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# Factor Structure of Autism Symptoms in 5-6-Year-Old Children: Age Perspective

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**Abstract**

The work identifies the factor structure of autism symptoms in older preschoolers to check their age dynamics. An Autism Marker Questionnaire containing 330 potential symptoms of autism spectrum disorder (ASD) was developed to be implemented as an online survey. 501 children were examined (371 with ASD) already classified by experts as a group of ASD, typically developing (TD) or with developmental delay (DD). At the exploratory stage, a relatively simple 8-factor structure was obtained: Speech Understanding (SU), Emotions (Em), Persistence on Sameness (Sam), Hyperactivity/Disinhibition (Hyp), Sensory disintegration (Sen), Echolalia (Ech). Each factor formed a sufficiently reliable scale in terms of internal consistency. Logistic regression demonstrated high accuracy in dividing children into groups with and without ASD. The model for confirmatory analysis included eight primary factors and 3 secondary factors: 1) Communication disorders, COM (SU, Em, Emp, Ech), 2) Sensory disintegration, SD (SD, PS, Ech), 3) Praxis impairment, PI (Hyp, Mot). The multigroup confirmatory analysis confirmed the equivalence of the model for boys and girls, as well as 5- and 6-year-old children. The factors obtained can be considered as key autistic

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symptoms for this age group and can shed some light on our theoretical understanding of the autistic symptoms age dynamics in preschoolers.

**Keywords**
ASD; autism symptoms; factor model; 5-6-year-olds

## 1. Introduction

Autism spectrum disorder (ASD) is a neurophysiological and developmental disorder characterized by communicative, behavioral, and emotional impairments that usually manifest in early childhood [1] and rarely after some period of normal development [2]. Even though the problem of autism has been intensively studied in recent decades, timely differential diagnosis of ASD is still a difficult task to obtain due to high diversity and heterogeneity in genetics [3], brain anatomy and functional brain networks [4], behavioral abilities and social cognitions [5], sensory profiles [6], adaptive skills and maladaptive behaviors [7], and developmental trajectories of the autistic population [8]. The problem of studying autism is also complicated because there is significant variation in both its short-term developmental trajectories [9] and later clinical and behavioral outcomes [10, 11]. In addition, there is a lack of distinct biological markers for autism since the clinical phenotypes of ASD overlap, especially in early childhood, with many other clinical conditions, among which the most common are ADHD (attention-deficit hyperactivity disorder) and DD (developmental delay) [12, 13]. It is essential to distinguish between early markers of ASD and DD as well as understand the developmental milestones and possible time windows and indicators of a changed development trajectory of typically developing children (TD). For example, it is known that children with DD may have symptoms similar to those of children with ASD, such as sensory processing dysfunctions [14], repeated behavior patterns [15], and delayed speech manifestation [16]. However, these symptoms tend to disappear as the child undergoes timely intervention and the cognitive distance between him/her and his/her typically developing peers decreases [17]. TD children are also believed to experience echolalia as a stage of normal speech development in early childhood at the level of sound imitation [18]. They may also experience minor elements of sensory disintegration [19] and minor jams on ideas, thoughts, or states [20]; however, these jams do not affect their communicative competence or social functioning [21]. In this way, improving the identification of ASD symptoms in childhood is a task of high significance among autism investigators because timely diagnostics allow the appropriate interventions, which helps to discover a child's solid sides and achieve the best possible behavioral and learning results over time. That is why the recent focus of research in the field has been on elaborating and identifying factor models of autism symptoms on the samples of different age children.

The majority of existing factor models of autism agree on the classic triad of the core autistic symptoms, such as impairments in social and communicative skills and prevalence of restricted interests and repetitive behaviors stated in The Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-V) [22]. However, each contributes to the general understanding by adding additional factors. Most of the work on determining the factor structure of autism was based on existing screening, scales or questionnaires, thereby predicting the structure of the

resulting model [23-27]. In addition to the pre-deterministic structure, another weak point of such models is measurement variance across cultures. It was shown that cross-cultural comparative studies require immutability of measurement [28]. Under this request, natural cross-cultural differentiations in a factor structure could be identified if the measuring tool estimates the identical feature in both cultures; however, there should also be an agreement on modern requirements for diagnostic criteria and a standardized assessment method [29], which is hard to perform when the diagnostic tool has been validated and adapted to another culture.

Another approach is to initially use a wide range of autistic symptoms to check the autistic symptoms structure without interfering with prerequisites. In our previous work, we obtained 7-factor model of ASD symptoms in 3-4-year-old children using a wide array of autistic symptoms [30], which could be considered as the vectors of its manifestation in this age range. The elaborated 7-factor model included from 9 to 14 items in each factor (78 items in total) and consisted of the following vectors: 1) "Persistence on sameness" (Sam); 2) "Emotional dysregulation" (Em); 3) "Alienation" (Al); 4) "Speech understanding" (SU); 5) "Disinhibition/Hyperactivity" (Hyp); 6) "Echolalia" (Ech); 7) "Sensory disintegration" (Sen). A multi-group confirmatory factor analysis allowed us to verify the factor validity and structural and measurement equivalence of the obtained model. As a result, 3 groups of loosely related symptoms were obtained: a group of communication disorders including such factors as Em, Al, Su, and Ech; a group of repetitive behavior consisting of the factors Sam and Sen; and the group of hyperactivity with the only one factor of Hyp which did not correlate with other elements.

This study is devoted to testing the hypothesis that, similar to 3-4-year-old children with ASD, autistic symptoms in 5-6-year-olds form at least three groups of symptoms, of which 1) communication disorders, 2) sensory disorders and 3) delay in motor development are distinguished since the first two are the key symptoms of autism and the third one was obtained in our previous model for 3-4-year-olds. The hypothesis of the influence of age on the identified groups of symptoms will also be tested.

## 2. Materials and Methods

### *2.1 The Sample and Materials*

The data was collected by 28 experienced specialists engaged in psychological and pedagogical support of children in specialized and ordinary preschool institutions of St. Petersburg and working with children regularly (in counseling mode). Among them, nine were clinical psychologists, six neuropsychologists, five speech therapists, four behavioral therapists, and four developmental psychologists. All clinical psychologists and neuropsychologists, as well as three speech therapists, were affiliated with specialized preschool educational institutions, while developmental psychologists and two speech therapists were affiliated with ordinary preschool institutions. These practitioners were involved in this project earlier as investigators (including studies of ASD markers in 3-4-year-olds) or participants of professional development groups. The research project managers invited these specialists to participate in an online investigation, providing a link to the project website and specifying the children of the groups that would be assessed (ASD, DD, TD). The distribution of the children into groups of ASD, DD, or TD was performed based on the results of official examinations conducted before the current survey. Data collection was carried out throughout 2023.

Specialists received all the data to answer questions about the methodology (behavioral characteristics, etc.) in the process of regular work with the child and counseling his/her parents in the process of regular meetings and classes without the need for any additional tests. After accumulating the necessary information, specialists entered the data on the child into the online form of the methodology at a specially designated time for this. The data was collected anonymously, without specifying the full real name of the children or their parents. The database recorded only the conditional code of the child, answers to questions, assignment to the group (ASD, DD, TD), date of birth, date of examination and the child's gender. For this study, data were collected on 504 5-6-year-old children: 374 ASD, 78 TD, 52 DD.

An online questionnaire of autism markers was elaborated for this study, containing 330 potential markers of ASD risk, combined into questions based on a common topic or a typical situation of such markers manifestation (in play, dressing, communication, etc.). The description of the signs and the situations of their manifestation was collected by interviewing experienced specialists providing versatile support, including behavioral therapy and neuropsychological correction, along with educational interventions for children in ordinary and specialized preschool institutions as a part of special commissions. The interviewed practitioners selected the most significant markers of ASD that they considered the most important ones for observational evaluation of the child's behavior and the survey of his/her parents. In this regard, a deliberately excessive array of well-known autistic markers was obtained, consisting of quite familiar ones used in well-known tools such as CARS, ADOS and revised ADOS-2, and specific signs proposed by specialists, but possibly relevant to the Russian sample.

The initial array also included items that showed their importance in an earlier study of ASD markers in 3-4-year-old children and they were included in that screening methodology [30-32]. Compared with these items, the current array was supplemented with markers noted by experts at an older age of 5-6 years or manifested in activities more typical for older preschoolers (for example, participation in group classes at a preschool institution). The questionnaire questions were grouped into 14 domains, homogeneous in their focus or field of observation. Each domain had from 1 to 14 question tasks (85 tasks in total). In each question task, the specialist had to select and save one or more statements - answers about the presence of specific markers characterizing the child or a statement about the absence of all these signs (this statement was not in the methodology for 3-4-year-olds and it was added according to the suggestions of experts to more clearly fix the absence of all signs and prevent errors in filling out the questionnaire in the form of skipping a question).

Examples of question tasks:

W03. Features of the play. Answer options (items):

W0301. A child plays significantly less than typically developing peers.

W0302. A child does not like to play and rarely enjoys playing.

W0303. A child does not show imagination in the game.

W0304. A child does not show symbolism, creativity, and complexity in the game.

W0305. A child plays primitively and meaninglessly (performs mechanical manipulations).

W0306. A child is fixated on playing with certain objects, toys, or some activity or action.

W0307. A child repeatedly returns to the same play or stereotypical actions - turning on/off the light, pouring water, opening and closing drawers, pouring over sand or cereals.

W0308. A child's play is destructive; it can interfere with other children's play.

W0300. There is none of the listed above.

Thus, the values of 330 items-variables of the same type as in the previous study of children 3-4-year-olds were recorded for each child. Where the item is one of the answers to the task, that is a hypothetical symptom (marker) of autism (0-no, 1-yes). The questionnaire of autism markers was implemented as an online survey on the project's website. Upon completion of data collection, the methodology was switched to demo mode (the current version is available at http://ras.testpsy.net/demo567).

### *2.2 Data Analysis*

The analysis sequence was similar to the one we used to identify the factor structure of ASD symptoms in 3-4-year-olds [30]. The data was analyzed in two stages. The first stage, exploratory, was aimed at selecting a compact set of items forming the simplest factor structure of ASD symptoms and included an analysis of the item's discriminant power (distinguishing ability) and Exploratory Factor Analysis (EFA). The second stage, the confirmatory one, was aimed at checking the identified structure factor validity of the identified structure, testing hypotheses about the structure of factor interrelationships, and checking the multigroup, structural, and measurement invariance of the identified model for 5-6-year-olds, boys and girls. For this purpose, the Parcels Formation and Confirmatory Factor Analysis (CFA), including intergroup CFA, were applied. The analysis ended with checking the diagnostic value of the identified factors. The described analysis sequence is presented in detail below in the respective subsections.

#### 2.2.1 Items Selection

In the first step, items with weak discriminativeness were deleted. Then, exploratory factor analysis (EFA) was applied to the ASD sample (N = 374). The simplest factor structure of ASD symptoms was identified under the following requirements: a) the factor load of each item included in the factor should be at least |0.4|. For other factors, its load should not reach |0.4|; b) each factor should include at least 7-9 such items; c) the factors must have a clear, meaningful interpretation; d) the items included in the factor ensure acceptable reliability of the scale (McDonald's ω is not lower than 0.7). The factoring method used was minimum residual, and the rotation method was promax. The analysis was based on tetrachoric correlations and was performed using the HASP 0.18.3 (Copyright 2013-2023 University of Amsterdam).

#### 2.2.2 Parcels Formation and Confirmatory Factor Analysis

The sample size N = 371 was clearly insufficient to apply confirmatory factor analysis (CFA). Therefore, a parcel approach was applied, implying the unification (parceling) of items included in one factor into several packages of items [30]. The items included in each factor were randomly distributed into 3 packages, from 2 to 5 items in a package. The value of each package was calculated as the average value of the items included in it. Thus, the number of estimated parameters for CFA was significantly reduced, and quantitative explicit variables were used instead of binary ones. The package CFA was performed using IBM AMOS 28 (Amos Development Corporation 3000 Village Run Road Unit 103, #315 Wexford, PA 15090 USA). Confirmatory factor models were evaluated using the following indices: the Chi-squared ratio to the number of

degrees of freedom ($\chi^2$/df) was not higher than 2, the comparative compliance index (CFI) and the Tucker-Lewis index (TLI) were not lower than 0.90, the standard error of approximation (RMSEA) was less than 0.70 and its accuracy (Pclose) was not lower than 0.20 [33, 34].

#### 2.2.3 Testing the Hypothesis about the Factors Interrelations Structure

The hypothesis was tested that, as in 3-4-year-old children with ASD, the symptoms of ASD in 5-6-year-olds form 3 groups: 1) communication disorders, 2) sensory disintegration, 3) praxis impairment. The hypothesis of the influence of age on the group of communication disorders was also tested. To test the hypotheses, 3 secondary factors were added to the measurement model obtained in paragraph 2.2.2, the indicators of which were the corresponding primary factors, and an explicit variable, Age (Days), was added, affecting the group of communication disorders.

#### 2.2.4 Checking the Model's Structural and Measurement Invariance

Equivalence of the multifactor structure obtained in paragraph 2.2.3 was checked against two pairs of samples: a) 5-6-year-olds and b) boys and girls. A multigroup CFA was used in IBM AMOS 28 version program. The decision on the equivalence of the models was made based on reducing the CDI or TDI by no more than 0.01 or an increase of RMSEA by no more than 0.01, which implies the equivalence of measurements [34, 35]. In our study, if any of these indices did not exceed this limitation, it was assumed that the more limited model had acceptable suitability.

#### 2.2.5 Checking the Selected Factors Diagnostic Value

The factors were calculated as the average values of the items included in them for ASD, DD and TD samples and then these samples were compared using Robust Walch Tests of Equality of Means, with multiple comparisons (Post Hoc Tests Gams-Howell). A logistic regression model was used to determine how accurately 8 factors separate a group of children with ASD from other children (DD + Norm).

### *2.3 Ethics Statement*

Specialists received all the data to answer questionnaire questions (behavioral characteristics, etc.) during regular work with the child and counseling parents, during regular meetings and classes, without the need for additional tests. Upon data collection completion, practitioners entered data concerning the child into the online questionnaire form outside of counseling or correctional work at a designated time. The data was collected anonymously, without revealing the real names of the children or parents or disclosing any personal information. The database recorded only the conditional code of the child, particular information related to online survey questions belonging to the group (ASD, DD, TD), date of birth and sex of the child, and date of examination. Therefore, there was no need to obtain the Ethical Committee's consent to conduct this study, for no personal information was disclosed, and belonging to the ASD, DD, or TD group happened prior to the study being conducted. Parents informed consent statement was not collected either because specialists transmitted for statistical analysis only the data on the combination of the presence or absence of specific markers of ASD in individuals anonymously

(without disclosing any personal information) and these data were the results of these specialists routine work (consultations and observations).

## 3. Results

The study collected data on 504 children. The composition of the sample based on diagnosis, gender, and age is presented in Table 1.

**Table 1** Composition of the sample by diagnosis, age, and gender.

| Age (Year) | | | Diagnosis | | | Total |
|---|---|---|---|---|---|---|
| | | | ASD | TD | DD | |
| 5 | Gender | M | 128 | 20 | 18 | 166 |
| | | F | 54 | 13 | 2 | 69 |
| | Total | | 182 | 33 | 20 | 235 |
| 6 | Gender | M | 142 | 24 | 22 | 188 |
| | | F | 50 | 21 | 10 | 81 |
| | Total | | 192 | 45 | 32 | 269 |
| Total | Gender | M | 270 | 44 | 40 | 354 |
| | | F | 104 | 34 | 12 | 150 |
| | Total | | 374 | 78 | 52 | 504 |

### *3.1 Items Selection*

The steps of this stage of the analysis are shown in Figure 1.

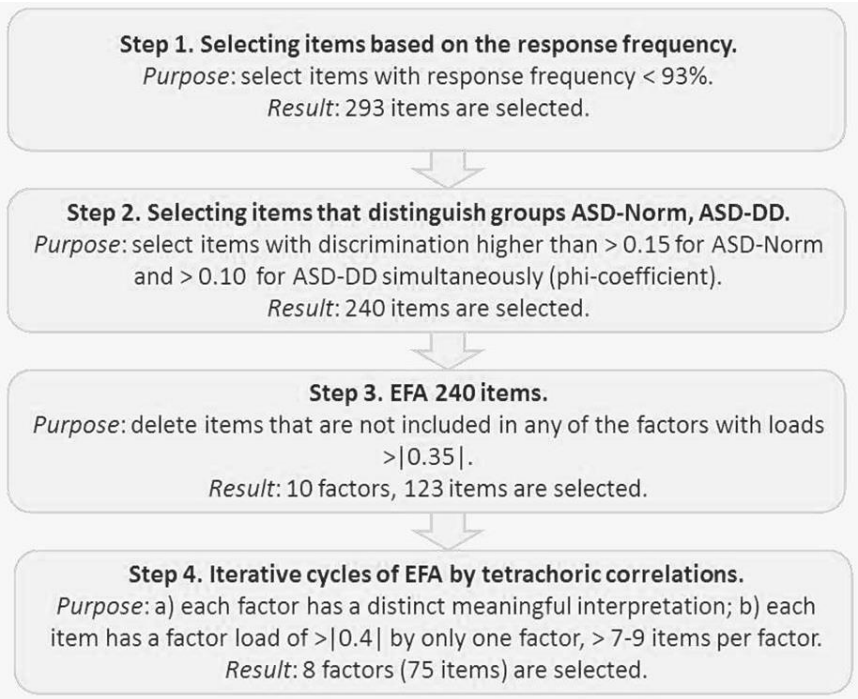


**Figure 1** The flowchart depicting key steps of items number reducing.

### *3.2 Exploratory Factor Analysis of Items*

Step 1. Out of 330 starting items, the items for which the answers to one of the two alternative questions (0-no, 1-yes) were less than 7% were initially excluded. There were 293 points left.

Step 2. For each item, 2 phi coefficients were calculated for the variables ASD-DD, and ASD-TD. 53 items were excluded for which the coefficients were less than 0.1 for the ASD-DD group and, at the same time, less than 0.15 for the ASD-TD group. There were 240 items left.

Step 3. EFA on tetrachoric correlations was used for the ASD sample. According to Scree Plot 16 factors were initially set for 240 items. But 4 included less than 6 items with loads of at least |0.35|. And 92 items were not included in any factor with loads of at least |0.35|. These 92 items were removed and the number of factors was reduced to 12. This step-by-step number reduction of factors by 1 and items reduction continued until 10 factors were obtained, each of which included at least 6 items with loads of at least |0.35|, and a total of 125 items. Two factors did not have a clear interpretation. And 42 items with loads of at least |0.35| were included in 2 factors.

Step 4. Items with maximum loads for 2 factors that did not have a clear interpretation were removed, as well as a part of the items from 2 factors with an excessive number of items; thus, the number of factors was reduced to 8. The removal of different groups of items was carried out repeatedly until an 8-factor structure was obtained as close as possible to the specified requirements: a) each factor has a distinct meaningful interpretation; b) each item has a factor load of >|0.4| only by one factor, >9 items per factor. The 8-factor structure (75 items) was the best, with a clear, meaningful interpretation of each factor. Factors are listed below in order of the sum of squared loads decreasing: Empathy (Emp), Speech Understanding (SU), Emotions (Em), Persistence on Sameness (PS), Hyperactivity/Disinhibition (Hyp), Sensory Disintegration (SD), Motor Disorders (Mot), Echolalia (Ech) (see Table 2).

**Table 2** Factor loadings for eight-factor solution (EFA) and reliability check on McDonald's ω scales.

| Rotated Factor loadings of 75 Items (n = 371), 53.2% of Variance | FL[1] |
|---|---|
| Factor 1 (Emp[3]): "Empathy" (10 items; 9%, ω = 0.855) | |
| W2403 A child finds it difficult to explain and predict certain behaviors of other people. | 0.858 |
| W2402 A child has difficulty understanding the behavior of other people. | 0.803 |
| W2407 A child finds it difficult to draw conclusions about the implicit mental states of other people (for example, feelings, beliefs, desires and intentions). | 0.778 |
| W2904 A child has difficulty understanding his/her own behavior in situations of social interaction. | 0.714 |
| W2507 A child has difficulty in cognitive empathy (rational understanding of the feelings and emotions of others in the context of a situation). | 0.707 |
| L1304 A child experiences difficulties in establishing friendships. | 0.671 |
| W2408 A child has difficulty understanding jokes, figures of speech, metaphors or sarcasm. | 0.661 |
| W2405 A child has difficulty understanding group interactions. | 0.659 |
| W2601 A child has difficulty understanding the rules of conversation. | 0.633 |
| W2905 A child finds it difficult to draw conclusions about his/her mental state (for example, feelings, beliefs, desires and intentions). | 0.533 |
| Factor 2 (SU[3]): "Speech understanding" (10 items; 8.9%, ω = 0.867) | |
| S4705 A child can point at the objects or their images when an adult calls a generalizing word (for example, "Show a piece of furniture", "Show a fruit"). | 0.824 |
| S4707 A child shows where the right/left hand is, (eye, leg, ear) (even if wrongly). | 0.822 |
| S4703 A child fulfills a double request: "Bring the keys to dad and then close the door!" Or "Pick up the book from the floor and give it to mom." | 0.784 |
| S0506 A child correctly shows the shapes when the adult calls them square, rectangle, triangle. | 0.761 |
| S0508 A child distinguishes between sounds made by different animals. | 0.738 |
| S0502 A child distinguishes between the words "big" and "small", "short" and "long", "wide" and "narrow". | 0.734 |
| S4708 Indicates an object of the same color that the adult calls. | 0.727 |
| S0503 A child can show where his/her arm, leg, eye, ear are (two answers are enough). | 0.697 |

| | |
|---|---|
| S4701 Fulfills the request "Give me another one." | 0.623 |
| Factor 3 ($Em^3$): "Emotions" (9 items; 7.1%, ω = 0.779) | |
| L1103 A child draws the adult's attention to some object or event, as if bragging, in search of their response or emotional empathy. | 0.812 |
| E7402 A child reacts to the positive emotions of others, "gets infected" with them, demonstrating a positive mood, laughs. | 0.806 |
| L0903 A child immediately looks at the person who is addressing him/her. | 0.765 |
| L7704 When a child hears his/her name, he/she immediately turns and looks at the speaker. | 0.730 |
| E0301 A child smiles as soon as he/she sees the friendly attitude of an adult. | 0.705 |
| L1003 When showing something to another person, a child positions the object so that it can be viewed, checks whether the person sees what he/she is showing. | 0.690 |
| E7403 When watching a cartoon, a child understands what is happening on the screen and emotionally reacts adequately in the same way in familiar situations. | 0.607 |
| W0201 A child plays "make-believe" games (he/she pretends to "feed" a doll or performs other imaginary actions with toys). | 0.507 |
| M7205 A child easily talks about his/her needs. Uses words, phrases, gestures and facial expressions. | 0.504 |
| Factor 4 ($PS^3$): "Persistence on sameness" (11 items; 6.6%, ω = 0.797) | |
| B2801 A child is stressed due to changes in routines (daily routine, walking routes, etc.). | 0.783 |
| W2805 A child gets upset because of minor changes in the regime and environment. | 0.705 |
| W3902 A child is characterized by ritualism in behavior. | 0.700 |
| W3903 A child wants to follow a certain order of events (actions); gets upset because of the changes. | 0.698 |
| B6401 A child insists on completing tasks in the same way every time. | 0.622 |
| F2304 It is difficult for a child to put on something new, he/she gets used to old clothes. | 0.585 |
| B6503 If it is necessary to change clothes (for example, when the weather or season changes), problems arise - a child refuses to wear unfamiliar clothes. | 0.564 |
| W0501 A child chooses certain clothes and wears only it. | 0.553 |
| B2804 A child follows rituals (putting to bed only according to one scenario, drinking only from his/her favorite cup, dressing only in a certain order, walking only along a certain route). | 0.545 |
| F2303 When dressing, a child is being naughty, demands to change into the clothes that he/she likes. | 0.535 |
| W2806 A child resists changes in the environment (for example, in people, places, objects). | 0.522 |

| | |
|---|---|
| Factor 5 ($Hyp^3$): "Hyperactivity/Disinhibition" (10 items; 5.7%, ω = 0.775) | |
| W3604 A child often shows external aggression directed at objects, parents or other people, especially when the child's personal space is violated. | 0.751 |
| B2901 A child is aggressive, pugnacious, is prone to physical violence against animals and other people. | 0.720 |
| B6201 A child loses self-control, is prone to emotional outbursts. | 0.692 |
| B2603 A child is often being angry and irritable. | 0.674 |
| W3401 A child is prone to emotional reactivity. | 0.645 |
| N6901 A child makes too many unnecessary movements in the activity, is fussy, he/she seems to be hyperactive. | 0.576 |
| B2605 A child does not obey and refuses to obey the established rules of adults. | 0.517 |
| B6202 In an effort to achieve his/her goal, a child easily loses his/her temper. | 0.505 |
| W4101 A child's movements are restless and erratic. | 0.498 |
| B2503 A child is difficult to control. His/her behavior is driven by external stimuli - "I see something - I run there" (field behavior). | 0.411 |
| Factor 6 ($SD^3$): "Sensory disintegration" (10 items; 5.4%, ω = 0.687) | |
| W3905 A child is characterized by motor stereotypes (repetitive movements - arms flapping, "wings", rocking, shaking his/her head, clamping his/her shoulders, etc.). | 0.603 |
| G2003 A child is interested in the parts, details of the object, and not the whole object (obsession with the wheels of cars, details of human clothing, clothes tags). | 0.600 |
| N4303 A child shows an extraordinary need to touch certain textures of surfaces, toys; he/she studies objects by touching. | 0.561 |
| W0307 A child repeatedly returns to the same play, to the same stereotypical actions - turning on/off the light, pouring water, opening and closing drawers, pouring over sand or cereals. | 0.552 |
| W4105 A child performs monotonous movements (swinging, waving, hands shaking, whirling, bouncing, etc.) | 0.514 |
| L1302 A child does not pay attention to the presence of others, does not respond to attempts by others to establish contact. | 0.496 |
| N4205 A child likes to watch the lights turning on and off, doors or blinds opening and closing, wheels or fans spinning, shiny objects, flashing pages when flipping through, etc. | 0.476 |
| W2906 A child demonstrates ritualistic or compulsive behaviors (for example, sniffing, licking, watching objects fall, shaking his/her arms, spinning, swinging, humming, tapping, sucking, rubbing clothes/textures). | 0.465 |
| N6704 A child protests against clothes that hug the body tightly, hard seams and certain fabrics that are unpleasant for | 0.452 |

| | |
|---|---|
| him/her, or mittens, hats, socks. | |
| W3203 A child has difficulty perceiving loud and/or sudden sounds. For example, he/she shudders, cries, covers his/her ears with his/her hands, screams, falls down. | 0.404 |
| Factor 7 (Mot): "Motor skills" (7 items; 5.3%, ω = 0.752) | |
| W4702 A child has difficulty with fine motor skills (for example, coloring, using scissors, gluing). | 0.807 |
| W4403 A child experiences a delay in the formation of fine motor movements. | 0.786 |
| W4404 A child experiences difficulties with the "tweezer" grip. | 0.734 |
| W4108 The child's fine motor skills lag behind their peers in development (for example, tying shoelaces, using scissors, etc.). | 0.694 |
| W4106 Large-motor awkward movements prevail over fine motor skills in a child. | 0.691 |
| W4304 A child often walks on their tiptoes. | 0.455 |
| W4808 A child closes up if he/she hears too many verbal instructions. | 0.432 |
| Factor 8 (Ech[3]): "Echolalia" (9 items; 5.2%, ω = 0.711) | |
| W1701 A child has echolalia (stereotypical manipulations with sounds, words, phrases without realizing their meaning). | 0.767 |
| S5404 A child's speech is full of echo reactions: repeats the words of other people, not for communication purposes. | 0.728 |
| M1604 When an adult names the objects that he thinks the child wants, the child responds by repeating the word that the adult has just said (immediate echolalia). | 0.643 |
| S5305 A child uses memorized phrases, without meaning, out of the context; it seems that there is no speech of his/her own. | 0.618 |
| W1906 A child makes verbal sounds while listening (for example, echolalia). | 0.601 |
| S5304 If a child hears a question or other appeal to him/her, he/she does not react adequately, but only repeats the words addressed to him/her. | 0.511 |
| W2010 A child repeats the last words or phrases several times. | 0.487 |
| W2005 A child speaks about him/herself in the third person. | 0.465 |
| S5405 A child "talks" with words and phrases from cartoons or previously heard from adult conversations. | 0.444 |

[1] Factor loadings.

The composition of 75 items for 5-6-year-olds includes 33 items obtained in the 7-factor structure of autism symptoms for 3-4-year-olds [30]. The final structure contains 75 items. Seven factors include at least 9 items, and only one factor (Motor skills) consists of 7 items with loads of at least |0.4|. The factor structure was quite simple: each item is included in the factor with a load of at least 0.4, having loads for other factors less than |0.35|. The exception was one item (S5405 A child "talks" with words and phrases from cartoons or previously heard from adult conversations), which has a load of 0.404 for the second factor (Speech understanding) and 0.444 for the eighth factor (Echolalia). However, the sum of the squared loads for the second factor is 6.654, and for the eighth factor - 3.907, 70% lower. Therefore, the relative contribution of this item to factor 8 ((0.444)2/3.907) is more than 2 times higher than in factor 2 ((0.404)2/6.654), which is a sufficient reason for including this item in the 8th factor.

The positive poles of the SU and Em factors correspond to the absence of ASD symptoms, so the items included in these factors were inverted. Thus, the SU_Inv factor represents the symptoms of impaired speech comprehension, and the Em_Inv factor represents the symptoms of emotional dysregulation.

Obtained 8-factor structure of autism symptoms with factor loads for 5-6-year-olds is shown in Figure 2.

| |
|---|
| **Factor 1 (Emp[3]): "Empathy" (10 symptoms; 9%)** |
| **Symptoms** connected with situations of understanding and predicting the behavior of other people based on the interpretation of their emotions and feelings. |
| **Factor 2 (SU[3]): "Speech understanding" (10 symptoms; 8.9%)** |
| **Symptoms** related to performing simple actions in accordance with the verbal instructions of an adult. |
| **Factor 3 (Em[3]): "Emotions" (9 symptoms; 7.1%)** |
| **Symptoms** linked to the situations of emotional contact with others, emotional response, emotional reaction in return to the emotions of others or rather the lack of it. |
| **Factor 4 (PS[3]): "Persistence on sameness" (11 symptoms; 6.6%)** |
| **Symptoms** related to the stress of change, the need for sameness in the regime and environment, ritualism, resistance to the new. |
| **Factor 5 (Hyp[3]): "Hyperactivity/Disinhibition" (10 symptoms; 5.7%)** |
| **Symptoms** connected with hyper-reactive behavior including aggression, reduced behavioral control, disinhibition. |
| **Factor 6 (SD[3]): "Sensory disintegration" (10 symptoms; 5.4%)** |
| **Symptoms** in its composition that are related with various indicators of increased or decreased sensory sensitivity and corresponding auto-stimulation actions or avoidance of certain stimulus. |
| **Factor 7 (Mot): "Motor skills" (7 symptoms; 5.3%)** |
| **Symptoms** linked with difficulties in performing finely differentiated motor movements and delayed motor development. |
| **Factor 8 (Ech[3]): "Echolalia" (9 symptoms; 5.2%)** |
| **symptoms** connected with immediate and delayed echolalia and verbal stereotypes |

**Figure 2** Factors of autism symptoms in 5-6-year-old children.

Indices 3 indicate that the same factors were obtained previously in the 7-factor structure of autism symptoms for 3-4-year-olds [30].

### *3.3 Parcels Formation*

For each factor, 3 packages were formed, with a random distribution of items into packages. For seven factors, there were 3-4 items in each package. For one motor factor (Mot), which includes 7 points, one package included 3 points, and the other two packages - two points each. Thus, 75 items were distributed in 24 packages, 3 packages for each factor, 2-4 items in each package. The average value of the items included in the package was calculated, and thus, 75 binary items were reduced to 24 new package variables presented on a 3- to 5-point quantitative scale under the number of items in the package. The numerical value of the package corresponded to the proportion of positive responses to the items included in the package. Further analysis was performed with these 24 new variables, 3 per factor.

### *3.4 Confirmatory Factor Analysis of Parcels*

An 8-factor model was tested, with 3 parcels for each factor. Statistically significant covariances between latent variables were added under modification indices. The best fit of the model was achieved by adding 14 covariances between the factors. The agreement indices confirm a good correspondence of the 8-factor model to the initial data: $\chi^2 = 466.340$; df = 238 ($\chi^2/df < 2$); CFI = 0.931, TLI = 0.921, RMSEA = 0.051, Pclose = 0.422.

### *3.5 Testing the Hypothesis about the Structure of the Factors Interrelationships and the Influence of Age*

According to the initial hypothesis of three groups of symptoms, 3 secondary factors were added to the 8-factor measurement model obtained in the previous step: 1) COM - communication disorders (primary factors SU_Inv, Em_Inv, Emp, Ech); 2) SD - sensory disintegration (primary factors SD, PS, Ech); 3) PI - praxis impairment (primary factors Hyp, Mot). The Age (Days) variable was added to check the effect of age on the COM factor. The following fit indices were obtained: $\chi^2 = 584.299$; df = 265 ($\chi^2/df > 2$); CFI = 0.905, TLI = 0.892, RMSEA = 0.057, Pclose = 0.036.

Since the fit indices demonstrate an unsatisfactory correspondence of the model to the data, regression weights from the secondary factor PI to the primary factors Em and Emp were released for evaluation by the modification indices. The final a posteriori model is shown in Figure 3. The fit indices demonstrate an excellent correspondence of the model to the initial data. All regression weights, covariance, and factor variances are statistically significant ($p < 0.01$).

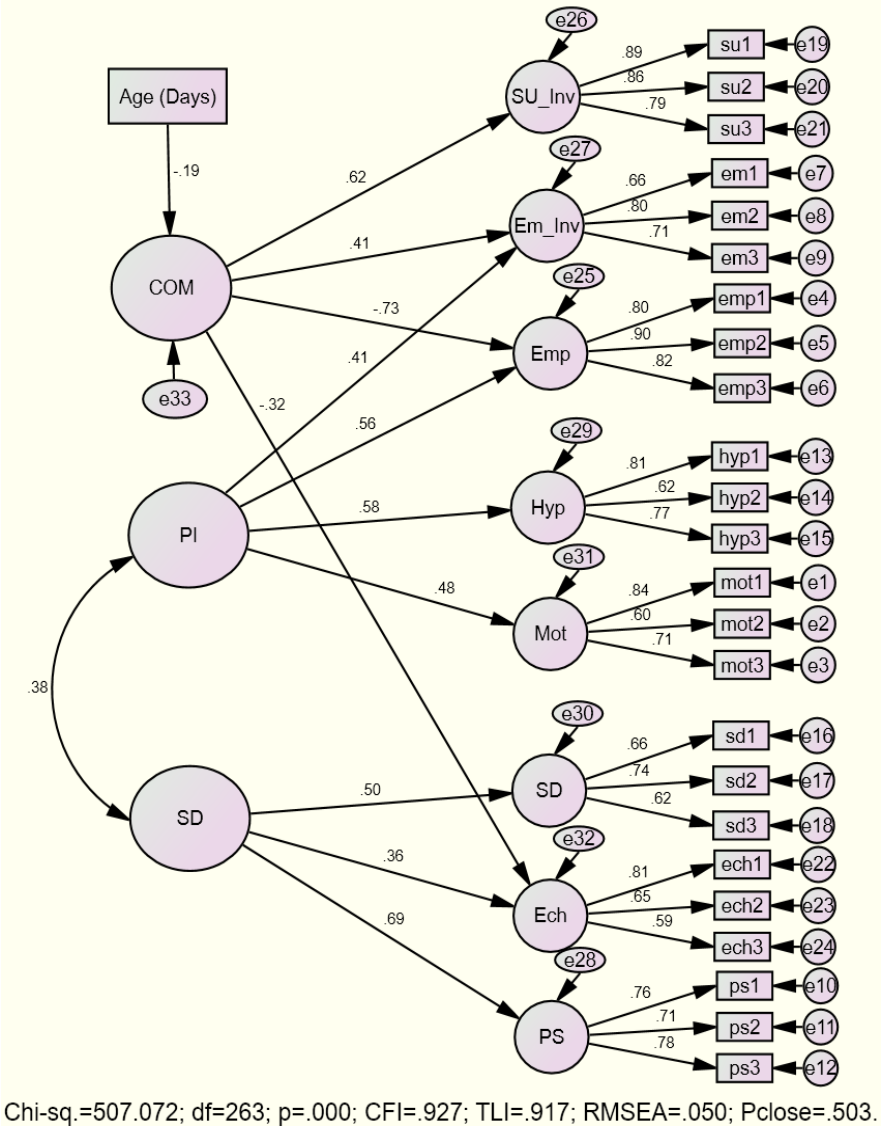


**Figure 3** A model of ASD symptoms structure in 5-6-year-olds.

### *3.6 Checking the Structural and Measurement Invariance of the ASD Symptom Model for 5-6-Year-Old Children*

Table 3 presents the results of checking the model's invariance for the samples of 5—and 6-year-olds.

**Table 3** Model fit indices for 5- and 6-year-olds.

| Model | $\chi^2$ | df | CFI | TLI |
|---|---|---|---|---|
| Unconstrained | 795.197 | 526 | 0.920 | 0.909 |
| Measurement weights | 824.227 | 542 | 0.916 | 0.907 |
| Structural weights | 840.903 | 551 | 0.914 | 0.906 |
| Structural covariances | 847.681 | 555 | 0.913 | 0.906 |
| Structural residuals | 859.823 | 564 | 0.912 | 0.907 |

The unconstrained model corresponds reasonably well to the data for all the given indices: -2/df < 2; CFI > 0.90 and TLI > 0.90; RMSEA < 0.05. To decide invariance at one or another level of parameter fixation, the differences in CFI, TLI, and RMSEA are essential for the subsequent and previous steps of the model constraint. The difference between these indices does not exceed 0.01 for each step of the limitations. Consequently, the configurational, metric, scalar, and strict invariance of the measurement model for 5-6-year-olds has been confirmed.

The results of the model invariance checking for the samples of boys and girls, 5-6-year-olds, are presented in Table 4.

**Table 4** Model fit indices for boys and girls.

| Model | $\chi^2$ | df | CFI | TLI |
|---|---|---|---|---|
| Unconstrained | 770.327 | 526 | 0.927 | 0.916 |
| Measurement weights | 804.225 | 542 | 0.921 | 0.913 |
| Structural weights | 811.016 | 551 | 0.922 | 0.915 |
| Structural covariances | 815.005 | 555 | 0.922 | 0.915 |
| Structural residuals | 823.673 | 564 | 0.922 | 0.917 |

The unconstrained configuration model corresponds well to the data on the consent indexes. The index difference for each constraint step does not exceed 0.01, confirming the model's invariance for boys and girls at all levels.

### *3.7 Analysis of the Predictive Value of the 8-Factor Model*

The sample of children with ASD was combined with TD children and children with DD, and the values of factors were calculated for all of them as the average values of the items included in the factors. Descriptive statistics for the 3 groups are given in Table 5.

**Table 5** Descriptives of the selected factors values for ASD, TD, and DD samples.

| | | N | Mean | SE | SE | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| Emp | ASD | 374 | 0.524 | 0.327 | 0.017 | 0.491 | 0.558 |
| | TD | 78 | 0.077 | 0.158 | 0.018 | 0.041 | 0.113 |
| | DD | 52 | 0.413 | 0.328 | 0.045 | 0.322 | 0.505 |
| | Total | 504 | 0.444 | 0.346 | 0.015 | 0.413 | 0.474 |
| SU_Inv | ASD | 374 | 0.510 | 0.340 | 0.018 | 0.476 | 0.545 |
| | TD | 78 | 0.038 | 0.069 | 0.008 | 0.023 | 0.054 |
| | DD | 52 | 0.378 | 0.354 | 0.049 | 0.280 | 0.477 |
| | Total | 504 | 0.424 | 0.358 | 0.016 | 0.392 | 0.455 |
| Em_Inv | ASD | 374 | 0.850 | 0.212 | 0.011 | 0.828 | 0.872 |
| | TD | 78 | 0.222 | 0.210 | 0.024 | 0.175 | 0.269 |
| | DD | 52 | 0.562 | 0.298 | 0.041 | 0.479 | 0.645 |
| | Total | 504 | 0.723 | 0.321 | 0.014 | 0.695 | 0.751 |
| PS | ASD | 374 | 0.305 | 0.263 | 0.014 | 0.278 | 0.331 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | TD | 78 | 0.033 | 0.088 | 0.010 | 0.013 | 0.052 |
| | DD | 52 | 0.154 | 0.239 | 0.033 | 0.087 | 0.220 |
| | Total | 504 | 0.247 | 0.262 | 0.012 | 0.224 | 0.270 |
| Hyp | ASD | 374 | 0.284 | 0.250 | 0.013 | 0.259 | 0.310 |
| | TD | 78 | 0.078 | 0.158 | 0.018 | 0.042 | 0.114 |
| | DD | 52 | 0.308 | 0.324 | 0.045 | 0.217 | 0.398 |
| | Total | 504 | 0.255 | 0.258 | 0.011 | 0.232 | 0.278 |
| SD | ASD | 374 | 0.390 | 0.245 | 0.013 | 0.365 | 0.415 |
| | TD | 78 | 0.026 | 0.069 | 0.008 | 0.010 | 0.041 |
| | DD | 52 | 0.192 | 0.208 | 0.029 | 0.135 | 0.250 |
| | Total | 504 | 0.313 | 0.261 | 0.012 | 0.291 | 0.336 |
| Mot | ASD | 374 | 0.426 | 0.307 | 0.016 | 0.395 | 0.457 |
| | TD | 78 | 0.104 | 0.166 | 0.019 | 0.067 | 0.142 |
| | DD | 52 | 0.459 | 0.296 | 0.041 | 0.376 | 0.541 |
| | Total | 504 | 0.380 | 0.311 | 0.014 | 0.352 | 0.407 |
| Ech | ASD | 374 | 0.264 | 0.250 | 0.013 | 0.239 | 0.289 |
| | TD | 78 | 0.003 | 0.020 | 0.002 | -0.001 | 0.008 |
| | DD | 52 | 0.130 | 0.206 | 0.029 | 0.073 | 0.187 |
| | Total | 504 | 0.210 | 0.245 | 0.011 | 0.188 | 0.231 |

Table 6 shows the results of ANOVA using the Welch criterion (free from the assumption of equality of variances). The groups differ statistically significantly ($p < 0.001$). The most significant contribution to the distinction of the 3 groups is made by Em_Inv (huge effect magnitude), then SD and SU_Inv (significant effect magnitude), then Emp, Ech, and PS (medium effect magnitude), and Mot (small effect magnitude).

**Table 6** Robust Walch's Tests of Equality of Means.

| Dep. Var. | F | df1 | df2 | p | Partial $\eta^2$ |
|---|---|---|---|---|---|
| Emp | 166.9 | 2 | 122 | <0.001 | 0.216 |
| SU_Inv | 313.1 | 2 | 126 | <0.001 | 0.225 |
| Em_Inv | 294.9 | 2 | 100 | <0.001 | 0.521 |
| PS | 129.7 | 2 | 129 | <0.001 | 0.152 |
| Hyp | 45.3 | 2 | 111 | <0.001 | 0.087 |
| SD | 301.3 | 2 | 131 | <0.001 | 0.275 |
| Mot | 92.8 | 2 | 121 | <0.001 | 0.144 |
| Ech | 204.7 | 2 | 122 | <0.001 | 0.157 |

The multiple comparisons of samples (Post Hoc Gams-Howell's Tests) are given in Table 7.

**Table 7** Pairwise comparisons (Gams-Howell's Post Hoc Tests).

| Dependent Variable | (I) | (J) | Mean difference (I-J) | Std. Error | p | Cohen's d* |
|---|---|---|---|---|---|---|
| Emp | ASD | TD | 0.44741 | 0.02459 | <0.001 | 1.458 |
| | | DD | 0.11087 | 0.04850 | 0.065 | 0.361 |
| SU_Inv | ASD | TD | 0.47164 | 0.01923 | <0.001 | 1.495 |
| | | DD | 0.13190 | 0.05218 | 0.037 | 0.418 |
| Em_Inv | ASD | TD | 0.62775 | 0.02615 | <0.001 | 2.825 |
| | | DD | 0.28800 | 0.04276 | <0.001 | 1.296 |
| PS | ASD | TD | 0.27194 | 0.01686 | <0.001 | 1.124 |
| | | DD | 0.15072 | 0.03577 | <0.001 | 0.623 |
| Hyp | ASD | TD | 0.20629 | 0.02211 | <0.001 | 0.835 |
| | | DD | -0.02320 | 0.04676 | 0.873 | -0.094 |
| SD | ASD | TD | 0.36473 | 0.01488 | <0.001 | 1.636 |
| | | DD | 0.19807 | 0.03144 | <0.001 | 0.889 |
| Mot | ASD | TD | 0.32150 | 0.02456 | <0.001 | 1.114 |
| | | DD | -0.03289 | 0.04399 | 0.736 | -0.114 |
| Ech | ASD | TD | 0.26083 | 0.01314 | <0.001 | 1.155 |
| | | DD | 0.13423 | 0.03131 | <0.001 | 0.594 |

* - large effect values (≥0.80).

Almost all differences are statistically significant ($p < 0.001$), except for differences in the ASD - DD pair by Emp, Hyp, and Mot factors. Figure 4 shows the means of the factors (the proportion of positive responses) for the 3 groups being compared.

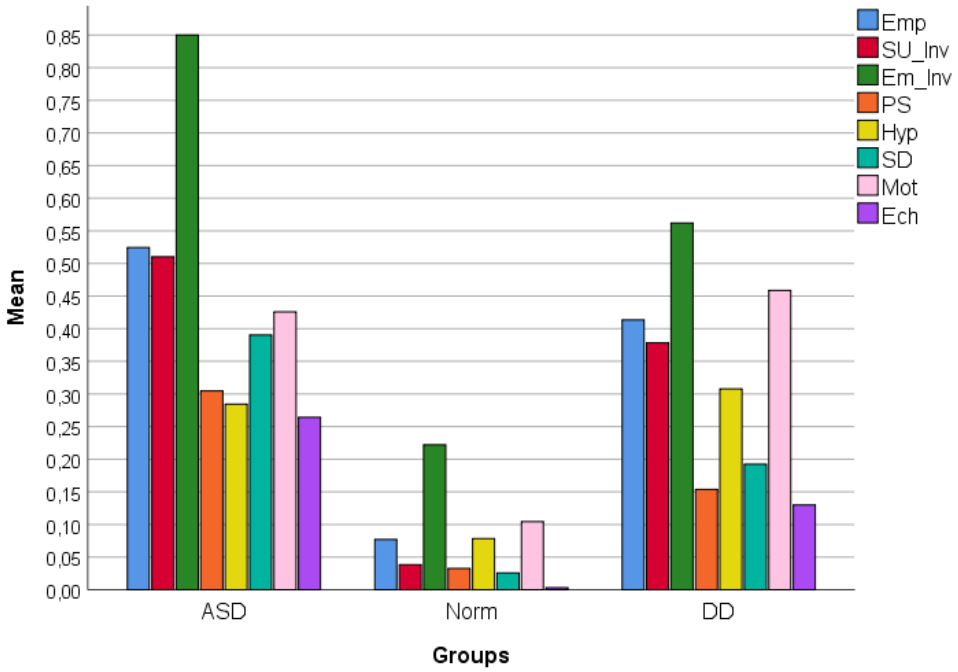


**Figure 4** The 8 factors of ASD symptoms for 3 groups compared.

To determine how accurately 8 factors distinguish a group of children with ASD from other children (DD + TD), a logistic regression model was used: dependent variable - Group (0-Not ASD (combining DD and TD), 1-ASD), independent variables - 8 factors of ASD symptoms. The classification cutoff (0.742) was set from the ratio of the number of ASD groups (N = 374) to the total number (N = 403). The classification results are presented in Table 8.

**Table 8** Classification table: the result of a logistic regression.

| Observed | Predicted | | |
|---|---|---|---|
| | Not ASD | ASD | % Correct |
| Not ASD | 112 | 18 | 86.2 |
| ASD | 40 | 334 | 89.3 |
| Overall Percentage | | | 88.5 |

## 4. Discussion

The primary result of our research was to obtain an 8-factor model of autism symptoms for 5-6-year-olds. Below listed the factors, in order of decreasing of the squares of the factor's loadings sum: Empathy (Emp), Speech Understanding (SU), Emotions (Em), Persistence on Sameness (PS), Hyperactivity/Disinhibition (Hyp), Sensory Disintegration (SD), Motor Disorders (Mot), Echolalia (Ech) (for more details see Table 2). First, we will interpret the names of the factors and then discuss how they contribute to ASD according to the current state of research in this area. The factor Emp was named so because it includes ten items connected with situations of understanding and predicting other people's behavior based on interpreting their emotions and feelings. The next factor, SU, consists of 9 items related to performing simple actions under the verbal instructions of an adult. The third factor is Em because it includes 9 items linked to emotional contact with others, emotional response, emotional reaction in return to the emotions of others or rather the lack of it. The next factor was called PS since it consists of 11 items related to the stress of change, the need for sameness in the regime and environment, ritualism, and resistance to the new. The fifth factor we name is Hyp because it includes 10 items connected with hyperreactive behavior, including aggression, reduced behavioral control, and disinhibition. The factor SD was named so due to 10 items in its composition related to various indicators of increased or decreased sensory sensitivity and corresponding auto-stimulation actions or avoidance of specific stimuli. The seventh factor is Mot because it consists of 7 items linked with difficulties in performing finely differentiated motor movements and delayed motor development. The final factor we named Ech since it includes 9 items connected with immediate and delayed echolalia and verbal stereotypes. Also, it should be noted that since the positive poles of SU and Em factors correspond to the absence of ASD symptoms, the items included in these factors were inverted. Thus, the SU-Inverted (SU_Inv) factor represents the symptoms of impaired speech understanding, and the Em-Inverted (Em_Inv) factor - the symptoms of emotional dysregulation. It is important to point out that in the broader context of investigating methods evolution in the area of ASD symptoms and neuropsychological taxonomy, historically, two main approaches coexist - a clinical approach based on diverse empirical evidence accumulated over years of practice and a psychometric approach. The clinical approach provides us with information concerning the etiology, pathogenesis, and clinical subtypes of ASD, allowing the development of

various psychodiagnostic assessments and subsequent behavioral and neuropsychological intervention techniques. The psychometric approach focuses on elaborating screening tools and may even be seen as a superficial approach in comparison with the clinical one - after all, it is a very fast-to-use method that does not provide any information about the etiology or pathogenesis, and there is no even a hundred percent guarantee that it allows ASD capture. Meanwhile, screening makes it possible to identify children who fall into the risk group of ASD, which ultimately leads to significant savings in the resources of specialists who focus on those children who objectively need to be examined by specialists to change the trajectory of their development promptly.

Now, the first factor with the highest proportion of the explained variance in our model of autism symptoms for 5-6-year-olds was the factor Empathy (Emp). It is noteworthy that formally, this factor does not belong to the classical triad of the core autistic symptoms but applies to them indirectly. Empathy is related to communication and its absence can cause communication problems [36]. Previously, it was shown that autism and alexithymia, which is understood as a failure to identify and express one's own emotions and feelings and are related to emotion dysregulation [37], often coincide in the autistic population [38]. Furthermore, it was hypothesized that well-known autistic symptoms connected with impaired communication, such as reduced eye contact, poor emotional recognition, scarce facial expression, and body language, could be explained by co-occurring alexithymia [39-42]. However, it was also shown that highly functioning autistic adults are capable of sharing affect, identifying emotions, and showing affective empathy [43], even though there are still some restrictions and some palpable differences between the autistic population and TD group in both cognitive and affective empathy [44]. Moreover, the idea is discussed that the associations between autism and empathy are a fraught area of research that is not devoid of bias due to the lack of unity of terminology, measurement, and theory [45, 46]. At the same time, it was shown that autistic children have trouble detecting someone else's emotional cues and maintaining joint attention, which are necessary keys to social cognition [47]. Then, it is assumed that in the socialization process, autistic children gradually master empathy, and learning success is associated with many biological and social factors [48]. Comparative research studying the autistic population and their TD peers notes that children and adolescents with ASD experience diminished attention to the emotional reactions of others, a lower level of emotion contagion, and lesser emotional arousal [49, 50]. Thus, the results obtained go along with the existing research body. It could be supposed that the lack of empathy is a critical autistic symptom for 5-6-year-old children. It is noteworthy that this symptom wasn't present for 3-4-year-olds. It may illustrate age dynamics in autistic symptoms and indicate improving emotional intelligence.

The second factor in the revealed 8-factor structure was Speech Understanding (SU). It is well known that language skills vary enormously in autistic populations, and this spectrum extends from the exquisite use of speech and linguistic creativity to its complete absence [51]. At the same time, early in life, many autistic children are diagnosed with language impairments due to neurological anomalies related to speech and language development in ASD [52]. It is also expected to distinguish specific language profiles or trajectories of speech development in children with ASD [53]. A vast part of the autistic population in early childhood is prelinguistic or minimally verbal [54]. Still, even preschoolers who mastered the speech exhibit higher rates of speech violations [55], abnormal pragmatics [56], grammar [57], semantics [58], syntax [59], vocabulary

[60], and atypical prosody [61]. Delays in expressive language are also typical indicators of ASD that tend to develop over time into prevalent latencies and impairments in other cognitive and behavioral areas [62]. In addition, some children experience language regression that is often not necessarily associated with less favorable developmental outcomes than those without regression [63]. It is not surprising that SU was our second factor because it is believed that speech development and language abilities are the most important predictors of social adaptation [64] and positive educational outcomes for autistic children later on [65]. It is also assumed that focusing on supporting language needs should be included in complex programs of early intervention for children with ASD [66].

The next factor we obtained was emotions (Em), or rather, the lack of adequate emotional responses to others' emotions or emotions-evoking situations. It is well acknowledged that preschoolers with ASD often suffer from emotional dysregulation (ED) known as a lack of ability to manage emotions and expressed in various parameters, among which are irritability, emotional hyper-reactivity, moodiness, impulsivity, emotional outbursts, inability to resist stress without becoming overly upset, anxiety, aggression and self-harming behavior [67]. The prevalence of ED among the autistic population is high [68]. Some researchers link ED with communicative impairment in ASD, highlighting the leading role of the first in social-emotional impairment [69]. It is also believed that ED is a very significant factor that leads to impairment in adaptive functioning among young autistic preschoolers due to maladaptive prosocial behaviors with peers [70]. Although ED is not included in the classic triad of autistic symptoms, it may be related to them as was shown that ED is associated with all core features of the disorder, especially with repetitive behaviors and social difficulties [71]. It is also known that ED manifestation is an alarming indicator connected with severe behavioral and clinical implications [72] that can lead to psychiatric disorders, primarily anxiety, and depression [73], as well as suicidal thoughts and behaviors [71]. It is believed that the problem of ED in autistic youth needs special attention and development programs of intervention aimed at building coping and emotion regulation strategies [66], among which cognitive reappraisal, problem-solving, acceptance, and flexibility are the most adaptive [74]. Our results correspond with the previous research. A positive tendency in building emotion regulation skills over time in autistic individuals was revealed, so the most vulnerable population for ED is preschoolers. It is getting better as autistic children get older, then it is affected by puberty with weakened emotional regulation in adolescence [71, 75], and then it becomes relatively sufficient in autistic adults [76].

Our forth factor was Persistence on Sameness (PS). It is a core autistic symptom, one of the subtypes of repetitive and restrictive behaviors, that includes such diverse cognitive and behavioral models as persistence on sameness, preference of established behavioral patterns and rituals, denial of the new [22], and its appearance is not surprising. However, it is noteworthy that it takes the fourth position according to factor load in our model of autism symptoms for 5-6-year-olds. It is expected to distinguish domains of PS manifestation, namely rituals, routines, and PS in interactions with others [77]. According to the results of previous research, PS is a persistent symptom in children with ASD that remains or aggravates with age [78]. PS is also enhanced by ED and anxiety [79]; the level of anxiety can even predict PS in younger autistic children [80]. Possibly, PS patterns are implemented to reduce anxiety as avoidance or self-stimulation strategies [81]. Also, the connection between sensory disintegration in the form of sensory hypersensitivity and ritualistic behaviors is discussed. It is assumed that routines and ritualistic patterns may help to

reduce or protect from far too solid and unpleasant sensory sensations [6] and thus can be considered as specific strategies of self-regulation performed by autistic individuals with higher levels of emotional dysregulation [77].

The next factor obtained was Hyperactivity (Hyp) or Disinhibition. This symptom doesn't belong to the core autistic symptoms and is considered as one of the most common concomitant conditions in autistic children [82]. At present Hyp in autistic children is regarded as a vital diagnostic sign that requires special attention because it is connected with lower adaptive behavior [83]. It is admitted that ASD and disinhibition, independent conditions, can manifest together but shall be assessed and treated separately [84]. Disinhibition symptoms can emerge early in life and remain through school age [82]. It is believed that Hyp in autistic children can be associated with several factors, among them neurochemical imbalance [85, 86], concurrent psycho-pathological symptoms [87], parenting stress [82]. It is supposed that if symptoms of disinhibition remain high at the time when a child starts the educational route at school, his/her learning outcomes will be much less promising [5]. Despite the fact that the problem of hyperactivity in autistic children is not well developed, practitioners agree that specific interventions targeting this aggravating symptom are needed. It is recommended to use a comprehensive approach that includes pharmacological interventions [88]; behavioral therapy [89], including naturalistic setting interventions [90]; educational environment-based interventions [91]; social skills development [92]; parent interventions [93] and neurodiversity approaches [94].

The sixth factor was Sensory Disintegration (SD). It is well known that autistic children have a great diversity in sensory profiles and experience sensory processing difficulties [95]. The appearance of this factor was not surprising, considering that the core autistic symptom of persistence on sameness is closely related to SD [22]. Generally, sensory difficulties can be described as under-responsiveness or over-responsiveness in sensory features and correspond to specific behavioral patterns, such as seeking sensory impressions or avoiding some sensory stimuli [96]. There is a large heterogeneity in sensory subtypes in autistic children, suggesting a key role of SD in this population [97]. It was also shown that SD is connected with sustained attention deficits in autistic children in comparison with TD ones and children with sensory processing disorder [98]. In another research, it was found that behavioral problems such as stereotypical repetitions, disinhibition, and emotional reactivity were related to SD manifested in craving for sensory sensations in autistic 3-9-year-olds [99]. It is believed that SD symptoms are associated with significant daily functional limitations and can be considered as a diagnostic criterion for ASD [100]. Supposedly, the best way to manage SD in autistic children is to provide sensory integration therapy [101]. However, it is assumed that this intervention is likely to be effective for individualized performance goals and should be designed for each child separately, considering their sensory profiles and specific sensory difficulties [97].

The next factor obtained was motor disorders (Mot). The items included in this factor focus mostly on fine motor movements and delayed motor development. Even though this symptom doesn't belong to the classic autistic symptoms, its appearance for 5-6-year-olds is not surprising because motor development in preschoolers is a significant predictor of subsequent psychosocial maladjustments and academic underachievements [102]. It appears that approximately a third of autistic older preschoolers experience motor difficulties [103]. Moreover, the tendency was found to increase the gap in motor skills development in both gross and fine motor skills in these

children comparably to TD peers [104]. It is known that autistic children generally suffer from sensorimotor integration impairments exhibiting lower levels in most sensorimotor parameters such as reaction time, peripheral sensation, limb strength, balance [105], and gait abnormalities compared to TD peers [106]. It was also revealed that motor skills at both the level of finely differentiated movements and the level of significant locomotion are associated with IQ level regardless of autism symptoms burden [107]. It is discussed that early motor impairment may even precede the manifestation of the typical ASD core symptoms [108]. Most researchers agree that early identification of motor impairment in autistic children may be important diagnostic clues [109, 110] and allow early intervention services to optimize developmental outcomes [104].

The final factor obtained was Echolalia (Ech), which is a common phenomenon in autistic children manifested in the repetition of others' speech [111] and affecting approximately 75-80% of verbal children with ASD [112]. There are widely documented and researched subtypes of Ech, and each has its functions [113]; it is also expected to distinguish between immediate and delayed echolalia [114]. It is noteworthy that DSM-V refers to this phenomenon as an abnormal and supposedly senseless repeating of a word or a phrase heard from someone else or perceived from multimedia content and includes this condition to the group of restrictive and repetitive behaviors of ASD [22]. Thus, the appearance of this factor in our model was not surprising. However, the recent focus in the field is on the functional role of Ech in autistic children, proposing its significance as a communicative and cognitive strategy [115]. It is believed that Ech, depending on its type, can be both - an indicator of speech development [116] or a sign of regression, stereotypes, and cognitive impairment [117]. It was proposed to distinguish multidimensional communication profiles in ASD to glimpse the functional role of repetitiveness in speech [118]. Besides, it is noteworthy that Ech, in the form of sound imitation, is a homotypic stage of speech manifestation in TD children [119]. Thus, Ech may facilitate language acquisition in autistic children if it is a transitional phase but not a permanent one by providing access to a higher degree of semantic generalization [120]. However, the problem of researching echo reactions in autism exists related to the lack of appropriate tools to determine different types of echolalia and its frequency in autistic children [121].

Next, we will compare the symptoms received by 3-4- and 5-6-year-olds to check their age dynamics. Previously, we achieved a 7-factor model of autism symptoms on a sample of 3-4-year-olds, which included from 9 to 14 items in each factor (78 items in total) and the following scales (factors): 1) "Persistence on sameness" (Sam); 2) "Emotional dysregulation" (Em); 3) "Alienation" (Al); 4) "Speech understanding" (SU); 5) "Disinhibition/Hyperactivity" (Hyp); 6) "Echolalia" (Ech); 7) "Sensory disintegration" (Sen) [30]. It is peculiar that there is a coincidence in six autistic symptoms for younger and older children such Speech Understanding, Echolalia, Emotions (its dysregulation), Persistence on Sameness, Hyperactivity/Disinhibition, and Sensory Disintegration, among which 2 belong to the core autistic symptoms according to DSM-V [22]. However, for older children, two new symptoms, Empathy and Motor Skills, while such symptoms as Alienation, which was captured for 3-4-year-olds, disappeared.

Alienation may turn into a lack of empathy over age. It is believed that in the process of socialization, autistic individuals gradually improve their empathy and communication skills; however, there are a lot of social, cognitive, and biological factors that affect this process and should be taken into account when assessing those skills [48]. It is also known that even in adolescence, a lack of empathy persists, manifested in recognition of emotions, sharing of

emotional states, and perspective-taking [122]. Supposedly, only by adulthood do autistic individuals develop empathic ability, still tending to experience higher emotional than cognitive empathy [123]. However, it is noteworthy that typically developing 6-7-year-old children are believed to have significant developmental gains in cognitive empathy ability at this age [124].

The appearance of Motor Skills regarding motor development impairment in 5-6-year-olds supposedly took place due to increased claims to older children, taking into account that TD peers at this age perform a great variety of gross- and fine-motor actions demanding dexterity, reaction time, balancing, and others motor skills [125]. The results obtained corresponded with the previous study, which showed that the motor skills delay in autistic children was more noticeable in older preschoolers than younger ones [104]. The other more recent research revealed that approximately 80% of 7-10-year-olds with autism had motor problems or were prone to developing motor delays [126], which makes this indicator important to develop personified intervention programs. Interestingly the symptom of alienation, which was present in the model for younger children, disappeared in the model for older ones. That may be an indicator of communicative skills development due to timely intervention. It goes by previous results, showing that there is a generalization of social communication over time [127].

Next, we are going to discuss the 8-factor model of autistic symptoms with three secondary factors for 5-6-year-olds. According to the initial hypothesis of three groups of symptoms, 3 secondary factors were added to the 8-factor measurement model: 1) COM - communication disorders (primary factors SU_Inv, Em_Inv, Emp, Ech); 2) SD - sensory disintegration (primary factors SD, PS, Ech); 3) PI - praxis impairment (primary factors Hyp, Mot). Since the consent indices demonstrate an unsatisfactory correspondence of the model to the data, regression weights from the secondary factor PI to the primary factors Em and Emp were released for evaluation under the modification indices. The final a posteriori model is shown in Figure 3. The consent indices demonstrate a good correspondence of the model to the initial data. All regression weights, covariance, and factor variances are statistically significant ($p < 0.01$). It should be noted that the high configuration, metric, scalar, and strict invariance of the measurement model has been confirmed at all levels of restrictions for both boys and girls and 5- and 6-year-olds (see Table 3 and Table 4).

Notably, in the model obtained, PI is not only connected with motor skills impairment and hyperactivity, which is obvious but also affects emotional dysregulation (ED) and Emp. This result is new in the field to the best of our knowledge. Previously it was shown that autistic children are experiencing prominent obstacles in fundamental motor skills development, such as object manipulating, balancing and locomotor skills, in comparison with their TD peers [126], which may cause emotional outbursts due to the frustration and can endanger emotional wellbeing by causing a range of negative emotions [128]. However, the connection seems deeply rooted because it also includes empathy and, thus, is connected to social adaptability. To explain this relationship, we may refer to the idea of cerebellar functional disturbance that aims to clarify the connection between motor impairments and some neurodevelopmental disorders, proposing the cerebellum's role in non-motor functions, including cognition and emotion [129]. It was also shown that motor dysfunction and ED share the same neurotransmitter mechanism of the alteration in the concentration of the main inhibitory amino acid GABA [130]. In recent research, the relationship between the impairment of fine motor skills and social maladaptation in autistic children was emphasized [131]. Thus, it is highly likely that motor development and emotional

regulation, along with features of social functioning, are rooted at the neurological and biological levels, interconnecting the abnormal brain function patterns of autistic children, which eventually results in a great diversity of dysfunctions.

The next link in the model is the COM (communication) factor related to speech development, emotional dysregulation, empathy, and echolalia. It appeared that the more pronounced symptoms of speech disorder (SU_Inv) and emotional dysregulation (Em_Inv) are the less expressed empathy (Emp) and symptoms of echolalia (Ech), and vice versa. Apparently, in order for the symptoms of Emp and Ech to manifest, a child must have sufficiently good speech development and less pronounced symptoms of emotional dysfunction. This result corresponds with the previous research. It was shown that minimally verbal autistic children experience more difficulties in emotional regulation compared to their verbal peers with ASD [132]. On the contrary, older preschoolers with lesser severity levels of ASD symptoms had more adaptive functioning with the tendency to improve in communication as they get older [133]. Also, some types of echolalia can be indicators of speech development [115, 120]. Concerning Emp, its development requires a sufficient level of cognitive development, speech understanding [49], and emotional regulation [48].

The indicators of the secondary SD factor are the primary SD, Ech, and PS factors, which designates a fairly close relationship between these groups of symptoms. We won't discuss this result in detail because it is in accordance with well-known classic autistic symptoms [22]. The connections between restrictive and repetitive behavioral patterns and sensory issues in ASD were widely researched and documented [77, 134]; whilst echolalia can also be considered as a type of repetitive verbal behavior [120] and in some of its forms may be an indicator of auto-stimulation connected with SD [135].

Thus, in the obtained model of autistic symptoms for 5-6-year-olds multiple interconnections of factors were revealed, such as the relationship between praxis impairment, hyperactivity, and emotional dysregulation, as well as the link between speech development, emotional dysregulation, empathy, and echolalia and connectivity between sensory disintegration, echolalia and persistence on sameness. It is noteworthy that those connections may show age-relevant key types of ASD manifestations for older preschoolers. However, it is possible that some of the revealed interconnections are not purely autistic features but rather have a more general basis common for different neurodevelopmental disorders. Apparently, such features may be clinically significant symptom complexes for specialists working with varying variants of dysontogenesis, allowing them to pay attention to possible concomitant clinical manifestations, provided that one of these features is detected.

When comparing ASD, TD, and DD samples according to the factors obtained, almost all differences were statistically significant ($p < 0.001$), except for differences in the ASD - DD pair by Emp, Hyp, and Mot factors. Figure 4 shows the mean values of the factors (the proportion of positive responses) for the 3 groups of children being compared (see Figure 4). Table 6 shows the results of ANOVA using the Welch criterion (free from the assumption of equality of variances). The groups differ statistically significantly ($p < 0.001$). The biggest contribution to the distinction of the 3 groups is made by Em_Inv (the largest effect value), then SD and SU_Inv (large effect value), then Emp, Ech, and PS (medium effect value), and Mot (small effect value). The expected accuracy of predicting belonging to one of the two groups (ASD - Not ASD) using 8 identified factors is 88.5% (sensitivity-89.3%, specificity-86.2%). It is noteworthy that the factor of emotional dysregulation

(ED) makes the biggest contribution to distinguishing between autistic and non-autistic 5-6-year-olds. Apparently, this symptom is the key one for this age group, along with SD and delay of speech development.

At the end of the discussion, we will compare the models received for 3-4- and 5-6-year-olds. Previously, on a sample of 3-4-year-olds, a 7-factor model of autistic symptoms was revealed, which included 9 to 14 items in each factor (78 items in total) and formed three groups of symptoms - communication disorders, sensory disintegration, and hyperactivity [30]. It is interesting that with age two of the symptom groups remained and they are the core autistic symptoms such as restrictions in communication and sensory disintegration. However, for younger children, there was a group of hyperactivity as an isolated factor that is not connected with other symptoms, while for older children, the new group of symptoms appeared named praxis impairment and connected with motor skills delay, hyperactivity, emotional dysregulation, and empathy. It seems that with age in autistic preschoolers, motor impairment starts playing a more prominent role in affecting levels of social functioning and emotional well-being. We believe that the model of autistic symptoms changes over the course of childhood and adolescence. However, the core autistic symptoms remain pronounced. Presumably, depending on the severity of autistic symptoms and the sufficiency of cognitive potential, indicators of emotional regulation, speech, and motor development improve over time, while parameters of communication disruption, restricted behavior, and narrow interests persist. Of course, further research focusing on different age periods is needed to confirm the assumptions' validity. In our opinion, studies of autistic symptoms in 2-3-year-old children are of particular interest.

## 5. Conclusions

An 8-factor model of autism symptoms for older preschool children was elaborated and empirically analyzed. The model has high sensitivity, specificity, and accuracy in predicting the diagnosis of autism for 5-6-year-olds, both boys and girls. 8 factors are indicators of 3 secondary factors, forming 3 relatively independent groups of symptoms: 1) COM - communication disorders (primary factors SU_Inv, Em_Inv, Emp, Ech); 2) SD - sensory disintegration (primary factors SD, PS, Ech); 3) PI - praxis impairment (primary factors Hyp, Mot) of which 2 groups belong to the core autistic symptoms. These groups are similar to the previously identified symptoms for 3-4-year-old children. The fundamental difference between these two age groups is related to the child's socialization and speech development. The consequence is a closer relationship between the selected groups of symptoms in 5-6-year-old children. In particular, praxis impairment begins to increase the symptoms of communication disorders (emotional disintegration and a lack of empathy), and there is a significant connection between praxis impairment and sensory disintegration. Peculiarly, the two groups of symptoms correspond to the core autistic ones according to DSM-V [22]. The third group, named PI, is not specific for ASD but reveals the connection between motor skills impairment and emotional dysregulation and empathy. We suppose that this result can emphasize that motor development and emotional regulation, along with the features of social functioning, are related at the neurological and biological levels, interconnecting the atypical brain function patterns of autistic children, which consequently results in a big diversity of dysfunctions. The factors that were obtained can be considered as the

key autistic symptoms for this age group and may contribute to our theoretical understanding of age-related dynamics in autistic symptoms in preschoolers.

## 6. Practical Implications

The age-related dynamics of autism symptoms in preschoolers allow the identification of the key autistic symptoms for each age range and can serve as a guide in elaborating specific personal strategies and interventions for children with autism. The identified factors form a fairly reliable scale of the future online screening methodology, enabling specialists to obtain a more accurate and "volumetric" assessment of the ASD risk in children of the appropriate age. During repeated examination, the dynamics of changes in screening results can also be used to assess the effectiveness of corrective measures.

## 7. Limitations

The advantage of this study is that the obtained 8-factor structure of autistic symptoms in 5-6-year-olds is founded on a wide range of primary hypothetical symptoms of autism (N = 330), i.e., on a relatively weighty amount of them. However, it can be supposed that the number of relatively independent factors of autism symptoms could be more prominent. Originally, we established the requirement for at least 7 symptoms per factor; in this regard, some probable factors may not be included in the model because of insufficient symptoms per factor.

## Author Contributions

Conceptualization, A.N.; methodology, A.N.; software, S.M.; validation, A.N. and S.M.; formal analysis, A.N.; investigation, S.M.; resources, S.M.; data curation, A.N. and S.M.; writing-original draft preparation, L.T. and A.N.; writing-review and editing, L.T. and A.N.; visualization, A.N.; supervision, A.N.; project administration, A.N.; funding acquisition, A.N. All authors have read and agreed to the published version of the manuscript.

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## Competing Interests

The authors have declared that no competing interests exist.

## Data Availability Statement

The current version of the methodology is available at: http://ras.testpsy.net/demo567. The data used for statistical analysis are presented at https://info23rnf.testpsy.net/5-6_Y_data.csv.

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