AUTISM AND LEXICAL CONTEXT EFFECTS ON SPEECH PERCEPTION

Mitsuhiko Ota[1] *and Mary E. Stewart*[2]

[1] University of Edinburgh; [2] Heriot-Watt University
E-mail: mits@ling.ed.ac.uk, M.E.Stewart@hw.ac.uk

ABSTRACT

The view that weak central coherence in processing causes autism implies that individuals with autistic tendencies should exhibit attenuated lexical context effects on speech perception. To test this hypothesis, we examined the degree to which phonetic categorization shifts to make the percept a known word (i.e., the 'Ganong effect') in a neurotypical population with varying degrees of autistic traits. Fifty-five university students were given the Autism-Spectrum Quotient (AQ) and a segment identification test using two word-to-nonword VOT continua (*kiss-giss* and *gift-kift*). A significant negative correlation was found between the total AQ score and the identification shift that occurred between the continua. The AQ score did not correlate with scores on separately administered VOT discrimination, auditory lexical decision, or verbal IQ, ruling out enhanced auditory sensitivity, slower lexical access or higher intelligence as explanations of the AQ-related shift in phonetic categorization.

Keywords: autism, speech perception, lexical identification shift, VOT, autism spectrum quotient

1. INTRODUCTION

Autism Spectrum Disorder (ASD) represents a continuum or spectrum of disorders characterized by a distinctive triad of impairments in social, communicative, and imaginative activities [1]. A number of cognitive models have attempted to explain the profile associated with ASD. One theory, Weak Central Coherence (WCC) suggests that those with ASD have a style of processing which results in a weakening of the ability to integrate information into a meaningful whole or a 'gestalt', while the ability to focus on the detail is preserved or even enhanced [4]. Although it is generally acknowledged that WCC does not offer a straightforward explanation of the entire range of behaviors exhibited by individuals with autism, it does receive empirical support from a number of characteristics associated with ASD, including resilience to visual illusions induced by embedding [6], facility in visual segmentation [13] and high incidence of absolute pitch [9]. Similar tendencies have been reported in linguistic tasks, where autistic individuals tend not to employ semantic context to disambiguate homographs [7] or sentences [10].

Findings such as these suggest that people with autism may also display local-context dissociation in lower levels of linguistic processing such as speech perception. As the existing evidence indicates that the effects are most likely to occur in areas where semantic information offers a backdrop for processing, we have turned our attention to the influence of lexical knowledge on phonetic categorization.

Auditory speech perception is known to be affected by the lexical status of a phonetic sequence. In a seminal study, Ganong [5] demonstrated that listeners shift their segment identification along a VOT dimension to make the percept a real word rather than a nonword (e.g., *kiss* vs *giss*). This process can be seen as a form of central coherence in that the lexical context of the sound influences the perception of the auditory stimulus top-down. We thus predict that the effect will be reduced in people with autistic traits. In this study, we elected to test this hypothesis within neurotypical individuals, taking their Autism-Spectrum Quotient (AQ) [2] as a predictor variable. Our decision is justified by an auxiliary hypothesis of WCC which sees the balance between local and global (top-down) processing as a matter of style rather than deficit [8]. Under this conceptualization, the underlying mechanisms that relate weak central coherence with autism should hold within neurotypicals as well.

An attenuated lexical effect in phonetic processing may be caused by other characteristics held by high AQ individuals, however. First, it is possible that high AQ is linked to high auditory sensitivity, which may lead to robust phonetic discrimination abilities that are immune to lexical effects. There is currently no conclusive evidence in support of such auditory sensitivity in autism. But given our still poor understanding of the nature of sensory features in autism [12], we have opted to examine this possibility by testing our participants' phonetic discrimination ability.

Second, it may be the case that high AQ is connected to slower lexical access, which in turn reduces the effects of the lexical status of the phonetic stimuli. The language delay often observed in children with ASD suggests the possibility that the mechanisms underlying autism affect the ability to process words. To measure the effects of this extraneous factor, we also administered a lexical decision task.

Lastly, there is the possibility that the degree of lexical involvement in perception task may be influenced by the listeners' verbal intelligence, which can be linked to their metalinguistic awareness. Therefore, we have also attempted to examine the contribution of IQ, using the Mill Hill Vocabulary Scale [11] as an indicator of verbal intelligence.

In sum, the main purpose of this study was to test the hypothesis that individuals with high AQs tend not to be influenced by lexical contexts in their phonetic speech perception. A secondary purpose of the study was to check the potential contributions of factors that are extraneous to the integration of lexical knowledge and phonetic information.

2. METHOD

2.1. Participants and general procedure

Fifty-five undergraduate students at a British university, all native speakers of English, took part in the study as part of a psychology course. All participants were given an identification task with word-to-nonword continua, an ABX discrimination task with a nonword continuum, and the AQ test. Participants who could return for additional sessions were also given the Mill Hill Vocabulary Scale (MHV) test and a lexical decision task (N = 49). The AQ test and MHV were administered as pen-and-paper tests. The details of the other tasks are described below.

2.2. Word-nonword continuum identification

2.2.1. Material

Two word-to-nonword VOT continua were produced by digitally cross-splicing naturally spoken tokens of *gift* and *kift*, and *kiss* and *giss*, respectively. The original tokens were read by a male RP speaker, and recorded at a sampling rate of 48 kHz. The initial proportions of *kift* and *gift* were replaced by those of *kiss* and *giss*, respectively, such that the endpoint pairs were acoustically identical up to 100 ms after the onset. These tokens were cross-spliced to produce two equal-step 7-point continua ranging from *gift* to *kift* and from *giss* to *kiss*. The VOT step was approximately 9.46 ms with some minor adjustments made in order to enable splicing at zero-crossings. The VOTs of the stimuli are given in Table 1. The stimuli were down-sampled at 11 kHz before they were mounted on a stimulus presentation program (E-Prime).

Table 1: Stimuli for the identification task.

Stimuli	VOT (ms)
1	8.77
2	18.23
3	27.69
4	37.14
5	46.60
6	56.05
7	65.50

2.2.2. Procedure

The participants listened to the recorded stimuli played on a computer over headphones and pushed the *g* or *k* key to indicate their impression of the first segment of each stimulus. The session consisted of two blocks of trials. In each block, all 14 stimuli were presented 4 times in a random order. Each stimulus was therefore played 8 times (4 times x 2 blocks).

2.3. Nonword ABX discrimination

2.3.1. Material

A 9-step continuum was created using a Klatt synthesizer (SenSyn version 1.1). Each utterance was 250 ms long and had the same rise-fall F_0 contour. Amplitude of frication (AF) was set to 63 dB for 5 ms at oral release. Formant transition patterns were set to make the stimuli sound like utterances ranging from /gI/ to /kI/. F1 was set at

225 Hz at oral release, and then linearly ramped to the steady-state value of 400 Hz over 40 ms. F2 was ramped from 2500 Hz at release to 1900 Hz over 90 ms. F3 was ramped from 2600 Hz at release to 2800 Hz over 70ms. F4 was set to a constant 3250 Hz, and F5 to a constant 3700 Hz. VOT was varied from -10 to 70 ms in 10 ms steps by increasing the amplitude of voicing (AV) at the end of the aspiration interval from 0 to 64 dB, and by increasing the amplitude of aspiration from 0 to 60 dB and the bandwidth of the first formant (B1) from 60 to 400 Hz for the duration of the aspiration interval. The base stimuli were generated at 16-bit resolution and 11 kHz sampling rate.

ABX stimuli were created by concatenating two base stimuli 20 ms apart (e.g., 0 and 20 ms) with an inter-stimulus interval of 1s.

2.3.2. Procedure

The participants listened to the ABX stimuli played on a computer over headphones and pushed the *1* or *2* key to indicate whether the third sample was identical to the first or the second sample. The session consisted of two blocks of trials. In each block, all 4 permutations (i.e., ABA, ABB, BAA, BAB) of the 8 sets of ABX stimuli were presented once in a random order. Each VOT step was therefore tested 8 times (4 times x 2 blocks).

2.4. Auditory lexical decision

The stimuli were 48 recorded tokens of real words and nonwords read by a male RP speaker. Half the tokens were experimental items designed to be similar to the word-nonword pairs in the identification task. They were all monosyllabic words with an initial stop onset, with the real word members matched for frequency with *gift* and *kiss* based on lemma counts in the British National Corpus [3]. The place of articulation ([p/b], [t/d], [k/g]) and the voice/voiceless direction with respect to the word-nonword status were controlled for. All experimental items are given in Table 2. The other 24 tokens were fillers, half of which were real words (e.g., *lift, cheese, brown*) and the other half nonwords (e.g., *ninch, rop, twale*).

Table 2: Experimental items for the auditory lexical decision task

Real word	Nonword
Pink	Bink
Pool	Bool
Bag	Pag
Boat	Poat
Tooth	Dooth
Tape	Dape
Depth	Tepth
Deep	Teep
Count	Gount
Cake	Gake
Gas	Kas
Golf	Colf

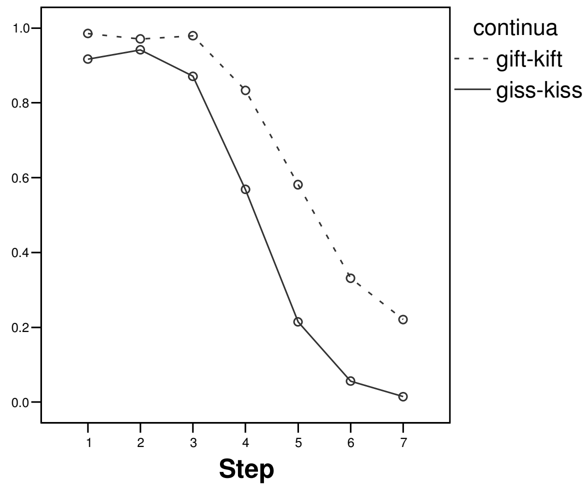
3. Results

Results of a repeated measures ANOVA on the mean proportion of ‘g’ responses in the identification task showed a significant main effect of continuum, as well as a main effect of step and an interaction between the two sources (see Table 3). As illustrated by Figure 1, the proportion of ‘g’ response was higher in the *gift-kift* continuum than in the *giss-kiss* continuum.

Table 3: Sources of variance due to continua (*gift-kift* vs. *giss-kiss*) and steps

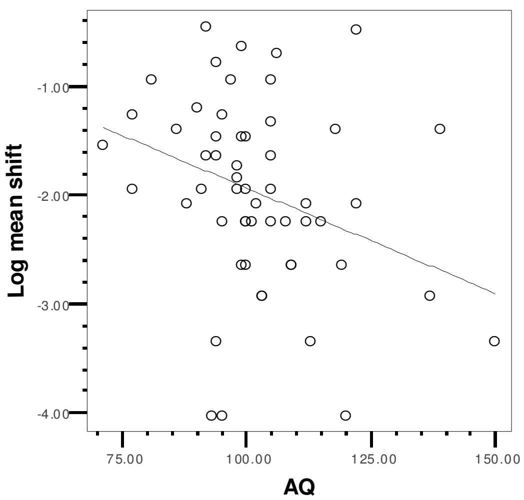
SOURCE	df	MS	F	p
Continuum	1	7.453	91.87	.000
Step	6	16.08	441.15	.000
Continuum x Step	6	0.457	21.52	.000

Figure 1: Mean proportion of ‘g’ responses



A significant correlation was found between the overall AQ score on a Likert scale and the mean identification shift between the two continua (log transformed) [r_s = -.317, N = 55, p = .018]. Figure 2 illustrates this relationship. Further analyses showed that the 'Attention switching' component of the AQ test correlated significantly with identification shift [r_s = -.270, N = 55, p = .040]. Correlation between the 'Social skills' component of the AQ test and identification shift approached significance [r_s = -.258, N = 55, p = .053]. On the other hand, no significant correlation was found between AQ and the Mill Hill Vocabulary score, the discrimination score (proportion of accurate responses), or the accuracy and reaction time in the lexical decision task. None of these variables showed a significant correlation with identification shift either.

Figure 2: AQ Likert total and log identification shift.



4. Discussion

Although most participants shifted their phonetic categorization to make the stimulus a real word, the effect was negatively correlated with the total AQ scores of the participants, supporting our hypothesis that individuals with autistic traits are less likely to be affected by lexical knowledge in their phonetic perception. Neither identification shift nor AQ correlated with the participants' phonetic discrimination, lexical decision or Mill Hill vocabulary score. This indicates that the connection between AQ and identification shift is not mediated by enhanced auditory sensitivity, slower lexical access or higher verbal intelligence. The results are thus consistent with the interpretation that the locus of the AQ-related effect is in the integration of acoustic and lexical information in phonetic processing.

Since the participants in this study were neurotypicals, whether the finding translates to more apparent cases of autism remains an empirical question. However, the fact that we see a connection between phonetic processing and traits relating to autism in such a cognitively and socially homogeneous population strongly suggests that a similar but more substantial effect would be found between neurotypicals and people with ASD. As such, the results of our study provide sufficient impetus to investigate further the link between language and auditory processing in autism.

5. REFERENCES

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