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# Weak central coherence – construct conception, development, research methods

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**Summary**

Central coherence allows for integration of different stimuli into a coherent whole. It also enables context-dependent information processing. This term was coined in an effort to arrange multiple observations of cognitive functioning of people with autism spectrum disorder (ASD). Weak central coherence, which is characteristic of ASD, is understood as a divergent cognitive style with a tendency to process incoming information locally. This allows us to describe central coherence as a continuous trait. Despite manifold research programs, a conclusive conceptualization of the construct is still lacking. The open question is whether weak central coherence constitutes a limited ability to integrate stimuli or rather an increased ability to focus on details. An important postulate concerns the establishment of a standard for measuring central coherence and its individual dimensions. Studies of central coherence outside of ASD context are scarce and deal predominantly with eating disorders. The following work is an overview of the current state of knowledge about central coherence construct and methods of research.

**Key words**: central coherence, weak central coherence, autism spectrum disorders

## Introduction

In recent years, attempts have repeatedly been made to determine the axial cognitive deficit underlying the symptoms characteristic of autism spectrum disorder (ASD). Three areas of research have been outlined: (1) disturbances in the theory of mind (ToM), (2) executive function deficits, and (3) weak central coherence theory [1–6].

## Ideas prior to central coherence theory

It is believed that the basis of human cognition is formed by a tendency for perceptual grouping. Studies show that people tend to perceive objects as whole, even if the perceptual data are not complete. It is assumed that this is the result of the need for a so-called perceptual closure, which allows us to understand the environment and gives us a sense of stability. In the context of these observations, a clear tendency to focus on details of objects, present in people with ASD, aroused great interest. Initially, this phenomenon was explained with the help of the concepts of field dependence/independence [7] and the one of closure flexibility (i.e., the ability to identify a previously known pattern, e.g., a shape, object, word or sound, from distracting material). According to this theory, individuals with a high field dependence have an increased propensity for context, while people independent of the field are naturally able to see the individual elements of a stimulus in isolation from the context or background.

Even though the term 'field dependence/independence' had not been operationalized, analyses showed that variability in extraction of a single stimulus from a complex matrix was the key factor underlying this concept [8]. In turn, Lovaas and Schreibman [9] in their studies noted the importance of a narrow and selective attention which would focus on some selected aspects of the stimulus, which led to the definition of the concept of stimulus overselectivity, i.e., an overfocus on detail, leading to failure in a comprehensive assessment of a sensory stimulus. Subsequent analyses have shown that overselectivity is not a distinctive feature of people with ASD, but that it is also associated with factors such as: age (mental and biological) and mental retardation. Moreover, not all people with ASD are over-selective [10].

## Development of the concept

Studies conducted in groups of individuals with ASD were of primary importance for the development of the idea of central coherence (CC). The term weak central coherence (WCC) was introduced by Firth to elaborate on the concepts of field independence and closure flexibility [3–6]. It is important to note that this term covers a much wider range of phenomena related to human perception than only the visual and spatial perception. An important area of discussion was the issue of the specifics of cognitive functioning of people with ASD under conditions of scarcity vs. those of abundance. Studies show that worse results in various test tasks may be due to a number of cognitive and perception deficits. On the other hand, people with ASD have certain unique abilities, which allow them to perform successfully on other types of tasks [11, 12] (e.g., *the Embedded Figures Task*, *Block Design*, *the Navon Task*, *the Fragmented*

*Pictures Task*, visual illusions, *Homograph Reading Task*, *Local Coherence inferences*, *Syntactic Disambiguation Task*.

It is assumed that the tendency of neurotypical people to integrate received information into a single whole is a manifestation of the need for central coherence. Hence, it is possible for them to properly understand cause-and-effect, to create a mental representation, to synthesize, to separate essential information from the hustle and bustle, and to merge conflicting information, in order to attribute a new meaning to it. It is believed that central coherence already appears in infants [13]. In turn, the tendency of people with ASD to focus on detail along with a reduced ability to integrate stimuli and ignorance of the context is defined as weak central coherence [2]. In this aspect, Frith's concept is consistent with Kanner's theory [14], which understood the autistic people's need for a stable environment as a consequence of disparate processing.

WCC is sometimes described as a different cognitive style, which allows us to present CC as a continuous trait [3]. People with ASD are at one end of this continuum. Among neurotypical people, one can distinguish those with an automatic tendency to process information globally, as well as those with a preference for detail analysis, at a cost of lower efficiency in information integration [3]. People gifted at drawing and painting show a propensity to local processing similar to the one characteristic of ASD subjects [15]. Researchers contend that the level of central coherence, or dependence on perceptual field, can be changed by cultural context [16]. Some authors note the differences between societies of Western culture, involving mainly analytical, context-independent processes of perception, and Eastern cultures, which put emphasis on placing objects within a context. Despite this, there are also studies suggesting a cultural independence of WCC in people with ASD [17].

Weak central coherence can be divided into two levels: high and low [4]. Low level WCC is concerned with processing stimulus details without context, and involves cognitive processes such as perception, learning and attention. An example of a task in which the tendency to weak central coherence at a low level guarantees better execution is the WISC-R (Wechsler Intelligence Scale for Children-Revised) *Block Design* subtest [18], where people with ASD typically do better than healthy controls [6]. In turn, high-level WCC refers to context-sensitive processing, especially with regard to linguistic stimuli (e.g., mispronunciation of homographs in people with ASD) [4, 19].

Over the years, with the development of studies involving different methods and groups, the original CC concept has undergone some modifications. Based on results of approximately 50 studies [3], it is fair to say that (1) the cognitive system of typically developing individuals is characterized by an intuitive tendency to make generalizations over the largest possible range of stimuli and in the widest possible context, and the tendency to focus on details, seen in individuals with ASD, is at the other end of the continuum; (2) there is no relationship between WCC and the cognitive-social ASD deficits; (3) WCC is a processing error (not a deficit) and work towards its elimination is possible; (4) reduced global processing, occurring in people with ASD, may be secondary to superior local perception (inability to integrate stimuli into a coherent whole as a consequence of excessive ability to focus on detailed data); (5) it is possible that the limited ability to integrate stimuli globally is an important aspect of WCC in ASD [11]. It also possible that WCC coexists with global integration [20].

## Alternative approaches to CC

Concepts alternative to WCC theory emphasize the importance of local processing in people with ASD in the absence of context-sensitive processing deficits.

The first one of those is the theory of enhanced perceptual functioning (EPF) [21]. It was formulated on the basis of research results showing that the ability to process globally is preserved in people with ASD at a level matching that of healthy individuals [22]. The difference is in their unusually developed low level perceptual processing and in their overly dominant high-level global processing. The inharmoniousness of these processes would lead to a decrease in perceptual process control through top-down mechanisms, which may explain ASD people's deficits in other areas of functioning and their problems acquiring new skills. Enhanced perceptual processing refers to simple tasks as well as to more complex processes. Consistency of EPF theory with the concept of stimulus overselectivity has been demonstrated. Recent studies confirm the ability of people with ASD to take context into account [23, 24].

Studies detecting gender differences in stimulus processing (men have a propensity for local processing) also resulted in a noteworthy theory. Baron-Cohen et al. [25] devised the theory of an ʽextremely male brain' and ʽhypersystemizing' account which assumes that in ASD, stimulus processing is dominated by ʽsystematization', associated with effective local processing, rather than ʽempathy'.

## Dimensions of central coherence and research methods

Central coherence is studied in three dimensions: (1) visual-spatial-constructional coherence, (2) perceptual coherence and (3) verbal-semantic coherence.

The visual-spatial-construction CC refers to the ability to analyze and synthesize spatial stimuli, and its study evaluates these processes using empirically proven methods [8]. Tasks used:

(1) *The Navon Task/Hierarchical Figures Task* consist of graphic signs in the form of capital letters composed from similar or different, smaller letters [26]. Focusing on the big letters is a sign of global processing, while drawing attention

to the small ones suggests the more locally oriented style. Different versions of the task provide an independent measurement of two factors: the degree to which global stimuli are processed faster than local stimuli (degree of global advantage), and the degree to which global stimuli disrupt the reception of local stimuli (degree of global interference).

(2) *The Rey-Osterrieth Complex Figure Task* is typically used in neuropsychological diagnosis of children and adults. CC is evaluated by calculating the Central Coherence Index (CCI) [27]. It is a weighted average of the Order of Constructing Index (OCI) (an assessment of whether the subject started drawing from detailed elements, or from the global form) and the Style Index (SI) (an assessment of whether the 6 main elements were drawn continuously, partially fragmentarily or fragmentarily). A low CCI indicates a more detailed and fragmentary processing style. An alternative to the CCI is the Q-score method [28], where points are attributed for identifying the main elements of the figure.

(3) *The Embedded Figures Task*, originally used to measure field independence, has gained great popularity in central coherence studies [29]. It consists of drawings within which geometric shapes are embedded. To succeed, the subject must ignore the whole picture and focus on the details in order to find the given figure in the drawing as soon as possible.

(4) *Block Design* is used as one of the subtests for measuring IQ [18]. The goal is to construct a puzzle out of blocks according to a pattern as quickly as possible. Success depends on analytical and synthetic thinking that allows one to see the individual elements in the image template, and then to reproduce it from individual blocks. Persons with a weak central coherence effectively cope with tasks of this kind [30].

(5) *The Fragmented Pictures Task* [31] consists of series of drawings depicting popular objects that are presented in an order from very fragmentary to complete. The goal is to identify the object as quickly as possible. The measure of central coherence is the average of correct answers in all tests. A low result means a lower ability to integrate information into a single whole.

The perceptual dimension refers to the ability to integrate and give meaning to sensory sensations. Its assessment relies on the study of the ability to see details vs. to specify context in the area of sensory stimuli, hence measuring perceptual CC processing occurs both at a lower level (greater range of detail) and at a higher level (global processing). The tasks used are:

(1) Drawing copying is used to evaluate the processing of visual stimuli (the task of redrawing specific objects or non-specific shapes). Planning, includ-

ing the order and continuity of drawing is monitored. Starting drawing from individual details or piece by piece drawing is symptomatic of a tendency for local processing [32].

(2) Presentation of visual illusions (for example, Ponzo illusion, Titchener circles, Kanizsa triangle, Müller – Lyer figures, Hering illusion, Poggendorff illusion). Validity studies indicate that with this type of stimuli, cognitive mechanisms that should not be associated with central coherence are also subject to evaluation [33].

(3) Recognition of melodies, similar or changed key or tempo [34].

The verbal-semantic dimension refers to the processes of analysis and synthesis of the semantics of a verbal message (understanding and integration of verbal material taking into account semantic, syntactic and context meanings). Tasks used:

(1) *Homograph Reading Task* (words with similar graphical notation, but with a different meaning and pronunciation) to assess the skills of using context to determine the correct pronunciation of words [4]. In Polish, frequency of homographs is very low, some rare examples are: *rozmarzać* (to stimulate to dream) and *rozmarzać* (to melt) and *cis* (the sound) and *cis* (the tree).

(2) *Phoneme Segmentation,* which consists of determining the presence of a particular phoneme in meaningless words up to three syllables long. It is assumed that missing the phoneme can be treated as a measure of auditory local processing. Persons with a tendency to process locally identify the phoneme equally rapidly, be it at the beginning, in the middle or in the end of the heard words. D'Souza et al. [35] used records of 45 meaningless words in which the phoneme /p/ was positioned at the beginning, in the middle or in the end of the heard words, or it was absent. The task was to stay alert to the phoneme and to tap the right key whenever it was present (or not).

(3) *Sentence Completion,* which consists in filling in the presented sentences with words, after considering the context in which they should be used. People with a tendency to local information processing will often fill in sentences with words without context [36]. The test is composed of 14 gapped sentences. E.g., the context of the sentence "Little boys grow up to be men and …" encourages the use of the word 'dads'. On the contrary, local processing of the phrase "men and …" will result in the response 'women'. Another example: context-dependent completion of the sentence "In the sea, there are fish and …" would require the use of the word 'whales'. Local processing will result in the response 'chips').

(4) *Local Coherence inferences,* used to assess *coherence inference* (i.e., the ability to draw conclusions from preceding and following events [19]). The task

consists in the presentation of short scenarios in which the first sentence (e.g., “George left the tap running”) gives the prerequisites or is a description of a situation and the last one (e.g., “George cleaned up the mess in his bathroom”) is causally related with the first. The person taking the test should pick a sentence which accurately explains the cause and effect relationship between the sentences. In this example, the correct inference is that the water from the bathtub poured down on the floor and caused a mess. The correct sentence to pick is “bathtub overflowed”. Correct inference allows for the creation of a coherent scenario.

(5) *The Ambiguous Sentence Test* [37] is used to quantify the ability to integrate linguistic material. It involves the presentation of pairs of sentences, the second of which is ambiguous, and the interpretation is imposed by the first phrase. The ambiguous sentence is presented twice, in two different contexts, with one context eliciting the usual, universal interpretation, and the second one – the unusual. Providing the right answer requires taking into account the expression as a whole and interpreting the message in a broader context. An example with the word ‘bank’, which can be understood as either a bank of a river or a financial institution, is presented below:
   a) Context eliciting an atypical interpretation: “Claire was robbed while she was walking on a river bank. The bank was the place of robbery. Where did the robbery take place?: On a river bank?, In a bank?, In a village bank?”;
   b) Context eliciting a typical interpretation: “A man aimed at the cashier. The bank was the place of robbery. Where did the robbery take place?: In a village bank?, On a river bank?, In a bank?”.

(6) *The Syntactic Disambiguation Task* [38] uses preposition phrases which make the sentence credible or incredible. Subjects are to listen to a phrase and then choose the image which illustrates it. In incredible sentences, the correct answer requires focusing on the details (in two possible syntactic structures), at the expense of global information.

(7) Tasks using *language-mediated eye-movements* assess difficulty in processing ambiguous linguistic information with respect to context [39]. The test involves presenting 4 images: target (e.g., a hamster), phonological competitor (e.g., a hammer), and two unrelated meaningfully distracting images forming a coherent pair. Simultaneously a pre-recorded, five word sentence is played. In context-related sentences, the verb is strongly linked to the target, e.g., “Joe stroked the hamster quietly”. In a neutral sentence the target verb would be ‘choose’, e.g., “Sam chose the hamster reluctantly”. The subject’s task is to signal when any word in a sentence matches any of the presented images while measuring eye movement.

Of the above, there are very few methods available in Poland. All tools for assessing the verbal and semantic aspect of CC require translation. Polish adaptation of auditory tasks and pictures for the assessment of perceptual CC is also recommended. Visual illusions are easily available in manuals and criteria for evaluating drawings proposed by Booth et al. [40] can also be applied. The visual-spatial-constructional CC can be assessed with the help of Polish versions of the following tests: *the Rey-Osterrieth Complex Figure Task*, Block Design from the WISC-R battery.

## WCC in autism spectrum disorder and other mental disorders

Central coherence theory is believed to be the first approach that consistently explains both the deficits seen in people with ASD and their exceptional abilities [3, 11, 12]. Moreover, WCC seems to be relatively stable – it has been demonstrated that over 3 years, deficits in the theory of mind and executive functions in people with ASD are subject to significant changes, as opposed to the level of central coherence [41]. Studies conducted among relatives of children with autism spectrum disorder suggest the possibility of inheritance of a detail-based cognitive style, which allows us to see WCC as a phenotypic ASD trait [6]. Some researchers see a relationship between WCC and severity of ASD symptoms and prognosis [42].

Possible associations between CC, theory of mind and executive functions in ASD are still subject to debate. Studies conducted in a group of typically developing children aged 4 to 5 years showed a positive correlation between the results of the visual-spatial dimension of CC and executive functions and found no correlation between the results for individual dimensions of central coherence, as well as between WCC and theory of mind [43]. It seems that deficits in executive functions may be related to a tendency towards local processing. This claim is supported by observations that global processing deficits are related to problems with directing attention away from details, rather than to problems with integration of individual elements into a single whole. In turn, other studies on the relationship between CC and planning skills indicate a lack of mutual dependency between WCC and executive functions in ASD [32].

Discussion on the relationship between WCC and ToM deficiency is ongoing. It seems that correct inference about the state of mind of others requires a holistic analysis of the information. Nevertheless, this claim has not been unambiguously supported by research. Some people with ASD who successfully solve problems involving ToM show a clear tendency to local processing [4, 6]. In addition, studies indicate a lack of association between WCC and the ability to understand false beliefs in people with ASD [44]. On the other hand, there are studies to prove that fragmentary perception of the face makes it impossible to correctly read emotions. They draw a relationship between WCC and ToM with respect to certain aspects of social situations. Some acknowledge the existence of a relationship between worse results in tests involving ToM and a greater tendency to detail processing, and some even see a causal relationship between WCC and ToM deficits [44, 45].

Propensity for local processing is also observed in patients suffering from anorexia nervosa (AN). Research shows that people with AN acquire worse results on tests requiring the inclusion of a broader context and better results on tasks requiring attention to detail, especially in the visual domain [46, 47]. A question remains, whether those results could be caused by the clinical condition of patients (e.g., cachexia, comorbid mental disorders). A significant correlation was obtained between the Rey Figure Central Coherence Index and the lowest BMI of a patient [47]. Alternatively, Lang et al. [48] argue that there were no differences in performance between AN patients with correct BMI and the control group. Weinbach et al. [49] observed similar results in a study with the Navon Task. However, compared to the control group, AN patients paid more attention to details and had troubles ignoring the irrelevant details. It is still not clear whether CC in AN patients is dependent on other psychopathological symptoms, e.g., depression or anxiety. Hamatani et al. [50] demonstrated that after treating depression, anxiety and after obtaining the correct BMI, AN patients still got lower Rey Figure CC Index values than controls.

There are single studies on WCC in patients with ADHD [51], dyslexia [52] and Alzheimer's disease [53]. Due to the small number of studies, it is impossible to draw general conclusions. In a study by D'souza et al. [35], the researchers compared the level of local and global processing in different modalities (sound-verbal, visual-spatial) and at different levels of processing (high, low) between groups of people with ASD, Williams syndrome, ASD, or Down syndrome [35]. It was demonstrated that, depending on the stimuli and tasks, a tendency to local and global processing was visible in all three neurodevelopmental disorders and, contrary to previous research results, people with ASD or Williams syndrome did not exhibit a general tendency for local processing and people with Down syndrome – trend for global processing. Those studies prove that people with the aforementioned neurodevelopmental disorders are able to properly process stimuli locally and globally, and that they use different and unusual methods, depending on the type of task being performed.

## Recapitulation: unsolved problems and future directions of research

Despite nearly 30 years of research, the problem of central coherence has not yet been solved. The current discussion deals mainly with the issue of whether WCC should be seen as a limited ability to integrate stimuli or as an enhanced ability to focus on details. The main difficulty is that WCC is perceived either as a deficit or as a resource depending on the type of used test battery [3]. In linguistic tasks, such as the correct pronunciation of homographs, the inclusion of context is a requirement of a correct test solution. Understanding and creation of a narrative or correct inference about cause-and-effect relationships also depend on the ability to integrate information. In turn, in tests of the perceptual dimension of cognition WCC acts as an essential resource for gaining the best result in visual-spatial tasks, although in the case of motor stimuli the correct reception requires the integration of information from the environment. An additional complication is that it is still unknown which tasks really measure CC-related skills (e.g., do linguistic tests assess stimulus perception, or general language abilities?) [39]. Moreover, it turns out that individual tests of the visual-spatial dimension of CC do not measure the same construct [43]. Some interesting results were produced in studies which yielded no significant correlation between test results for different dimensions of CC. In addition, CC levels differ according to dimension among people with ASD (some people with ASD show a greater tendency to process locally in the visual-spatial dimension and a lower tendency to process globally in the linguistic dimension, while in others a weak CC may affect only one of the dimensions) [54].

It seems that further study of perceptual styles should be conducted using various tests relating to different dimensions of central coherence. Milne and Szczerbinski [8] pointed out many inaccuracies in the study of central coherence. The results of their analyses, in addition to remarks on control groups, suggest the use of tools that are sensitive to different modalities and that operate at different levels of CC. Currently, attempts are being made to create new tasks and testing tools by modifying the existing ones and by creating new research procedures that will allow for an evaluation of CC in several dimensions simultaneously [27, 35].

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