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**Title: Sensory Characteristics and Handwriting Performance of Children with ADHD
In Comparison to Typical Children.**

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Abstract

Research Rational: Handwriting is a complex human skill and is considered to be the fastest form of graphic communication (Feder & Majnemer, 2007). In order to produce a written product, the writer must activate, simultaneously, motor skills (e.g. creating a hand position and grasp force, in-hand manipulation, and motor planning), cognitive skills (e.g. attention, memory, and the use of executive functions), and sensory skills (e.g. tactile or proprioceptive discrimination in the hand) (Rosenblum & Frish, 2008). Handwriting is an *activity* which is expected of the child so that he/she will be able to *participate* in the daily routine of the classroom, and is imperative to academic success. Children spend 31-60% of their day in the classroom writing or performing other fine motor tasks. Handwriting difficulties are one of the most common reasons that school-age children are referred to occupational therapy (Rosenblum & Frish, 2008).

Many of the children that are being referred to occupational therapy with writing difficulties are diagnosed with Attention-Deficit Hyperactivity Disorder (ADHD). ADHD is a developmental disorder characterized by difficulties in sustained attention, distractibility, impulsiveness, and hyperactivity (Barkly, 1997, 2000). In addition to having writing difficulties, a large percentage of children with ADHD 40-60%, present with *Sensory Processing Difficulties – SPD* (Miller & Fuller, 2006). While the literature mostly deals with the difficulties in kinesthetic awareness that children with ADHD experience, and the implications of these difficulties on their handwriting, the research lacks information

regarding the characteristics of handwriting in children with ADHD while taking into account their sensory characteristics as well.

The purpose of the study: To outline the process and product of handwriting in children with ADHD, while considering their sensory processing characteristics. The understanding of the handwriting process and product of this group, and the understanding of the involvement of the sensory processing characteristics in their handwriting, can lead to the development of new evaluation and treatment programs that will meet their unique needs.

Hypothesis: The main hypothesis was that differences would be found in the process and product characteristics of the handwriting of children with ADHD when compared to the control group of typically developing children. In addition, among children with ADHD correlations would be found between the sensory processing patterns and the process and product characteristics of their handwriting.

Methods: 58 children aged 8-11 years participated in this study. 31 of them were diagnosed with ADHD (ADHD group) and 27 were typically developing children (control group). The ADHD group was comprised of children that were referred to two separate child development centers of *Clalit Health Services* and were given a diagnosis of ADHD by a neurologist. The control group matched by age and socio-economic status to the ADHD group, included children with a clean medical history, with no reported difficulties in learning, handwriting or sensory processing, and with no diagnosis of ADHD. After the study was approved by an ethics committee the parents of the children participating in the study signed written consent forms and were then asked to fill out the following questionnaires: (1) a personal information questionnaire; (2) A *Conners' Parent Rating Scale – Revised (S)* (Conners, 1997) for identifying behaviors of ADHD; (3) *Short Sensory Profile – SSP* (McIntosh, Miller, Shyu, & Dunn 1999) for identifying SPD, and (4) *Children Activity Scale-Parents ChAS-P* (Rosenblum, 2006) for identifying behaviors that may indicate Developmental Coordination Disorder (DCD). The parent questionnaires helped characterize the behaviors of the ADHD group and assisted in

improving inclusion criteria in this study. In addition to the parent questionnaires, all children completed a short reading screening task (from *Aleph Ad Taph* - Lachman, Shalem, Bahat, & Zayger, 2006) in order to rule out reading difficulties. Following the reading task, each child was asked to complete two writing tasks: first a question answering task, then "Alef-Alef" paragraph-copying task (from *The Hebrew Handwriting Evaluation (HHE)* - Erez & Parush, 1999). The tasks were performed on a computerized system - *Computerized Penmanship Evaluation – ComPET* (Rosenblum, Parush & Weiss, 2003a) that collected data on the execution process (Temporal, spatial and pen pressure variables). The product variables were analyzed by criteria selected from The Hebrew Handwriting Evaluation (HHE). In addition, proprioceptive sensation was evaluated using a nonstandard clinical test of imitating a wrist position (Carey, Matyas, & Dip, 2002).

MANOVA and t-tests were used to examine differences between the two groups on the different dependent variables, and the Pearson test was used to examine the correlations within the ADHD group. The significance level was set at $p \leq .05$.

Results: Significant differences were found in the processes and product variables between the ADHD group and the control group. Children with ADHD showed less legibility and organized products, and a different execution profile – smaller writing strokes (height, length and width), slower speed and more pressure on the pen during handwriting. In addition, children with ADHD showed more behaviors indicating SPD, according to the total and sub domain of the SSP. It was found that the areas of *auditory filtering* and *sensory seeking* were the most impaired in the children with ADHD that demonstrated SPD as defined by the SSP, and that the *sensory seeking* domain had the largest effect on writing processes in these children.

Conclusions: Children with ADHD may show unique characteristics of the handwriting process and product, in comparison to typically developing children. It is possible that children with ADHD and SPD have a unique writing profile of their own, because of the

sensory seeking characteristics. Further studies in the area of handwriting should examine the relationship between sensory processing abilities and handwriting, in populations known for their high comorbidity with SPD, such as ADHD, DCD or autism. Designing follow-up research studies with similar methodologies and further examination of the handwriting characteristics of these populations, can lead to improving the evaluation and intervention processes in the field of occupational therapy, which, in turn, will encourage participation in handwriting activities.