traits. In other words, this study investigates if and how individuals' perceptual differences in using the F0 scaling and timing parameters are correlated with the AQ total and sub-category scores; if so, this study further examines how the correlation appears by female and male listeners. By testing the perceptual association with the AQ score, this study attempts to understand how the linguistic innovators can be explained in the sound change.

2. Methods

2.1. Participants

18 (10 females, 8 males; mean age = 21 years old, s.d. = 1.53) Kyungsang speakers participated in the Two-Alternative-Forced (2AFC) identification task. All the participants were born and have been educated in the South Kyungsang area (near Changwon, Pusan and Ulsan cities) under the parents with the same Kyungsang dialect of Korean. The participants took part in the perception experiment for a nominal fee, and none of them reported hearing and speaking problems. After the speech identification task, the participants filled out the AQ questionnaire in a paper form.

2.2. Auditory stimuli

The present study selected one base token, *moley* HH 'the day after tomorrow', produced by a 21-year-old female Kyungsang speaker. 28 auditory stimuli were created by manipulating acoustic parameters, considering F0 scaling (i.e., onset and peak pitch values) and F0 timing (i.e., peak duration) properties. The manipulated stimuli reflected mean acoustic values of the HH and HL words reported in Lee & Jongman (2015). For manipulating the F0 scaling property, onset and peak pitch values were manipulated for the base token; manipulated auditory stimuli has two levels of onset pitch (low: 170Hz, high: 210Hz) and three levels of peak pitch (low: 230Hz, mid: 250Hz, high: 270Hz). For manipulating the F0 timing property, this study created 7-step continuum varying the location of peak from 20% to 80% of the entire word duration

(400ms) in 10% steps. That is, the stimulus with 20% peak is closed to a HL word (i.e., *molay* HL 'sand') and that with 80% peak is similar to a HH word (i.e., *moley* HH 'the day after tomorrow). A total of 28 stimuli was created (2 onset pitch x 2 peak pitch x 7 steps). <Table 1> and <Figure 1> present the acoustic properties of the base and manipulated token(s) and the schematized pitch contours of the manipulated tokens, respectively.

Table 1. Acoustic properties of the base and manipulated token(s).

	Base token	Manipulated tokens
Onset pitch	218Hz	170Hz, 210Hz
Peak pitch	233Hz	230Hz, 250Hz, 270Hz
Offset pitch	231Hz	(fixed to) 170Hz
Peak duration	332ms	7-step continuum (20%-80%)
Entire duration	400ms	(fixed to) 400ms

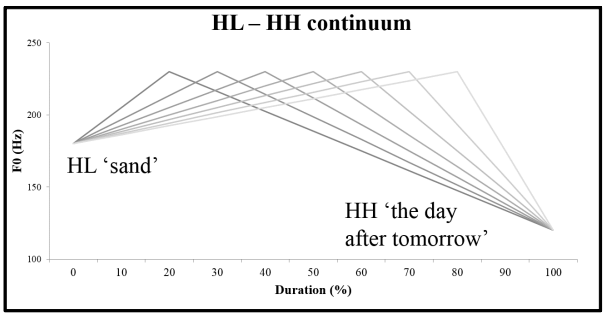

Figure 1. Schematized pitch contours of the manipulated tokens.

2.3. Procedure

For the 2AFC identification task participants were instructed to respond what they heard by pressing a keyboard button either for *moley* (HH) 'the day after tomorrow' or *molay* (HL) 'sand'. Corresponding pictures for the words were provided close to the buttons. The 140 stimuli were randomly presented within each of five blocks, and thus the five blocks provided five repetitions. Each listener responded to a total of 140 trials (28 stimuli × 5 repetitions). For the AQ questionnaire each participant filled out the paper-and-pencil AQ questionnaire after the identification task. Each of the 50 AQ questions of Baron-Cohen *et al.* (2001) was translated into Korean. Given that the AQ scores were remarkably similar across different cultures and languages (Wakabayashi *et al.*, 2006), this study did not expect a potential effect drawn by the translated version of the AQ questionnaire.

2.4. Analysis

For the identification data, listeners' perception was modelled using logistic mixed-effects regression in R. A dependent variable was the HH response (HH = 1, HL = 0). The model contains three fixed factors: Step indexed a location of the accent word on the HL-HH continuum; onsetPitch indexed high and low onset pitch values, and peakPitch the high-mid-low peak pitch values. The model includes a by-subject random intercept. The categorical variables (onsetPitch, peakPitch) were further contrast-coded (1, -1), and the continuous variable (Step) was centered. A log-likelihood test based on ANOVAs evaluated the significance of an interaction effect by comparing the models with and without interaction terms.

For the AQ data, this study used the same scoring criteria with Baron-Cohen *et al*. (2001). The AQ score was calculated for each of the participants. In the second phase of the present analysis, correlation tests were conducted based on individuals' AQ scores and their coefficients estimated by random coefficients to the three fixed effects of acoustic parameters (e.g., correlation between AQ scores and onsetPitch). The correlation tests explored the relationship between individuals' AQ traits and the utilization of the acoustic cues contrasting HH and HL pitch accent words.

3. Results and discussion

3.1. Perception pattern of the lexical pitch accent

<Figure 2> shows the mean percent of HH responses by Step, onsetPitch, peakPitch between male and female listeners. <Table 2> presents the estimates for the predictors of the logistic mixed-effect models. Given that addition of any of the two-way interaction terms did not improve the model significantly, this study reported the model including the main effects only [$\chi^2(9) = 8.13$, $p = 0.52$].

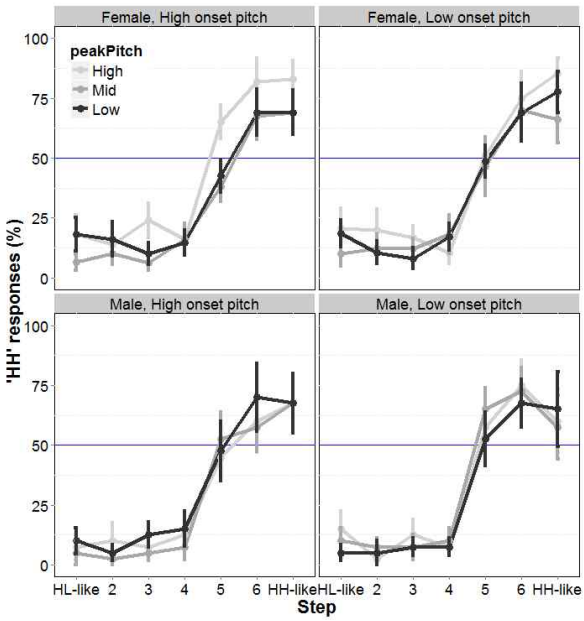

Figure 2. Mean percentage (%) of HH responses as a function of Peak and Onset pitch values between Female and Male listeners. The horosontal line marks the 50% of the y-axis.

For predicting the HH response, the effect of Step was significant [$\beta = 1.89$, $p > 0.001$], indicating that Kyungsang listeners are more likely to hear stimuli as the HH word as the peak is realized further back within the word. This effect of Step is consistent with the previously reported acoustic pattern for the Kyungsang dialect in that the peak is realized earlier for HL words than for HH (Chang, 2007; Lee, 2008). Notably, contrary to the recent observation where the peak location between HH and HL became non-distinct for younger speakers (Lee & Jongman, 2015), the present perception finding indicates that in the perception younger Kyungsang listeners effectively distinguish HH from HL words as a function of the peak location. In other words, while younger speakers did not effectively distinguished HH from HL as much as older speakers did in the

production, they could differentiate the two accented words in the perception.

The onsetPitch predictor, however, was not a meaningful predictor [β = -0.06, p = 0.77], that is, listeners do not rely on the onset pitch difference in differentiating HH from HL words. For the peakPitch predictor, it significantly predicted HH responses [β_{low} = -0.79, $p < 0.001$; β_{mid} = -0.45, p = 0.03]. Listeners heard less HH for the stimuli with low peak pitch (230 Hz) than high peak pitch (270 Hz); similarly, listeners also tended to hear less HH for the stimuli with mid Peak pitch (250 Hz) than high Peak pitch. The effect of the peakPitch predictor was not consistent with the reported acoustic pattern where the peak pitch values were not different between HH and HL accent words for the younger Kyungsang speakers; also, this was not consistent with the acoustic pattern known for the older generation because for older speakers' production HH words had lower peak values than HL words. Finally, male listeners were less likely to hear stimuli as the HH word than female listeners do. To summarize, the present observation indicated that the acoustic parameters contrasting the lexical pitch accent words were effective in the perception of the accent words, which is contrary to the production pattern (Lee & Jongman, 2015).

The inconsistency between production and perception means that while younger Kyungsang speakers' production targeted innovative phonetic forms for the two contrastive accents, the innovative target variants were not necessarily reflected in their perception. This comparison between the production and perception of the lexical pitch accent might suggest that it is premature to conclude the accent merger of the HH and HL classes as questioned by Lee *et al.* (2016), but rather the current status might suggest a false merger. There would be two possible ways to test the suggestion. First, it would be worthwhile examining the correlation between production and perception for the potential accent change. By testing the correspondence between production and perception based on the same speaker and listeners it could be answered if the on-going change indeed moves to the accent merger or near merger, or it is merely a false merger where phonemic contrast is not distinct only in the production but is distinct in the perception. Second, comparing younger listeners' perceptual pattern with older listeners' would also allow us to directly examine if younger listeners' use of the F0 timing cue is indeed innovative. If the way that younger listeners use the F0 timing cue is progressive, it might be said that the pitch accent shifts towards the accent merger starting from the production. This proposal is currently under investigation by this author.

Table 2. Estimates for predictors of the logistic mixed-effects models in analyzing HH responses by Peak and Onset pitch values and Step. R-style formular was [glmer(response) ~ (Step + onsetPitch + peakPitch +gender) + (Step + onset Pitch + peakPitch |subject)].

	Coef. β	SE(B)	z value	p value
(Intercept)	-0.69	0.28	-2.44	0.01
Step	1.89	0.55	3.42	0.00***
onsetPitchlow	-0.06	0.20	-0.29	0.77
peakPitchlow	-0.79	0.27	-2.97	0.00**
peakPitchmid	-0.45	0.21	-2.15	0.03*
gendermale	-0.84	0.42	-1.99	0.04*

3.2. Individual differences and correlations between perceptual patterns and AQ scores

This study examined if and how the AQ scores were correlated to the perceptual pattern. In other words, it was tested if each of the acoustic parameters is correlated with individuals' AQ scores, questioning if individuals' autistic-like traits are the source of individual difference in using perceptual cues. <Table 3> summarizes the descriptive AQ scores; along with the total AQ scores, five AQ sub-scores were presented between females and males. Overall, the pairwise sample *t*-test revealed that the total AQ scores were not significantly different between the two genders (p = 0.74), contrary to Baron-Cohen *et al*. (2001) where females reported lower AQ scores than males. But the small number of participants in the present study should be noted before assuring the gender effect on the AQ scores.

The multiple correlation tests were conducted based on the individuals' AQ total and sub-scores and random coefficients to each of the three acoustic parameters (i.e., Step, peakPitch, onsetPitch) within and across the genders. In <Figure 3>, individual coefficients estimated by random coefficients to the onsetPitch and peakPitch predictors indicated that some individuals relied more on the two acoustic cues (coefficients deviated from zero) than others (coefficients closed to zero).

Table 3. Descriptive statistics of measured AQ scores.

Factor	Gender	Mean	SD
Total AQ		18.15	5.2
	female (n = 10)	18.6	5.2
	male (n = 8)	17.7	5.3
Social Skills		2.25	1.75
	female (n = 10)	2.0	1.6
	male (n = 8)	2.5	1.9
Att. Switching		4.35	1.55
	female (n = 10)	4.3	1.8
	male (n = 8)	4.4	1.3
Att. to Detail		6.05	1.7
	female (n = 10)	6.6	2.0
	male (n = 8)	5.5	1.4
Communication		2.2	2.1
	female (n = 10)	2.0	1.7
	male (n = 8)	2.4	2.5
Imagination		3.35	1.7
	female (n = 10)	3.7	1.8
	male (n = 8)	3.0	1.6

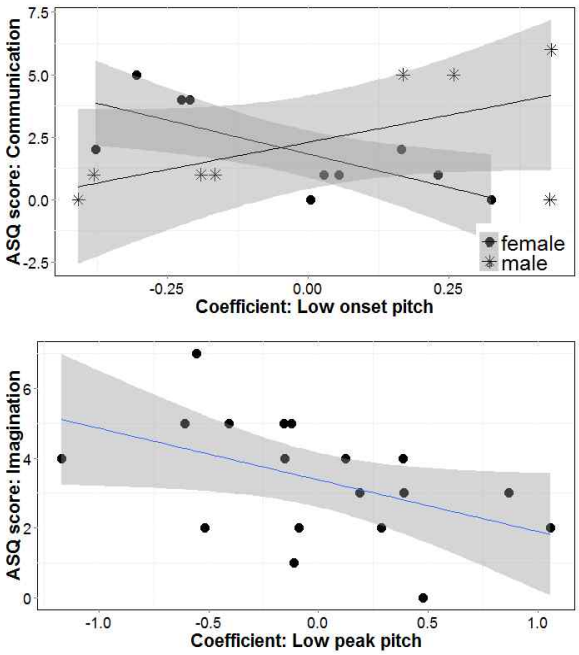

Figure 3. Correlations between individuals' coefficients and AQ scores.

The total AQ scores were not significantly correlated with any of the predictors estimated by random coefficients. This might suggest that the overall individuals' autistic-like traits are not an explanatory factor for individual variation in the perception of the lexical pitch accents. However, some sub-scores of the AQ were significantly correlated with individuals' coefficients, and the meaningful correlations were all in the negative direction. First, female listeners' coefficients for the onset pitch variable were negatively correlated with their AQ sub-score, communication; that is, female listeners who were less autistic in terms of the communication skill (i.e., better communication skill) tended to hear stimuli with the low pitch value as the HH word compared to more autistic-like female listeners [r (8) = -0.729, $p > 0.01$].

Second, listeners' coefficients across genders for the peakPitch predictor were also negatively correlated with the sub-score of imagination [r (16) = -0.47, $p = 0.048$]; listeners with lower imagination sub-score (better imagination) were more likely to respond HH words for the stimuli with low peak pitch.

Second, this study found correlations between sub-category AQ scores (communication, imagination) and individuals' use of two acoustic parameters (onsetPitch, peakPitch). Regarding the correlation between the AQ communication scores and onset pitch variables, more communicative female listeners were more likely to hear low onset pitch stimuli as HH words rather than HL words. A similarly meaningful correlation was observed between the AQ imagination scores and peak pitch variables; more imaginative listeners (across genders) tended to hear low peak pitch stimuli as HH words rather than HL. Recall that HH accent words have low onset/peak pitch compared to HL words, although the pitch distinction became smaller among the younger generation. Together, the correlations indicate that more communicative females and imaginative listeners (i.e., less autistic) tend to more effectively use the F0 scaling cues compared to the listeners with poor communication and imagination skills. Although the present study found the existence of correlation between individuals' perceptual pattern and their cognitive characteristics by the AQ scores, the direction of the correlation was opposite from the previous observation. While the previous studies reported that less autistic individuals exhibited more deviant percepts (Yu, 2010) or acoustic patterns (Kang *et al.*, 2015), the present results showed that less autistic individuals were more likely to rely on the conservative perceptual cues. Various factors might be related to the discrepancy between the previous and present findings. One possibility is the small number of participants in the present study; while Yu (2010) and Kang *et al.* (2015) observed 60 and 42 listeners, only 18 listeners participated in the present work. The fact that the presence of the correlation related to only the AQ subscores, but not the total AQ score might suggest that the 18 participants were not enough to reflect the overall spectrum of the population's AQ scores.

4. Conclusion

The present study investigated if the age variation of Kyungsang Korean's lexical pitch accent words was present in the perceptual pattern as well as the acoustic property. Then, it was tested if the listener variation was associated with individuals' AQ scores.

Overall, the present finding implied that perception might not pattern together with production in the context of sound change; listeners' perceptual pattern could not be innovative as much as their production pattern. In addition, this study provided evidence that individuals' perceptual variations might be explained by individuals' cognitive differences related to their autistic traits.

References

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The Autism-Spectrum Quotient (AQ): Evidence from Asperger Syndrome/high-functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders*, 31, 5-17.

Bonnel, A., Mottron, L., Peretz, I., Trudel, M., Gallun, E., & Bonnel, A.-M. (2003). Enhanced pitch sensitivity in individuals with autism: A signal detection analysis. *Journal of Cognitive Neuroscience*, 15, 226-235.

Eckert, P. (1989) The whole woman: Sex and gender differences in variation. *Language Variation and Change*, 1, 245-267.

Janse, E., & Jesse, A. (2014). Working memory affects older adults' use of context in spoken-word recognition. *The Quarterly Journal of Experimental Psychology*, 67(9), 1842-1862.

Kang, S., Kong, E., & Seo, M. (2015). Individual differences in autistic traits and variability in production patterns: A case of affricates by young Seoul Korean speakers. *Phonetics and Speech Sciences*, 7(1), 125-131.

Kenstowicz, M., & Park, C. (2006). Laryngeal features and tone in Kyungsang Korean: A phonetic study. *Studies in Phonetics, Phonology and Morphology*, 12, 247-264.

Kong, E., & Edwards, J. (2016) Individual differences in categorical perception of speech: Cue weighting and executive function. *Journal of Phonetics*, 59, 40-57.

Kong, E., Kang, S., & Seo, M. (2014). Gender difference in the affricate productions of young Seoul Korean speakers. *Journal of Acoustical Society of America Express Letters*, 136(4), 329-335.

Labov, W. (1990). The intersection of sex and social class in the

course of linguistic change. *Language Variation and Change*, 2, 205-254.
Labov, W. (2001). *Principles of Linguistic Changes: Social Factors*. Oxford: Blackwell.
Lee, H. (2008). *Pitch accent and its interaction with intonation: Experimental studies of North Kyeongsang Korean*. Ph.D. Dissertation, Cornell University.
Lee, H., & Jongman, A. (2015). Acoustic evidence for diachronic sound change in Korean prosody: A comparative study of the Seoul and South Kyungsang dialects. *Journal of Phonetics*, 50, 15-33.
Lee, H., & Kong, E. (2016). Relationship between individual traits and variability in processing Korean stops: Implication on mechanism of sound change. *Language & Linguistics*, 71, 215-236.
Lee, H., & Zhang, J. (2014). The nominal pitch accent system of South Kyungsang Korean. *Journal of East Asian Linguistics*, 23, 71-111.
Lee, H., Jongman, A., & Zhang, J. (2016). Variation and change in the nominal pitch-accent system of South Kyungsang Korean. *Phonology*, 33(2), 325-351.
Lee, K., & Ramsey, R. (2011). *A history of the Korean language*. Cambridge: Cambridge University Press.
Min, H. (1997). A Study on the Sociolinguistic Features of Men's and Women's Language in Korean. *The Sociolinguistic Journal of Korea*, 5(2), 529-587.
Mottron, L., Dawson, M., Soulie`res, I., Hubert, B., & Burack, J. (2006). Enhanced perceptual functioning in autism: An update, and eight principles of autistic perception. *Journal of Autism and Developmental Disorders*, 36, 27-43.
Ohala, J. (1993). The phonetics of sound change. In C. Jones (Ed.), *Historical Linguistics: Problems and Perspectives* (pp. 237-278). London: Longman Academic.
R Core Team (2015). R: A language and environment for statistical computing. Retrieved from https://www.R-project.org/ [R Foundation for Statistical Computing, Vienna, Austria] on April 1, 2015.
Robinson, E. B., Koenen, K. C., McCormick, M. C., Munir, K., Hallett, V., Happe`, F., Plomin, R., & Ronald, A. (2011). Evidence that autistic traits show the same etiology in the general population and at the quantitative extremes (5%, 2.5%, and 1%). *Archives of General Psychiatry*, 68(11), 1113-1121.
Stevens, M., & Harrington, J. (2014). The individual and the actuation of sound change. *Loquens*, 1(1), e003.
Stuart-Smith, J. (2007). Empirical evidence for gendered speech production: /s/ in Glaswegian. In J. Cole & J. Hualde (Eds.), *Laboratory Phonology 9* (pp. 65-86). New York: Mouton de Gruyter.
Wakabayashi, A., Baron-Cohen, S., Wheelwright, S., & Tojo, Y. (2006). The Autism-Spectrum Quotient (AQ) in Japan: A Cross-Cultural Comparison. *Journal of Autism and Developmental Disorders*, 36(2), 263-270.
Yu, A. (2010). Perceptual compensation is correlated with individuals' "autistic" traits: Implications for models of sound change. *PLoS ONE*, 5(8), e11950. Retrieved from https://doi.org/10.1371/journal.pone.0011950 on May 1, 2016.
Yu, A. (2016). Vowel-dependent variation in Cantonese /s/ from an individual-difference perspective. *Journal of the Acoustical Society of America*, 139(4), 1672-1690.
Yu, A., Grove, J., Martinović, M., & Sonderegger, M. (2011). Effects of working memory capacity and 'autistic' traits on phonotactic effects in speech perception. *Proceedings of the International Congress of the Phonetic Sciences XVII* (pp. 2236 – 2239). Hong Kong.
Yu, A., Abrego-Collier, C., & Sonderegger, M. (2013) Phonetic imitation from an individual-difference perspective: Subjective attitude, personality, and 'autistic' traits. *PLoS One*, 8(9), e74746.

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