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Interpretation of Metaphors and Similarities by Individuals With Cerebellar Lesions

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Abstract

Objective: The cerebellum participates in both the coordination of motor activities and the regulation of mental processes. The symptoms of cerebellar damage are diverse, relatively non-specific, and difficult to systematize.

Aim of the study: The aim of this exploratory study was to conduct a neuropsychological diagnosis of hypothetical disorders of selected (meta)linguistic and cognitive processes that are involved in solving problems containing metaphors and similarities. The epidemiology, severity, clinical specificity, and sociodemographic correlates of the analyzed disorders were characterized.

Method: The study involved 25 adults with isolated cerebellar injury, most often of vascular origin. Three tests were used: the Polish version of the WAIS-R Similarities Subtest (PL) and two metaphor processing tests from the Polish version of the Right Hemisphere Language Battery (RHLB-PL), i.e. the Written Metaphor Test (TMP) and the Written Metaphor Explanation Test (TWMP). At the outset, the mean values and standard deviations were calculated for the whole group. In addition, each patient's test scores were assessed separately based on the data and norms included in the test manuals. Individual raw scores were replaced with converted scores and expressed in percentiles (similarities subtest) or on a sten scale (metaphor tests).

Results: The performance on the WAIS Similarities Subtest was below average in the whole group, with 9 subjects having significant problems with solving the subtest. In turn, the score in the TWMP was determined in the range of 5–6 sten. Although the group's overall performance in the TWMP did not differ from the norm, the result scored by nearly half of the subjects did not exceed 4 sten. In comparison, the average score on the TMP was relatively high, and low results (<4 sten) were obtained by only 4 patients. An estimated profile analysis (based on the pattern of all test results) showed intra- and

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inter-individual differences which were clinically illustrated by heterogeneous, often selective disorders of the examined functions. The sociodemographic correlates of test results were age and education.

Conclusions: In the majority of patients, various cognitive deficits were implicated in disorders associated with solving problems that contain metaphors and similarities. Disorders in purposeful associative thinking, including inference by analogy and interpretation and verbalization of concepts, were predominant, whereas linguistic knowledge, including comprehension of figurative meanings, was generally unaffected.

Keywords: cerebellum, metaphors, inference by analogy, neuropsychological assessment

Many years of research have demonstrated (Ahmadian et al., 2019; Beck & Bikeles, 1911; Gilbert, 2022; Liu et al., 2022; Murdoch, 2010; Schmahmann, 2009; Timmann & Daum, 2007) that the cerebellum participates not only in the coordination of motor activities, but also in the regulation of mental processes, through a loop of anatomical and functional connections with both the spinal cord, the reticular formation of the trunk, the thalamus, and the associative cortex of the brain (especially the frontal lobes). Cerebellar disorders are thus sensitive to the functioning of "psychologically strategic" brain structures whose activities are inhibited and/or disorganized (Clark et al., 2021). For example, congenital functional-structural anomalies of the cerebellum are considered in the etiology of some mental illnesses, including schizophrenia, affective psychosis, and autism (Rapoport et al., 2000; Schmahmann, 2009).

Furthermore, cerebellar injuries acquired in adulthood, regardless of their etiology, increase the risk of various disorders with different severity and clinical symptoms that should be diagnosed by multidisciplinary teams involving a neurologist, a neuropsychologist, a psychiatrist, a radiologist, and, in many cases, a speech therapist (Jodzio, 2011; Liu et al., 2022; Starowicz-Filip et al., 2017). The identified symptoms of cerebellar damage include executive dysfunctions, attention deficits, visual memory and procedural learning disorders, visuospatial dysfunctions, manual and motor disorders, language deficits (word-finding difficulties, agrammatism, aphasia, alexia, agraphia), affective disorders, and even full-blown and advanced dementia (De Smet et al., 2007; Jodzio, 2020a,b; Jodzio et al., 2007; Liu et al., 2022; Rapoport et al., 2000; Schmahmann, 2009; Starowicz-Filip et al., 2017). The need to systematize this wide range of symptoms was recognized by Jeremy Schmahmann and Janet Sherman who introduced the concept of cerebellar cognitive affective syndrome (CCAS) to diagnostic language in 1998 (Ahmadian et al., 2019; Schmahmann, 2009). The surprisingly similar results of 20 patients with selective, but etiologically heterogeneous cerebellar lesions in the posterior lobe provided an empirical incentive to propose CCAS as a diagnostic entity. According to the authors, this syndrome consists of four typical cerebellar symptoms: (i) executive dysfunctions such as rigidity of thought, difficulty concentrating for longer periods of time, flexible attention, disorganized behavior with a tendency to perseverate; (ii) impaired

visuospatial functions, including visual memory; (iii) personality changes with shallow and blunt affect, disinhibition, or socially inappropriate behaviors; (iv) language problems, including dysprosody, agrammatism, and mild anomia.

Twenty-five years later, CCAS is still not included in popular taxonomies of syndromes based on etiological, anatomical, topographic, functional, or clinical criteria. There are several reasons why CCAS is moderately (at most) popular among clinicians. Firstly, the syndrome does not have a specific etiology and the patients studied by Schmahmann and Sherman (op. cit.) presented with cerebellar symptoms of various disorders. Secondly, the anatomical aspect of CCAS is also ambiguous, and it has attracted at least two competing interpretations. The first emphasizes the destruction of the "psychologically" specialized posterior lobe that occupies most of the cerebellum, while the second emphasizes the disruption of its modulatory interactions with selected parts of the brain. At the same time, it is difficult to determine whether the cessation of these neuromodulation processes in patients with CCAS should be attributed primarily to anatomical (structural) *disconnection* in its classical (associationist) sense (Walsh & Darby, 2008), or rather to contralateral cerebral hypoperfusion resulting from crossed diaschisis (Ahmadian et al., 2019; Bartczak et al., 2011; Pietrzykowski et al., 1997). It has been established that certain disorders (language, memory, visuospatial and motor) are associated not only with the extent (Schmahmann & Sherman, 1998), but also with the lateralization (side) of cerebellar injury (Cook et al., 2004; Jodzio, 2020b). Thirdly, the characteristics of CCAS seem to be of little use in describing the patient's functional state, including their daily problems and ability to return to a pre-morbid lifestyle. Fourthly, recent studies have shown that the clinical picture of CCAS described by Schmahmann and Sherman (1998) is not consistent or complete. For example, Jodzio (2020b) found that visual memory disorders in cerebellar ischemic stroke patients were discrete in nature, which contrasts with more severe manual disorders, such as slow, isolated, and sequentially organized movements of the index finger of each hand (so-called tapping). Clark et al. (2021) argued that the clinical picture of cerebellar syndrome does not contain an entire set of symptoms (CCAS), but rather inherently selective, yet specific disorders, most of which belong to the spectrum of executive dysfunctions (Jodzio, 2022). It should also be noted that degenerative diseases of the cerebellum are more likely to cause generalized mental deterioration typical of more severe forms of dementia than a four-symptom syndrome (Jodzio et al., 2007; Liu et al., 2022). According to Schmahmann (2009), patients with cerebellar degeneration had been diagnosed with dementia and/or psychosis, especially in later stages of the disease, already in the mid-twentieth century. More recent screening studies indicate that the epidemiology of dementia in various cerebellar dysfunctions ranges from 12% (Jodzio, 2020a) to even 24% (Liu et al., 2022).

The literature review indicates that symptoms of cerebellar damage, such as cognitive dysfunctions, are diverse, relatively non-specific, and difficult to systematize. The clinical characteristics of cerebellar pathology have not been fully explored to date despite the fact that the first research efforts had been initiated in the first half of the nineteenth century (Beck & Bikeles, 1911;

Murdoch, 2010; Schmahmann, 2009; Voogd, 2022)[2] and were continued and intensified in multidisciplinary studies in successive decades (Gilbert, 2022; Rapoport et al., 2000; Timmann & Daum, 2007). It may come as a surprise that disorders of communication competence and metalinguistic abilities, including problems with understanding and/or using figurative meanings (metaphors and proverbs) or using analogies during reasoning, are rarely considered in routine diagnostic tests of patients with cerebellar disorders. These symptoms are not uncommon in adults with acquired cerebellar damage of various origin (Cook et al., 2004; De Smet et al., 2007; Guell et al., 2015; Liu et al., 2022; Murdoch, 2010). The present research was undertaken to fill in this knowledge gap. Due to their complex nature and function in linguistic, psychological, and social domains (Kordys et al., 2001; Lakoff & Johnson, 2020; Ulatowska et al., 2000), metaphors became the subject of interdisciplinary debate many years ago (Billow, 1975; Gorham, 1956; Winner & Gardner, 1977). The diagnostic significance of proverbs (as a type of metaphor) was described already in the 1920s. Piaget (as cited by Kordys et al., 2001) systematically used proverbs in analyses of cognitive operations in children. In recent years, proverbs and other metaphors have attracted the interest of neuropsychologists researching brain disorders and mechanisms responsible for processing these linguistic constructs (Benedek et al., 2014; Bottini et al., 1994; Jodzio et al., 2001, 2005; Łojek, 2007).

Research Objectives

This exploratory research study was undertaken to provide a neuropsychological description of hypothetical disorders of selected linguistic-cognitive processes involved in solving problems that contain metaphors and similarities. These disorders have been characterized in the broadest possible manner based on their (a) epidemiology (prevalence), (b) severity (depth), (c) clinical specificity, including heterogeneity manifested by individual differences, and (d) sociodemographic predictors. The processes responsible for the comprehension of figurative

[2] Schmahmann (2009) reports that cases of mental disorders in patients with cerebellar agenesis or atrophy were first described in the early nineteenth century. Their behavior deviated from the norm in terms of intelligence, emotions, personality, and social interactions. Gerbrandus Jelgersma was one of the pioneers of basic research on the cerebellum and its role in the regulation of behavior (Voogd, 2022). Jelgersma conducted systematic research on the anatomy and function of the cerebellum at the turn of the twentieth century. His results were published in three books and numerous articles in Dutch and German. Jelgersma emphasized the importance of cerebellar plasticity which can be attributed to bilateral connections of the cerebellum and brainstem with the frontal parts of the brain, which he referred to as *intelectuarium*. The cerebellum, brainstem and their connections running through the basal nuclei of the telencephalon to the cerebral cortex form the "intellectual system". The mechanisms responsible for cerebellar-cerebral communication were also analyzed and described by Adolf Beck and Gustaw Bikeles in a paper published in Polish in 1911.

meanings and flexible mental associations during the verbalization of relationships (similarities) between objects or concepts were analyzed simultaneously because both processes require the ability to abstract and make inferences by analogy. Abstraction and perception of analogies are often mentioned in the description of the similarities subtest in D. Wechsler's Intelligence Scale (Brzeziński & Hornowska, 1993, p. 207; Hornowska, 2004, p. 90; Kaplan et al., 1991), as well as various tasks for studying the perception and understanding of metaphorical expressions, including proverbs (Jodzio et al., 2001; Kordys et al., 2001; Ulatowska et al., 2000; Winner & Gardner, 1977). In the light of the psycholinguistic theories described by Biela (1981) and Chlewiński (1999), *metaphorical language* relates to the ability to express newly perceived *similarities* with the use of familiar sets of word symbols, rather than the ability to use new expressions in general. This approach emphasizes the role of *analogy* as a cognitive process that facilitates the grasp of *similarities*.

Method

Participants

The study involved 25 patients (5 women and 20 men) with isolated cerebellar injury, who were hospitalized at the Department of Adult Neurology of the University Clinical Center in Gdańsk. All patients were subjected to conventional magnetic resonance imaging, and computed tomography exams were performed in 7 patients. In 18 patients, cerebellar damage was focal and lateralized (on the left side in 7 patients and on the right side in 11 patients). Patients with concomitant brain injuries (including in cerebral hemispheres and the diencephalon), individuals abusing alcohol and/or psychoactive substances, and subjects undergoing long-term psychiatric treatment were excluded from the study. The etiology of cerebellar injury was differentiated, with a predominance of vascular disorders, including ischemic stroke (19 subjects), primary degenerative atrophy (5), and neoplasm (1). The patients were aged 25 to 77 years, with a mean age of 54 years (SD = 14.0), and had an average of 12.64 years of education (SD = 3.12). The patients' educational status was included in the study as a continuous variable.

Measuring Tools

Problem-solving abilities in tasks containing metaphors and similarities were assessed individually. Three diagnostic tests with satisfactory psychometric properties were used. The structure of the similarities subtest in D. Wechsler's Adult Intelligence Scale has been analyzed extensively in the literature, and it was described only briefly (Brzeziński & Hornowska, 1993; Brzezinski et al., 1996, 2004; Hornowska, 2004; Spreen & Strauss, 1998). In the test, the

subjects are asked to find similarities between two concepts by identifying common features or a common class to which both concepts belong. The test requires abstract thinking and concept formation skills. The test also evaluates the subjects' attention span, verbal fluency, verbal comprehension, organization of knowledge in long-term memory, and thinking, which is most often described as abstract, conceptual, logical, and associative. Similarities are a good measure of the general intelligence factor *g* (Hornowska, 2004). The test was a part of the diagnostic battery used by Schmahmann and Sherman (1998) to examine patients with cerebellar injury.

The processing of metaphors was assessed with the use of two other tests. The Written Metaphors Test (TMP) and the Written Metaphor Explanation Test (TWMP) are a part of the Battery for the Study of Language and Communication Functions of the Right Hemisphere of the Brain (The Right Hemisphere Language Battery, RHLB-PL) developed by Emilia Łojek (2007). The TMP not only assesses the knowledge of common metaphors, but also the ability to think abstractly when processing complex linguistic material. The subjects are asked to read a sentence containing a metaphor and then choose the appropriate explanation from a set of three answers. One of the sentences is correct, the second contains a literal interpretation of the metaphor, and the third is too general and inadequate. The test consists of an example and ten target sets placed in a test book. One point is given for choosing the correct answer (10 raw points in total). According to a study that was conducted for the purpose of developing the Polish adaptation of the TMP (Łojek, 2007), over 70% of healthy people and only one in three patients with damage to the right hemisphere of the brain answered all questions correctly. The location of post-stroke injury in the right hemisphere of the brain was not a significant predictor of TMP or TWMP performance (Jodzio et al., 2005).

The TWMP is similar to the TMP in terms of content and procedure, and according to the RHLB-PL protocol, the TMP is conducted directly after the TWMP. Although the TMP and the TWMP contain the same metaphors, the results of each test are analyzed separately. In the TWMP, the subjects are assessed not only for their ability to understand metaphors, but also for their ability to explain the metaphors in figurative language. One point is awarded for correctly describing the abstract meaning of the metaphor (10 raw points in total). According to a study that was conducted for the purpose of developing the Polish adaptation of the TMP (Łojek, 2007), around 60% of healthy people and 30% of patients with damage to the right hemisphere of the brain made only one mistake or answered all questions correctly.

It should also be noted that the decision to present metaphors in written form rather than as drawings (this option is also available in the RHLB-PL) was made to obtain a method that is sufficiently difficult and thus sensitive to the analyzed disorders which are often benign and easy to overlook during routine examinations of patients with cerebellar damage. Biela (1981) reviewed numerous psycholinguistic experiments and concluded that metaphors are more effectively retrieved from memory when the stimuli facilitating reproduction are visual rather than written.

Test Procedure

Hospitalized patients were selected for the study based on the results of neuroimaging exams (damage affecting only the cerebellum – refer to the *Subjects* section) and their medical history. The study was conducted in a psychologist's office, and all patients agreed to participate in the research. The research had been approved by the Ethics Committee for Research Projects at the Institute of Psychology of the University of Gdańsk (29/2020).

Statistical Analysis

The correctness of each test administered to the patients had to be evaluated to ensure that the subjects were reliably assessed in the four indicated areas (cf. *Research Objectives* section). For this purpose, raw results were converted into percentages or sten scores (cf. *Results* section). Descriptive and correlational statistics were then used. Advanced statistics could not be used due to the small size of the analyzed population (25 patients). However, the double dissociation model, a popular tool in neuropsychological research, was also used in the study (Walsh & Darby, 2008). Double dissociation refers to two cognitive faculties that are linked, but function independently, which could explain the disproportions in the severity of symptoms (refer to the *Discussion* section).

Results

In the first step, the mean values (of the recalculated results – see below) and standard deviations were calculated for all patients. The patients' performance in each of the three tests was evaluated based on the data and standards in the test manuals. For this purpose, individual raw scores were expressed in percentiles (similarities test) or sten scores (metaphor tests). As a result, the scores in each test were classified as normal, low, or relatively high (above average). In the similarities test, a score of less than 8 points (25th percentile) was considered low. The scale of the results calculated relative to the percentile scale distribution has been described in detail by Brzezinski et al. (1996, 2004). In the metaphor tests, a score of 1–4 sten was considered low and potentially indicative of a cognitive disorder (the average result is 5–6 sten) (Brzeziński, 1980).

Epidemiology and Severity of Disorders

The mean score (converted) in the similarities subtest (7.76; $SD = 3.73$) was below the average in the whole group, and 9 subjects had significant problems with solving the subtest (<25th percentile) (36%, darker rows in Table 1, p. 128). In addition, 7 other patients (28%) scored only 8 points, which is regarded as the

lowest normal score (25th percentile). Three patients (12%) received above-average scores (13 and 15 converted points, Table 1).

Table 1

Converted results of patients with cerebellar damage in the Similarities Subtest of the Wechsler Adult Intelligence Scale.

Score	*n*	Percentage of valid observations	Cumulative percentage
1	2	8	8
4	5	20	28
5	1	4	32
6	1	4	**36***
8	7	28	64
10	3	12	76
11	2	8	84
12	1	4	88
13	2	8	96
15	1	4	100

n – number of patients

* lines (rows) marked with a darker color represent patients (percentage) with low scores indicating the presence of disorders

The mean sten score in the TWMP was 5.12 (*SD* = 2.30). According to the methodological standard, 5–6 sten is regarded as an average score (Brzeziński, 1980). Although the overall group performance in the TWMP did not differ from the norm, nearly half of the subjects (12 subjects, 48%) obtained low results that did not exceed 4 sten (darker rows in Table 2, p. 129). Similarly to the previous test, 3 patients (12%) received above-average scores (10 sten). The results were also widely distributed across the entire scale (1–10 sten).

In comparison, the mean score in the TMP was relatively high (7.24; *SD* = 2.86), and 12 subjects (48%) received the maximum score of 10 sten (Table 3, p. 129). Only 4 patients (6%) received a low score (≤4 sten).

It is worth mentioning that one patient received an above-average score in all three tests. This patient was a 47-year-old male with a university degree who had suffered a cerebellar stroke. Upon admission, the patient had been experiencing dizziness, balance disorders, numbness in the left half of the face, headache in the occipital region, and double vision for several hours. The patient described his overall health as good before the onset of the disease, without somatic loads. A follow-up MR neuroimaging test performed in three planes after 11 days revealed an ischemic focus with a diameter of 3 cm in the left cerebellar hemisphere, without signs of edema, corresponding to an infarction. No changes

were found in the supratentorial structures. The ventricular system was described as normal. A neuropsychological examination was performed 17 days after the onset of the disease.

Table 2

Sten Scores of Patients With Cerebellar Damage in the Written Metaphor Explanation Test (TWMP) From the Polish Version of the Right Hemisphere Language Battery

Score	*n*	Percentage of valid observations	Cumulative percentage
1	1	4	4
2	1	4	8
3	3	12	20
4	7	28	**48***
5	2	8	56
6	8	32	88
10	3	12	100

n – number of patients
* lines (rows) marked with a darker color represent patients (percentage) with low scores indicating the presence of disorders

Table 3

Sten Scores of Patients With Cerebellar Damage in the Written Metaphor Test (TMP) From the Polish Version of the Right Hemisphere Language Battery

Score	*n*	Percentage of valid observations	Cumulative percentage
1	1	4	4
4	3	12	**16***
5	6	24	40
6	3	12	52
10	12	48	100

n – number of patients
* lines (rows) marked with a darker color represent patients (percentage) with low scores indicating the presence of disorders

Clinical Specificity of the Disorder

The specificity of individualized (heterogeneous), clinically-based disorders was analyzed based on the estimated profiles reflecting the patterns of all recalculated test results. For this purpose, a binomial distribution was created to distinguish between (above) average or low scores. The columns in Table 4 (p. 130) represent patients with specific outcome profiles that were characterized by both

inter- and intra-individual differences. A generally disharmonious pattern of results obtained by 10 subjects (40%) in the middle columns (columns B, C and D) points to the specificity of the examined disorders. However, 4 other patients (16%, column E in Table 4) did not perform any of the tests correctly. In addition, 14 patients (56%) performed at least one test incorrectly (columns B–E), and the configuration of correct answers in the similarities test and the TWMP was inverse (columns B or C; darker rows in Table 4). In neuropsychology, an inverse (opposite) configuration of symptom severity is most often interpreted in the context of double dissociation (refer to the *Discussion* section; Walsh & Darby, 2008).

Table 4

Differentiated and Dichotomously Expressed Correctness of Test Performance by Patients With Cerebellar Damage

Test	Classification of patients differing in the patterns of test results				
	A $n = 11$	**B** $n = 5$	**C** $n = 2$	**D** $n = 3$	**E** $n = 4$
Similarities	+	+	–	–	–
TWMP	+	–	+*	–	–
TMP	+	+	+	+	–

n – number of patients

(+) normal (average or above average) score; (–) below-normal (below-average) score.

* the lines marked in a darker color are described in the text (see *Results* and *Discussion* sections).

Similarities subtest of the Wechsler Adult Intelligence Scale (WAIS-R[PL]).

TWMP – the Written Metaphor Explanation Test (TWMP) from the Polish version of the Right Hemisphere Language Battery (RHLB-PL).

TMP – the Written Metaphor Test (TMP) from the Polish version of the Right Hemisphere Language Battery (RHLB-PL).

In the following step (complementary to the previous analysis), the relationships between the variables were examined by calculating Pearson's correlation coefficients (r).

The variables were expressed on a continuous scale as recalculated results. The scores in the similarities test were correlated with TMP scores ($r = 0.71$, $p < .001$) and TWMP scores ($r = 0.58$, $p < .01$), and the scores in the metaphor tests were also bound by a significant, but weaker, correlation ($r = 0.47$, $p < .05$).

Sociodemographic Correlates of Disorders

Age and education (years of study) were significant sociodemographic correlates of test results. Age was negatively correlated (Pearson's r) with the results

of the similarities test (r = 0.50, p < .05), TWMP (r = -0.42, p < .05), and TMP (r = -0.67, p < .001), whereas education was positively correlated with the subjects' performance in the similarities test (r = 0.56, p < .01) and the TMP (r = 0.48, p < .05).

Discussion

The present study confirmed that cerebellar damage is relatively often accompanied by cognitive dysfunctions. These disorders were characterized and interpreted based on the four criteria indicated in the *Research Objectives* section.

Epidemiology (Prevalence) of Disorders

More than half of the studied patients (56%) found it difficult to complete the similarities subtest and to verbally explain the meaning of metaphors. In a previous study of the same group of patients (involving the Mini-Mental State Examination and the Brief Psychiatric Rating Scale – popular screening tests that are inherently less accurate than a full neuropsychological examination), abnormalities were identified in 36% of the cases (Jodzio, 2020a). Other authors found that cognitive and/or emotional impairment can be expected in 64% of adults with acquired cerebellar injury of any (heterogeneous) etiology (Liu et al., 2022), where vascular disorders have a more optimistic prognosis than degenerative disorders. According to Cook et al. (2004), figurative language disorders after cerebellar injury are not as common as other language problems, such as reduced verbal fluency. In the current study, the TMP turned out to be a relatively simple task. Nearly half of the examined patients (48%, Table 3, p. 129) obtained the maximum score (10 sten). In the work of Łojek (2007), more than 70% of healthy people and only one in three patients with damage to the right hemisphere answered all questions correctly.

Given the limited number of participants (n = 25), these epidemiological estimates point to the varied etiology of the examined disorders, as well as the fact that the interpretation of metaphors, proverbs and similarities did not pose the only challenge for the respondents. Other symptoms, including visual-constructive dysfunctions (making it difficult to draw), psychomotor deficits, and nonspecific emotional problems such as strong preoccupation with own health, emotional tension, anxiety and depressed mood, were also identified in the same group of patients in the author's previous studies (Jodzio, 2020a,b).

Severity of Disorders

The severity of the examined disorders was relatively mild, but due to individual differences (as described below), these results should be interpreted with

caution. The patients were unable to correctly complete two (TWMP and the similarities test) of the three tests. The interpretation of figurative language in the TMP proved to be the easiest task. There is a growing body of evidence to suggest that the symptoms of acquired cerebellar injury in adults are often mild or even transient, which contrasts with the deeper, often dramatic behavioral consequences of cortical damage (Timmann & Daum, 2007).

Clinical Specificity of the Disorders

The current study paints a clinically complex picture of cerebellar damage emerges. The results are only partly consistent with the "classical" characteristics of CCAS that were described in the late twentieth century, when metalinguistic deficits relating to metaphor processing and inference by analogy were not taken into consideration. The multisymptomatic presentation of cerebellar disorders is also supported by meta-analyses of neuropsychological, psycholinguistic, and psychiatric studies (Ahmadian et al., 2019; De Smet et al., 2007; Rapoport et al., 2000). Thus, the inability to understand figurative language and impairment of other metalinguistic abilities caused by cerebellar damage are important, but not the only deficits in linguistic competence, communication competence, and verbal activities. This observation corroborates the results of neurolinguistic analyses conducted by Guell et al. (2015), who identified three subtypes of cerebellar damage symptoms, namely specific configurations of grammatical and semantic errors of varying degree, disorders in the processing of contextual data during the interpretation or formation of sentences, as well as problems with logical reasoning during the reception of sequentially structured verbal material, incidentally similar to the similarities subtest in the WAIS-R.

Due to the heterogeneity of cerebellar damage symptoms, attempts were made to profile individual differences in the administered tests (Table 4, p. 130). Up to five patterns were identified in the three tests: only correct results (column A), different proportions of correct and incorrect results (B–D), and only incorrect results (E). These observations suggest that cerebellar injuries tend to exert a selective, rather than a generalized influence on the mechanism of semantic interpretation of metaphors and similarities. On the one hand, the presence of significant correlations between all test results suggests that the observed differences stem from a common factor. This common factor was probably inference by analogy, namely a thought process where both similarities (WAIS-R subtest) and figurative meanings, (tasks that involve the use of metaphors, such as the TWMP) are perceived. On the other hand, patients correctly recognized the meaning of metaphors in the TMP. Unlike the TWMP, the TMP mainly examines the understanding of metaphors, without having to explain them verbally with self-decoded knowledge. The similarities subtest and the TWMP are more difficult than the TMP because they assess not only specific knowledge *(its state*), including semantic memory and crystallized intelligence, but also the *(meta)processes* that support the retrieval of knowledge, including quick access to the mental representation of metaphors. Examples of the above include free

acquisition, processing, and use of knowledge in the processes of concept formation, perception of analogies, or abstraction. There is no doubt that metaphorical expressions have multifaceted and complex characteristics; therefore, the ability to process these expressions should be examined in relation to various mental processes. The disruptions in these processes, including as a result of cerebellar damage, will be affected by the quality of figurative processing. Research has demonstrated (Ulatowska et al., 2000) that the use of metaphors requires not only an understanding of the linguistic layer, a sense of figurative properties and knowledge of pragmatic rules, but also appropriate interactions between non-verbal cognitive mechanisms, such as the rules of abstraction and inference. Therefore, unlike degeneration of the temporal cortex (Jodzio, 2011; Walsh & Darby, 2008), cerebellar damage generally does not lead to the loss of knowledge (memory), but can disrupt the processing of knowledge, namely the execution of intentional and purposeful non-verbal activities. This psychological interpretation refers to the popular conceptualization of executive functions (Jodzio, 2022) because executive function disorders are one of the best described symptoms of cerebellar damage (Clark et al., 2021; Schmahmann & Sherman, 1998). However, the psychological interpretation has a number of limitations. In principle, due to their structure and standardization, the applied tests cannot be used to assess the impact of the situational context on the comprehension of pragmatically and lexically ambiguous statements. This problem has received considerable attention from theoreticians (Gildea & Glucksberg, 1983), and it should be considered in further neuropsychological studies of patients with cerebellar disorders.

In some cases, the scores in the similarities subtest and the TWMP were characterized by intra- and inter-individual differences (dark rows in Table 4, p. 130). Five patients (column B) failed only one test (TWMP), but completed the other test (similarities) correctly. A directly inverse relationship was noted in two other patients (column C). As mentioned in the *Results* section, a model where two differences are inverted, yet complementary (symptoms, outcomes) is referred to as the double dissociation model. This model can be used to identify the specificity of the effects of brain damage – in this case, the cerebellum. Although the diagnostic usefulness of the double dissociation model has been confirmed, the word "symptom" should be used with caution when referring to the results of a psychological test (Walsh & Darby, 2008). In some cases, this simplification is necessary to preserve the clarity of thought in a theoretical discussion. In the present study, double dissociation highlights the role of highly specialized and at least partly autonomous processes (perhaps also modularly organized) that promote the creation of quickly integrated and complex inference mechanism and facilitate verbal explanation of metaphors and similarities by analogy.

Sociodemographic Correlates of Disorders

As expected, test results were significantly correlated with the participants' age and education. Older and less educated patients tended to make more

mistakes, which had a negative impact on their scores. A similar pattern was described in test manuals based on studies of healthy subjects and patients with other neurological disorders (Brzeziński et al., 1996, 2004; Hornowska, 2004; Łojek, 2007; Spreen & Strauss, 1998). However, the correlations identified in the entire group in the statistical analysis do not exclude strongly individualized test results and symptoms. Some patients with serious neurological conditions (e.g. cerebellar stroke) scored normal or even above-average results (!). Such intriguing observations prompt clinicians to conduct research on cognitive resources and the so-called neural reserve which are considered important prognostic factors that slow down or even prevent brain disease (Jodzio, 2011). Further research should be conducted by interdisciplinary teams composed of psychologists, neurologists, neuroradiologists, and psychiatrists. Previous studies have demonstrated that the localization of cerebellar damage affects mental functioning (Jodzio, 2020b). The extent to which damage to the left and right hemisphere of the cerebellum inhibits right-brain activity as a result of crossed diaschisis (Bartczak et al., 2011; Pietrzykowski et al., 1997) and impairs the interpretation of metaphors and similarities should be also compared. In the traditional approach, the right hemisphere of the brain plays a dominant role in the development of communication competence and the ability to process complex linguistic material, including metaphors (Jodzio et al., 2005; Łojek, 2007; Walsh & Darby, 2008). In addition, studies investigating potential relationships (suitability, compatibility) between symptoms of cerebellar damage and neurological descriptions of cerebellar syndromes would also contribute to neuropsychological assessments. Cerebellar vermis and hemispheric cerebellar anomalies have been recognized in neurology. The first disorder leads to postural disorders and sailor's gait, whereas the second anomaly presents mainly with limb ataxia and dysmetria (Mazur & Nyka, 1997). According to Schmahmann (2009; Schmahmann & Sherman, 1998), dysmetria often affects the patients' mental functioning, which could explain at least some of the symptoms of CCAS. However, further research in psychology and psychopathology is needed to validate this rather general hypothesis and explore the pathological mechanisms underlying CCAS.

Conclusions

The majority of the studied patients presented with mild or moderate cognitive deficits which affected their ability to solve problems containing metaphors and similarities. Disorders affecting conceptual associative thinking, including inference by analogy, as well as interpretation and verbalization of concepts, were more prevalent than disorders affecting linguistic knowledge, including the comprehension of figurative language. The study involved patients with cerebral pathologies who were assessed for their ability to interpret metaphors and similarities based on inference by analogy, and it demonstrated that diagnostic methods should be sensitive to metalinguistic, verbal, and problem-solving aspects of mental functioning.

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