

# **Tele-evaluation and intervention among adolescents with handwriting difficulties – Computerized Penmanship Evaluation Tool (ComPET) implementation**

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## **ABSTRACT**

Writing is a complex and essential human activity. During adolescence, there is an increase in the complexity and quantity of writing required for communication, self-expression, and for demonstrating academic ability. Deficits in handwriting performance limit the writing abilities, and hence the participation of adolescents in many areas of life. Computer-based tele-rehabilitation has the potential to address handwriting assessment and treatment. The goal of the present study is to examine the potential of the ComPET as a tool to assess and treat adolescents with handwriting difficulties. A case report is presented.

## **1. INTRODUCTION**

### *1.1 Handwriting*

Writing is indispensable for participation in school activities. As their schooling progresses, students are expected to cope with more difficult tasks, to demonstrate their knowledge understanding on a progressively higher level, and to integrate the material they have previously studied (Graham, Berninger, Weintraub, & Schafer, 1998). The demands for written work increase dramatically during the middle and secondary school years (Weintraub, Drory-Asayag, Dekel, Jakobovits, & Parush, 2007). No other school task requires as much synchronization of abilities as does handwriting (Levin, Oberklaid, & Meltzer, 1981). It follows that this complex occupational task demands the integration of many underlying component skills, which if lacking, may interfere with handwriting performance (Feder & Majnemer, 2007). Deficits in handwriting performance limit the school participation of adolescents, negatively affect students' grades (Christensen, 2005), self esteem, motivation for studying and social interaction (Sassoon, Nimmo-Smith, & Wing, 1986).

To date, most of the theoretical and research knowledge in the area of handwriting relates to elementary school students (Graham & Weintraub, 1996). Graham and Perin (2007) state that writing in general, and teaching writing skills to struggling adolescent learners in particular, has not received enough attention by researchers and educators. They point out that we cannot assume that instructional strategies and approaches validated with younger struggling writers are equally effective for students in the middle and upper grades. A meta-analysis conducted by Graham and Perin (2007) indicates the need to perform a careful evaluation of a teenager's handwriting performance, through both formal and informal methods, before choosing the appropriate remediation approach. The instruments chosen should best match the adolescent's areas of handwriting difficulty so as to facilitate the implementation of an effective treatment strategy. A quantitative scoring system is critical in identifying the problem areas to be targeted during remediation, in monitoring a client's progress after intervention, and in communicating the results more clearly (Feder & Majnemer, 2007).

It is understood that privacy, accessibility and anonymity considerations are very important when planning intervention with adolescents (Barak, 2006). However, the capacity to provide effective evaluation and treatment to adolescents with writing difficulties may be limited by difficulties experienced in accessing occupational therapy services. Such difficulties may arise because of the distance involved in commuting to service locations, financial limitations and institutional prioritization of cases. Tele-rehabilitation, a service delivery model in which rehabilitation services are provided at a distance, using information and

communication technology, may offer an alternative or adjunct service delivery model to facilitate or enhance access to service for adolescents who are struggling with writing difficulties (Torsney, 2003).

### 1.2 Computerized Handwriting Process Evaluation

Technology enables the analysis and precise assessment of the writing process and product (Wann & Kardirkamanathan, 1991). The development of the digitizer (Rosenblum, Parush, & Weiss., 2003) enables the measurement of a rich variety of spatial, pressure, and temporal measures by a computerized system (CompPET) (see Rosenblum, Parush, & Weiss, 2003). The Computerized Penmanship Evaluation Tool (CompPET, previously referred to as POET; Rosenblum, Parush, & Weiss, 2003) is a standardized validated handwriting assessment that utilizes a digitizing tablet and on-line data collection and analysis software. It was developed for the purpose of collecting objective measures of the handwriting process (for more details see: Rosenblum et al., 2003; Rosenblum, Chevion, & Weiss, 2006; Rosenblum & Livneh-Zirinski, 2008),

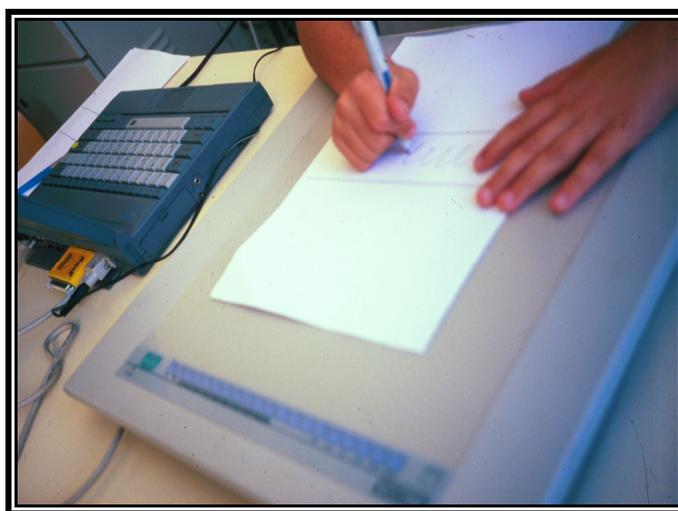
The tasks are performed on A4-sized lined paper affixed to the surface of a WACOM Intuos II x-y digitizing tablet (404 x 306 x 10mm), using a wireless electronic pen with a pressure-sensitive tip (Model GP-110). This pen is similar in size and weight to regular pens commonly used by adolescents and, as such, does not require a change in grip that might affect writing performance.

Displacement, pressure and pen tip angle are sampled at 100 Hz via a 1300 MHz Pentium computer.

It seemed likely that the use of the CompPET in the assessment and training of adolescents with handwriting difficulties might be an appropriate approach for their needs. For example, this approach eliminates the need for eye contact, neutralizes the bias of age status, and enables the creative use of coded language, drawings, symbols and interpersonal communication on a textual basis. These are just some of the features that make tele-rehabilitation advantageous and affordable through the use of the CompPET technology. These features might enable effective alternatives that address the special needs of this age group for growth, emotional maturation and for skill acquisition and learning. In addition, the unique features of this approach can help construct a positive and significantly attractive intervention program for youths.

The CompPET allows for greater flexibility in choosing appropriate tasks for the client. For example, tasks can be performed in any language and without regard for task length or time limits. To enable the choice of functional tasks that address each individual adolescent's needs, an interview could be conducted prior to the initiation of treatment.

The case report that will present below will demonstrate these ideas.



**Figure 1.** *Computerized Penmanship evaluation Tool (CompPET).*

### 1.3 Tele-Rehabilitation

Home healthcare has assumed an increasingly important role in healthcare over the last 20 years. Occupational and physical therapy interventions that may be suitable for tele-rehabilitation include assessment of the home environment and training in adaptive strategies (Hoenig et al., 2006). In recent years, a number of studies have examined the use of computer-based tele-rehabilitation systems (Brennan, Georgeadis, Baron, & Barker, 2004; Hill et al., 2006; Mashima et al., 2003). As a result of the relatively low

cost of installation and maintenance of computers, as well as their general availability, such systems may help to alleviate difficulties in accessing rehabilitation services.

It is also important to note that computer-based tele-rehabilitation provides the opportunity to focus on an individual's unique abilities and difficulties, thus enabling the development of a tailor-made intervention approach and the utilization of techniques that suit his or her specific needs. The flexibility derived from computer-based tele-rehabilitation may also allow for the use of established practices, such as the ability to deliver standardized assessment tools in an online capacity. For instance in Australia, the wide distribution of the population and increased use of technology in regional and remote areas support the use of computer-based tele-rehabilitation systems (Lloyd & Bill, 2004). The application of computer-based tele-rehabilitation is also supported within populations of people with disabilities. For tele-rehabilitation to be truly effective, researchers must establish valid and reliable assessments that can be performed from a distance. This requirement is important not only for initial assessment and diagnosis but also for ongoing monitoring and maintenance of client progress (Hill et al., 2006).

#### *1.4 Method for Integrating the Use of the CompPET and Tele-Rehabilitation to Assess and Treat Adolescents with Handwriting Deficits*

The main idea behind the development of the proposed method is to combine the opportunities offered by tele-rehabilitation and the CompPET, in order to provide an intervention program that can best fit the needs of adolescents with handwriting difficulties.

We propose the use of a multistage process. To begin, we send an invitation to participate in our research through internet forums targeting adolescents or adolescents' parents. We will state that we are looking for volunteers who might have handwriting problems and would be interested in attempting our novel approach. Respondents will be asked to share with us their experiences with writing assignments and the influence that writing problems have had on their lives.

Next, these adolescents will be mailed a questionnaire that focuses on their activities and degree of participation in daily life occupations (Kirby & Rosenblum, 2007). To complete the background data collection, an interview will be conducted with the participants through Skype, to solicit more detailed information regarding the typical environments which they occupy, as well as their daily life activities.

Based on the information received an individual CompPET evaluation program will be set up.

*1.4.1 Tasks and Apparatus.* This research represents the first time the CompPET is to be used for treatment following the evaluation process. The plan is to choose tasks from an ecological perspective, such that they are familiar and common tasks that the individual routinely performs at school, relevant to client's context and that are based on information drawn from the questionnaire and from the Skype conversations. The tasks are to be written in Hebrew, a language in which the writing progresses from right to left. In Hebrew, successive letters are usually not connected, even in script or cursive writing and some letters are comprised of two separate, unconnected strokes.

*1.4.2 CompPET Outcome Measures.* The primary outcome measures are to be comprised of temporal, spatial and pressure measures for each writing stroke, as well as overall performance on the entire paragraph. The temporal measures will include 'on-paper' time (the time during writing performance in which the pen is in contact with the writing surface) and 'in-air' time (the time during writing performance in which the pen is not in contact with the writing surface) (Rosenblum, Parush, & Weiss (2003). The spatial measure will include the mean stroke height and width for each task. In addition, the CompPET computes the mean pressure applied to the paper, as measured in non-scaled units from 0 to 1024, as well as the mean pen tilt in the range of 0-90 degrees (i.e., the angle between the pen and its projection on the tablet).

*1.4.3 Procedure and data analysis.* As was described previously, the tasks will include a message on the internet's forum, the completion of a written questionnaire that is to be mailed to the adolescents that responded to our message and a Skype interview with each of them. This information will form the basis for the choice of the assessment writing tasks and their performance via the CompPET.

Once the findings from the evaluation and assessment sessions are examined, we will build an individually tailored intervention program, designed from a combination of intervention techniques suited for each of our client's needs. We will reassess the client's performance after each intervention session, so the client, and we, can follow his or her progress throughout the process.

The case report will illustrate the background data collection process and examples of data that can be derived through the use of the CompPET.

## 2. CASE REPORT

### 2.1 Personal Details

In a feasibility survey conducted to explore the potential viability of selecting participants via the internet, we sent a message to 10 internet forums that target adolescents or adolescents' parents, and asked for volunteers who might have writing problems and would be interested in participating in our novel research. Within 48 hours we received responses from 12 adolescents or their family members.

O.B., a 16 years-old Jewish boy, is one of the adolescents that replied to our message. O.B. is an Israeli born high school student who lives in the city. He informed us that he uses his right hand for writing and usually writes in Hebrew. His parents reported that he experiences difficulties with writing assignments, has illegible and dysfluent handwriting, and has great difficulty in completing his assignments on time.

Following O.B.'s reply, we mailed him a questionnaire focusing on his activities and degree of participation in daily life occupations (Kirby & Rosenblum, 2007). From his responses, we learned that he has difficulties with a variety of activities of daily life, such as in organizing his room, organizing the tasks he needs to do so that he can get to school on time and in spatial orientation. In addition, it was apparent that O.B. has difficulties in performing other complex motor activities, for example, riding a bike or playing music. To complete our background data collection, we conducted a Skype conversation with O.B. to solicit more detailed information regarding the typical environments which he occupies, as well as his daily life activities.

In O.B.'s case, because we suspected that his handwriting difficulties relate to his organizational problems, difficulty in preserving letter forms and motor problems, we chose a series of tasks in a graded progression. Initially, we started with automatic tasks, such as writing his name. Later, we gave him tasks requiring unrestricted writing, followed by tasks in which he was to copy short texts and then longer ones. He completed assessment tasks that were given without any time limitations. He was assessed in a 20 to 40-minute individual session at home. He was asked to sign his name five times, to write a paragraph about his activities during a typical day and to copy a short paragraph. Data were analyzed with the digitizer.

The Rey Complex figure, a standardized test for the evaluation of visuo-spatial organization was also performed on the digitizer and the temporal, spatial and pressure data of the performed task were analyzed by ComPET.

## 3. RESULTS

To demonstrate the advantages of the ComPET system, examples of some of O.B.'s evaluation results are presented below (left side) alongside comparative results of a matched control participant with proficient handwriting (right side). Presenting the results in this manner allows for the illustration of the ComPET's ability to both distinguish between poor and proficient handwriting, as well as to highlight the deficient components underlying his handwriting problems. This information then enables the development of an individually tailored intervention program most suitable to his needs.

In the following figures and tabular presentations of the results, temporal measures are recorded in seconds, spatial measures in centimeters and pressure measures in non scaled units ranges from 0-1024.

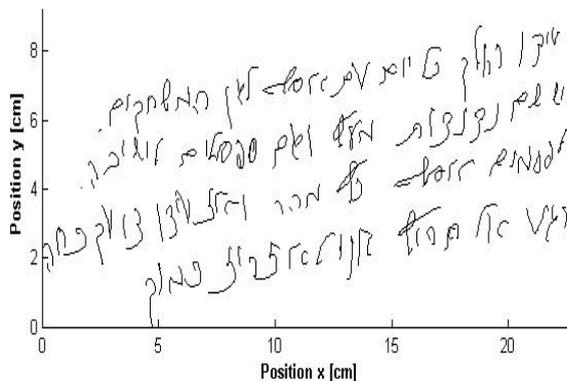


Figure 2A. O.B. – paragraph copying.

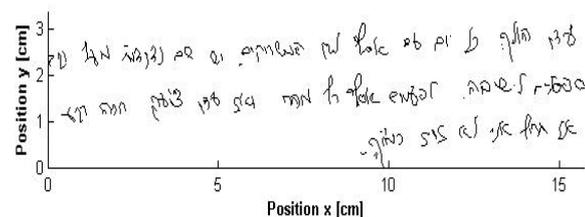
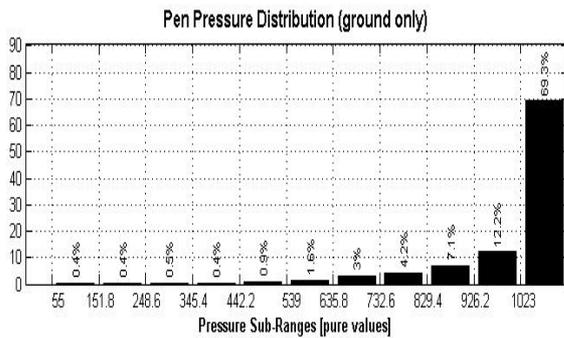


Figure 2B. Proficient handwriter – paragraph copying.

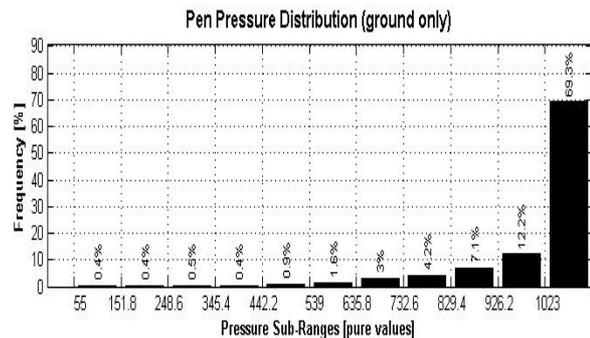
On the left side (Fig. 2), a short paragraph copied by O.B is presented. The handwriting product demonstrates several problems. Specifically, there is no clear difference in the spacing between letters and words (i.e., in Hebrew, a space of about one millimeter is required between each letter, while a space of about four millimeters is required between words. To illustrate the problem, some words are lined). Furthermore, some letters (marked by circles) are not readable, the sentences are markedly sloped and the organization of the writing product is not properly organized within the writing space.

Figure 3 (A&B) refers to the pen pressure applied by the pen to the writing surface during the performance of the paragraph copying. The X axis represents the pressure values, ranging in non scaled units from 0-1024; the Y axis represents the frequency of those values throughout the performance.

The graph reveals that during 70% of the writing performance time, O.B placed very high levels of pressure on his pen, while the skilled adolescent shows varied levels of pressure while writing.



**Figure 3A.** O.B. – pen pressure value distribution in the paragraph copying task.

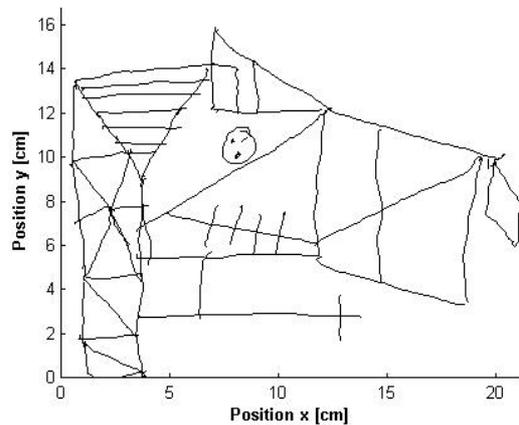


**Figure 3B.** Proficient handwriter – pen pressure value distribution in the paragraph copying task

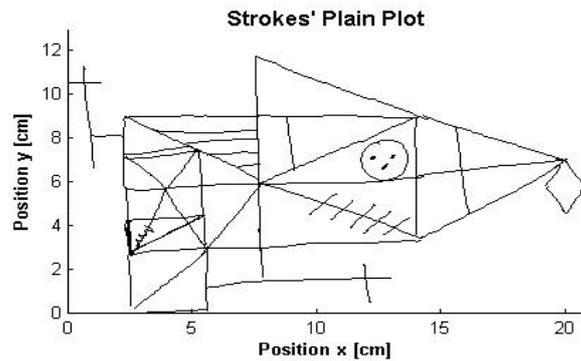
As was previously mentioned, the data supplied by ComPET provides objective measures relating to handwriting performance. To illustrate, we have presented some examples of the data collected from the assessment of O.B. in comparison to data collected from an assessment of a proficient handwriter of the same age. ‘On paper’ refers to the time in which the pen is in contact with the paper, whereas ‘in air’ refers to the time in which the pen is not in contact with the paper (i.e., the time in which the pen is located in the air, such as between letters and words).

**Table1.** Temporal measures, Velocity and Pen-pressure values obtained from O.B’s paragraph copying task in comparison to those of a proficient handwriter.

Measure	O.B.	Proficient handwriter
Overall duration of the writing task	116.74 sec.	40.24 sec.
Overall duration of the on paper strokes	68.83 sec.	19.11 sec.
Overall duration of the in-air strokes	45.97 sec.	18.73 sec.
Mean stroke duration	0.15 sec.	0.46 sec.
Mean velocity (cm per second)	3.93 sec.	3.42 sec.
Mean pen pressure	962.15	825.33



**Figure 4A.** OB's performance of the modified Rey-Osterrieth Complex Figure.



**Figure 4B.** Proficient handwriter's performance of the modified Rey-Osterrieth Complex Figure.

The two figures presented above illustrate the ability of the CompPET to demonstrate organizational problems. These figures also illustrate how one might combine the use of the findings of the Rey-Osterrieth Complex Figure tool with the measures of pen-pressure and velocity via the CompPET. The capability and flexibility provided by the use of the CompPET in combination with other assessment tools enables the therapist to identify deficiencies in handwriting performance and, in this way, helps the therapist design a suitable intervention program for the client.

#### 4. DISCUSSION

The case report presented here supports our stated objective regarding the CompPET's potential as a tool to assess and treat adolescents with handwriting difficulties. Based on the information collected from the questionnaire and the interview, we were able to focus on O.B.'s special needs and to choose fitting tasks for his assessment. Similarly, we can use these methods to build an appropriate intervention program for him.

It was very important for us to learn that O.B. enjoyed the process and appreciated that it could be accomplished in the privacy of his home and that his assignments were saved in a secure personalized area within a secure internet site that was not accessible to outsiders. In this way, he could review his work and monitor his progress throughout the process in an unthreatening manner.

Our future research will continue to examine the efficacy of the CompPET as a tool to assess and treat adolescents with handwriting difficulties. In addition, it will focus on developing optimal intervention methodologies through the use of the CompPET. As was mentioned previously, proficient handwriting requires the synchronization of a complex variety of underlying abilities and skills. Thus, handwriting intervention requires the therapist to perform a careful assessment and develop a tailored, individualized treatment program for each client.

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