Psychophysiological research on healthy children and adolescents, and those with developmental disabilities and disorders: A review

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Abstract

Aim: With this review, I aim to provide psychophysiological research on healthy children and adolescents, and those with developmental disabilities and disorders. Method: A literature was conducted study design (EEG, electro-dermal activity, ECG), and developmental disabilities and disorders were collected. The EEG recording was carried out during the waking subjects sitting with eyes closed. The procedure of electro-dermal activity and ECG included baseline recording, a passive listening task, instruction, and simple and discriminative active-listening tasks. Result: EEG research on healthy children has shown that approximately 10 years old is a critical age for developmental transition of EEG spectra to alpha frequency. The delay of this critical age in children with developmental disabilities was found. In electro-dermal activity, the younger healthy children exhibited significantly larger habituation than the older children. Hyperactive preschool and school children exhibited to have shorter attention spans. ADHD subjects showed less respiratory sinus arrhythmia than healthy children. High HR before episodes of stereotyped behavior significantly decreased or tended decrease compared that after episodes of the stereotyped behavior in ASDs. They, moreover, showed that the low HR before episodes of stereotyped behavior significantly increased or tended to increase compared that after episodes of the stereotyped behavior. For children with DS had lack of excise, HR variability of the children decreased in school environment. Interpretation: Not withstanding varying etiologies and varying degrees of retardation of these studies, many findings were presented. The significance of psychophysiological study should be noticed, at least, in the people with developmental disabilities and disorders.

Key word: psychophysiological research, healthy children and adolescents, those with developmental disabilities and disorders, a review

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I Introduction:

1. Electroencephalogram (EEG)

It has, recently, been reported that different resting state EEG features in children from Switzerland and Saudi Arabia were studied[1]. The authors identified many similarities, some substantial difference with respect to the resting state EEG data. It has, moreover, been to investigate EEG dynamics using complexity analysis in children with attention deficit hyperactivity disorder (ADHD) compared with healthy children when performing a cognitive task[37]. The mean Lempel-Ziv complexity of ADHD children was significantly larger than healthy children over the right anterior and right posterior regions during the cognitive performance. It has, moreover, been proposed calculating the Renyi entropy of eigenvalues derived from the signal correlation matrix to measure the global synchronization in multichannel EEG from 16 children with autism spectrum disorder (ASD) and 16 sex-matched healthy controls at the resting state[9]. The results indicate that there is a significantly diminished global synchronization from ASD to healthy control. It has, moreover, been reported to study peculiarities of brain functioning in children with adolescence idiopathic scoliosis (AIS) according to EEG studies[17]. Data obtained suggest that brain structures play a much more important role in etiology and pathogenesis of AIS right-side forms compared with left-side one. However, systematic studies were a few for developmental characteristics, developmental process, and chronological changes in persons with Down syndrome (DS).

EEG research on healthy children has shown that approximately 10 years old is a critical age for developmental transition of EEG spectra to alpha frequncies[11,12]. However, few of the studies of developmental disabilities have clarified such a critical age for EEG transition to alpha band. The author expected the delay of this critical age in children with developmental disabilities beyond the age for healthy children. In this review, transition of EEG spectra in children with developmental disabilities was examined with a focus on transition to alpha frequencies.

2. Electro-dermal activity

2.1 Healthy preschool children: It is widely accepted that younger preschool children have shorter attention spans than older preschool children. Preschool children attend to stimulation both passively and actively. A measure of attention, amplitude of electro-dermal response to stimulation, is larger during attention. As for the attention of normal healthy school children, electro-dermal activity during stimulation has been studied in control groups and groups of hyperactive [27] and autistics [6] school children. In these studies, however, little attention has been paid to healthy preschool children. In the present review, the author studied the electro-dermal activity during passive and active listening attention by preschool children, and the correlation between electro-dermal activity and age was examined.

2.2 Hyperactive preschool children: Attention is a state in which preschool children attend to stimulation not only passively but also actively. Amplitude of electro-dermal response to stimulation is larger during the attention to a task than during a non-attended condition[19]. As for

the attention of healthy preschool children, passive and active responsiveness to simple stimulation have been investigated using electro-dermal activity[19]. However, in such study little attention has been paid to hyperactive preschool children. There are few reports, for example, on attention by hyperactive preschool children. In the review author studied the electro-dermal activity during passive and active listening by the hyperactive preschool children.

2.3 Temporal variation: The skin conductance response (SCR) is not simply a measure of reactivity but also an index of the attention process. It is assumed that the temporal variations of the SCR are correlated with attention[20]. In the present review, author studied the temporal variation of the SCR during passive and active attention of preschool children while they are listening. The author, moreover, indicated how the temporal variation of the SCR during active and passive listening tasks relates to the level of attention of preschool children.

2.4 Healthy school children; It is widely accepted that younger school children have shorter attention spans than their older schoolmates. According to complains of school teachers, the younger child is characterized by poor concentration, short attention span, and low frustration tolerance. These attention problems of the younger child disappear with normal (cognitive) development. No studies, however, have investigated these problems of attention in terms of age, school and home environment, and parental education.

In the present review the author studied SCR during passive and active attention by healthy school children while they were listening. The author also indicated the level of attention as measured by the SCR in young school children. The author wished to be able to tell whether a particular child was attending to a teacher or not, using the SCR measure.

2.5 School children with ADHD; ADHD in children is one of the most extensively studied childhood psychiatric disorders. Such children are characterized by problems of sustaining attention, inhibiting impulsive responses, and modulating activity. In addition, there are a number of problems associated with this disorder, including learning difficulties, disordered peer relations, and aggressive and non-compliant behavior.

The study of attention is classified into the three categories of selective function, vigilance, and allocation of attentional processing resources. The mechanism of the central nervous system which controls electro-dermal activity is based on the nervous control of the sweat gland. Although attention can be readily observed behaviorally, certain manifestations cannot be visually identified so easily.

In the present review the author studied the SCR during passive and active attention by ADHD children while they were listening to tones. The author assessed attention as measured by this response for we wished to be able to tell whether a particular child was attending to a teacher or not, using the measure.

2.6 Age difference; One of the most widely used physiological measures of arousal and an increasing popular index of attentions is electro-dermal activity. There has been little evidence that younger children were responsive than older children in response to stimulus termination during habituation trials.

Electro-dermal activity during stimulation has been studied in healthy school children[26] and in groups of hyperactive[27] school children. In these studies, however, little attention has been paid to healthy preschool children. Moreover, no systematic study of preschool and primary school children and adults has been undertaken using electro-dermal activity during stimulation. Although attention can be readily observed behaviorally, certain manifestations cannot be visually identified so easily.

In the present review, the author investigated the age-related effects of SCR during passive and active attention by children in nursery and primary school as well as by university students while they were listening to tones. The predictions were threefold. First, the author expected that there would be an increase in SCR amplitude of the younger children. Second, the author expected that there would be higher mean SCR amplitude during the active than during the passive task. Third, the author expected that, on the passive task, when presenting the same stimulus continuously, a tendency toward a decrease in SCR amplitude would occur.

3 Heart rate (HR)

3.1 Respiratory sinus arrhythmia (RSA) in children with ADHD: It has been reported that the specific type of baseline HR variability related to infant's attentional response is RSA in HR[4,21]. Compared to infants with low baseline RSA, infants with high baseline RSA show larger and more sustained HR responses during sustained attention [4,21]. Infants' magnitude of baseline RSA is positively correlated with visual recognition scores and HR responses during visual habituation[19].

Assessment of autonomic function in humans by HR spectral analysis has been reported[20]. Low-frequency fluctuations are increased by standing and are jointly mediated by the sympathetic and parasympathetic nervous systems. Higher frequency fluctuation is decreased by standing analysis of hemodynamic variables may provide a very powerful technique for assessing cardiovascular regulation in health and disease.

In the present review the author investigated the relationship between baseline RSA and HR response during passive and active attention by ADHD children while they were listening to tones. The prediction was that ADHD children showed less RSA than healthy children but were similarly responsive to tone stimuli.

3.2 Children with ASD: ASD had been identified on the basis of a multidisciplinary may diagnosis by a pediatrician, each of whom independently applied DSM-V standards (APA)[2]. A diagnosed symptom in these standards was stereotyped behavior. ASD do the stereotyped behavior without object or aim. The stereotyped behavior did, moreover, repeatedly and could see by the study of the stereotyped behavior. The study reported that stereotyped behavior decrease HR. The study, moreover, reported that the level of stereotyped behavior is related to a chronically level of arousal. Stereotyped behavior may serve to maintain arousal within acceptable limits. The author can often see the behavior in children with ASD. It was included scream, finger jigging, hold his and her eye.

Sugita, Era and Oota[35] found the relationship between the stereotyped behavior and the arousal in the children with ASD. They described the arousal hypothesis of autism regulation for

understanding the stereotyped behavior. By the hypothesis the organism have the regulation of the arousal for making best condition to the external stimulation. As for the children with ASD over and none response to external stimulation were found, because their arousal regulation was not work. The stereotyped behavior of children with ASD might make the best condition of arousal regulation to the external simulation. It was considered that they used the stereotyped behavior for the arousal regulation.

The prediction was the following. The author expected that a decrease in the HR appear when arousal is higher. But, an increase in the HR appears when arousal is lower. In observing the stereotyped behavior of school children with ASD, some teachers check for distraction of stereotyped behavior, short of long duration span of stereotyped behavior. These manifestations of stereotyped behavior impairment can be observed behaviorally. There is, however, a manifestation that cannot be visually grasped so easily,

In the present review the author reported a single-subject design study investing the HR of three children with ASD before and after episodes of stereotyped behavior in school environment. The author, moreover, studied arousal hypothesis of the stereotyped behavior in children with ASD.

3.3 A child with DS: Physical fitness is related to health at all ages. Information about physical fitness in DS, however, is scare, especially when the author considers children[5,7,36]. The paucity of studies and their conflicting findings prevent a clear understanding and substantiation of limitations on their physical activity[10,18]. It is too difficult that the author can found when lack of the excise happen. The author, however, thought that the HR variability of the subjects was investigated in the school environment, because the lack of the excise often happened.

The prediction was the following. The author expected that the increase in the HR appears when activity is higher. But, the decrease in the HR appears when activity is lower. For children with DS has lack of excise, HR variabilities of the children decrease in school environment. In observing the lack of the excise of school children with DS, some teachers check for distraction of the lack of the excise, short or long duration span of the lack of excise. These manifestations of the lack of the excise can be observed behaviorally. There is, however, a manifestation that cannot be visually grasped so easily.

In the present review the author reported a single-subject design study investing the HR of a child with DS lacking of excise and a child with developmental disabilities in school class environment. The author, moreover, studied the prediction that the increase in HR appears when activity in higher. But, the decrease in the HR appears when activity is lower. For children with DS has lack of excise[15,16], HR variability of the children decrease in school environment.

To summarize, with this review I aim to provide psychophysiological study on healthy children and adolescents, and those with developmental disabilities and disorders.

II Method

1 Material

A literature search was conducted using the electronic databases EDS. The publications of Shibagaki et al and Katada et al were, moreover, selected.

The definition of developmental disabilities is primarily a legislative and legal definition, with several criteria stipulated by institutes, organizations, or associations (e.g. the American and Japanese Association on Intellectual and Developmental Disabilities). The definition of ADHD and ASD of developmental disorders is APA[15].

They were 265 persons with DS, 242 with non-DS mentally retardation (MR) and 239 healthy persons, were selected for the study [11,12,13]. They were, moreover, 14 children with developmental disabilities (from 7 yr. and 3 mo. to 16 yr. and 1 mo. of age)[30,31]. They were, moreover, 21 girls and 15 boys with developmental disabilities, whose ages ranged from 3 mo. to 7 yr.[22]. They were, moreover, 43 healthy preschool children (aged 4 yr., 8 mo. to 6 yr., 5 mo.)[24]. Subjects were, moreover, included 4 preschool ADHD children (from 3 yr., 9 mo. to 6 yr., 2 mo.)[23]. Subjects were, moreover, 49 healthy school children (aged 6 yr., 8 mo. to 12 yr., 4 mo.) (17 girls and 32 boys)[26]. They were, moreover, 18 ADHD school children (aged 6 yr., 4 mo. to 12yr., 9 mo.)[27]. Subjects were, moreover, 38 university students (aged 19 yr., 4 mo. to 23 yr., 9 mo.)[28]. Subjects were, moreover, included three children with ASD (11yr., 12yr. and 15yr.)[32,33], and a child with DS (12yr.)[34].

2 Procedure

EEGs were recorded in the waking subjects sitting with eyes closed in easy chair in a sound-proof, electrically shield dark room[11,12,13]. Electrodes were located in the frontal, central, parietal and occipital regions along the midline, in the left and right temporal regions, and on both earlobes linked bilaterally as a reference. The bipolar and monopolar EEG recording were, moreover, obtained from electrodes attached to the scalp and earlobe. The recording was always done while the child's eyes were closed[11,12]. EEG recording was performed once a year between April and July for two or four years[30,31]. The first recording of each subject was made from 7 yr. 16 yr.. EEG samples were taken while resting in the arousal state.

Electro-dermal activity recording were carried out in a quiet, familiar sound-attenuated room during the morning[23,24]. Preschool children generally feel uneasy and afraid of recording electrodes attached to the body for the measurement. When recording electrodes are attached to the hand for the first time, for example, preschool children are frightened, so the experiments cannot be varied out. The experimenter must illustrate placement of the recording electrodes on the volar surface of the palm and forearm by demonstration, dispelling fears and uneasy feelings. Standard Ag/Ag-CI electrodes were affixed with paste to the volar surface and forearm of the left arm. The procedure included baseline recording, a passive listening task, instruction, and simple and discriminative active-listening tasks. A telegraph key was situated in front of the subject's right arm during the active listening task. Tone stimulation and key press recordings were simultaneously made with recording of electro-dermal activity.

Electro-cardiogram (ECG) was recorded in quiet, familiar, sound-attenuated room during the morning. Children generally uneasy and somewhat afraid of having recording electrodes attached

to the bodies[32,33,34]. When recording electrodes are attached to the ribcage for the first time, for example, children frequently become so frightened that experiments cannot be conducted. To dispel these fears the experimenter must first demonstrate placement of the recording electrodes on either side of the ribcage to familiarize the children. R-R interval lengths were recorded and transformed to instantaneous HR using a cardio-tachometer. The cardio-tachometer calibrated before and after each subject. ECG was measured with Nihon-Denki San-ei bio-potential electrodes attached on either side of ribcage. The experimental procedure included baseline recording, a passive listening task, instructions, and both simple and discriminative active-listening tasks. A telegraph key was situated in front of the subject's right hand during the active listening task. Tone stimulation and key press recordings were made simultaneously with the recording of electro-cardiac activity.

III Results

Seventeen studies were reviewed. The earliest report found was from 1981.

1 EEG

1.1Developmental characteristics: From the cross-sectional study, the following was obtained[11,12,14]. (1) In the healthy children, the frequency of the dominant components changed with age until about 10 Hz. However, the time course of the change was different among regions. The dominant component of about 10 Hz appeared in all regions at about 10 years. In the children with developmental disabilities, dominant components of 10 Hz were hardly observed and frequencies of the dominant and subordinate components varied widely among individuals and age groups. (2) In both healthy children and those with developmental disabilities, earlier dominant components at the lower frequency later became the subordinate one without changing frequency or eventually disappeared. Moreover, a previously subordinate component or new one at a higher frequency grew into a new dominant component. (3) EEGs generated in the process of maturation are composed of different components at discrete frequencies that differ from each other in origin. The frequency of the dominant component is heightened not continuously but stepwise with increasing age. (4) It may be accepted that the relative dominancy among the components reflects in part the maturational progress or retardation of the brain and that the process of developmental change of the brain functioning in the children with developmental disabilities are essentially identical to that of the healthy except for some pathological cases.

1.2 Developmental process: The relationship between the dominant and the subordinate components was investigated in the developing EEGs, and a commonly available schema of the developmental process of EEG applicable was proposed for both health children and those with developmental disabilities[12]. Regarding the longitudinal changes of peak components in the spectra of healthy children, it was observed that an earlier subordinate component became dominant at the same frequency, and that this component showed thereafter decreased power and

became a subordinate one which eventually disappeared. At the same time or in advance to the above, another peak component appeared at a higher frequency, and the dominant component of about 10 Hz appeared at last. While EEG frequencies of children with developmental disabilities were lower than those of healthy children in the same age, the course of changing showed similarity in the both groups. Therefore, the developmental changes of EEG can be schematically apprehended that it takes the course of stepwise heightening of the dominant frequency, and that each component undergoes the change of growing and diminishing so that the dominancy of the component alternates at different stages.

1.3 Chronological changes in persons with DS: It was tried to know specificity of aging in persons with DS from the aspect of EEG frequency changes through the cross-sectional and longitudinal studies, in comparison with healthy persons as well as those with developmental disabilities except the DS (non-DS)[13]. In cross-sectional study the number of subjects with DS who showed dominant component within 8 Hz band of the basic rhythm reached maximum in its appearance rate at 40-44 years of age in the occipital area, but this slowing progressed already at 30-34 years of age. While in non-DS, the number of subjects who showed dominant component at 8 Hz reached maximum at 45-49 years of age, and this slowing of the basic rhythm was not so clear as in DS. In the following-up study for subjects with DS, although the lowering in EEG frequency to 8 Hz took place in various years of age individually, earlier distinct decrease of the frequency was commonly noticed.

1.4 Developmental transition to alpha band in children with developmental disabilities: Developmental transition of EEG spectra to alpha band of 14 children with developmental disabilities was studied by auto-power spectrum analysis longitudinally[22,30,31]. The results showed the mean age (14.1 ye. to 14.8 yr. in the four regions of the frontal, central, and occipital regions) for subjects and their mean frequency (4.2 Hz to 4.7 Hz in the 4 regions) at which EEG shift started from theta band, and those means (15.1 yr. to 15.7 yr. and 9.5 Hz to 9.6 Hz in the 4 regions) at which EEG shift reached the alpha band. Prior EEG research on healthy children has shown that approximately 10 years of age is critical for developmental transition of EEG spectra to alpha frequencies. It is suggested that the present data showed a delay of this critical age for this sample of children with developmental disabilities relative to 10 years for healthy children reported by other researchers[3,11,12].

2 Electro-dermal activity

2.1Healthy preschool children: Electro-dermal activity during passive and active listening tasks of 43 healthy preschool children (aged 4 yr., 8 mo. to 6 yr., 5 mo.) was studied[24]. An increase in mean amplitude of SCR was found during the active listening task over the level for the passive listening task over 10 trials. On the passive listening task from Trial 1 to Trial 10, habituation of mean SCR amplitude occurred. The younger children, moreover, exhibited significantly greater habituation than the older children. Habituation of mean SCR amplitude did not occur during the active listening task. No significant difference was found in mean SCR amplitude during the active

listening task for the two age groups. The children seemed to pay more attention during the active listening task than during the passive listening task. The younger children, moreover, are believed to have shorter attention spans.

2.2 Hyperactive preschool children: Electro-dermal activity during passive and active listening tasks for 4 hyperactive (from 3 yr., 9 mo. to 6 yr., 2 mo.) and 43 healthy preschool children (from 4 yr., 8 mo. to 6 yr., to 5 mo.) were studied[23]. The hyperactive subjects tended to exhibit lower levels of arousal, as indicated by the frequency of spontaneous responses, and more marked habituation with repeated stimuli. Also, they tended not to show the increased responsivity expected when attention is active rather than passive. Hyperactive preschool children, moreover, are believed to have shorter attention spans.

2.3 Temporal variation: Temporal variation of electro-dermal activity during passive and active listening tasks of 43 healthy preschool children was studied[25]. The frequency of spontaneous SCRs showed a significant negative correlation with SCR latency and rise time. Mean SCR amplitude, moreover, displayed a significant negative correlation with the SCR latency and rise time. Reaction time exhibited a significant negative correlation with age. A decrease in the SCR latency was noted during the active listening task below that for the passive listening task over 10 trials. The children seemed to pay more attention as SCR latency and rise time decreased, and the younger children seemed to pay attention later than the older ones. Children seemed to pay more attention during the active than during the passive listening tasks, since the need to press the key should require and perhaps increase general attention.

2.4 Healthy school children: During passive and active listening tasks electro-dermal activity of 49 healthy school children was studied[26]. On the passive listening task from Trial 1 to 10, habituation of the amplitude of the SCR occurred. Habituation of SCR amplitude did not occur during the active listening task. The children seemed to pay more attention during the active listening tasks than during the passive listening task, since the need to press the key is apt to require and may even increase general attention. As for temporal variables of SCR, the frequency of spontaneous SCRs showed a significant negative correlation with SCR latency and rise time. Reaction time exhibited a significant negative correlation with age. An increase in reaction time was found during the discriminative active-listening task over that for the simple active-listening task during the course of 10 trials. The younger children (6-8 yr.) seemed to require longer to pay attention than the older ones (10-12 yr.). Children seemed to pay more attention during the discriminative than during the simple active-listening task, since the need to press the key for discrimination should require and is likely to increase general attention.

2.5 School children with ADHD: Electro-dermal activity during passive and active listening tasks of 18 children with ADHD and 49 healthy school children was studied[27]. ADHD subjects tended to exhibit lower arousal as indicated by the decrease in amplitude of the SCR. Present findings confirm classical observation that ADHD children have shorter attention spans.

2.6 Age differences: Age differences in characteristics of the attention process of electro-dermal activity during passive and active listening tasks were studied with 43 nursery and 49 primary

school children and 38 university students[28]. Significant differences in SCR were found among the three age groups. The SCR became smaller for the groups of increasing ages only for the active listening task. As the trials progressed, there was a trend in the three age groups for decreasing SCR amplitude during the passive listening task.

3 HR

3.1 RSA of children with ADHD: During passive and active listening tasks baseline respiratory sinus arrhythmia (RSA) and HR responses were studied of 18 children with ADHD and 49 health school children[8,29]. ADHD subjects showed less RSA than healthy children but were similarly responsive to tone stimuli.

3.2 HR of children with ASD: The author reported the case study investigating the HR of three ASD (three boys, 11 yr., 12yr., and 15yr.) before and after episodes of stereotyped behavior in school environment[32,33]. The research is based the arousal hypothesis of stereotyped behavior. The analysis showed that high HR before episodes of stereotyped behavior significantly decreased or tended decrease compared that after episodes of the stereotyped behavior in subjects A, B and C, except for the speaking to himself as stereotyped behavior of subject C. They, moreover, showed that the low HR before episodes of stereotyped behavior significantly increased or tended to increase compared that after episodes of the stereotyped behavior in subject A, B and C, expect for the speaking to himself as stereotyped behavior in subject B. The purpose of the study seems to have been met.

3.3 A child with DS: The author reported a single-subject design study investing the HR of a child with DS lacking of excise (A, a boy, 12 yr. 7mo.) and a child with developmental disabilities (B, a boy, 12yr. 2 mo.) in school class environment[34]. The author expected that for children with DS has lack of excise, HR variability of the children decrease in school environment. The analysis showed that the mean HR in the excise class significantly increased compared that of the sitting class in both of subject A and B. The maximal HR and the difference between the maximal and minimal HR of subject A significantly decreased compared those of subject B in the excise class. The purpose of the study seems to have been met.

IV Discussion

1 EEG

1.1 Developmental characteristics: Compared with the fairly consistent relation between dominant EEG frequency and age in health children, the frequency varied widely in children with developmental disabilities both within individuals and across age groups. A component at 8 Hz, known as the slow alpha, was observed in many cases of older children with developmental disabilities.

Despite the above differences between the healthy children and those with developmental

disabilities, however, it may be said that the course of the developmental changes in the dominant EEG component appears similar between two groups[11,12]. Based upon our results, it might be further argued that not only the frequency of the major components, but also the relative dominancy among the components may partly serve as an index of the developmental stages of the brain.

The present longitudinal study shows that the earlier dominant component at a lower frequency may later become a subordinate one without changing its frequency, and that eventually it may disappear, while a previously subordinate component at a higher frequency may become dominant[11,12]. In a certain stage in development, double components of almost equal power might exist together within the alpha frequency band. Eventually, the higher frequency component of the pair will surpass the lower frequency component.

From the above discussion, it can be argued that EEG frequency spectrum is composed of different generation, and that the frequency of the dominant component is heightened stepwise with age[11,12]. The results also suggested that, through with certain chronological delays, children with developmental disabilities may terns in the EEG spectra during childhood. The immediate relationship of the latter finding to the degree of mental retardation remains unclear.

1.2 Developmental process: If the authors[12] consider the developmental disorder of children with developmental disabilities, it may be rather important to elucidate how their basic rhythms undergo a developmental change, and what properties are common to both healthy children and those with developmental disabilities. The authors introduced further the developmental schema of EEG which was derived from the patterning relationship in dominancy between main frequency components, and authors could confirm its availability to the developing EEGs both healthy children and those with developmental disabilities.

1.3 Chronological changes in persons with DS: Considering the present results, the slowing of alpha component in those with DS may develop very earlier, more than almost 30-40 years earlier than the healthy aged[13].

As for those subjects with non-DS examined using cross-sectional, the appearance rate of 8 Hz component became maximum in the 45-49 year range in the occipital and central areas and 40-44 year range in the frontal are[13]. This fact suggests earlier beginning of aging also in these subjects than in healthy persons. However it was not so clear as in DS when EEG slowing starts in individual cases. This may be due to the variety of the etiology in non-DS. If one of the senile signs is indicated by slow alpha waves in adulthood, a degradation of the brain function may progress in 30-40 years of age in DS[13].

In the present study, the authors did not perform any behavioral or clinical assessments concerning deterioration of psychological function[13]. Therefore, the authors withhold to deduce direct relations between DS and Alzheimer disease (AD). As long as frequency decrease of alpha rhythm concerned, at least the followings may be pointed out: first, although that EEG change may be an early manifestation of aging in DS, it may not necessarily reflect such pathological

deteriorations of the brain in AD. Secondly, however, since this earlier sign in EEG is more specific to DS than in non-DS MR though a few persons with DS did not show clear slowing of the alpha rhythm, it may be one of the important indications suggesting the relevance to somewhat multiplied chromosomal anomalies.

1.4 Developmental transition to alpha band in children with developmental disabilities: EEG research on healthy children has shown that approximately 10 years of age is the critical age for developmental transition of EEG spectra to alpha frequncies[22,30]. In the present study, these subjects with developmental disabilities had 15 years of age as the critical age for the EEG transition to alpha band. The present study showed a delay of the critical age for those children with developmental disabilities when compared with prior data for healthy children. It may be inferred that in part the retardation of brain development and the developmental change in the brain function with developmental disabilities were indicated by these data.

2 Electro-dermal activity

2.1Healthy preschool children: On passive listening task from Trial 1 to Trial 10, a decrease occurred in mean SCR amplitude, a nonspecific response associated with novel stimuli. As the novelty or information value of the stimuli decreases, the SCRs also decrease in amplitude[24]. For some subjects they disappear completely, while in others they remain, but at a markedly attenuated level. The decline in amplitude as a function of presenting the same stimulus seems to represent habituation. The authors would expect no habituation to tones occurring during an active listening task, since the need to depress the key should require and perhaps increase the general level of attention.

The ratio of the number of no-SCR trial vs all trial on passive listening task shows a significant negative association with age. It is suggested that the younger children habituated faster and have shorter attention spans than the older children. Mean SCR amplitude shows positive correlation with age over 10 trials on the passive listening task. However, there was a significant positive but moderate correlation with age only on Trial 2, and none of the remaining correlation were significant.

An increase in mean SCR amplitude was found during the active listening task over the level for the passing listening task over 10 trials. Arousal during the active listening task appeared to have been higher than during the passive listening task. The younger children, moreover, exhibited significantly larger habituation than the older children. Perhaps low arousal of the younger children seems to drop more quickly than of the older children.

It is probable that in the present study the younger children exhibited significantly greater habituation than the older children. Electro-dermal activity seems useful in study of preschool children's attention.

2.2 Hyperactive preschool children: One of the characteristics of hyperactive school children or hyperactive preschool children is poor attention. Despite the few hyperactive subjects in the present study, it was suggested that the hyperactive preschool children who have diminished or no

SCRs to tones show less psychophysiological arousal to environmental stimulation. The evidence of electro-dermal hypo-arousal coupled with a decrement in amplitude of SCR for hyperactive preschool children suggests an auto-nomically based correlate of certain behavioral manifestations and learning deficits in later life. The hyperactive preschool children are, moreover, believed to have shorter attention spans.

2.3 Temporal variation: Spontaneous electro-dermal activities and an increase in SCR amplitude appear when arousal is higher, but there are no spontaneous electro-dermal activities and a decrease in SCR amplitude when arousal is lower[25]. In the present report, SCR latency and rise time showed a significant negative correlation with spontaneous SCRs and SCR amplitude. The children seemed to pay more attention when the SCR latency and rise time were decreasing. Reaction time during the active listening task showed a significant negative correlation with age. The younger children seemed to pay attention later than did the older children.

2.4 Healthy school children: Autonomic hypo-responsivity to stimuli appears associated with the attentional impairments. SCR is not simply a measure of reactivity but also an index of attentional process[26]. It is assumed that the temporal variables of SCR are correlated with attention.

The purpose of this paper was to establish a relationship between the skin conductance response and attention in school children[26]. The results show that, when the children are required to pay more attention, SCR amplitude increase; younger children appear to require longer to pay attention than do older ones. Children were assumed to pay more attention during the active than during the passive listening tasks, since the need to depress the key is apt to require and may even increase general attention. The purpose of the study seems to have been met.

Spontaneous electro-dermal activity and an increase in SCR amplitude appear when arousal is higher. But, there is an absence of such activity as well as a decrease in SCR amplitude when arousal is lower. In the present report SCR latency and rise time show a significant negative correlation with spontaneous SCRs and SCR amplitude. This suggests that, when the children were more attentive, the SCR latency and rise time decreased.

Reaction time during the active listening task showed a significant negative correlation with age. The younger children seemed to require longer to pay attention than did the older ones. An increase in the reaction time was found during the discriminative active-listening task over the level for the simple active-listening task across the 10 trials. The children seemed to pay more attention during discriminative than during the simple active-listening task, since the need to press the key for discrimination is likely to require and perhaps increase general attention.

2.5 School children with ADHD: Hyperactive preschool children showed less electro-dermal responsiveness to stimuli than the healthy preschool children[23]. In the present report, a decrease in SCR amplitude among the ADHD children was observed during the passive-listening task, and both simple and discriminative active-listening tasks. This decrease in SCR amplitude was similar to that described for the hyperactive preschool children participation in studies by other researchers[23].

One of the most widely used psychophysiological measures of arousal is electro-dermal activity.

Just as activity is often related to arousal, the attention paid an object may also be a function of arousal. One of the characteristics of ADHD children is poor attention. It was suggested that the ADHD children who have diminished SCR amplitudes to tones show less psychophysiological arousal to environmental stimulation. The evidence of electro-dermal hypo-arousal coupled with a decrement in amplitude of SCR for ADHD children suggests an auto-nomically based correlate of certain behavioral manifestation and learning deficits. The results of the present study corroborate the common belief that ADHD children have short attention spans.

2.6 Age difference: The purpose of this paper was to establish the association between the SCR and attention for preschool and primary school children and adults[28]. The analysis shows that, when persons are required to pay more attention. SCR amplitude increases; younger children appear to require longer to pay attention than do adults. Persons were assumed to pay more attention during the active than during the passive listening task since the need to depress the key is apt to require and may even increase general attention. The purpose of the study seems to have been met.

University students often showed the smaller mean SCR amplitude than the means of nursery and primary school children. There was less increase in responsiveness from passive to active tasks by university students. The findings of studies in the influence of stimulation on autonomic or central function intimate that some university students are probably under-reactive to environmental stimulation or are less arousal than are children.

A child might be a better experimental subject than an adult, for the child passively sits (sometimes be wiggles a bit more than we like) and allows himself to be stimulated without worrying about what else might occur in the situation. Adults on the other hand, are notorious for being hypothesis-generating organisms and will, in the face of as simple a situation as being monotonously stimulated with a given stimulus for X number of trials, generate expectancies of other things that might occur in the experimental situation. It is such expectancies that, the autor believe, interfere with the habituation process. This report confirmed this suspicion.

3 HR

3.1 RSA of children with ADHD: It has been reported that mean HR change during sustained attention was correlated with baseline RSA, with high RSA infants showing a prolonged maintenance of lowered HR during sustained attention compared with the low RSA infants[8,29]. In the present study, healthy children with an appearance of baseline RSA showed a HR deceleration during the tone stimulation but ADHD children without an appearance of baseline RSA showed HR deceleration during the tone stimulation[61]. These studies showed that RSA may be indexing a HR response for a general attentional capacity in healthy subjects, but RSA may not be indexing a HR response for general attentional capacity in ADHD subjects.

3.2 HR of children with ASD: This is a single design study investigating the HR of three children with ASD before and after episodes of stereotyped behavior in the school environment[32,33]. The research is based upon the arousal hypothesis of stereotyped behavior.

Notwithstanding varying ages, varying magnitudes of retardation of the present subjects and

small case, the main finding was that a decrease in HR appeared when arousal was higher. But, an increase in the HR appeared when arousal was lower. Limitations of the study and future directions should, however, be discussed. The subjects were required to add in the future study, because the sample of the three children was small case. The arousal hypothesis should be presented with a lot of the subjects with ASD.

For this small case report, the discussion needs to be toned down in its conclusions. This report did not have evidence to conclude that there is a class of repetitive behavior which is automatically elicited by elevations of arousal and that these have an adaptive function[5]. They served this role through the monotony induced by the repetitive motor behavior as well as blocking further novel sensory input. This data did not speak at all to how or why the HR changed. The purpose of this paper was to establish the association between the stereotyped behavior of children with ASD and arousal hypothesis of Sugita, et.al.[35]. The analysis showed that the high HR before an epoch of stereotyped behavior significantly decreased or tended to decrease compared that after an epoch of stereotyped behavior in subject A, B, and C, The low HR before an epoch of the stereotyped behavior significantly increased or tended to increase compared that after an epoch of the stereotyped behavior in subject A, B and C. The purpose of the study seems to have been met.

3.3 A child with DS: This is a single-subject design study investing the HR of a child with DS lacking of excise and a child with developmental disabilities in school class environment[34].

Notwithstanding varying ages, varying magnitudes of retardation of the present subjects and small case, the main finding was that increase in the HR appeared when activity was higher. But, the decrease in the HR appeared when activity was lower. Limitations of the study and future directions should be, however, discussed. The subjects were required to add in the future study, because the sample of a child with DS was very small case. The prediction hypothesis should be presented with a lot of subjects with DS.

For this small case report, the discussion needs to be tone down in its conclusions. This report did not have evidence to conclude that there is the high HR behavior which is automatically elicited by elevations of activity. The data did not speak at all to how or why the HR changed.

The mean HR in the excise class significantly increased compared that of the sitting class in both of subject A and B. The former was the before morning meeting class of moving, and the latter the school life class of no moving. It was suggested that the excise class increased the HR in both of the subject A and B. The effect of training was showed in children with DS.

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