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Child with ASD and CAPD: Investigation of Central Auditory Processing Disorders and the Effectiveness of Auditory Training

In recent times, there has been a notable rise in the number of children exhibiting indications of Central Auditory Processing Disorders (CAPD). It is frequently the case that the symptoms exhibited by young people are overlooked, and the symptoms of the disorder are erroneously attributed to stupor, discourteous behaviour, reluctance to heed the instructions of adults and even hearing loss. This has significant implications for children's communication and functioning in educational settings. The objective of this article is to highlight the existing issue, identify the fundamental symptoms of CAPD in accordance with the current state of research, and examine the possibilities of assessing the functioning of a child with Central Auditory Processing Disorders. Furthermore, potential avenues for examination and therapy for individuals with CAPD will be delineated. The article presents the case of a girl who exhibits such difficulties. Furthermore, it outlines the potential avenues for evaluating the client's condition and suggesting tailored training programmes. The case of a child with Autism Spectrum Disorder (ASD) and Central Auditory Processing Disorder (CAPD) was selected for analysis. The article has both a theoretical and a practical dimension. The child's condition was evaluated using an interview sheet, tests examining Central Auditory Processing Disorders, and methods and techniques aimed at neural networks to enhance brain neuroplasticity and improve Central Auditory Processing Disorders. The results of the Central Auditory Processing Disorder (CAPD) test and the effects of training were discussed. The proposals included in the article for both testing and auditory training of a child showing symptoms of CAPD are based on the author's observations of both testing and therapy on a daily basis.

Keywords: Central Auditory Processing Disorders, case study, auditory training

Das Kind mit ASD und CAPD: Untersuchung zentraler auditiver Verarbeitungsstörungen und der Wirksamkeit des Hörtrainings

In der jüngeren Vergangenheit ist ein signifikanter Anstieg der Prävalenz von Kindern mit Anzeichen für Zentrale Auditive Verarbeitungsstörungen (CAPD) zu verzeichnen. Es ist zu beobachten, dass die Symptome bei jungen Menschen häufig nicht erkannt werden. Die Symptome der Störung werden fälschlicherweise als Teil von Zuständen wie Apathie, unhöflichem Verhalten, einer Verweigerungshaltung gegenüber Anweisungen von Erwachsenen und sogar als Hörverlust interpretiert. Dies hat wesentliche Konsequenzen für die Kommunikation und das Verhalten von Kindern in Bildungsinstitutionen. Die Intention dieses Artikels besteht darin, die bestehende Problematik zu beleuchten, die grundlegenden Symptome der Zentralen Audiologischen Verarbeitungsstörung (CAPD) gemäß dem aktuellen Forschungsstand aufzuzeigen und die Möglichkeiten zur Einschätzung der Funktionsfähigkeit eines Kindes mit zentraler audiologischer Verarbeitungsstörung zu untersuchen. Des Weiteren werden mögliche Untersuchungs- und Therapieansätze für Personen mit CAPD erörtert. Im Folgenden wird der Fall einer jungen Frau präsentiert, die unter den genannten Schwierigkeiten leidet. Des Weiteren werden mögliche Evaluationsverfahren zur Einschätzung des individuellen Zustandes sowie die Entwicklung maßgeschneiderter Trainingsprogramme erörtert. Im Rahmen dieser Untersuchung wird der Fall eines Kindes mit Autismus-Spektrum-Störung und Zentral-Auditorischer Verarbeitungsstörung analysiert. Der Artikel umfasst sowohl eine theoretische als auch eine praktische Dimension. Die vorliegende Fallstudie basiert auf einer Evaluation des Kindes mittels eines Interview-Leitfadens, Testverfahren zur Diagnose von Central Auditory Processing Disorders

(CAPD) sowie Methoden und Techniken zur Förderung der Neuroplastizität des Gehirns und zur Verbesserung von CAPD. Die Resultate des Tests zur zentralen audiologischen Verarbeitungsstörung (CAPD) sowie die Auswirkungen des Trainings wurden erörtert. Die in dem Artikel vorgestellten Vorschläge für die Testung und das auditive Training von Kindern mit Verdacht auf CAPD basieren auf den täglichen Beobachtungen der Autorin des Autors bei der Testung und Therapie.

Schlüsselwörter: Zentrale auditive Verarbeitungsstörungen, Fallbeispiel, Hörtraining

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In today's world, people are exposed to auditory deprivation almost from birth and are also exposed to many factors that reduce or even impair their perceptual abilities. This affects children's development, the effectiveness of the educational process and, above all, their quality of life. For these reasons, there is interest in studies that propose supra-standard, multifaceted assessments of bodily functions.

Many people declare (or have their parents or teachers declare on their behalf) difficulties in functioning in the school community, difficulties in learning, and a decrease in self-esteem and quality of life due to an inability to find their way in conditions with a large number of sound distractors. Often these individuals include those who have a confirmed diagnosis of ASD.

To fully understand what Central Auditory Processing Disorders (CAPD) are, it is important to emphasise the importance of physiological hearing conducting auditory information from receptors in the cochlear organ up to the primary auditory cortex located in the temporal lobe. The function of the central pathway is to regulate the flow of auditory information reaching the brain by influencing receptor sensitivity (Liberski/Kozubski 2020: 22). Dysfunction in the conductive part (outer and middle ear) causes hearing loss, which in many cases can be treated, while damage in the receptive pathway (inner ear, cochlear nerve, cortical areas) causes hearing loss or total deafness. This perceptual pathway is activated when we hear sounds from outside. Crucial for the development/functioning of speech are those areas directly responsible for the connections between the primary auditory cortex and the association cortex. Damage in this area most often results in aphasia. It is therefore important to correctly localise the area where the damage is located. Since the smallest defect or loss can affect speech production or comprehension, the patient's hearing should be tested before assessing CAPD. This activity will allow a better design of the therapy at the outset. The basic test we perform is impedance audiometry. We only admit people to the ASD assessment who have a normal tympanometry result (Prauzińska 2014: 150), otoacoustic emission testing (the test only indicates a tendency to hearing loss; if the result is abnormal, the diagnosis is deepened) and tonal audiometry. It is important that people taking the test do not have a reduced IQ.

If the tests performed show that the patient has normal hearing and a normal tympanometry result, the diagnosis should be extended and other areas should be searched for causes of hearing discomfort or dysfunctions commonly associated with ear disease, as a properly built and well-functioning hearing organ does not necessarily guarantee correct hearing (Łuria 1976: 90).

With a properly functioning hearing organ (i.e. efficient operation of the peripheral functions) and at the same time observed difficulties in hearing and finding one's way around in difficult listening environments, one should consider a diagnosis of Auditory Perception Disorder or Auditory Processing Disorder. Specific perceptual disorders were first described in the mid-20th century by Helmer Myklebust. His research focused on psychoneurological learning difficulties and he developed the first model of auditory processing (Myklebust 1960). Since then, many research centers have undertaken similar studies, expanding both in terms of finding new diagnostic tools and therapeutic options (see also Moore/Rosen 2013, Vermiglio 2014a).

American Speech-Language-Hearing Assosiation (ASHA) defines central auditory processing (CAP) as „the perceptual processing of auditory information in the central auditory nervous system" and as „the neurobiological activity underlying this processing"[1]. Central auditory processing consists of mechanisms that analyse, organise and interpret information from the auditory circuit. These mechanisms underlie a number of skills, including skills such as auditory discrimination, temporal processing and binaural processing. Among these three basic skills are the ability to recognise auditory patterns, temporal aspects of listening (including temporal integration and resolution) temporal ordering, temporal masking, sound localisation and lateralisation, and auditory performance when competing or degraded auditory cues are present. Central auditory processing disorders also appear in the literature under the names language processing disorders or auditory information processing disorders (McFarland/Cacace 2009: 93–107). In the work presented here, the name proposed by ASHA – Central Auditory Processing Disorder (CAPD) – will be used.

A few additional important terms need to be pointed out here:

1. Neuroplasticity of the brain, i.e. the brain's ability to reorganise itself during life, which can be observed at the synaptic, neuronal and also macroscopic level (cf. Zucker/Regehr 2002: 355–405, Turrigiano/Nelson 2000: 358–364, Woolf/Salter 2000: 1765–1769, Draganski et al. 2004: 427). Kossut's research suggests that neuroplasticity is a fundamental process underlying learning and memory (Kossut 2018: 27). When it comes to stimulation issues for people affected by CAPD, brain plasticity is important, and to the extent that we are interested it will relate to the adaptation of the auditory cortex to new auditory stimuli;
2. The case study refers to children, which is all the more important as plastic changes occur more intensively in the developing nervous system (see Kossut

[1] Vgl. www.asha.org/policy/, date of access: 19.7.2024.

2018: 27). We therefore have a reasonable expectation that the therapeutic interactions will have measurable positive effects. stimulation based on repetitive, constant patterns – the method of stimulation and the dominants associated with it will be directly related to the developmental norm of particular functions in the neurotypical child, while stimulation actions will be adapted to the place of the child's development at a given moment and the anticipated progress resulting from the actions taken (Nęcka 2003: 150);

3. Phonemic hearing, considered as an elementary ability enabling „the detection and reception of sensory information – the sound of individual speech sounds. […] It allows the verification of different utterances and the identification of the same ones. Properly developed phonemic hearing is a necessary condition for the development of phoneme perception of words in terms of analysis and synthesis" (Łuria 1976: 171, transl. A. K.). It significantly affects both understanding and broadcasting of speech. In his research, Luria uses results from observing patients with severe brain damage. It is worth emphasising that auditory processing disorders have analogous mechanisms. When we read that the defect takes the form of an auditory verbal memory disorder or a specific acoustic-mnestic disorder we know that its main feature is the inability to hold even small series of sounds, syllables or words in memory. The patient then confuses their order or finds that some of the elements of the series simply disappear, we can easily relate these words not only to people with aphasia. They are characteristic of those who have not suffered any particular trauma but have trouble decoding or holding speech sounds in memory. This picture is completed by Frank Musiek, who, based on his own research, talks about four important types of temporal processing: integration, sequencing, resolution and masking (Musiek 2016). All of these elements can be attributed to the transmission and reception of human speech;
4. Corpus callosum, which, in addition to many other functions, is also involved in the transfer of auditory information, as it helps distinguish between relevant and irrelevant auditory stimuli (so-called figure-on-figure distinction), influences phonological processing and distinguishes non-verbal stimuli (Musiek 1994). It is also important for other sensory spheres, e.g. it is responsible for body map recognition, lateralisation of language functions or associating sounds with symbols (i.e. reading and writing);
5. Quality of life: along with reduced auditory processing abilities comes a decrease in quality of life. Studies emphasise that in families where a child with CAPD is raised, quality of life is reduced (Kobosko et al. 2002).

CAPD is often diagnostically associated with other disorders: aphasia, ASD, ADHD and dyslexia. One case of childe with ASD and CAPD have been selected for discussion, because such individuals usually have multiple sensory problems and also perceive stimuli non-specifically (Allman/Falter 2015: 38).

Szeląg writes that patients with ASD are unable to relate their own responses to the duration of the stimulus (2004: 269). We also know that children on the autism spectrum have the most difficulty finding their way around in larger groups, generally generating random sound stimuli, which is directly related to CAPD, in so it is an interesting field for observation and research. Children with ASD are rarely considered in clinical studies. The studies I am aware of give the following statistics for the co-occurrence of CAPD with other disorders: 50 % of children with specific language development disorder SLI (Ferguson et al. 2011), 50 % of children with specific learning difficulties SLD (Sharma/Purdy/Kelly 2009: 706–722), 30 % of children with dyslexia (Dawes/Bishop 2010: 432–436).

It was therefore decided to describe the process of assessing the status of Central Auditory Processing and the training and stimulation of a child with ASD and CAPD: from the assessment, through the establishment of the training pathway, the training course and the CAP reassessment.

The girl had an ADOS-2 examination at the age of five and is under the constant care of a neurologist. The functional diagnosis based on the ADOS-2 examination included the following conclusions: difficulties in social interaction, observed difficulties in speech acquisition. The child's general level of speech development reduced in relation to age norms. In the kindergarten, unusual behaviour evident, isolation from the group, which was not observed by the parents in the home setting.

Girl (Zosia), born 2016, twice attempted adaptation in kindergarten, the first unsuccessful when Zosia was 3 years old, the second at 5,5 (positive). No significant worrying signs before or during birth. The child did not reach milestones in motor development, was ill a lot in the first year, also with high fever. In terms of speech, the development initially (at the word stage) was in line with developmental norms, she entered the sentence stage with difficulty, her mother's attention was drawn to her frequent losing of the thread, carrying on conversations in a way that Zosia imposed. She often confused the meaning of words. Due to her high auditory sensitivity, Zosia did not go on any kindergarten trips, and her mother also often left her at home to reduce her daughter's stimulation.

On the basis of an analysis of the medical records, previous diagnoses, opinions from the kindergarten, free observation of Zosia in the office setting and the neurologopaedic diagnosis, the following course of action was recommended:

- Exclusion of hearing impairment.
- ENT consultation.
- Myofunctional therapy (The patient presented with multiple orofacial disorders, including interdental lisping and an abnormal tongue position at rest).

The girl underwent myofunctional therapy – it supported work on both articulation and higher auditory functions. For the therapy, the UTTR oral-facial regulatory therapy method was chosen, as well as elements of Anita M. Kittel's myofunctional therapy. A strong emphasis was placed on hand therapy to influence the development of neural networks and myelination of neural pathways (Regner 2019: 43).

After ruling out ear and throat disease, it was decided to assess for Central Auditory Processing Disorder. This decision was made because the girl was having difficulty hearing speech in impaired conditions, as well as developing communicative competence. The baseline measures are shown in Chart 1.

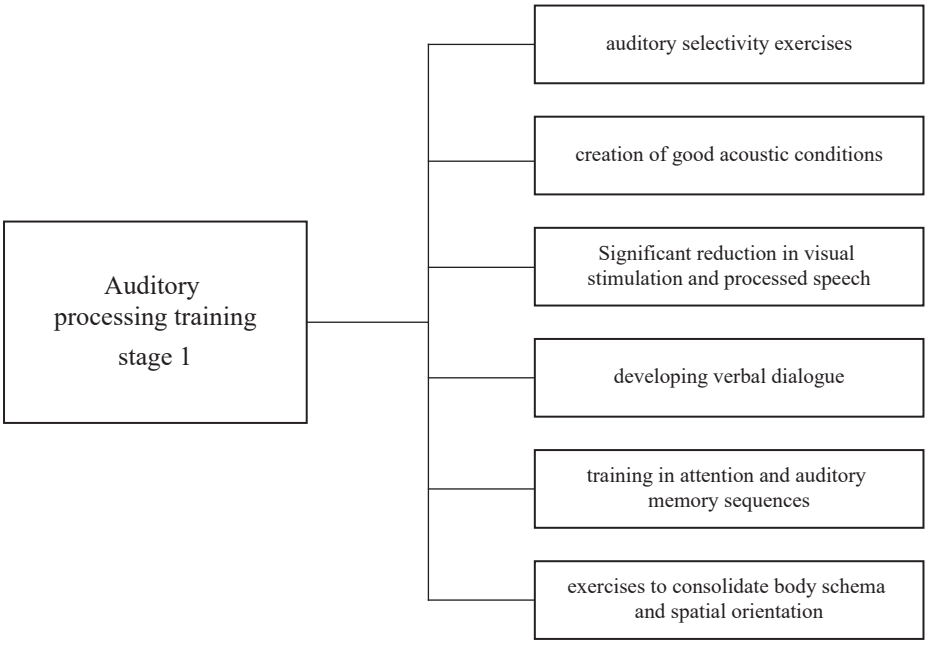

Chart 1. First stage of training

Gradually, sequential and auditory memory was developed using materials prepared by the Krakow Method Centre (sequence puzzles, memory exercises), auditory memo, and games of listening and repeating sequences of sounds, gradually introducing the clapping of heard rhythm. Using songs supported by movement, we consolidated the body scheme. The girl quickly increased her vocabulary and was increasingly willing to form sentences, but only in the office setting and at home. In the group, although she was small and did not generate too much noise, she still remained mainly an observer.

Parents were also advised to reduce visual stimulation and processed speech significantly – as a result, they gave up all media at home, read aloud more and prompted storytelling. In the office and at home, we also conducted auditory selective attention exercises – capturing so-called figure-on-background. The work was mainly on musical material: teaching what musical instruments sound like, capturing their sound in simple musical pieces. She repeated the exercises at home with her parents. Gradually I also introduced exercises to develop short-term memorisation on syllable material – at first Zosia memorised two syllables on average, but within 6 months she had increased this ability to 4 syllables, which brought her closer to the age norm.

During the 11 months of stimulation, the girl made significant progress in her speech development – she started to use sentences spontaneously, but only under conditions that were conducive to her. The parents noticed that when they were, for example, at a family gathering, in a place with more people or outdoors where there were additional, unexpected sounds, Zosia became withdrawn, reluctant to participate in conversation and had outbursts of anger when they returned home. The work on eye-hand coordination has slowed down and the incremental growth in short-term memory skills has also stalled. Zosia has not passed the 4-syllable threshold.

After consultation with the parents, based on observations of the girl during tasks, her behaviour and her work in the office, it was decided to test the child with a battery of Neuroflow tests:

- Visual reaction test (TRW) – assesses reaction time to a visual stimulus.
- Auditory Reaction Test (TRS) – assesses reaction time to an auditory stimulus.
- Aural Reaction Test (TRS) – assesses auditory response time to an auditory stimulus.
- Word Comprehension in Noise (ASPN-S) – the test result indicates the signal-to-noise ratio for which the subject understands half of the words presented.
- Sentence-noise Comprehension Test (ASPN-Z).
- Dichotonic digit test (DDT) – dichotonic digit test assessing divided auditory attention and hemispheric dominance for speech comprehension.
- Frequency pattern test (FPT) – assesses pitch differentiation skills and short-term auditory memory.[2]

The girl received abnormal results in both ASPN tests, the DDT test for both ears and the FPT test. In interpreting the results, we assumed that difficulties in speech comprehension under impaired conditions still persisted in Zosia, the DDT and FPT tests confirmed the previous observations and indicated the causes of attention and short-term memory problems. The last test also indicated phonological difficulties and immaturity of the corpus callosum. As Senderski noted: „Children with APD are a heterogeneous group of patients. In practice, we most often encounter three clinical profiles with different dominant symptoms and different forms of auditory training:

- disorders of auditory attention and speech understanding in noise (Spatial Processing Disorder),
- disorders of phonology and perception of temporal aspects of sound,
- disturbances in the exchange of information between the hemispheres via the corpus callosum" (Senderski 2014: 79, transl. A. K.).

As the test results showed, the girl has all three clinical profiles. The results were not surprising; they only confirmed what had long been suspected. A new therapeutic regimen was developed for Zosia (chart 2). The child's functional conditions were adapted to her current needs.

[2] Based on the Higher Auditory Function Test Report with the Neuroflow ATS test battery.

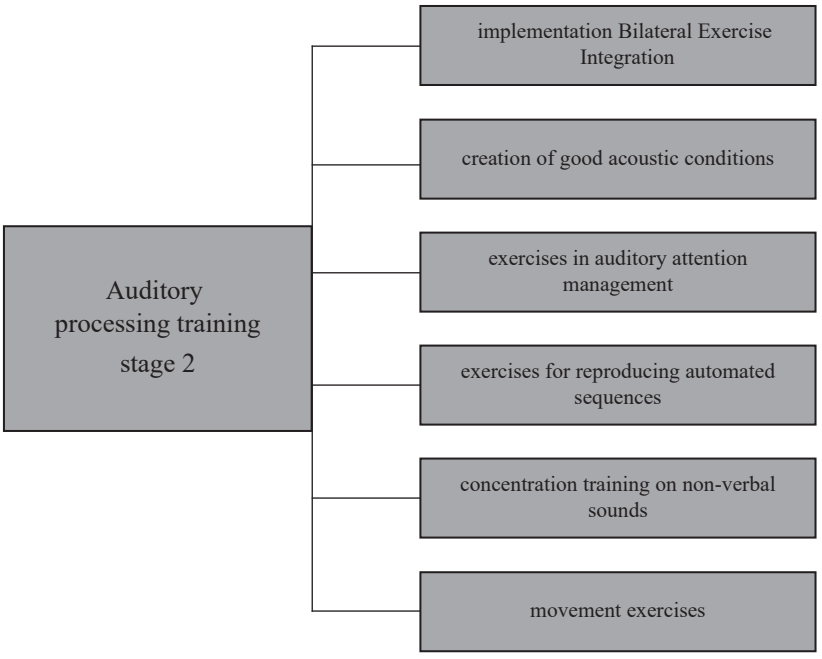

Chart 2. Stage two of training

In the second stage of stimulation, this intensive programme was added, as it was desired to give the child more stimulation In neurological training, exercises to direct free auditory attention were maintained – repetition of sequences, learning the names of months, lots of rhythmic listening games. They were extended to include exercises in recognising slight differences in pitch, localising the source of a sound and distinguishing close-sounding sounds (preparation for learning to write and read).

It should be added that the progress in the girl‘s functioning is very much linked to the parents‘ involvement. They support the girl, doing similar exercises at home as they observe in the study. They also initiate many additional physical activities. In order to develop correct integration and coordination mechanisms, they go with Zosia to the climbing wall, and they have also increased their own activity in search of opportunities to sensitise their daughter to catch important auditory stimuli. Combining sensory play with daily activities, they often go to the forest, where Zosia has the opportunity for proper auditory, visual and tactile stimulation. Their activity and cooperation with the provider is very successful. During the two years of therapy, Zosia has made very good progress. By understanding speech better, the girl herself felt the need to communicate and express herself better. As Cieszyńska-Rożek rightly pointed out, „exercises stimulating the development of the cortical centres of auditory information processing should be conducted both in natural conditions and at a table. Both techniques are equivalent, fulfil different tasks and shape different skills. Listening in an open space (on a walk, in a playground, in a zoo, in a forest, on a journey) shapes

auditory attention, teaches the filtering of sounds, builds visual imagination motivated by sounds, forms the ability to listen to speech in the presence of non-verbal sounds. Listening to sounds in an enclosed space, but during free activities, is a prerequisite for effective language learning, for dialogue" (Cieszyńska-Rożek 2018: 189, tranl. A. K.). This type of stimulation is provided for Zosia in an almost perfect way. The girl's parents welcome any suggestions and look for paths to help their daughter themselves. The ADOS-2 diagnosis they made before starting training did not discourage them from trying to help their daughter. Their intention is for the girl to reach her full potential with the support of her family and therapists. They do not want the diagnosis to be used to facilitate or stigmatise the child, so they left it to their own knowledge and that of the therapist. They have not presented it to the school that Zosia will attend.

The second link in the therapy is the provider and office stimulation. From the first contact, the girl participates in the activities very systematically, willingly and with great commitment, with tangible results. Both the child and the parents are aware that table stimulation plays an extremely important role in shaping free attention, concentration on non-verbal and verbal auditory stimuli, forms learning skills (Cieszyńska-Rożek 2018: 189–190). Of course, it should be stressed that the term „table-based" here is only a reference to working in an enclosed office. This is because we work both at the table and on the floor, doing movement exercises, artwork, combining different elements to increase brain activity.

It will soon be a year since modifications were made to the overall auditory and myofunctional training model, which will give the opportunity to correct the measures planned at this point. If the re-examination shows that some of the higher auditory functions have reached an age-appropriate level, this will not only be a sign that the applied therapy is working, but also information on which areas need to be worked on more intensively.

The case study presented here shows how strongly the development of a child – even with a holistic disorder such as ASD – depends on the support of the family, the correct assessment of the child's condition and, of course, systematic implementation of training recommendations. Although it is clear that the sooner we take action, the greater the results. Case studies make it clear that even later action, but carried out systematically, can produce excellent therapeutic results. In the case presented here, diagnosing the child for ASD was crucial, as this step triggered all subsequent ones. The parents were right to follow the path of what bothered the girl the most in her everyday life, i.e. auditory hypersensitivity. Thus, they moved from an ADOS-2 diagnosis to working with a neuro-speachtherapist.

Finally, it is still worth mentioning why a high-functioning child on the autism spectrum was chosen for the case study, when this disorder is not among the most commonly mentioned co-occurring disorders with CAPD. Considering the findings of Beck and his team, „The links identified reinforce the complexity of the tasks involved in assessing central auditory processing and the need for multidisciplinary assessment

in the differential diagnosis of auditory processing disorders. Confirming the presence or absence of co-occurrence of different disorders allows to target therapeutic behaviours and to reduce the impact of possible auditory and/or cognitive deficits on different daily life situations of children" (Back et al. 2022: 20). It was felt that there was a unique opportunity with the certainty of one diagnosis (ASD) to expand the knowledge of the causes of the girl's condition. This was done to facilitate the stimulation process. And this has had a tangible effect, as the simultaneous diagnosis of ASD and CAPD has allowed us to look through the lens of the main problem the girl had – the difficulty in understanding speech in disadvantaged conditions and the consequences that follow (lack of peer contact, excessive hyperactivity, failure to understand speech, lack of speech development). Without a CAPD test, she could have been left without help, as auditory hypersensitivity and impaired social interaction are in the picture of a disorder such as autism spectrum disorder.

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