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## **Graphomotor skills in dysarthric persons. As exemplified by dysarthria in cerebral palsy**

### SUMMARY

Graphomotor skills are the object of research in the developmental aspect (in the normal and in diverse pathological cases, in the context of the child's acquisition of basic school skills) and in the cases of their loss, e.g. in the course of neurodegenerative diseases. Because of the fact that writing disorders often accompany speech disorders, particularly those determined neurologically, the assessment of graphomotor skills as a sphere important for written communication (and thereby linguistic communication) should be an obligatory element of logopedic diagnosis. In the case of dysarthric patients and accompanying graphomotor disorders the analysis of specificity of these disorders (both the course of graphomotor activities and their products) may help diagnose clinical neuromotor symptoms, which in turn facilitates diagnosis of a clinical type of dysarthria.

**Key words:** graphomotor skills, writing, dysarthria, cerebral palsy, Parkinson's disease, Huntington's disease, ataxia

### INTRODUCTION

In their investigations of graphomotor skills the inquiries of scholars first focused on the result of graphomotor activities, chiefly writing, while at present graphomotor skills are viewed in many dimensions – a broad approach to graphomotor skills (understood as writing/drawing graphic signs, complex psychomotor activities, whose course and result depend on the level of development of functions involved in them and on their cooperation – in the first place, on the level of developed manual skills, visual perception, and on visual-motor coordination) is based on combining the course and products of graphomotor activities, thus determining the multi-faceted assessment of this sphere of human functioning

(Domagała, Mirecka 2010a). An example of change in the approach to the problem is studies taking into account the kinematic analysis of writing, which are carried out using digital drawing boards to assess writing and drawing activities (Stasik et al. 2009; Caliguri, Mohammed 2012), in which, apart from the quality of handwriting, the writing movements (their automation, fluidity, duration, pressure, etc.) are examined.

Graphomotor skills, an important sphere of man's psychomotor development, are the subject of interest of many disciplines, first of all psychology, pedagogy and logopedics (speech therapy) (Domagała, Mirecka 2013f). They are investigated particularly with regard to their developmental aspect, both in normal and in diverse pathological cases, in the context of the child's acquisition of basic school skills (Domagała 2012). Graphomotor skills acquired during education may be degraded, and as such they become the object of diagnostic and therapeutic management in adults. The capabilities and limitations in this sphere of human functioning, particularly occurring in different cases of speech pathology, are also essential to speech therapists: from the logopedic perspective writing difficulties are seen as linguistic communication disorders (Domagała, Mirecka 2009).

### GRAPHOMOTOR SKILLS DISORDERS IN DYSARTHRIA CASES

The definition of dysarthria, proposed in the standard of speech therapy management, treats this speech pathology entity as a type of neuromotor disorders – a disorder at the executive level of the motor mechanism of speech, caused by injuries to the central or peripheral nervous system (the upper and lower motor neuron, the extrapyramidal system, and the cerebellum) manifested in dysfunctions within the respiratory, phonatory and articulatory apparatus, resulting in distortions of the phonic substance of utterances at the segmental level (realization of phonemes and of word structure) and on the suprasegmental plane (prosodic organization of the phonic sequence regarding intonation, stress, speech rate and rhythm, phrasing, and resonance and voice quality) (Mirecka 2008; Mirecka 2012).

Damage to and dysfunctions of the central nervous system, which cause dysarthria, occur in cases of craniocerebral injury, cerebral stroke, cerebral tumor, multiple sclerosis, cerebral palsy (CP), neuroborreliosis, Huntington's disease (HD) and in many other neurological conditions (see Pruszewicz 1992; Murdoch 1998). Dysarthric disorders have a different range and intensity – in extreme cases they consist in the impossibility of producing speech sounds. Dysarthria is often accompanied by other neuromotor disorders (e.g. dysphagia, disorders of gait and posture, or manual activity disorders); cognitive disorders (in thinking, memory, attention, visual-spatial disorders or in linguistic functions) may also appear, as well as mental ones (affective, delusional, obsessive-compulsive) (see e.g. Dubas-

Ślemp et al. 2012; Wieczorek et al. 2013). The occurrence of other than dysarthric symptoms in dysarthric patients depends on the location and extent of injuries of the nervous system, their character being related to the specificity of a neurological condition.

Disorders of graphomotor skills in dysarthric patients are relatively seldom the object of research, and even in clinical diagnosis, both in cases of congenital and acquired dysarthria, they are not taken into account. Most information on the subject can be found in studies devoted to acquired dysarthria in Parkinson's disease (PD) and to congenital dysarthria in CP.

In diagnosing of PD patients, in whom hypokinetic dysarthria is usually diagnosed, handwriting and the drawing of the Archimedean spiral are analyzed: these simple tests of graphomotor skills are regarded as useful in assessing the degree of disability caused by tremor and bradykinesia, the symptoms regarded, together with stiffness and posture disorders, as axial motor symptoms in this condition (Poluha et al. 1998; Friedman 1999; Wieczorek et al. 2013). Apart from these visual, subjective diagnostic tests, objective methods are introduced based on the digital analysis of the tremor signal and motor dysfunctions of limbs (Orzechowski, Wochlik 2011). One of the most characteristic pathological symptoms in the handwriting of PD persons is micrography consisting in the decreasing size of letters in the course of writing. Micrography manifests in the patient particularly in longer writing (while taking down several lines of text): what can be clearly noticed is the letters gradually becoming smaller, and the handwriting becomes illegible. This is caused by hypokinesia, typical of the disease: a decrease in the movement amplitude in the situations when it is consecutively repeated (cf. Gatkowska 2012; Domagała, Mirecka 2013d).

In HD patients, the main pathological motor symptoms are involuntary movements (chorea), difficulties with beginning voluntary movements (akinesia), or slowing down of movements (bradykinesia): they cause the patient's many different problems, *inter alia* hyperkinetic dysarthria and writing difficulties manifested in shapeless, sharply defined letters, and in macrography (handwriting is too large or gradually increases in the course of writing), which occurs when chorea is stronger than bradykinesia (cf. Phillips et al. 1994; Nicewicz, Pełka-Wysiecka, 2008; Gatkowska 2012; Domagała, Mirecka 2013c).

The deterioration of handwriting is one of the early symptoms in Wilson's disease, also resulting in dysarthria (usually spastic-hypokinetic-ataxic). The main symptoms of this condition are: tremor or involuntary movements, discoordination of movements; there is usually rigidity, dysphagia, salivation, gait and posture disorders, bradykinesia, adiadochokinesis, disorders of mimic expression and of eyeball movements. Graphomotor skills disorders manifest in macro- or micrography, and in the diminished flow and legibility of handwriting (Hermann et al. 2002; Brewer 2001).

Diminished graphomotor skills are usually observable in persons with ataxic dysarthria – these disorders can be accompanied by dysphagia, abnormal eyeball movements, as in e.g. spinocerebellar ataxia SCA 15 (Anderson et. al. 2005). In our studies (Gustaw, Mirecka 2000), in the patient with ataxia, in the course of cerebelloolivary degeneration of Holmes, dysarthria occurred together with balance disorders and ataxia of movements, restricting motor activity (including manual), and with nystagmus. The problems of this patient with activities requiring precise manual movements, which include graphomotor skills, were analyzed based on writing tests (see Domagała, Mirecka 2011). The analysis of handwriting showed irregularities pertaining to the writing line (hesitant, trembling line, varied pressure of the writing instrument), distortions of letter forms in a word, variable size and direction of the slope of writing, and problems of keeping the line (wavy verse line). Observation of the course of writing activity made it possible to find disorders in the movements of the dominant hand during writing (ataxia of movements, trembling hands, varied muscle tone, frequent breaks of the writing movement, very slow rate of writing) and in the movements of the auxiliary hand (inadequate use of the sheet, whose position on the table changed in an uncontrollable way). The patient very reluctantly began to perform graphomotor activities (this was also the case with other tasks requiring manipulation) as he noticed his growing difficulties.

### GRAPHOMOTOR SKILLS IN PERSONS WITH CEREBRAL PALSY

The term *cerebral palsy* (CP) currently defines “a group of permanent disorders in the development of movement and posture, causing restrictions of activities. They are attributed to non-progressive disturbances that occur in the development of the brain of the fetus or infant. Motor disorders in infantile cerebral palsy are often accompanied by disorders in sensation, perception, cognition, communication and behaviour, by epilepsy and secondary musculoskeletal problems” (Gajewska 2009: 68). In the clinical picture of this disease syndrome the dominant ones are “symptoms indicating the injuries of the central motor neuron (limb pareses), subcortical nuclei (involuntary movements), and the cerebellum (disorders of coherence of movements and balance)” (Kułak, Sobaniec 2006: 442). The most lucid categorization of CP, developed by B. Hagberg (cited after Borkowska 2001) shows three clinical forms of CP, distinguished based on the dominant symptom: spastic (resulting from injuries within the pyramidal system), dyskinetic (caused by damage to the extrapyramidal system) and ataxic (caused by injuries of the cerebellar structures). Some researchers and practitioners also point to mixed forms of CP, arguing that these are the largest group of CP cases;

according to Borkowska (2001) the development of children in whom the mixed form is present is more complicated than in the case of a typical form.

Investigations into graphomotor skills of CP persons concern almost exclusively children, as the survey of literature on the subject shows. Opinions on the graphomotor abilities of children with CP are best expressed in M. Synder's words (2002: 31): "A child with cerebral palsy exhibits restricted abilities in visual-motor coordination. His writing is as a rule illegible. Many children use computers in writing, which immensely helps the child's development and communication with the environment". These opinions are partly confirmed by the results of experimental studies. While examining children aged 7–12, it was found that in the group of children with CP there was a far lower increase in graphomotor skills (assessed based on the drawing of human figure) than in the control group (Mihilewicz 2005). It was shown that the significant decrease in the handwriting skill and writing parameters in children aged 8–12 with left-sided CP (as compared with their peers) was influenced by the disorder in the proprioception of the right-side (not affected by palsy), by the diminished mobility and speed of the upper limbs, and by impairing of bilateral coordination, visual and spatial perception, visual-motor organization and of the sense of touch (Bumin, Tukul Kavak 2010). A diminished level of the writing skill and of handwriting because of the weaker development of visual-motor integration was found in children with CP (diplegia and hemiplegia) aged 5–6 (Desai, Rege 2005). In pupils with CP (Loska 2005) problems were observed with reproducing the shapes of letters and digits ("uneven, too small or too large, going beyond the line or not touching it", p. 31), with writing down mathematical calculations in the form of graphs, there were problems with free grip, including holding the writing instrument (incorrect arrangement of fingers, with a tendency to keep the hand tightly clenched), which was attributed to abnormal muscular tension, movement incoherence and diminished precision of movements, occurrence of involuntary movements, disordered visual-motor control and visual perception, and limitations of the field of vision; moreover, what drew attention was the frequent lack of cooperation between both hands, making it difficult or even impossible to perform manual actions (which necessitated additional stabilization of writing tools and pads, e.g. fastening the sheet to the table/desk), and also problems with assuming and keeping the correct sitting position, and with controlling the position of the head. Increasing manual difficulties in children with CP who begin to learn writing (at the age of ca. 7 years) were assessed by J. Bogucka (2001) – in studies on a 140-subject group (93.5% with the spastic form 3.5% with the extrapyramidal form, and 3% with the cerebellar form) using the Katz's four-degree index she found in 22% of children minimal impairment of manual skills (lack of difficulties in using the arm and hand in personal activities), in 37% – mild impairment (certain difficulties with movement precision, slower performance of manual activities, e.g. drawing),

in 28% – moderate impairment (difficulties in activities of daily living, difficulties in reproducing a circle and a cross), in 13% – severe impairment (lack of independence in activities of daily living, incorrect way of holding a spoon, a pencil; incoherence of movements, involuntary movements, tearing the paper while trying to draw, writing single signs).

### GRAPHOMOTOR SKILLS IN DYSARTHIC PERSONS IN CEREBRAL PALSY. EXEMPLIFICATION OF THE PROBLEM

Limitations of manual (including graphomotor) skills in patients with CP can co-occur with dysarthria, which is diagnosed in ca. 30% of children with CP (Obrębowski, Woźnica 1997; Mirecka, Gustaw 2005). In English-language literature dysarthria in CP is classified as developmental dysarthria, also termed congenital dysarthria. (Murdoch 1998; Love 2000). Three main types of dysarthria in CP are diagnosed corresponding to three main clinical forms of CP: spastic dysarthria, dyskinetic dysarthria, and ataxic dysarthria; the kinds of symptoms and their intensity in particular types of dysarthria are linked to the location and degree of injuries of the central nervous system (see Mirecka 2013). The surveyed literature on the subject in Polish and in English of the last 20 years provides no information on epidemiological and experimental studies devoted to the co-occurrence of dysarthria and graphomotor skills disorders in persons with CP; there are only case studies (e.g. Hryniewicka 1992; Gross-Tsur 2006).

The examination of graphomotor skills, presented below, was carried out in a forty-nine-year-old male with dysarthria in CP.

The clinical form of CP in the studied patient is a mixed one: spastic-dyskinetic – the neurological diagnosis indicated the paralysis of the upper and lower limbs and with symptoms of heightened spasticity and bilateral athetosis, the dominant symptoms being on the left side of the body (Łuckiewicz et al. 2009). Psychological studies (Hryniewicka 1992) showed the high development level of cognitive functions, with emphasis placed on the fact that his psychomotor development in childhood was retarded: he sat up and uttered the first words only when he was four, he stood up with the help of an adult at five, and when he was thirteen he moved when held by the hand; he was not able to longer maintain the standing position by himself; when performing manual activities, he used the backs of both hands and elbows; learning to write was hindered by disorders of visual-motor coordination, of movement precision and manual dexterity, and by numerous head and limb synkineses.

In logopedic diagnosis (the patient was undergoing logopedic treatment conducted by the author of the article at the Maria Curie-Skłodowska University Speech Therapy Lab from 1993 to 1994 and between 2000 and 2005) severe spastic-dyskinetic dysarthria was diagnosed. The muscles of the speech apparatus

were in a paralyzed condition: increased symptoms of heightened spastic muscle tension, muscle weakness, limitations of the range and precision of movements and their slowing, as well as the occurrence of involuntary movements were reported. A considerable reduction in the intelligibility of the patient's utterance was directly due to pathological phenomena caused by dysfunctions in the work of the respiratory, phonatory and articulatory apparatus, which manifested in the phonic aspect of the utterance – at the segmental level (deformations and substitutions of vowels and consonants, assimilation of phones, and simplifications of consonantal groups) and at the suprasegmental (weak, tense, breathy voice, unstable volume, hypernasality, slow speech rate, unstable pitch, shortened phrases, speech on residual air). The identified accompanying disorder was dysphagia. Difficulties with maintaining the normal body posture while speaking were also observed.

When examining graphomotor skills (the test was carried out in 2015) the experimental version of the *Graphomotor Skills Profile*<sup>1</sup> for testing of adults was used. The test consisted in copying a short text (Fig. 1) on a sheet with single line ruling, and in reproducing letter-like designs (Fig. 2) on an unlined sheet (the format of sheets with the text and designs, and also the format of the sheets on which the patient wrote and reproduced designs was A5). The assessment of graphomotor skills was carried out based on the observed course of graphomotor activities and on analyses of the samples of handwriting and letter-like designs according to the criteria specified in the *Observation Protocol* and the *Chart of Assessment of Handwriting and Letter-like Designs* – parts of the *Graphomotor Skills Profile* (see Domagała, Mirecka 2010b).

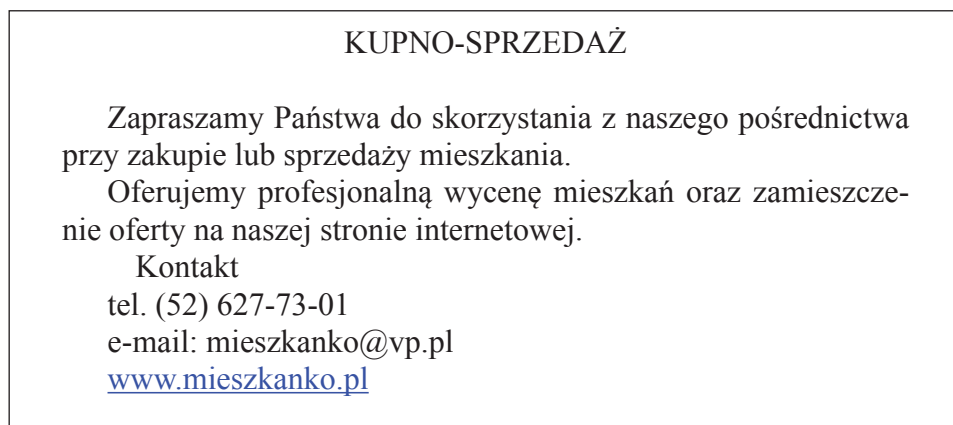


Fig. 1. Text to be copied on the lined sheet

<sup>1</sup> The *Profile of Graphomotor Skills* as a diagnostic technique for identifying the capabilities and limitations in the sphere of graphomotor skills in children aged 7–13 has been presented in many publications (*inter alia* Domagała, Mirecka 2009; Domagała, Mirecka 2010a).

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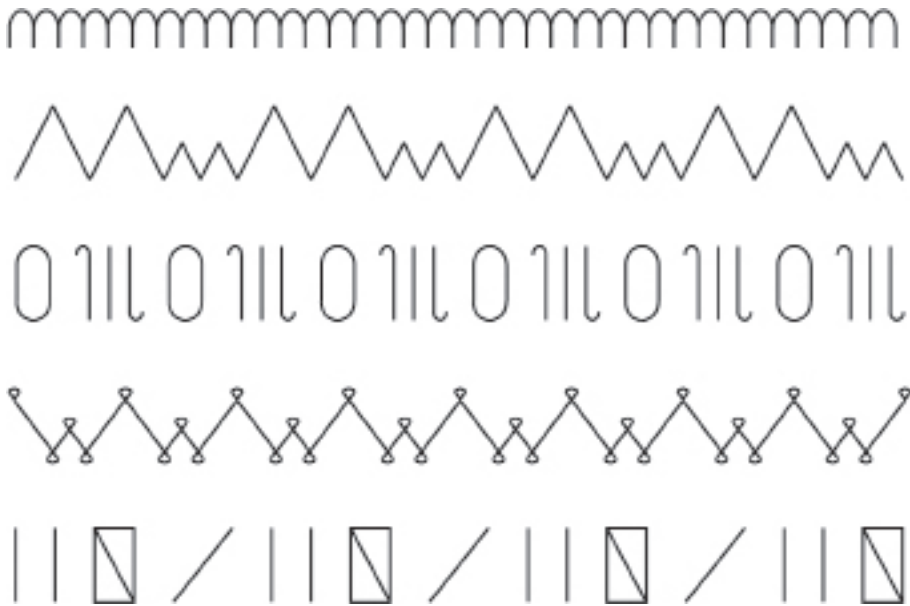


Fig. 2. Designs for reproduction

The observation of the course of graphomotor activities showed considerably heightened graphomotor skills disorders – irregularities were found in six out of the eight specified categories of describing phenomena:

- I. THE DOMINANT (GUIDING) HAND – the right hand;
- II. THE WAY OF HOLDING THE WRITING INSTRUMENT – improper grip: the ballpoint placed on the clenched index finger, tightly pressed with the thumb, with a too long distance of the finger from the writing end (see Photo 1);
- III. THE DOMINANT HAND ARRANGEMENT – incorrect: a too tight grip of the hand, resulting in the wrong positioning of the ballpoint (upright position), unstable support of the hand and wrist (the right hand supported by the left hand in order to minimize involuntary movements (see Photo 1);
- IV. THE DOMINANT HAND MOVEMENT – disordered: the writing movements performed with the whole palm (writing movements without moving fingers), inharmonious, poorly coordinated movements of the hand, arm and fore-



arm, frequent interruptions of the writing movement (after each graphic sign or even while writing it), considerably heightened muscle tension;

V. THE AUXILIARY HAND (the left hand) – incorrect activity: the left hand primarily stabilizes the right hand, often without holding the sheet (see Photo 1);

VI. THE POSITION OF THE SHEET – correct;

VII. BODY POSTURE – incorrect: excessive bending of the torso, involuntary movements (of the head and limbs);

VIII. THE PACE OF GRAPHOMOTOR ACTIVITIES – improper: very slow (reproduction of letter-like designs: 3'40'', copying the text: 10'10'' – because the patient was tired of graphomotor tests, the tester suggested omitting the sentence: *Oferujemy profesjonalną wycenę mieszkań oraz zamieszczenie oferty na naszej stronie internetowej [We offer professional valuation of apartments and placing of your offer on our webpage]*).

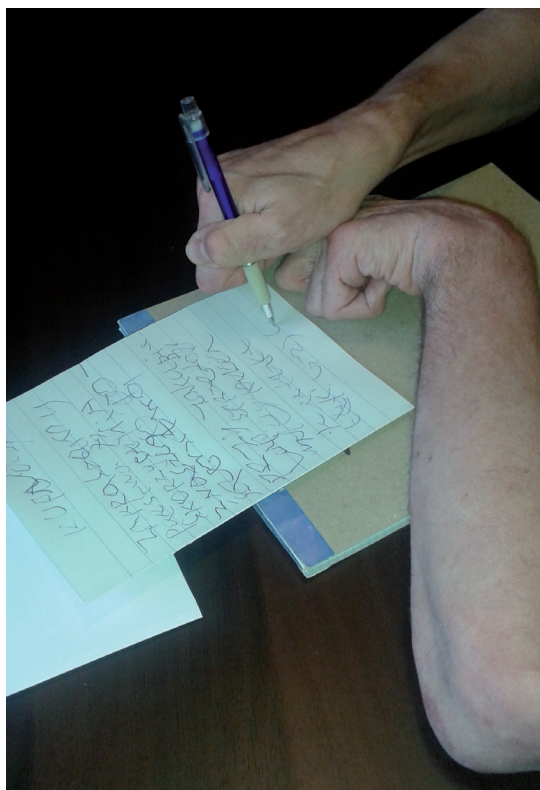


Photo 1. Irregularities in category II. THE WAY OF HOLDING THE WRITING INSTRUMENT, category III. THE DOMINANT HAND ARRANGEMENT and in category V. THE AUXILIARY HAND

The analysis of the products of graphomotor activities – the text copied by the patient (Fig. 3) and the reproduction of letter-like designs (Fig. 4) – made it possible to find irregularities in the following categories:

I. LINE – changing clearness of the handwriting track, which evidences problems with controlling the pressure of the writing instrument, arising from disordered muscle tension (assessment made based on the analysis of the copies of the track of the writing instrument), the line: hesitant, trembling, irregularities and distortions of the line;

II. LETTER/ LETTER-LIKE DESIGN – distortions and loss of the form of letters and letter-like designs, incorrect combinations of the constituent elements of letters and letter-like signs, disordered proportions within letters and letter-like signs;

III. A LETTER IN A WORD/A LETTER-LIKE SIGN IN THE DESIGN STRUCTURE – the changing size and slant of letters and letter-like signs, and their incorrect combinations in the word/in the structure of design

IV. WRITING DOWN OF THE TEXT/LETTER-LIKE DESIGNS – macrography;

V. VERSE ORGANIZATION – the written entries incorrectly situated in the line (letters and words go beyond the line);

VI. PAGE ORGANIZATION – incorrect margins, no indentation.

Due to the slow pace of performing graphomotor activities, great fatigability, and, first of all, because of highly diminished legibility of handwriting the patient mainly uses a computer in daily activities, pressing the keys with his index or middle fingers of the right hand, and supporting the right hand with the left hand. He uses handwriting at present almost exclusively when signing (e.g. while staying in hospital, to express his consent for treatment). In the past the patient used to write more with his hand – compositions in primary and secondary school (although, because of the low legibility of his handwriting, his knowledge was checked mainly through his oral answers); when he was a student, he practiced handwriting techniques by copying letters and texts. Typing on a typewriter was very difficult for the patient, more than typing on the computer keyboard (because he had to press the keys harder), yet the use of the computer is not easy for him, first of all on account of the limited precision of movements and involuntary movements, and also because of problems with maintaining the proper body position, which is why this activity is time-consuming and tiring.

## CONCLUSION

In the diagnosis of graphomotor skills, when analyzing the products of the writing activity, one should take account of the fact that a person's handwriting (individual graphism) evolves with his/her age. The first 2–3 years of learning to

KUPAŁO SPEC

ZAKRASAŁO SIĘ  
 POKUSIŁO SIĘ  
 SKORZYSAŁO SIĘ  
 Z NASZEGO  
 SPORSAŁO SIĘ

PRZY ZAKUPIA  
 WYPRZEŁO SIĘ  
 WŁYSAŁO SIĘ

KUPAŁO SIĘ  
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Fig. 3. The text copied by the patient

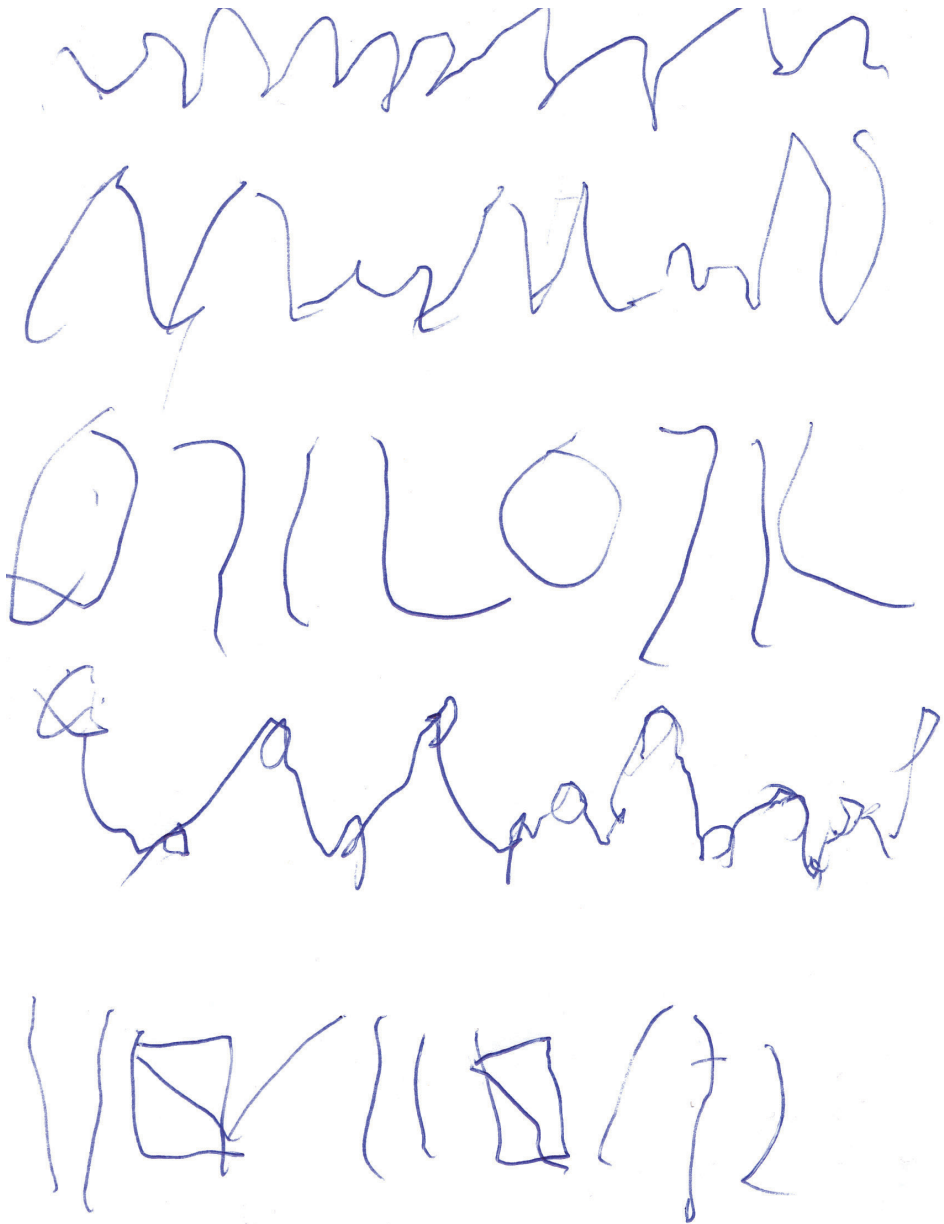


Fig. 4. Reproduction of letter-like designs

write is the acquisition and consolidation of the calligraphic (primer-based) patterns of handwriting (the stage of learning the patterns of letters and their combinations) and then comes the period of modification and, subsequently, individualization of handwriting, which is accompanied by the improvement of the motor apparatus of the hand and automation of writing movements, the result of which is, *inter alia*, an increase in writing speed; at the age of about 20–25, handwriting is already relatively stable (the period of “writing maturity”) and when a person turns sixty the quality of handwriting begins to deteriorate: its esthetic qualities decline, legibility diminishes, the line becomes shaky, unsteady and less fluid, writing speed also decreases, and changes in the pressure force also appear (see Widła 1986; Domagała, Mirecka 2013e). Degradation of graphism can occur regardless of age as a result of a person’s diseases, especially those manifesting in dysfunctions in the manual and visual spheres (Domagała, Mirecka 2013a).

Due to the fact that writing disorders often accompany speech disorders, particularly those neurologically determined (e.g. in dysarthria, aphasia, and in dementia), assessment of graphomotor skills as an important sphere for the course of written communication (and thereby for linguistic communication) should be an obligatory element of logopedic diagnosis. In the case of patients with dysarthria and co-occurring graphomotor disorders, the analysis of the specificity of the disorders (both of the course of graphomotor activities and their products) may help identify clinical symptoms, which in turn facilitates diagnosis of a clinical type of dysarthria (cf. Gatkowska 2012). It should be remembered that while assessing the handwriting of persons who learned to write before disease symptoms appeared, one should refer to the earlier level of this activity and compare the current level with the previous one. In progressive diseases it is essential to monitor the patient’s capabilities – this also includes the sphere of written communication (see Bloch, Clarke 2013). The treatment programs of patients with dysarthria and with co-occurring graphomotor skills disorders need to take into account manual rehabilitation, which should also include graphomotor skills exercises. Graphomotor skills exercises (with activation of fine motor skills, visual perception, proprioception, and visual-kinesthetic-tactile-motor integration) need to be carried out both on the letter material (handwriting) and using other graphic signs. In the cases of neurodegenerative diseases, patients often withdraw from difficult life situations, and avoid oral and written communication; consequently, an important task in the rehabilitation of these patients is to maintain their activity, taking psychotherapeutic measures into consideration.

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