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Children with Heavy Prenatal Alcohol Exposure Exhibit Deficits when Regulating Isometric Force

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Abstract

Background—Production of isometric (i.e., constant) force is an essential component of performing every day functional tasks, yet no studies have investigated how this type of force is regulated in children with confirmed histories of heavy prenatal alcohol exposure.

Methods—Children 7 to 17 years old with heavy prenatal alcohol exposure ($n = 25$) and without exposure ($n = 18$) applied force to a load cell in order to generate an isometric force that matched a criterion target force displayed on a computer monitor. Two levels of target force were investigated in combination with three levels of visual feedback frequency that appeared on the computer monitor as a series of yellow dots. Force was maintained for 20 seconds and participants completed 6 trials per test condition.

Results—Root-mean square error, signal-to-noise ratio, and sample entropy indexed response accuracy, response variability and signal complexity, respectively. The analyses revealed that in comparison to controls, children with gestational ethanol exposure were significantly less accurate and more variable in regulating their force output and generated a response signal with greater regularity and less complexity in the time domain.

Conclusions—Children with prenatal alcohol exposure experience significant deficits in isometric force production that may impede their ability to perform basic motor skills and activities in everyday tasks.

Keywords

Prenatal alcohol exposure; Isometric force

Introduction

Fetal alcohol spectrum disorders (FASDs) is a non-diagnostic umbrella term used to describe a range of neurobehavioral deficits resulting from prenatal alcohol exposure (O'Malley and Nanson, 2002). At the extreme end of the continuum are children who meet the full criteria for a diagnosis of fetal alcohol syndrome (FAS) as defined by the triad of characteristics of central nervous system (CNS) damage or dysfunction, pre- and post-natal

growth retardation, and distinct facial anomalies (Jones and Smith, 1973). Furthermore, the degree of CNS damage increases with increasing proximity to the extreme end of the FASD continuum (Astley, et al., 2009), which might explain why neuroimaging studies reveal that children without the dysmorphic characteristics of FAS, but who have histories of heavy prenatal alcohol exposure, also have compromised CNS functioning (Norman et al., 2009). Prenatal alcohol exposure also negatively impacts the peripheral nervous system (PNS) in the form of reduced numbers of spinal motor neurons (Bradley et al., 1997; Bradley, 1999), reduced motor neuron size (Heaton et al., 1999), impaired development of the neuromuscular system (Nyquist, Uphoff and Cole, 1987) and slower peripheral nerve conduction velocity (Avaria et al., 2004).

At the level of the CNS, gestational alcohol exposure leads to significant morphological abnormalities in the corpus callosum, cerebellum and basal ganglia (Guerri, Bazinet, and Riley, 2009). Importantly, many of these CNS structures are involved in the generation and control of motor skills (Prodoehl, Corcos and Vaillancourt, 2009; Shin and Ivry, 2003). Therefore, young children with gestational alcohol exposure typically exhibit developmental delays in motor function (Kalberg, et al., 2006) and older children experience dysfunctional balance (Roebuck, Simmons, Mattson and Riley, 1998), gait (Marcus, 1987), bimanual coordination (Roebuck-Spencer et al., 2004) and motor timing (Simmons et al, 2002; Wass et al., 2002). Although these reports have provided important information on deficits in selected gross motor skills and motor timing, other motor control parameters such as force regulation have yet to be examined in this clinical population. Knowledge of this parameter is important because the appropriate application of force is critical to the successful performance of daily functional tasks. For example, when grasping and lifting a Styrofoam cup, large muscles move the hand-arm complex towards the cup using a range of movement trajectories (Prodoehl, Corcos and Vaillancourt, 2009), but small muscles stereotypically apply finely regulated and sustained opposing forces, via the thumb and fingers, that allow the cup to be grasped and lifted (Blennerhassett, Carey and Matyas, 2006). Application of too little force and the cup will slip, while application of too much force could cause the cup to crumple.

The purpose of the study was to assess isometric force control in children with and without heavy prenatal alcohol exposure. Motor performance was indexed using three measures. First, to assess response error, we used a root-mean-square error (RMSE) measure, which estimates how much the force produced by the child deviates from a criterion force over time. RMSE is calculated by squaring each of the deviation values and, in succession, averaging the values and calculating the square root. The result is a single absolute value that represents the average response error relative to the target force.

Second, the signal (i.e., the mean of the response) to noise (i.e., the standard deviation) ratio was used to index response variability, which during isometric force production is directly related to severity of developmental disability (Sprague, Deutsch and Newell, 2009). In this context, the CNS is considered to be a major source of noise that can interfere with the motor signal. A high signal-to-noise ratio (SN) reflects low noise levels, whereas a noisy system produces high response variability and a low signal-to-noise ratio.

Third, the structure of the force signal was examined in the time domain using sample entropy (SampEn) (Lake, Richman, Griffin, and Moorman 2002), as provided by the open source PhysioNet (<http://www.physionet.org/>). SampEn is a measure of how the force signal changes with respect to time by estimating the probability that a response pattern occurring in one epoch of the time series will repeat in subsequent epochs. A response signal with high regularity and less complexity will yield a single SampEn value close to zero, whereas

progressive increases in the SampEn value reflect decreasing signal regularity and increasing signal complexity.

In the present study, generation of isometric force is assessed under two levels of percent of maximum voluntary force and three frequencies of visual feedback. This combination of independent variables represents a difficult motor skill for children without prenatal alcohol exposure (Deutsch & Newell, 2004), and was expected to be even more challenging for children whose CNS is compromised by *in utero* alcohol exposure. CNS dysfunction in this clinical group not only limits isometric force production (Keisker et al., 2010) but also reduces visual-motor coordination (Willford, Chandler, Goldschmidt and Day, 2010) which is critical to integrating visual feedback with the motor output. Therefore, we predicted that children with histories of heavy prenatal alcohol exposure would produce significantly less accurate, more variable and less complex (i.e., less structured) force signals than control children, and that these force deficits would be accentuated as target force increases and frequency of visual feedback decreases.

Methods

Participants

Prenatal Alcohol-Exposed Sample (ALC)—Twenty-five children between the ages of 7-17 years and with confirmed histories of prenatal alcohol exposure were recruited from a registry of participants enrolled with the Center of Behavioral Teratology (CBT) at San Diego State University. One ALC child produced outlier scores for the RMS error and SE dependent variables and data for this child was not included in the statistical analyses for these two measures. Consequently, for these analyses the ALC sample size was 24 children. ALC participants were evaluated by a trained psychometrist using a comprehensive neuropsychological battery of tests that included assessment of Full Scale IQ (FSIQ), as determined through use of the Wechsler Intelligence Scale for Children—Third or Fourth editions. Additionally, all participants were evaluated and screened for prenatal alcohol exposure by a dysmorphologist using established criteria of specific facial anomalies (e.g., short palpebral fissures, long philtrum, and short epicanthal folds), pre- and/or post-natal growth deficiency (at or below the 10th percentile for either height or weight) and evidence of CNS dysfunction (Jones & Smith, 1973). Based on this screening process, the ALC group comprised 9 children with a diagnosis of FAS and 16 children with histories of heavy prenatal alcohol exposure but without the physical features of FAS. Children were excluded from the ALC group for the following reasons: if mental deficiency resulted from known causes other than prenatal exposure to alcohol; a FSIQ score below 60; or an incomplete history concerning prenatal alcohol exposure.

Non-exposed Control Sample. (CON)—A non-exposed control group (CON) of 18 children between the ages of 7-17 years was also recruited through referral to the CBT, electronic and non-electronic public notices, and recruitment through community events such as health fairs. Children in the two groups were matched as close as possible on age, gender and handedness. CON children were evaluated for prenatal exposure to alcohol use and other teratogenic agents using the same assessment battery used to evaluate children of the ALC group. CON participants were excluded for the following reasons: closed head injury with significant loss of consciousness; a FSIQ score below 60; if greater than the minimal prenatal alcohol exposure (1AA/day prior to pregnancy recognition) was known or suspected or if alcohol exposure information was unavailable.

Apparatus and Methods

The apparatus consisted of a 51-cm (diagonal measure) flat screen computer monitor placed on a standard table 0.5 m in front of the participant. Positioned between the participant and the monitor was a circular response key (15-mm diameter) mounted above a force transducer (ELFS-B3: 1.27 cm diameter; range 2-20 lbs; sensitivity 7.8 mV/l: Entran Devices, Fairfield NJ), and two computer wrist pads. Force applied to the response key was registered by the load cell, amplified and sampled at a rate of 100 samples per second (16-bit analog-to-digital board: National Instruments, Austin, Texas, USA) using customized software based on LabView programming (National Instruments, Austin, Texas, USA). The force-time record was permanently stored on a PC for additional analysis.

Prior to testing, and in accordance with institutional review board procedures, informed consent and participant assent were provided by the legal guardian and child, respectively. The participant was asked to sit upright in a height adjustable chair with the dominant hand (defined as the hand used for writing) resting in a neutral, pronated position on the wrist pads and with the distal pad of the index finger placed comfortably on the response key. The other fingers and thumb were flexed and did not contact the response key. The non-dominant hand was placed in the child's lap. The participant was positioned so that the response key was aligned with the shoulder of the dominant hand.

The general procedures are based on an experimental protocol previously described by Deutsch and Newell (2001). Prior to any testing the apparatus was calibrated. To facilitate comparison of force generation between participants, absolute force was normalized to each participant's maximum voluntary force (MVF). MVF was assessed by each participant exerting maximum force on the response key for four seconds with the extended index finger. Four MVF trials were recorded for each child, with the first trial serving as a practice trial and the average of the last three trials providing an estimate of MVF. The base of the palm of the hand was placed on the wrist pads during each trial.

Following MVF assessment, a verbal description and demonstration of the task was provided. To initiate each trial participants applied a single brief pulse of force to the response key, at which point a series of yellow dots appeared on the monitor and unfolded left-to-right across the screen. The child was told they could control the vertical position of the dots by varying the force applied to the response key: movement 'up' and 'down' on the monitor reflected increased and decreased force, respectively. Dots appeared on the screen at frequencies of 50Hz (20ms), 3.15Hz (320ms), or 1.35Hz (740ms). These frequencies were similar to rates of presenting visual information reported in the force literature (Deutsch and Newell, 2004). Also displayed on the monitor for the duration of the 20-second long trial was a single, straight, red horizontal line spanning the width of the monitor. The line represented a target force of 5 or 20 percent of MVF and participants were instructed to apply sufficient force to the response key so that the yellow dots superimposed over the red target force line. At the completion of a trial, a dialogue box appeared on the monitor for 10 seconds and displayed the RMSE score for the trial. Participants were told that low scores indicated more accurate responses. At the conclusion of the 10-second inter-trial-interval the visual display on the monitor automatically cleared and participants initiated the next trial.

For each combination of target force levels and three-feedback frequency conditions, participants completed a block of six trials (total trials = 36). The presentation order of the two force conditions and three feedback frequency conditions were separately counterbalanced across participants. The first trial of each block served as a practice trial and was not included in the analyses. A mistrial occurred if hand position was not maintained, the participant 'bounced' his or her finger on the response key, or the child failed to meet the conditions of the experiment for the duration of the trial. Mistrials were

repeated at the end of the trial block. The average number of mistrials for the CON and ALC groups was 0.06 and 0.12, respectively. At the conclusion of testing, each child was provided a small monetary reward.

The experiment reported here was one of two projects investigating regulation of different types of force in children prenatally exposed to alcohol. A five-minute rest period separated the two projects, and to offset potential learning effects and possible fatigue, the presentation order was counterbalanced across participants. A total of 20 (80%) alcohol-exposed children and 14 (78%) control children participated in both projects. Total testing time for each project was approximately thirty minutes.

Statistical Analysis

Demographic information relating to participant age, Full Scale IQ (FSIQ), and socioeconomic status (SES) were independently assessed using *t*-test procedures for independent samples. The last 13 seconds of data for each trial were analyzed. These data were examined for outlier scores, defined as values exceeding 2.5 standard deviations above the mean value for each condition. RMSE (root mean square error of the difference between the target and response), SN ratio (mean/standard deviation for each trial) and Sampen (a measure of signal complexity) were used as dependent variables. With regard to Sampen, the length of the epoch over which the signal was evaluated was designated as *m*, and the tolerance that successive points match was signified as *r*. In the present experiment, *m* = 3, *r* = 0.2 and the time series was normalized with the mean set to zero and the standard deviation at 1.0.

Data for the three dependent variables were analyzed using a 2 (group) × 2 (force level) × 3 (feedback frequency) repeated measures analysis of variance (ANOVA) with group (ALC and CON) as the between subject variable and force level (5% MVF and 20% MVF) and feedback frequency (50Hz, 3.15Hz and 1.35Hz) as within subject variables. Age was entered into each analysis as a covariate. Significant interactions between two or more variables were further evaluated using repeated measures ANOVAs, and *t*-test procedures were used for post-hoc comparisons using a Bonferroni correction. Confidence interval (CI) values at the 95% level were calculated for each significant outcome (Seaman and Serlin, 1998). Assumptions of sphericity and homogeneity of variance were examined using Mauchly's and Levene's tests, respectively. Violations of sphericity prompted the use of the Geisser-Greenhouse conservative estimate of degrees of freedom and violations of homogeneity of variance invoked post hoc comparisons using Games-Howell procedures. Alpha was set to 0.05 for all tests of significance. Data were analyzed using SPSS version 17.0.

Results

Demographic Information

Demographic information for the two groups is presented in Table 1. There were no significant differences between the two groups for age and socio-economic status ($p > 0.05$). Analysis of FSIQ did reveal a significant difference ($p < 0.001$) with the ALC group having a lower average FSIQ than the CON group. This result was expected since prenatal alcohol exposure is typically associated with impaired intellectual functioning.

Representative Force-Time data

Figure 1 illustrates representative force-time signal records for two 8-year-old participants without (top three panels) and with prenatal alcohol exposure (bottom three panels), respectively, during the 20 % MVF condition. Panels A, B and C are for visual feedback

frequencies of 50Hz, 3.15Hz and 1.35Hz, respectively. The straight horizontal line represents the target force and the scale of the vertical and horizontal axes has been standardized for all panels to facilitate visual comparison between the two children and across frequency conditions. The figure reveals that deviation of the force signal about the target force increases for both children as visual feedback frequency decreases, and at each frequency the child with prenatal alcohol exposure produces a larger and more variable force signal than the control participant.

Maximum Voluntary Force (MVF)

The average MVF for the CON and ALC groups was 29.2N (S.D. = 8.4) and 28.5N (S.D. = 7.3), respectively. There was no statistical difference between the group average MVF values, $t(32) = 0.78$, $p > .05$.

Root-Mean-Square Error (RMSE)

Main effects for force level [$F(1,40) = 4.35$, $p < .05$, $\eta^2 = .10$] and feedback frequency [$F(2,82) = 13.37$, $p < .002$, $\eta^2 = .25$] were found, but the group effect just failed to reach significance, [$F(1,40) = 3.92$, $p < .06$, $\eta^2 = .09$]. The analysis also revealed a significant group $\times$ force level interaction, [$F(1,40) = 4.63$, $p < .05$, $\eta^2 = .10$] (presented in Figure 2), together with a significant force level $\times$ feedback frequency interaction, [$F(2,80) = 3.26$, $p < .05$, $\eta^2 = .08$]. Follow-up analyses revealed no significant group differences at 5% MVF [$F(1,40) = 1.21$, $p > .27$, $\eta^2 = .03$; 95% CI $_{\Delta}$ -.15 to .51] but at 20% MVF, RMSE values were significantly higher for the ALC group than the CON group [$F(1,42) = 6.42$, $p < .02$, $\eta^2 = .13$, 95% CI $_{\Delta}$.13 to 1.16]. With data for each group collapsed, the force level $\times$ feedback frequency interaction indicated that for all three levels of feedback frequency RMSE values were lower at the 5% MVF level, and did not significantly differ. In contrast, RMSE values at 20% MVF were inversely related to decreasing feedback frequency.

Signal-to-Noise Ratio (SN)

Analysis of the SN data revealed a significant main effect for group, [$F(1,41) = 7.18$, $p < .02$, $\eta^2 = .15$], but no significant main effects for force level [$F(1,41) = 1.06$, $p > .30$, $\eta^2 = .03$] or frequency [$F(2,82) = .37$, $p > .68$, $\eta^2 = .01$] were detected. No significant group $\times$ force level, [$F(1,41) = .06$, $p > .80$, $\eta^2 = .00$] or group $\times$ feedback frequency [$F(2,82) = 2.52$, $p > .08$, $\eta^2 = .06$] interactions were found. Regardless of force level and feedback frequency, SN ratio values were significantly higher for the CON group than for the ALC group (95% CI $_{\Delta}$ 1.42 to 10.12). Figure 3a and 3b illustrate the SN data as a function of force level and feedback frequency, respectively.

Sample Entropy (SampEn)

A significant group $\times$ feedback frequency interaction [$F(2,80) = 4.28$, $p < .05$, $\eta^2 = .10$] as well as a significant main effect for group [$F(1,40) = 15.99$, $p < .001$, $\eta^2 = .29$] was found. An illustration of the interaction is presented in Figure 4. No other significant interactions or main effects were detected ($p > .05$). Follow up one-way ANOVAs at each frequency indicated significant group differences at 50Hz [$F(1,42) = 13.72$, $p < .002$, $\eta^2 = .25$, 95% CI $_{\Delta}$.04 to .12], 3.5Hz [$F(1,42) = 8.72$, $p < .006$, $\eta^2 = .18$, 95% CI $_{\Delta}$.02 to .09], and 1.35Hz [$F(1,42) = 7.16$, $p < .02$, $\eta^2 = .15$, 95% CI $_{\Delta}$.01 to .07]. At each frequency, children in the CON group had significantly higher SE values than those in the ALC group.

Discussion

Three main findings from the study indicate that prenatal alcohol exposure impairs isometric force regulation. First, response error significantly increased as feedback frequency

decreased and force level increased in children with and without prenatal alcohol exposure. However, as seen in Figure 2A, force level had a differential effect on group error. There was no difference between the groups in response error at the 5% MVF level, but at the 20% MVF level the alcohol exposed children produced greater response error than controls.

A second result revealed that the SN ratio was significantly lower in children with prenatal alcohol exposure regardless of force level or feedback frequency (Figure 3). These results indicate that even when the target force level was low (5% of MVF) and feedback frequency was high (50Hz), children with gestational alcohol exposure experienced greater difficulty in consistently responding than control children. In typically developing children, the SN ratio increases with maturity, possibly as a result of synaptic pruning in the prefrontal cortex which serves to make the surviving networks more efficient in processing information (Blakemore and Choudrey, 2006). At the cognitive level, this efficiency is manifested, in part, by the development of executive function, which includes the ability to filter out irrelevant information or noise within the sensorimotor system. It has been proposed that children with prenatal alcohol exposure do not experience normal cortical synaptic pruning (Sowell et al., 2002) and have reduced executive function (Mattson, et al, 1999) which limits or eliminates noise filtering processes and results in atypically low SN ratios.

The difficulties observed in alcohol-exposed children in filtering noise may be problematic for the construction of therapeutic programs designed to reduce motor variability in these children. However, some studies have demonstrated that in typically developing children reducing force variability is not contingent on noise reduction, but occurs when sufficient practice is provided to allow the sensorimotor system to organize in a way that better meets the demands of the task (Deutsch & Newell, 2001; Deutsch & Newell, 2004). According to these research findings, motor therapies should not focus on reducing noise by improved filtering, but should be directed at providing physical practice that facilitates re-structuring of the sensorimotor system. Klintsova and colleagues (Klintsova, et al., 2000; Klintsova et al., 2002) have previously demonstrated the benefits of motor therapy in the animal model. When rats with gestational alcohol exposure are provided practice in a motorically challenging environment, alcohol-related motor deficits are ameliorated and the cerebellum undergoes plastic changes.

When the results for response accuracy and response variability are considered together, additional insight into the motor skill performance of children with prenatal alcohol exposure emerges. As previously noted, when target force was low (5% MVF), children with and without alcohol exposure produced comparable levels of response accuracy, but alcohol exposed children produce greater response variability than controls. These results suggest that response variability provides a more sensitive index of isometric force deficits in the alcohol-exposed child. It could be important for clinicians to know that at low levels of force production children in this clinical group are as accurate as control children, but they are significantly more variable in responding and that any form of therapeutic exercise that reduces response inconsistency would be beneficial.

A third result indicated that the structure of the force signal in the time domain was also adversely affected by prenatal alcohol exposure. As indicated by SampEn values (Figure 4), regardless of force level or feedback frequency, isometric force signals generated by the control group had significantly higher complexity and lower regularity than the relatively simple and highly regular signals produced by children with prenatal alcohol exposure. Furthermore, post hoc analysis of a significant interaction between feedback frequency and the two groups revealed that alcohol-exposed children did not change the structure of the force signal as the frequency of visual feedback decreased. In contrast, control children modified the signal from one that was complex and irregular when visual feedback was

readily available to a signal with a regular and simple structure as visual information decreased.

Estimation of a target force involves using visual feedback to reduce the difference between the target force and the generated force. When visuomotor integration occurs, the structure of the resulting force signal is complex and irregular and when visuomotor integration is weak, signal structure is simple and regular. In the present experiment we manipulated visuomotor integration by systematically reducing the frequency of visual feedback. This manipulation produced a shift in signal structure for the control children but not children with prenatal alcohol exposure. The latter group produced a force signal that was simple and regular for all levels of feedback frequency which is consistent with the notion that alcohol-exposed children were less able to integrate visual-motor information (Sowell, et al., 2008; Uecker and Nadel, 1996).

The observed behavioral deficits in force regulation may be related to the teratogenic effects of prenatal alcohol exposure on the CNS. This damage can include complete or partial agenesis of certain neural structures and volumetric reductions in basal ganglia and the cranial and cerebellar vaults (Guerri et al., 2009). Significantly, many of these neural systems are involved in the scaling of fine-graded isometric forces in typically developing individuals. Neuroimaging studies reveal that the primary motor area (M1) and somatosensory cortex, ventral premotor and inferior parietal areas, the cerebellum (Brandauer et al., 2008; Keisker et al., 2009) and basal ganglia (Pradhan et al., 2010) are active at some point during force production, although the extent of involvement is specific to control parameters inherent to the movement. For example, when regulating variable or constant timing of force, the primary motor area and dorsal premotor area are involved. Application of variable or constant force invokes the primary somatosensory area, the dorsal premotor area and the anterior intraparietal area. When timing and force are co-regulated, activity in the supplementary motor area and anterior intraparietal area is prominent (Haller et al., 2009). Relatedly, reduced visuomotor integration is associated with bilateral damage to the lateral aspects of the splenium of the corpus callosum caused by prenatal alcohol exposure (Sowell et al., 2002).

The practical ramifications of our results are significant. An inability to maintain isometric force over a sustained period can translate into reduced performance of daily tasks such as hand writing (which could affect school performance), use of eating utensils, tying shoe laces etc. In a similar vein, applying a constant force to the brake of a bicycle to control speed requires precise application of force, and failure to do so could be life-threatening. Moreover, when deficits are apparent, especially to typically developing children, the effect of rejection, embarrassment, and being ostracized from peer group activities can be socially and emotionally devastating to the child with prenatal alcohol exposure, and often results in long-term and permanent damage to the child's self confidence and esteem (Poulson 2004; Rosenblum and Livneh-Zirinski, 2008). Future work is needed to identify intervention programs that can be used by teachers, parents and clinicians to improve regulation of force in this clinical population. Specifically, training should include a variety of task conditions that facilitate visuomotor integration and transfer to the performance of functional tasks.

In summary, children with histories of heavy prenatal alcohol exposure experienced significant deficits in regulating isometric force. For this clinical group, the force signal was less accurate and more variable than the signal produced by control children, and the structure of the force signal in the time domain was comparatively simplistic and regular. Additionally, the observed force deficits were pervasive across two levels of target force and three frequencies of visual feedback. The motor deficits reported here may be related to the

teratogenic effects of prenatal alcohol exposure on structures of the CNS that are involved in regulation of isometric force.

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Figure 1.

Representative force-time signal records for two 8-year old participants without (top three panels) and with prenatal alcohol exposure (bottom three panels), respectively, during the 20 % MVF condition. Panels A, B, and C are for visual feedback frequencies of 50Hz, 3.15Hz and 1.35Hz, respectively. The horizontal line in each graph represents the target force value (20% MVF).

Figure 2. RMSE for the ALC and CON groups as a function of force level (2A) and visual feedback frequency (2B). Significant differences are indicated by the asterisk ($p < .05$).

Figure 3. SN values for the ALC and CON groups as a function of force level (3A) and visual feedback frequency (3B). Significant differences are indicated by the asterisk ($p < .05$).

Figure 4. SampEn values for the ALC and CON groups as a function of force level (4A) and visual feedback frequency (4B). Significant differences are indicated by the asterisk ($p < .05$).

Table 1

Demographic information.

	ALC	CON
Sex (M:F) (M:F%)	15:10 (60.0:41.7)	15:3 (83.3:16.7)
Age (yrs) M (SD) (Range)	11.2 (2.5) (7.25-16.5)	12.0 (2.4) (7.5-17.25)
FSIQ ¹ M (SD)	88.5 (17.8)	107.8(12.6)
Hollingshead Score ²	48.2 (11.1)	49.1(5.9)
Hand Dominance		
L:R	3:21	4:17
L:R%	(12.5:87.5)	(19.0:81.0)
Race n(%)		
African American	6 (25.0)	1 (4.8)
Caucasian	13 (54.2)	12 (57.2)
Mixed	3(12.5)	4 (19.0)
Hispanic	2 (8.3)	4 (19.0)

¹ Intelligence scores were derived from either the Wechsler Intelligence Scale for Children-III or Wechsler Intelligence Scale for Children-IV depending on the time the child enrolled at the CBT

² Socioeconomic status was estimated using the Hollingshead Four Factor Index of Social Status (Hollingshead 1975, unpublished data)