

# **THE DEVELOPMENT OF THE COMPETENCE OF COUNTING IN A CHILD BETWEEN THREE AND SIX YEARS WITH A SPECIFIC LANGUAGE IMPAIRMENT**

Birgit Brandt

MLU Halle

*This article concentrates on mathematical processes of negotiation with pre school children and adults in various social contexts. The main focus is on Britta-Marie, a girl diagnosed in kindergarten with specific language impairment (SLI). Situations of interaction in which Britta-Marie encounters mathematical activities in her familial context were compared with situations in which she works on mathematical queries with peers from her kindergarten and an assisting adult. The theme of inclusion becomes relevant in that the kindergarten that Britta-Marie visits is a communal institution without an emphasis on speech therapy.*

The case of Britta-Marie that is described is part of the research project „early Steps in Mathematics Learning“ (erStMaL) (cf. Krummheuer 2013a,b; Brandt 2014, Vogel 2014).<sup>1</sup> The overarching goal of research in erStMaL is to develop elements of a theory of mathematical thinking in the ages from three to nine. Certain chosen children are observed in their familial contexts of social interaction in kindergarten and partially also in their families as they deal with play and discovery situations. In the beginning sample of 144 children there were children with special language impairment (SLI). Britta-Marie belongs to this partial sample and attends a communal daycare center without special forms of support.

The theory that is to be developed concerning the evolution of mathematical thought comprises all essential mathematical domains that are relevant in pre and primary school. The play and discovery situations that are developed for the research project are part of one domain but also allow for activities in other areas (cf. Vogel 2014). In the case to be illustrated situations will be described from different areas concerning only the aspect of the developing competence of counting of Britta-Marie because in all episodes that are analyzed, the reconstructed negotiation of themes concerning counting is reduced to aspects of the development of the competence of counting by Britta-Marie.

In the following the stand of theories on the development of counting (1.) and of SLI (2.) are described. The interactionist perspective on learning processes is then

---

<sup>1</sup> This project is part of the research center IDeA (Individual Development and Adaptive Education) in Frankfurt am Main ([www.idea-frankfurt.eu](http://www.idea-frankfurt.eu)). The IDeA-center was founded in a cooperation of the German Institute for International Research in Pedagogy (DIPF), the Sigmund-Freud-Institute (Research Institute for Psychoanalysis and its Application, SFI) and the Goethe-Universität Frankfurt .

introduced (3.) upon which the development of the competence of counting by Britta-Marie is reported (4.). The article ends with a conclusion (5.).

## 1 DEVELOPMENT OF THE COMPETENCE OF COUNTING

Counting is seen as a fundamental competence in the area of numbers and operations. As a process, counting connects the cardinal number- and the ordinal number aspect with each other: While counting, the objects of a set are brought with the help of counting into order (ordinal aspect) and the last named number corresponds to the amount of counted objects (cardinal aspect). Fundamentally, it is the knowledge that through the counting quantities can be determined (Fuson 1988, pg, 89ff.). According to Gelman and Gallistel (1978, pg. 52) there are five principles that must be taken into consideration in order to correctly determine the number of objects with the help of the sequence of numerals:

- |                           |                                |                       |
|---------------------------|--------------------------------|-----------------------|
| 1. One-to-one principle   | 2. Abstraction principle       | 3. Cardinal principle |
| 4. Stable-order principle | 5. Order-irrelevance principle |                       |

The learning of the numeral sequence is integrated in the general process of language acquisition. From a linguistic perspective, numerals can be differentiated in (a) cardinal numbers (*eins, zwei drei*: one, two, three), (b) ordinal numbers (*erste, zweite, dritte*: first, second, third...) and (c) words for multiplication (*einmal, zweimal, dreimal*: once/one time, twice/two times, thrice/three time). First, however, children must learn to differentiate numerals from other words, especially from other adjectives (green houses versus three houses; the green house versus the third house), something that children are capable of at approximately the age of about 2½ years at the level of understanding language (cf. Wynn 1992).

For the production of German numerals the following lexical and grammatical language competences must be learned (cf. Moser Opitz 2007, S. 84):

- As independent word the beginning of the numerals 1 to 12, the numeral 20 as well as further decimal numbers (hundred, thousand, million)
- Derived numerals:
  - 13, 14, ...19 und 30, 40, ...90 with ending syllables (*zehn*: teen; *zig*: ty) and as well as the number words for the intermediate steps 10.000, 100.000.000 (ten thousand, hundred thousand, hundred million; multiplicative)
  - Composition for numbers with two or more digits, which is a combination of addition and multiplication. For German numerals, these rules include the inversion of the last two digits (321: *Dreihundert-ein-und-zwanzig* threehundred-one-and-twenty)

At the beginning of school about 96% of the children have learned the sequence of numerals up to 10, about 5% count above 100; around the number 20 is a cut off.

For the development of the productive, active use of numerals, five steps in the developmental process are differentiated in connection with the further development of the concept of number as well as the development of concept of operations by Fuson (1988):

. Level 1: String	. Level 4: Numberable chain
. Level 2: Unbreakable chain	. Level 5: Bidirectional chain
. Level 3: Breakable chain	

Most often children reach at the ages of 3 years level 2 and at school begins level 3 or 4 in different limited number intervals.

## 2 IMPAIRED LANGUAGE DEVELOPMENT

In Germany, approximately 6-8% of children who are otherwise normally developed have massive problems in learning their mother tongue, without having signs of sensory or neurological damage or massive cognitive, social or emotional impairment. The language acquisition is receptively as well as productively delayed and it can come to an end of language development at a very low level. This impairment of language acquisition is summarized in F.80 ICD-10<sup>2</sup> as “special language impairment” (SLI) and, among others, as a “developmental dysphasia” (Grimm 2003, pg. 124). Thus SLI affect in comparison to other impairments a relatively high percentage of children at least temporarily. This is meaningful since children with SLI are, in comparison with children without SLI, more often affected by social-emotional problems and in fact already in kindergarten age.

Children with SLI are late in learning words, i.e. their vocabulary does not correspond to the average results of normal speech development (i.e. lowest range of 50 words with 24 months) whereby 50% of these children catch up on this developmental deficit as “late learners”, the “word explosion” is thus delayed, the further language development is however, inconspicuous (ibid. p. 129). Children with SLI are characterized also in their further speech development by less vocabulary (productive). More striking however is the development of grammar that is not only delayed but also demonstrates qualitative discrepancies. This is seen on the level of syntax of speech production, for example, through explicitly shorter sentences and anomalies that do not appear in normal developmental processes of children with German as a mother tongue (e.g. ibid., pg. 136: missing the final position of the verb<sup>3</sup>: *den du anziehst* instead of *den sollst du anziehen*; You should dress this on). With increasing development of speech other morphological deficits become more apparent, as the wrong usage of articles (*der Frau*; he, the

---

<sup>2</sup> ICD-10 is the current version of the internationally recognized diagnosis classification of disturbances and related health problems <http://www.dimdi.de/static/de/klassi/icd-10-gm/kodesuche/onlinefassungen/htmlgm208/index.htm>.

<sup>3</sup> This is a typical mistake of foreigners learning German, but not a typical mistake in the language acquisition process of German children.

woman), of missing fit of subject and object (the children runs). In their longitudinal study Grimm could show that SLI children at the age of eight years especially have problems with complex sentence structures and with morphologic markers (ibid. p. 139).

As a spectrum of causes, Grimm identifies four areas that are seen as not independent of each other and a web of relationships that together build an effective explanation (ibid. p. 154):

- Auditory short-term- and working memory: Children with SLI have a significantly shorter memory span for sequences of words.
- Speed of processes of speech processing: The processing of children with SLI of a fast sequence of auditory stimuli is significantly inferior to that of children with normal speech.
- Strategies of speech processing: While children with normal speech development use a more unified processing strategy and, for example, imitate patterns of sentences, the majority of children with SLI use singular strategies in speech processing and take up only single words or simple word connections.
- Use of prosodic information in speech offerings: The processing of rhythmic-prosodic language structures is significantly inferior in children with SLI than in children with normal speech and thus, they cannot use the rhythmic structure, for example, in the support of the auditory memory.

Regarding the question if the speech of the surroundings plays a role in causation, extensive research on the mother-child interaction has been conducted. Marked differences in the speech of mothers with children with SLI in comparison to the speech patterns of mothers of same aged children without SLI were found, as well in the complexity of the speech production as in the use of strategies of teaching language (e.g. imitating and expanding of sounds of the children). They ask fewer questions that demand complex answers, but above all “quiz-questions” that demand simple names of concretely visible objects. Speech patterns of mothers of children with SLI are comparable to mothers of younger children who are at a similar level of speech development. Thus, mothers show an adaptive speech behavior that is oriented to the linguistic abilities of the children, thereby not collaborating the hypothesis of a primary cause of SLI. However, Grimm shows that speech patterns of mothers of children with speech disorders change over time and that their strategies of teaching language are reduced, thereby eliminating just those aspects of speech that could help children to learn grammar rules (ibid. p. 144). Further, through the increase of naming routines, the aspects of dialogue and the cognitive quality of the mother-child interaction are limited. The adaptive speech behavior orients itself to the speech production of the children and not to the more appropriate cognitive developmental stand.

## 2.1 Speech Disorders and the Development of counting Competence

Speech disorders are not necessarily a hindrance for the learning of mathematics, however, a relatedness between speech disorders and the development of dyscalculia and limited counting competence is discussed in various research settings. Fundamentally more mistakes in verbal counting and the learning of counting words or the sequence of numerals have been documented in different studies of children with speech disorders. (cf. Moser Opitz, 2003, p. 87).

The significantly shorter memory span for word sequences in dysphasic children can also be set in relationship to the reproduction of number sequences (Grimm 2003, p. 127 und p. 155). Children with speech disorders can reproduce number sequences forwards better than one syllable, semantical meaningless, words; however they were significantly worse than children with normal speech. If the sequence of numbers should be reversed, the deficits become more distinct. Deficits in the auditory memory can become significant in connection with the development of counting competence especially with bigger numbers since here the complete storage of all syllables in the correct position is decisive for the correct decoding of the number (e.g. three thousand two hundred vs. two thousand three hundred; cf. Nolte 2009, p. 218).<sup>4</sup> Deficits in the processing of auditory stimuli can lead to confusion between similar sounding syllables which again can lead to inexactness in the understanding of the number, (Nolte, 2003, p. 56), as in the mistaking of similar sounding, semantically important syllables „-zehn“ (ten – teen) und „-zig“ (ty).

The deficits in the use of prosodic information of language can let problems in different steps of use of the numeral sequence be expected after Fuson. Counting as „string“ (level 1) are comparable with “nonsense words” as a row of syllables. Children without SLI use prosodic information for the reproduction of “nonsense words”. The rhythmic-prosodic structuring of numeral sequences can however often not be used by children with SLI in order to reproduce these as a „string“. In German this is especially difficult for children with SLI through the repetition of the vowel sound [ei] in the beginning counting series (*eins-zwei-drei*) since the semantically meaningful consonants have a less distinct auditory stimulus. Further, the prosodic information cannot be used to structure the „string“ into single words that is decisive for the transition to level two (unbreakable chain). Thus, the use of number words as single words for the one-to-one- classification and thereby for the counting procedure can be delayed. The deficits in the receptive as well as in the productive speech prosody make the flexible use of the numeral sequence through the rhythmically structured process of counting more difficult for the use of the numeral sequence of the first adding strategies (level 4 und 5; e.g. one-two-**three**-four-five-**six**).

---

<sup>4</sup> A relationship between the limited phonological capacity for storage and difficulties in learning the competence of counting are described by Fazio (1999).

For the learning of the numeral sequence, the deficits on the morphologic level could be relevant. As mentioned above, after the number 12 in German certain rules of word construction are semantically meaningful, and that must be recognized and transposed. This can be more difficult, when semantically important syllables have acoustic similarities, which can lead to mistakes even when normally learning the numeral sequence (*neunzehn* nineteen versus *neunzig* ninety; cf. Nolte, 2009, p. 223).

### **3 AN INTERACTIONISTIC PERSPECTIVE ON LEARNING PROCESSES IN SOCIAL CONTEXT**

Beyond the above mentioned aspects, for the most part psychologically oriented approaches, we adhere in our own work to a sociological, social-constructivistic perspective. Fundamental works concerning this position lie in the approach of Krummheuer and Brandt (2001) of an interactional theory of mathematical learning. It is based on three basic assumptions:

1. The learning content as well as the conditions of learning emerge locally in an interactive exchange between the persons involved.
2. The constitutive social condition of the possibilities of mathematical learning is the participation in a collective argumentation.
3. An expression of a successful learning process of the child is the increasingly autonomous participation in the development of the interaction or in the following interaction that fits thematically to the current situation.

Under this perspective learning is not only conceived as an inner cognitive process of restructuring, but as a process that takes place dually within the individual in the sense of a cognitive restructuring as well as in the interactive processes in which the person participates, in which he is anchored (c.f. „dual inheritance“ as discussed by Tomasello, 2003; p. 283).

Learning can be understood on the interactive level as “advancement” in participation. Sfard (2008) suggests that the perception of learning as „learning-as-acquisition“ should be replaced with „learning-as-participation“ (S. 92). Lave und Wenger (1991) suggest that the beginning of such a learning process could be understood as a “legitimate peripheral participation” (ibid, S. 35;) (see Krummheuer 2011a). This concept leads to the following two questions:

1. At the level of interaction: In which way does the interaction system make an increasingly autonomous participation of all the participants possible that in the beginning were more in the status of the legitimate peripheral participation?
2. At the individual level: In which way does the individual take his/her chance that is offered by the interaction system to change his participating status?

Both questions are closely related.

Brandt (2004) introduces the term “Partizipationsspielraum” (scope of participation<sup>5</sup>, PSR) (p. 58): It describes under which emerging conditions in the interaction a person can model his participation in the sense of “the sum and swarm of participation” (Bruner 1990, p. 107). Such conditions can be so far reduced that, for example, a student is given no other offer of participation than that of imitating. The PSRs are interactively negotiated in the particular situations and used by the participating children in child- and situation- specific ways. In the study erStMaL, the institutional framework is hereby taken into consideration that makes it understandable why and how the specific PSR are eventually repeated, modified or only used once. Krummheuer (2014) describes these processes of transformation and stabilisation as evolutionary spiral, which embrace two kinds of adaption:

1. The child uses the PSR that is offered to him in its individual way<sup>6</sup> and the development of his thinking becomes understandable as an individual process of adaption of participation possibilities.
2. Through the processes of adaption the structures of the PSR are modified not only directly to the situation but in certain cases also beyond it. At the broader situational level modification of the general frame of the situation can occur.

In the following, several scenes involving a girl with SLI will be analysed. Thereby, her counting competence in different social contexts will be the focus with respect to these two aspects of adaption.

#### **4 THE CASE OF BRITTA-MARIE**

In order to exclude massive cognitive limitations in the diagnosis of speech development disorders, the general cognitive abilities of the children with speech disturbances in the project erStMaL are tested with the HAWIWA<sup>7</sup> III (Performance scale; Ricken et al. 2007). The language abilities are diagnosed with the SETK (*Sprachentwicklungstest für 3- bis 5jährige Kinder*; standardized language test for 3- to 5 year old children; Grimm 2001). Britta-Marie attains in the HAWIWA III a score of 87% and thus a result in the area of the lower average (85–100 %). The average results in SETK 3–5 are 50 TW; scores between 40 TW und 50 TW would thus correspond to the IQ scores 85–100 %. The results of Britta-Marie in SETK are clearly abilities that are under average in all areas (23 TW to 33 TW); the lowest score was in the area of morphologic construction of rules. Particularly conspicuous in our data are the difficulties in the articulation (not age specific substituted sounds

---

<sup>5</sup> Krummheuer (2014) translated the German Term “Partizipationsspielraum” as “leeway of participation”. I will not follow this translation in this article.

<sup>6</sup> Referring to individual types of using the emerging PSR, Brandt (2004) speaks of a „participation profile“ of the child (p. 147 ff; cf. Brandt 2007). In her terminology one could say that the child can more clearly structure its swarm and can present a stable „unity of participation“ (Goffman 1974) beyond a situation.

<sup>7</sup> HAWIWA is the German variation of the WPPSI (Wechsler Preschool and Primary Scale of Intelligence).

in the area of consonants). Britta-Marie has been regularly observed in the studies erStMal and erStMal-FaSt (Acar Bayraktar 2014) since 2009 (age 3.6) in partner and group situations as well as in family situations dealing with the mathematical areas of number and operation, structures and patterns as well as geometry and measurement (family). This article focusses on the counting processes of Britta-Marie in different situations in the age between 4.6 - 5.10:

Age	Situation (mathematical area)	Other participants <sup>8</sup>
4.6	Construction (geometry)	Father, Mother, Brother Tom (L1, SLI, 6.1)
4.6	Wooden animals I (numbers)	Olivia (L1), Orli (L2, SSES), Samuel (L2) (all children 4.6) Assisting adult (female)
5.2	Cards with pattern (geometrical pattern)	Olivia (L1, 5.2); assisting adult (m)
5.10	Wooden animals II (numbers)	Olivia (L1), Orli (L2, SLI), Samuel (L2) (all 5.7); assisting adult (female)

The situations 1 and 2 will be analyzed in more detail, in order to find out specific aspects of the social contexts. The further situations will then be additionally shortly described and taken into the comparison of the analysis.

### Constructing

As first scene a play situation in the setting of Britta-Maria's family is analyzed. This game has to do with two dimensionally illustrated pictures of buildings that are to be constructed with wooden rectangular building blocks of equal sizes. According to the rules, the family members draw a card one after the other and the next member of the family must reconstruct it. In the following scene Britta-Marie draws the card on

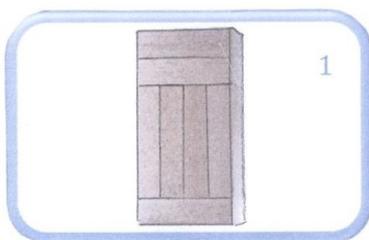


Fig 1. It is the second card of Britta-Marie, but the first time, counting comes directly into the interaction in connection with the construction of the building.

**Fig. 1: The given card**

The father sits directly left of Britta Marie. He asks her to count first the number of the needed stones. Britta-Marie apparently follows this request. She counts with short pauses and touches the card of the illustrated building with her index fingers:

eins, ei, neun, pier, tex, diebn, akt	eins, (zwei?), neun, vier, sieben, acht	one, (two?), nine, four, seven, eight
---------------------------------------	--	--

<sup>8</sup>L1: German as mother tongue (before the 2 year); L2: German as a second language; SLI: Special language impairment.

In commenting on this opening sequence one can first maintain that Britta-Marie names seven words in her attempt to count. One could couple her attempt to count with the usual numeral sequences as follows:

Eins (1)	Zwei (2)	Drei (3)	Vier (4)	Fünf (5)	Sechs (6)	Sieben (7)
Eins	Ei	Neun	Pier	Tex	Diebn	Akt

While watching the video recording of her action, one has the impression that she does not deliberately touch the rectangles one for one rhythmically fitting to the word sequence but rather more or less haphazardly lets her fingers pass over the picture. akt, which is similar sounding to the numeral word “Acht”, can be understood as the result of her attempt in the sense of the cardinal principle. The father takes up the card and reacts not only seven (...) one two three four five six seven and tips with each numeral with his index finger on the card apparently touching a rectangle each time.

With his negation the father might have taken the last word of Britta-Marie as her attempt to express the numeral 8 and thus assume that his daughter had incorrectly counted eight rectangles on the card according to the cardinal principle. Possibly he may also have understood the remarks of his daughter while touching the card with her index finger that she was merely carrying out with this movement just a similar movement and not counting “right” according to the one-to-one principle. His relative demonstrative counting procedure seems to be an “educational” measure to show his daughter a correct procedure of counting with respect to a clear classification of the numerals to the rectangles as well in a canonical sense with correct pronunciation of the first numerals. Britta-Marie dwells during this passage in the status of a spectator and listener.

Additionally the interpreters ask themselves what had occurred to the father that he asked his daughter to count first. It was not explicitly expressed in the problem, and before this move of Britta-Marie, five pictures were reconstructed by family members without “counting first” (including one correct construction of Britta-Marie). Britta-Marie could have solved the problem without any competence of counting (and speech competence) in that she pulls the rectangles one by one out of the box and successively constructs the picture. We could explicate two mutually supporting hypothesis as reasons for the actions of the father:

1. The father knows (of course) that Britta-Marie’s pronunciation diverges from the norm and additionally that she does not have full command of the demands of the counting process in the naming of numbers. This problem that could be considered as a part of spatial geometry is “changed” into a learning sequence about the pronunciation of the “right” numerals and as a demonstration of the “correct” procedure of counting.
2. An element of spatial geometry interests the father: It can be helpful for the judgment concerning the figure at the end of the series of problems to check the number of the wooden rectangles. The problem has to do with the construction of a compact “large” rectangle whereby it is relatively difficult to decide by

looking at the figure if six or nine wooden rectangles in the “large” rectangle correspond to the illustration on the card. If the necessary number of wooden rectangles is placed separately on the table, it is easily checked if the big cube is constructed out of seven blocks.

In the scene Britta-Marie now takes a wooden building block out of the box and places it upright in front of herself on the table and is about to take a second wooden building block. Just at this moment the mother asks her but first take out the building blocks you needed/ and directly afterward the father tells her now count\ . He means probably that she should count as she takes out the wooden building block how many blocks she collects in front of her on the table. Britta-Marie takes in the following however without speaking five more building blocks out of the container and places them on the first block that had fallen over in the meantime. The mother supports one more; Britta-Marie however takes two blocks out of the box and increases her collection of



blocks as shown in the illustration (Fig. 2). Britta-Marie seems to want to take more blocks out of the container. The mother warns that she already has enough blocks. Britta-Marie picks up the current card as if she wants to make it easier for her mother to recognize the number of blocks on the card. The mother continues take one away\ and the father points at the pile of blocks in front of his daughter.

**Fig. 2: Britta-Marie’s collection of building blocks.**

Britta-Marie picks up the top block and the mother repeats take one away. Britta-Marie puts this block back in the container and the father comments exactly\ . Britta-Marie then again puts another wooden building block back into the container. The mother reacts with take o-n-e away\ . The daughter first points at her block collection, touches at the same time a wooden block in the container and looks all the time at her mother. The mother laughs – while watching this scene on the video, the interviewers find her laughter as loving and understanding. Britta-Maria puts her hands over her face, lowers her head ashamed and looks at the card. The mother smiles and encouragingly asks her to again take a block from the container. This, however, is done by the father, who places it on top of the collection of blocks and says: you have them all (you can) build\ .

From the perspective of the interpreters it is unclear in view of the mathematical aspects of this passage, how much Britta-Marie understands the connection between the last sequence of the counting of the rectangles on the card and that she now needs seven wooden building blocks to reconstruct the building. If one interprets Britta-Marie’s “counting activities” on the card in the sense that she had not completely understood the one-to-one principle of counting and additionally cannot probably reproduce a numeral sequence in a stable form – with whatever words she can – then one can assume that she cannot understand the attempt of the father to support her by counting the rectangles on the card. It may have been helpful for her, at the passive level of comprehending to understand a correct counting procedure. His assumed

attempt of support seems however to have little constructive effect on the spatial geometric understanding of the problem.

Also the intervention of the mother, that consistently follows the assumed intentions of her husband, cannot from the here developed view of the interaction help Britta-Marie any further: From the interpreters perspective the problem becomes only more complex and more complicated for the girl through the demands of counting activities. She should solve a construction task of spatial geometry on the basis of an apparently insufficiently developed concept of numbers and counting. In the dialogue with the mother a “funnel pattern” (Bauersfeld 1988) emerges in which the daughter attempts to react locally to the challenges of the mother (take a block from the container) in which too, typically for these specific patterns of interactions, the reasons are not spoken about. The rationality of all of the plans initiated by the father and mother remains in the dark (cf. Schütte 2009: comments on „Impliziten Pädagogik“ implicit pedagogy).

The scene continues with Britta-Marie constructing from the seven blocks on the table a figure with no further interventions of the parents that up to the missing bottom block corresponds to the illustration on the card (Fig. 3). She apparently sees it as a solution. Also the unused seventh stone that lies on the table next to the building does not make her reevaluate her construction. Her father tells her that is unfortunately wrong. The girl buries her head in her hands, evidently disappointed. Both parents suggest that she should look at the picture again. The father takes the



initiative, lifts the finished figure and puts the missing block horizontally under it. He does this while directly speaking to Britta-Marie: Look again carefully look at this at this picture carefully ... the first one must lie like this look.

**Fig. 3: Britta-Marie’s reconstruction of the building**

From the interpreters’ view the construction of the building seems to happen in an effortless and geometrically competent way. She places without difficulty the four needed perpendicular, standing blocks uninterruptedly, in place with short glances to the card. After looking at the card more carefully, and then she places two blocks horizontally on top. The assessment of the father is practically correct but is in its radical diction definitely demotivating and probably frustrating. One could have called the figure as “almost completely correct”. The father’s pushing of the last block by himself is in our interpretation done in a loving way. Although he demands a careful look to the picture, he does not comment again on the beginning process of counting and did not link the remaining block with the incomplete reconstruction. Thus, his request is imprecise and could refer to the number of blocks as well as to their geometrical positioning.

In this situation Britta-Marie carried out one counting process. Her accompanying gesture is in the rhythm of her numeral word production, but not directed to the objects, which she has to count. Thus, the fit between the numeral words and the

amount of objects seems to be rather by chance than by a correct application of the one-to-one principle. This was the only counting attempt in this situation, which is carried out with responsibility by Britta-Marie. Further counting processes were done by her parents with more or less ostentation. For the counting of the rectangles of the picture, she is a listener of a demonstration of the procedure, which seems to be conducted to “teach” her. In the process of counting the needed blocks, she is involved as a henchman, who relies on the authority without insight in the process and goal. This is done in a loving way by her parents, thus it is a comfortable way of participation for Britta-Marie, which unburdened her from difficulties in counting aloud.

#### 4.1 Wooden animals I



**Fig. 4: the beginning of the play situation  
*Wooden Animals I***

The play and exploration situation *Wooden Animals I* is a unsorted collection of various wooden animals in different colors and proportions that the children are given (Fig. 4). In a first phase of the free exploration Britta-Marie imitates the sounds of the animals and begins by gathering the pink pigs. After about eight minutes all of the children have their own collection of sorted figures in front of them (Fig. 5).

– Olivia (not visible in Fig. 5) has put her figures in a row.



**Fig. 5: sorted wooden animals**

With the question of which animals are there the most\ the assisting adult initiates a first comparison of amount. In the following discussion section as a comparison that shows no observable counting behavior but un-sharp conception of numbers (approximation attempt) or subjective wishes, Britta-Marie is not actively productive but in a role of legitimate peripheral participation (see above Lave & Wenger 1991). In the course of the following interaction Olivia set up “her” animals. This makes it possible by means of the comparison of the set amounts using a measurement technique of spatial geometry (length). The assisting adult places blue figures next to each other and comments her act with a challenge now we want to see of which animals are there the most.

Thus, the assisting teacher again forces the situation into a situation of *comparing amounts*. But now, it is Samuel who introduces the numeral series into the interaction with the words | will count mine\. Actually in the following, different processes of counting can be observed parts of which happens simultaneously but here can only be looked at singly for an easier understanding.

a) Samuel touches single (lying) dogs (Fig. 5) and says the numeral sequence fluidly and without mistakes up to 12, jumps then auf 21, 22, 23, 25. He gradually

speaks very softly and at the end cannot be understood. While reciting, he does not adhere to the one-to-one principle. Finally he asserts twelve I have as the last named numeral in correct sequence as the number of “his” animals. Thus he does not adhere to the principle of cardinal numbers but thus refers to a part of his counting process that he can recite very well – and does not rely on the counting process that follows

b) Britta-Marie observes Samuel’s process of counting and participates for the first time actively at the comparison of sets:

etz kähl ich meine\ du kost meine tähln\.	Jetzt zähl ich meine, du kannst meine zählen	Now I count mine, you can count mine
---	--	--------------------------------------

It is possible that Britta-Marie recognizes the meaning of counting as a means of measurement set amounts, but in view of her “many” animals, she gives the responsibility for the procedure to a person who from her perspective is competent enough. This person feels that she has been addressed but reacts though without a content-related comment I get your animals/. With a questioning tone of voice she hints that she may have misunderstood something, however Britta does not correct her. Furthermore she closes with an uncertain amount of her partial collection.

ich habft viel	Ich habe viel	I have lots
----------------	---------------	-------------

Somewhat later Britta-Marie and Samuel have put “their” animals into rows (Fig. 6) like Olivia and the adult asks for a further another play suggestion. This time Olivia suggests to count. That idea is confirmed by Orli and the adult as a possible activity. In the following process of interaction, in unison counting processes as well as counting processes that follow one after the other are observed, whereby the children count “their” partial collection. With reference to the active-productive participation of Britta-Marie, the connection of her counting processes with those of Samuel and Olivia is interesting.

c) Samuel begins touching blue and green figures of dogs from left to right and says rhythmically the fitting numerals (Fig. 6). Britta-Marie finally begins to recite the numeral sequence starting with four – thereby synchronizing her verbal counting process with that of Samuel (counting chorally).

Via tünf sechs wieben akt neun zehn els efzig	Vier fünf sechs sieben acht neun zehn elf (not relatable to a numeral)	Four five six seven eight nine ten eleven
---	--	---



**Fig. 6: Counting the wooden figures that are set up in rows**

The coordination of the two counting processes is comparable to the in unison reciting of numeral sequences in a classroom. Thereby Britta-Marie’s numbers from 4 to 11 are understandable as such even when they are partially not correctly

pronounced. Thus, she is able – at least with choric support – to say the sequence even if from another number than one (level 3: breakable chain). Her last uttered word *efzig* is not directly related to a numeral, but her own word creation, which she uses as numeral. Using the ending *-zig*, she applies the rule of building the numerals 20 (*zwanzig*) to 90 (*neunzig*), however leaving out the numbers of 13 to 19. It can be assumed that the two ending syllables *-zig (ty)* and *-zehn (teen)* are not sufficiently differentiated in her perception because of the similarity of their sound (cf. chapter 2.1.) Her pointing gesture from left to right in connection with the numeral sequence is recited rhythmically. She begins with her first animal figure of her row although she starts with the numeral four. Otherwise she gestures with her hand in an arch form above the animal figures (Fig. 6) that does not directly touch the single figures, but rather points to short sections of the row giving them a numeral, comparable to the process of measuring a line with a certain unit of length. With the last numeral used by her, she ends the counting process and sits on the lap of the adult seated directly next to her. From there she observes Samuel's further counting process. With respect to the stability of the numeral sequence, the one-to-one principle, and the cardinal principle, this counting process is alike his earlier one, ending with twenty-four I have).

d) Olivia observes first the counting process of Samuel, then begins her own counting process after Samuel had ended his aloud counting and had silently counted the small figures at the end of his row (Fig. 8). She touches the animals that stand in front of her from right to left, going one by one, but leaves out, as Samuel, some of the animals. Thereby she recites the numeral sequence fluidly and without mistakes up to 14 and then counts further leaving out single numbers 17, 18, 21, 23. She breaks off and Samuel helps her with the next numeral 24, showing himself to be an intent observer. Moving along her row of animal figures, Olivia starts the numeral sequence several times, arrives safely 14 and repeats also the stable, but not correct numeral sequence 17, 18, 21, 23, 24, (25). In her last trial she ends her counting process with the last animal figure with the numeral seven. According to the cardinal principle she names this last numeral word as her number of figures to the adult I have seven.

e) When Olivia has arrived at the numeral 17 for the second time, Britta-Marie starts with an own counting process. She counts at the same time as Olivia, but not chorally with her. She begins several times with one and names afterwards different, partly not understandable own word creations. She also touches single animal figures with her index finger, moving again from left to right along the row, jumping over single figures:

Eins neun tia es sechzehn fifzehn neuzehn piebzehn neuzehn siebzehn eins eins nell vier fuf sech sieben att neu zehn elf vizehn	eins neun (vier?) (?) sechszehn fünfzehn (siebzehn?) neunzehn siebzehn eins eins (null?) vier fünf sechs sieben acht neun zehn elf (vierzehn?)	one nine (four?) (?) sixteen fifteen sixteen (seventeen?) nineteen seventeen one one (zero?) four five six seven eight nine ten eleven fourteen
---	--	---

Even though the numeral sequence recited by her is only partially correct in certain sequences, it is possible for her in this attempt to adhere to the one-to-one principle. Besides an odd articulation, she uses the correct sequence 4 to 11 (vier fünf sechs sieben acht neun zehn elf), as in her counting process parallel to Samuel. It is remarkable that this time she uses numeral sequences in several repetitions and thereby falls back on the numerals for the numbers between 13 and 19, which is fitting to the magnitude of figures. Somewhat later she ends her counting at the right end of her row with ä h h h, thus closing off this counting process with no result.

In this situation Britta-Marie imitates the counting processes of her peers with an observable increase of autonomy in the participation: In the first sequence (b) she attempts first to give the responsibility for her own counting process to the adult person. Her own contribution makes it possible to assume that she has a basic understanding of the counting but that her own counting competence is too minimal for the problem that is to be solved. In the next sequence (c) she uses Samuel's counting process through its parallel form as a support for her own independent attempt at counting – here she can successfully recite the numeral sequence in sections. In the last attempt (e), parallel to Olivia's attempt to count, the accompanying gestures show affinity to the one-to-one principle. She finishes each attempt without a concrete number so that her counting processes cannot be seen as counting to determine a quantity. Furthermore the adult's attention in the interaction is directed at the parallel counting processes of the other two children (Samuel, Olivia), as well as the attention of the other children. Thus, Britta-Marie uses a 'neutral' zone of the PSR with less attention of other participants and without any evaluation for her own counting attempts.

### **Additional processes of counting**

Here counting processes of Britta-Marie from other situations will be described.

*Cards with pattern:* In this situation, the children get quadratic cards with different lines and curves for designing geometric or ornamental pattern.

Britta-Marie aligned cards of one type and is asked by the adult how many cards did you use. Without a recognizable relationship to her cards she says eins zwei drei vier fünf, (one two three four five) that can be understood as an attempt to say the numerals one to five, however, without attempting to count the objects. Olivia begins to count 1, 2, 3, 4, 5, 6, 7, 8 and points at the cards that lie in front of Britta-Marie. Thus, she makes the missing connection clear and says the numeral sequence correctly articulated and goes further than Britta-Marie. Britta-Marie begins to scream loudly.

*Wooden animals II:* In this situation, the children get a card deck with different representations of the numbers from 1 to 10 (digits, dots, animal figures). Some common card games could be played with this card deck.

The adult shows Britta-Marie a card with four dots (arranged like on a die) and asks how many there are. Without a recognizable process of counting Britta-Marie answers correctly articulated five, perhaps she confused the representations of 4 and 5.

With an interrogative tone the adult repeats five and Samuel and Olivia call in unison no four. The adult asks Britta-Marie to count the dots, who clearly refuses I don't want to count. Directly afterwards Samuel explains here are two and here are two so there are four.

Somewhat later Samuel and Orli have left the room, Olivia is still present. The adult shows Britta-Marie a card with ten dots, arranged as "double five". In a very high thin voice (like a comic figure) Britta-Marie counts quickly one, two, three, four, five, six, seven, eight, nine, ten and touches rhythmically the appropriate card. It is not apparent if she correctly follows the one-to-one principle; the articulation cannot be judged because of the distorted voice, however the numerals can be understood.

### **Summarizing**

Even though all of the here discussed processes of counting for Britta-Marie never show all counting principles to be correctly recognized and coordinated, still clear differences are apparent in her attempts. It is conspicuous that in the family situation she counts with a rhythmic pointing gesture, but using a distorted sequence of numbers and a rather undirected pointing to the rectangles. The counting processes in the kindergarten situation *Wooden animals I* that took place several days later clearly show bigger difficulties in the coordination of the numerals and the objects, but Britta-Marie tries to imitate the counting processes of her peers – and the attention to the one-to-one principle seems to increase within the situation. In the kindergarten situation *Cars with pattern* she does not make any attempt to connect the beginning sequence of the numerals with the objects that are to be counted. There is no sign that is recognizable as counting objects (like assigning the numerals to the cards by pointing or by glance); she relates the question "how many" with reciting the numeral sequence, and the numeral sequence is correct. The most "successful" attempt is in the last situation *Wooden animals II*, in which Britta-Marie is already 5.10 years old, when she distances herself through the change in voice: The numeral sequence is correct and the gesture of pointing seems to show at least a clear attempt to take into account the one-to-one principle. However shortly before she refuses directly to count five dots; also she is not successful in connecting the picture of five on a die with the correct numeral. The presence of the two very dominant boys that in the meantime have started school may have contributed here to a higher social-emotional stress than is the case in the final phase with the presence of her girlfriend Olivia.

It can be said in summary that there is no further linear development of the counting competence in the sequences that can be recognized, but a rather situational dependency in the coordination of the partial competences. Clearly recognizable is however a better articulation of numerals and an increase in stability of the beginning sequence that in comparison to the peers who are also involved is in all situations much shorter.

## CONCLUSIONS

In the previous paragraphs the counting performance of Britta-Marie are analyzed with reference to the social conditions of her mathematical thinking and her SLI. As seen the given problems are related to different mathematical areas. However all of the adults in the situations ask for processes of counting. Thus one must ascertain that despite the intentions of the design of the problems that on the social interactive levels conditions of learning are generated that from their content have to do with counting. This focus can be understood that counting is seen up to a certain fluency as a basic qualification for a successful beginning for school and that at the same time Britta-Marie is given diagnostically and compensatory both productive as well as receptive chances of participation in these processes. For the kindergarten this becomes especially clear in the later situations that were added here: The adults' counting demands targeted Britta-Marie, who is the child with the lowest counting competence in the situation; the other children may "assist" her in the case of fail. From the view of mathematics didactics it must be objected that the learning and the reproduction of the correct numeral sequences is only one part of the learning of an all-embracing concept of numbers, and that one must not necessarily connect these broader learning processes with advancement in the learning of reciting numeral sequences.

With concrete reference to the analyzed scenes it becomes evident that in the situations in kindergarten no direct evaluation of the processes of counting is made through the adults. If the process of counting of Britta-Marie is perceived at all by the adults and is seen by these as "incorrect", they mark these as an incorrect process of counting while giving the problem of counting to the other peers. In the familial play situations the parents mark directly the incorrect counting processes, demonstrate the correct process and thus give the answer to a question for Britta-Marie of a quantity to be determined. This demonstration of the parents on the level of the social-emotional aspects of participation could function as "face saving" (Goffmann, 1972; see too Brandt & Tatsis, 2009): The inserted counting problem is solved smoothly, and another fail of Britta-Marie is avoided, even though it is connected with disappointment. It can also be connected with an everyday understanding of the parents that emphasizes the idea of the demonstration as learning model (Bruner, 1996; see too Brandt, 2014) and also a dominant position of the learning of the numeral terms.

In the play and exploration situations in the kindergarten no such adoption of the adult demonstrations was observed. In these situations, same aged peers are given the opportunity to demonstrate their ability to count by solving the inserted problems. The demonstration is fulfilled by the peers whereby the difference in the counting abilities is emphasized. For Britta-Marie, this demonstration model can rather be seen as a "loss of face" (Goffmann, 1972; see too Brandt & Tatsis 2009). One can observe just in the later peer situations defense mechanisms (screaming), strategies of avoidance (I don't want to count) and attempts to distance herself (squeaky

voice).<sup>9</sup> In the peer context of the kindergarten in the counting situations that for the most part were evoked by the adults, a legitimate, peripheral participation give her the chance of participation in a “face saving” manner; her difficulties compared to her peers leads in surmounting this status to a personal loss of face by which Britta-Marie “slides” into the position of the legitimate peripheral participation (e.g. by avoiding strategies).

In all scenes the teaching strategy of demonstrating emerges and in connection with it the allocation of Britta-Marie to the participatory status of the legitimate periphery of participation. From the view of learning-as-participation (see Chapter 3) however, a longer persistence in this status of participation dealing with problems concerning the same theme (here: arithmetic) and somewhat equal levels of difficulty is not adequate for the learning of content. This should have been mirrored over time in a more elaborated profile of participation.

From the standpoint of pedagogical inclusion the question arises if one could not involve SLI children in teaching-learning arrangements in which mathematical learning contents include also more active forms of participation. Methodologically it would be possible to offer for this purpose, the acquisition of number concept less closely linked to counting and for example, to include more geometric and/or rhythmic-psychomotor activities. The case illustrated here shows however how massively the everyday concepts of parents and preschool teachers are based on a methodological concept that links very closely the learning of number concepts to the learning of the right numeral sequence. From this perspective, a pedagogical approach of inclusion would have to anticipate these everyday concepts that are eventually also contra-productive and to react to them with appropriate concepts.

## References

- Acar Bayraktar, E. (2014). The reflection of spatial thinking on the interactional niche in the family In: Kortenkamp, U., Brandt, B., Benz, C. Krummheuer, G. Ladel, S. & Vogel, R. (Eds.): *Early Mathematics Learning. Selected Papers of the POEM 2012 Conference*, p. 85–109. New York: Springer.
- Bauersfeld, H. (1988). Interaction, construction, and knowledge--Alternative perspectives for mathematics education. In D. A. Grouws & T. J. Cooney (Eds.), *Perspectives on research on effective mathematics teaching: Research agenda for mathematics education* (p. 27–46). Reston, VA: NCTM & Lawrence Erlbaum.
- Brandt, B. (2004): *Kinder als Lernende - Partizipationsspielräume und -profile im Klassenzimmer*. Frankfurt a. Main u.a.: Peter Lang.
- Brandt, B. (2007): Certainty and uncertainty as attitudes for students participation in mathematical classroom interaction. *Proceedings of CERME 5*. Larnaca, Zypern. [[http://wiki.dzlm.de/images/1/10/Multiple\\_perspectives\\_on%28...%29.pdf#page=79](http://wiki.dzlm.de/images/1/10/Multiple_perspectives_on%28...%29.pdf#page=79)] (30.05.2014)

---

<sup>9</sup> Cf. Chapter 2: SLI-Children are more often affected with social-emotional problems.

- Brandt, B. (2014). "I have a little job for you." In: Kortenkamp, U., Brandt, B., Benz, C. Krummheuer, G. Ladel, S. & Vogel, R. (Eds.): *Early Mathematics Learning. Selected Papers of the POEM 2012 Conference*, p. 55–70. New York: Springer.
- Brandt, B. und Tatsis, K. (2009): *Using Goffman's concepts to explore collaborative interaction processes in elementary school mathematics*. *Research in Mathematics Education* 11(1), p. 39–56.
- Bruner, J. (1990). *The act of meaning*. Cambridge, MA: Harvard University Press.
- Bruner, J. (1996). *The culture of education*. Cambridge, MA: Harvard University Press.
- Fazio, B. (1999): Arithmetic calculation, short-term memory, and language performance with specific language impairment. A 5-year follow-up. In: *Journal of Speech, Language, and Hearing Research* 42, p. 420–431.
- Fuson, K. (1988). *Children's Number and Counting Concept*. New York: Springer.
- Gelman, G. & Gallistel, C. (1978): *The child's understanding of number*. Cambridge: Harvard University Press.
- Grimm, H. (2001): *Sprachentwicklungstest für 3- bis 5jährige Kinder*. Göttingen: Hogrefe.
- Grimm, H. (2003). *Störungen der Sprachentwicklung*. Göttingen: Hogrefe.
- Goffman, E. (1972): *Interaction ritual: Essays on face-to-face behavior*. Harmondsworth, Middlesex: Penguin University Books.
- Krummheuer (2014): The realization between cultural expectation and the local realization of a mathematics learning environment. In: Kortenkamp, U., Brandt, B., Benz, C. Krummheuer, G. Ladel, S. & Vogel, R. (Eds.): *Early Mathematics Learning. Selected Papers of the POEM 2012 Conference*, p. 71–84. New York: Springer.
- Krummheuer, G. (2013a). Research on mathematics learning at the "Center of Individual Development and Adaptive Education" (IDeA)—an introduction. *Educational Studies in Mathematics*, Vol. 84(2), p. 177–181.
- Krummheuer, G. (2013b). The relationship between diagrammatic argumentation and narrative argumentation in the context of the development of mathematical thinking in the early years. *Educational Studies in Mathematics*, Vol. 84(2), p. 249–265.
- Krummheuer, G. (2011a). Representation of the notion "learning-as-participation" in everyday situations of mathematics classes. *Zentralblatt für Didaktik der Mathematik (ZDM)*, 43(1/2), 81–90.
- Krummheuer, G. & B. Brandt (2001): *Paraphrase und Traduktion. Partizipations-theoretische Elemente einer Interaktionstheorie des Mathematiklernens in der Grundschule*. Weinheim u.a.: Beltz Verlag.
- Lave, W., & Wenger, E. (1991). *Situated learning. Legitimate peripheral participation*. Cambridge: Cambridge University Press.

- Nolte, M. (2003). *Rechenschwäche und gestörte Sprachrezeption*. Bad Heilbrunn: Klinkhardt.
- Nolte, M. (2009). Auswirkungen von sprachlicher Verarbeitung auf die Entwicklung von Rechenschwäche. In Fritz, A., Ricken, G. & Schmidt, S. (Hrsg.). *Handbuch Rechenschwäche* (2. Auflage), (p. 214–229). Weinheim und Basel: Beltz Verlag.
- Ricken, G., Fritz, A., Schuck, K. D., Preuß, U. (Eds.). (2007). *HAWIVA® -III, Hannover-Wechsler-Intelligenztest für das Vorschulalter-III. Manual zur Durchführung und Auswertung*. Göttingen: Huber.
- Tomasello, M. (2003): *Constructing a language: a usage-based theory of language acquisition*. Harvard University Press.
- Vogel, R. (2014): Mathematical situations of play and exploration as an empirical research instrument. In: Kortenkamp, U., Brandt, B., Benz, C. Krummheuer, G. Ladel, S. & Vogel, R. (Eds.): *Early Mathematics Learning. Selected Papers of the POEM 2012 Conference*, p. 223–236. New York: Springer.
- Wynn, K. (1992): Children's acquisition of the number words and the counting system. *Cognitive Psychology* 24, p. 220–251.