Acoustic Change Complex (ACC) in Children with Selective Auditory Attention Deficit

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Abstract

Background: Selective auditory attention (SAA) refers to the ability to acknowledge some stimuli while ignoring others that occur at the same time. Cortical auditory evoked potentials (CAEPs) reflect the neural detection and/ or discrimination of sound underlying speech perception. When obtained in response to a stimulus changes such as speech, the resulting waveform is referred to as the acoustic change complex (ACC).

Objectives: To assess children with SAA disorders using ACC potential and to evaluate the clinical use of (ACC) as an objective tool for assessment of speech in noise ability

Methods: ACC was recorded in 30 normal hearing children ranging in age from 5 to 13 years and 15 children with SAA deficit ranging in age from 6 to 14 years. Stimuli used were vowel /o/ in presence of pink noise, presented at 80 dBnHL at different SNRs (+8, +4.0, - 4, - 8). ACC response parameters were studied and compared to Words In Noise test results.

Results: Onset response (P1 and N2) was recorded in all children, while ACC response (ACC P1 and ACC N2) was recorded in all normal children and two children with SAA in +8 SNR only with significant decrease in ACC percent identification as noise increased. There was a significant increased latency and decreased amplitude as SNR decreased in both Onset and ACC responses.

Conclusions: ACC can be elicited in the majority of young children evaluated especially using SNR +8, +4& 0. It can be used to evaluate young children who cannot be behaviorally assessed. However, since there is not a response elicited in children with SAA deficit, further research is needed using higher SNRs to study the relationship between behavioral and electrophysiological methodologies.

Keywords: Cortical auditory evoked potentials, acoustic change complex, selective auditory attention, speech in noise.

دراسة مركب التغيير الصوتى فى الأطفال المصابين بخلل فى الانتباه السمعى الاختيارى

يعرف الانتباه السمعى الانتقائى بأنه الإنصات لبعض المنبهات مع تجاهل المنبهات الأخرى التى تحدث فى نفس الوقت. ونظرا لأن صعوبة الفهم فى وجود ضجيج فى الخلفية مشكلة شائعة، وتصبح هذه الصعوبة الإدراكية شديدة بشكل متزايد مع زيادة مستويات الضوضاء الخلفية المتنافسة بمعنى أن نسبة الإشارة إلى الضوضاء تنخفض، وعادة ما تضعف الاستجابات العصبية عند زيادة مستويات الضوضاء؛ لذلك فإن هناك ارتباطات قوية بين إمكانات السمع المستحثة القشرية وتدابير إدراك الكلام فى الضوضاء. وتمثل القدرات القشرية السمعية المحفزة مجموعة من النشاط العصبى الموجود فى القشرة السمعية كاستجابة للأصوات. ويعتقد أن قمم المركب تعكس النشاط العصبى للنظام السمعى المركزى استجابة للخصائص الطيفية والزمنية لمحفز معين. ويمكن قياس القدرة التمييزية من خلال تعديل المنهجية التقليدية لتسجيل P1N1P2؛ وعندما يتم الحصول عليها استجابة للتغير الصوتى داخل الصوت، أو استجابة للتحفيز الذى يحتوى على تغييرات صوتية متغيرة بمرور الوقت مثل الكلام، يعرف شكل الموجة الناتج باسم مركب التغيير الصوتي.

كانت هذه الدراسة مصممة لتقييم إمكانية استخدام مركب التغيير الصوتى (التى أثارتها محفزات مصممة خصيصا للكلام فى الضوضاء) كأداة موضوعية لتقييم التمييز السمعى القشرى لدى الأفراد الطبيعين، وتقديم بروتوكول مركب التغيير الصوتى فى الأطفال المصابين بخلل فى الانتباه السمعى الاختيارى من أجل تقييم صلاحيته.

كونت هذه الدراسة من مجموعتين، مجموعة التحكم وتتكون من ٣٠ طفل طبيعى تراوح اعمارهم بين ٥ الى ١٣ سنة ومجموعة الدراسة وتتكون من ١٥ طفل مصاب بخلل فى الانتباه السمعى الاختيارى.

وأوضحت هذه الدراسة إمكانية تسجيل استجابة مركب التغيير الصوتى فى جميع الاطفال الطبيعية وعدم تسجيله فى الاطفال المصابة بخلل فى الانتباه السمعى ماعدا طفلين تم تسجيله فى نسبة الاشارة الى الضوضاء +٨ فقط.

وقد يثمر عمل المزيد من الأبحاث باستخدام نسب إشارة الى الضوضاء أعلى من +٨ التى يمكنها اثارة مركب التغيير الصوتى بنسبة أعلى فى الأطفال المصابيين بخلل فى الانتباه السمعى.

Introduction:

Selective auditory attention (SAA) is defined as the ability to acknowledge some stimuli while ignoring other stimuli that occur at the same time. In other words, it is the action in which people focus their attention on a specific source of a sound. (Acoustical Society of America, 2013).

Difficulty in understanding speech in the presence of background noise is a commonly reported problem especially in children and becomes more severe as competing background noise levels increase (i.e., signal to noise ratio (SNR) decreases). This problem is obvious at classrooms as children spend much of their time in noisy classroom environments where they are expected to listen and learn. (Sperling et.al, 2005)

Compared to behavioral tasks as (speech in noise test), many electrophysiological measures do not require active participation from listeners and can be reliably recorded from infants and very young children (Hillyard& Picton, 1978)

The CAEPs are brain responses evoked by sound and are processed in or near the auditory cortex (Van Dun et.al., 2012). These measures include obligatory cortical response such as P1- N1- P2 complex (onset response), and discriminative potentials such as mismatch negativity (MMN), P300 and ACC (Kim, 2015).

The neural processing underlying behavioral discrimination capacity can be measured by modifying the traditional methodology for recording the P1- N1- P2. When obtained in response to an acoustic change within a sound or in response to stimulus that contains multiple time- varying acoustic changes such as speech, the resulting waveform has been referred to as the acoustic change complex (ACC) (Martin et.al., 1999).

The ACC has been obtained in response to intensity, frequency, and phase modulations in speech and non- speech stimuli (Tremblay et.al., 2003).

There is growing interest in the use of more complex multiple- onset speech stimuli (rather than single- onset tones or speech sounds) to evoke CAEPs that may be more representative of everyday speech.

Many studies were done in adults and to lesser extent in young children to recorded CAEPs in noise. CAEP peaks recorded from speech sound onset are generally reduced in amplitude and delayed in latency for adults (Billings et.al., 2013; Small et.al., 2018; Anderson et.al., 2010; Cunningham et.al., 2001). Only two researches recorded ACC in noise in normal hearing adults (Billings et.al., 2017; Brint et.al., 2017).

Objectives:

To assess if that ACC provoked by specifically designed speech in noise stimuli can be used as an objective tool for assessment of cortical auditory discrimination in normal individuals. Second aim is to apply the developed ACC protocol in children with SAA deficit in order to assess its validity.

Subjects And Methods:

The present study comprised 30 normal hearing children (Control group) and 15 children with selective auditory attention (SAA) deficit (Study goup) selected according to following criteria: Age ranged from 4 to 14 years old, Normal hearing sensitivity and normal middle ear function, No history of neurological disorders nor mental subnormality, No history of recurrent otitis media with effusion, Normal scores in behavioral word- in- noise perception test (WIN test) according to their age in normal children (control group) and abnormal scores in children with SAA (study group), Co- operative child from whom reliable hearing threshold can be obtained. Children were selected from subjects who attend at El- Demerdash clinic in the last two years. A verbal consent was obtained from the subjects' parents prior to contribution in the study.

Equipment:

Audacity software version 2.1.3 1999- 2017, mounted on a laptop for recording and editing of stimuli used in AEP recording. Two- channel audiometer model Grason- Stadler Inc (GSI) model 61 connected to a laptop, model hp with CD player. Immittancemeter Grason- Stadler Inc GSI, model 33 (manufactured in USA). Sound treated room IAC model 1602. Bio- logic Navigator Pro Auditory Evoked Potential (AEP) System (version 7.0.0) connected to a loudspeaker

Development of Stimuli for ACC: All stimuli were recorded and/or edited using the Audacity software program version 2.1.3. The total duration of the stimuli was 500 msec. in order to conform to the technical specs of the Biologic Navigator Pro AEP system. The following stimuli were used:

1. Stimulus with No- Change: vowel /o/ and its duration 500 msec.
2. Stimuli With Change: Speech stimulus (vowel /o/, its duration 300 mesc) in presence of noise (pink noise, its duration 500 msec) presented at 80 dBnHL at different signal to noise ratio (+8,+4.0,- 4,-8) The vowel /o/ presented at 200 msec from the beginning of the stimulus. then They merged together.

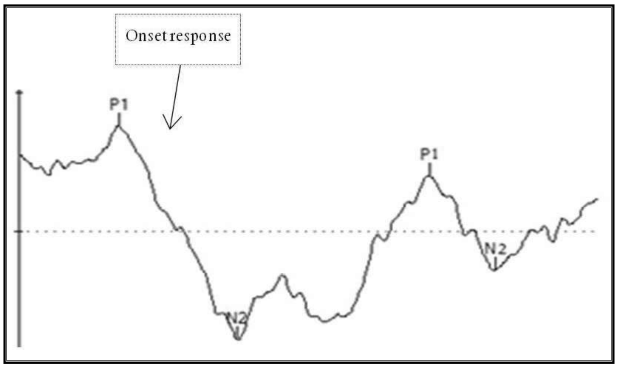
Statistical Procedures:

The collected data was revised, coded, tabulated and introduced to a PC using Statistical package for Social Science (SPSS 15.0 for windows; SPSS Inc, Chicago, IL, 2001). Data was presented and suitable analysis was done according to the type of data obtained for each parameter. Descriptive statistics: Mean, Standard deviation (± SD), for numerical data, Frequency for non- numerical data. Analytical statistics: A comparison between ACC response and onset response was done to show how deviant the ACC response was from the onset response, using Mann-Whitney test& Independent- Samples test. Effect of magnitude of change on ACC was studied in stimuli used One- Way ANOVA test. P value <0.05 was considered statistically significant.

Results:

The results of the present study are shown in the following tables

- Onset response response parameters in control and study group: Onset response was identified in all children of the two groups using both vowel /o/ and vowel /o/ in noise at all Signal- Noise Ratios (SNRs) used in the study. Onset waves: P1 was defined as the first robust positivity in the waveform followed by negative wave N2



Tables (1) show comparison between control and study groups with the effect of change of SNR on Onset P1 latency and amplitude. P1 latency significantly increased as SNR decreased in control group with no special pattern in study group, however latencies were longer in the study group, while P1 amplitude non- significantly decreased in both groups as SNR decreased but larger in the study group.

Table (1) Comparison between control& study groups as regards P1 latency and amplitude using vowel /o/ and vowel /o/ in noise

Stimuli			Mean	+/- Sd	Z Or T	P Value	Sig.
P1 Latency (Msec.)	Vowel	Control Group	116.1	23.6	2.85	0.004	HS
		Study Group	138.3	22.4			
	Snr +8	Control Group	95.3	14.5	3.03	0.003	HS
		Study Group	135.9	45.4			
	SNR0	Control Group	104.6	17.9	3.70	<0.001	HS
		Study Group	131.2	19.8			
	Snr- 8	Control Group	108.0	20.4	2.63	0.012	S
		Study Group	128.6	32.0			
P1 Amplitude (Mv)	Vowel	Control Group	5.3	2.7	0.09	0.931	NS
		Study Group	5.4	1.8			
	Snr +8	Control Group	6.5	2.4	0.67	0.507	NS
		Study Group	7.0	2.7			
	SNR0	Control Group	5.2	2.5	1.51	0.138	NS
		Study Group	6.5	3.0			
	Snr- 8	Control Group	4.1	2.0	1.91	0.062	NS
		Study Group	5.3	2.0			

Mann-Whitney Test& Independent Samples t Test

¤ Acc Response Parameters: ACC response was elicited in 100% of control group at SNRs (+8, +4 and 0). It elicited in 70% in control in SNR- 8: No comparison was done between two groups as it was not elicited in the study group. ACC waves were defined as typical shape of first wave (P1& N2) after it by 200 msec

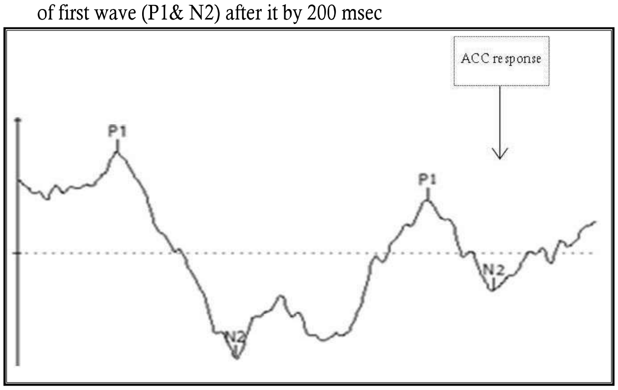


Table (2) shows effect of change of SNR on ACC P1 latency and amplitude using One- Way ANOVA test in control group. There was a significant increased latency and non significant decreased amplitude as SNR decreased

Table (2) Effect of change of SNR on ACC P1 latency and amplitude in control group using One- Way ANOVA test

Stimuli	ACC P1 Latency (Msec.)				ACC P1 amplitude (µV)			
	Mean ±SD	F Value	P Value	Sig	Mean ±SD	F Value	P Value	Sig
Snr +8	107.7±15.0				3.7±2.2			
Snr +4	118.9±18.6				3.2±1.7			
SNR0	118.6±17.5	3.08	0.018	S	3.6±2.3	9.03	0.060	NS
Snr- 4	119.6±17.1				2.7±1.7			
Snr- 8	122.4±16.3				2.2±1.3			

N.B: There is No ACC in the study group except in two children in SNR +8 only

¤ Behavioral test word- in- noise (WIN) test: Word in Noise test was done for all subjects showing significant decreased scores with decreased SNRs in both groups, with abnormal scores for all study group as compared to the normative data done

Table (3) Comparison between control& study regards WIN test In Different Snrs

Stimuli		Win%				
		Mean	SD	Z Or T	P Value	Sig.
Snr +8	Control Group	93.3	3.5	5.51	<0.001	HS
	Study Group	61.9	13.0			
Snr +4	Control Group	91.3	3.5	5.54	<0.001	HS
	Study Group	54.7	14.6			
SNR0	Control Group	88.8	3.2	5.56	<0.001	HS
	Study Group	47.7	16.2			
Snr- 4	Control Group	65.8	10.0	5.44	<0.001	HS
	Study Group	33.1	15.2			
Snr- 8	Control Group	57.4	9.2	5.56	<0.001	HS
	Study Group	13.1	7.3			

Discussion:

The present study is a case control study designed to evaluate the clinical use of Acoustic Change Complex (ACC) stimuli at different signal to noise ratios (SNRs) as an objective tool for assessment of speech in noise ability. The second aim was to apply the developed ACC protocol in children with SAA deficit in order to assess its validity in diagnosis.

Onset response was identified in all children in the two groups at different SNRs.

According to comparison between study and control groups (table 1), onset P1 latency was prolonged in study group than control group. It was noted that P1 amplitude in the study group larger than the control group and this may be due to greater neural effort to facilitate the sound segregation process.

Anderson et.al. (2010) recorded cortical responses to the speech syllable /da/ in quiet and multi- talker babble noise in 32 children and reported reduction of P1 amplitude across both bottom and top speech in noise (SIN) groups. They also found that N2 amplitude was larger in the bottom SIN perceivers than the top SIN perceivers as the addition of babble noise results in an apparent increase in neural activity or effort, even when children are not attending to the stimulus

In the present study in control group, P1 and N2 latencies increased and P1 amplitude decreased as SNRs decreases without affection of N2 amplitude. These results are similar to the previous studies that reported that in presence of background noise CAEP peaks recorded from speech sound onset are generally reduced in amplitude and delayed in latency

(Anderson et.al., 2010; Small et.al., 2018) but this pattern was not obvious in study group as in control group.

ACC response was detected in the control group and 2 children of study group in SNR +8 only. It was elicited in 100% of children at SNRs +8, +4 and 0 and in 70% in SNR- 8. Compared to other researchers, no similar research was done on children using different SNRs to elicit ACC.

Table (2) showed that ACC P1 latency increased and ACC P1 amplitude decreased as SNR decreased Billings et.al. (2017) also reported that as SNR decreased, peak latencies increased and amplitudes decreased. This may be result from the masking effect of the background noise. Brint et.al. (2017) who recorded ACC by using four vowels (/ɑ/, /i/, /ɔ/, /u/) and four fricatives (/ʃ/, /s/, /v/, /z/) with speech- shaped noise added at +4 dB SNR or- 3 dB SNR, found also that as the SNR decreased, the ACC amplitude of the response decreased and the latencies increased. However, no similar research was done on children using different SNRs to elicit ACC

Word in Noise test table (3) was done for all subjects showing decreased scores as noise increased in both groups which could be attributed to the masking effect of noise with abnormal scores for all study group as compared to the normative data done.

Similar results were obtained by Anderson et.al. (2010) who tested 32 normal children with a /da/ stimulus, and compared HINT (Hearing in Noise Test) scores to P1- N1- P2- N2 response characteristics. They found that those who performed worse on the HINT task had a larger N2 onset response than those who performed well and this suggest that those who done well may be recruiting fewer neural resources due to greater neural efficiency.

Conclusion& Recommendations:

- ACC is a good electrophysiological tool for cortical auditory discrimination.
- It is better to use (0 SNR) in screening or evaluation of young children who are suspected to have selective auditory deficit, or who cannot be assessed behaviorally due to age or language limitations
- ACC P1 latency and amplitude is a better indicator of cortical discrimination compared to ACC N2 latency and amplitude because it is consistently affected by magnitude of change.
- Further research is needed to study correlation between ACC and behavioral tests. It is also recommended to use higher SNRs than +8 that could elicit ACC with higher percent detectability in children with SAA deficit.

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