Z Erziehungswiss (2023) 26:319–344
https://doi.org/10.1007/s11618-022-01114-y

ZfE

SCHWERPUNKT

Cognitively stimulating maternal language as predictor for vocabulary growth

Dave Möwisch · Kira Konrad-Ristau · Sabine Weinert

Received: 30 November 2021 / Revised: 12 May 2022 / Accepted: 14 June 2022 / Published online: 12 August 2022

Abstract Maternal interaction behavior, particularly maternal language input, is considered to be one of the key factors for child vocabulary development. Previous studies have shown that a higher quantity and diversity of maternal language input is associated with faster vocabulary development. In the present study, we examined cognitive-verbal stimulation as a specific aspect of maternal input, controlling for other relevant internal child characteristics and external environmental influences. Additionally, we compared the effects of cognitive stimulation on vocabulary development with a standard measurement of maternal language input, such as its quantity, to identify specific the effects of cognitive-verbally stimulating interaction behavior. We used data from the Newborn Cohort Study of the German National Educational Panel Study ($N = 1127$ families) and conducted latent growth curve modeling to examine the vocabulary growth of children between 3 and 7 years of age. As control variables, we also included maternal education and household income in the analyses as well as the children's age, gender, and initial vocabulary level when they were 2 years old, their phonological working memory, and whether they were learning another native language other than German. The results indicated that general aspects of maternal input, such as the quantity and length of the utterances of maternal language input for 2-years-olds, were relevant in the earlier stages of

Dr. Dave Möwisch (✉)
Leibniz Institute for Educational Trajectories, Wilhelmsplatz 3, 96047 Bamberg, Germany
E-Mail: dave.moewisch@lifbi.de

Kira Konrad-Ristau · Prof. Dr. Sabine Weinert
Department of Developmental Psychology, University of Bamberg, Markusplatz 3, 96047 Bamberg, Germany

Kira Konrad-Ristau
E-Mail: kira.konrad-ristau@uni-bamberg.de

Prof. Dr. Sabine Weinert
E-Mail: sabine.weinert@uni-bamberg.de

vocabulary development, while cognitive stimulation was an important predictor of growth across the later stages of vocabulary development in 3- to 7-year-olds.

Keywords Vocabulary Development · Maternal Language Input · Cognitive Stimulation · German National Educational Panel Study · Latent Growth Curve Modeling · Phonological Working Memory

Kognitiv-sprachliche Anregung der Mutter als Prädiktor für die kindliche Wortschatzentwicklung

Zusammenfassung Die mütterliche Sprache gilt als einer der Schlüsselfaktoren für die früh-kindliche Wortschatzentwicklung. Vorangegangene Studien haben gezeigt, dass eine höhere Quantität und Diversität des mütterlichen Sprachangebots mit einer schnelleren Wortschatzentwicklung assoziiert ist. In der vorliegenden Studie wird das kognitiv-sprachliche Anregungsverhalten der Mutter unter Kontrolle weiterer relevanter internen Kindesmerkmale und externer Umwelteinflüsse untersucht. Zudem wird der Einfluss des mütterlichen kognitiv-sprachlichen Anregungsverhaltens auf die kindliche Wortschatzentwicklung mit einer, in der Forschung häufiger verwendeten, stärker quantitativen Messung des mütterlichen Sprachangebots verglichen, um spezifische Effekte beider Anregungsindikatoren zu identifizieren. In der Studie wurden Daten der Neugeborenen-Kohortenstudie des Nationalen Bildungspanels ($N = 1127$ Familien) verwendet und eine latente Wachstumskurvenmodellierung durchgeführt, um die Wortschatzentwicklung von Kindern zwischen 3 und 7 Jahren zu untersuchen. Kontrolliert wurden die mütterliche Bildung und das Haushaltseinkommen sowie – auf Seiten des Kindes – das Alter, Geschlecht, ihr Wortschatz mit 2 Jahren, das phonologische Arbeitsgedächtnis sowie, ob die Kinder monolingual deutschsprachig aufwuchsen. Die Ergebnisse zeigen, dass allgemeine Aspekte der mütterlichen Sprache, wie beispielsweise Menge des Sprachangebots und Äußerungslänge, in den früheren Phasen der Wortschatzentwicklung prädiktiv waren, während eine kognitiv-sprachliche Anregung ein signifikanter Prädiktor für den Wortschatzzuwachs in den späteren Phasen der Wortschatzentwicklung zwischen 3 und 7 Jahren war.

Schlüsselwörter Wortschatzentwicklung · Mütterliche Sprache · Kognitiv-sprachliche Anregung · Nationales Bildungspanel · Latente Wachstumskurvenmodellierung · Phonologisches Arbeitsgedächtnis

1 Introduction

Vocabulary acquisition is a complex phenomenon which has not yet been completely deciphered by scientists. The acquisition of vocabulary is particularly complex because it includes many different processes, from the reception of single phonemes to understanding complex sentences (Grimm 2012; Owens 2019). Furthermore, vocabulary is an important variable for (and partially depends on) the acquisition of other important linguistic and pragmatic skills such as grammar and verbal communica-

tion (e.g., Moyle et al. 2007), listening comprehension of texts (Heppt et al. 2014), or reading competence (e.g., Baumann, 2008). Moreover, vocabulary also associated with the cognitive, socio-cognitive, and social development of children (Weinert 2004, 2020), which is why vocabulary acquisition is fundamental for further child development.

Although there are inter-individually similar patterns of vocabulary growth (Hoff 2008; Owens 2019), empirical research has also revealed substantial variability in vocabulary development (Bates et al. 1994; Fernald and Marchman 2011; Ramey and Ramey 2004). This variability is affected by numerous variables, including the internal characteristics of a child and external environmental factors (Aktas 2020; Hoff 2008). A particularly important factor for successful language acquisition is the language input provided in the family environment, especially the input provided by mothers, as the primary caregiver in most families (e.g., Hoff, 2003). Previous research has shown that a high quantity and quality of language input has a positive impact on children's vocabulary development (Hart and Risley 1995; Hurtado et al. 2008; Huttenlocher et al. 1991). For example, studies have demonstrated that the number of words (Huttenlocher et al. 1991) and the diversity of linguistic input (Huttenlocher et al. 2010; Pan et al. 2005; Rowe 2012) correlate positively with vocabulary growth.

In contrast to the majority of previous research, the present study examines cognitive stimulation as a specific aspect of maternal input. Cognitively stimulating language includes why-questions, hypotheses, or mental words that challenge children to shift from a concrete situation to a more abstract conception. Thus, the main aim of this study is to investigate how maternal cognitively stimulating language is related to later child vocabulary growth. Moreover, the effects of cognitive stimulation are compared with the effects of a general indicator of maternal input, which covers aspects that have been shown to be relevant for children's early language acquisition. Compared to cognitive stimulation, this indicator includes more quantitative linguistic aspects, such as the amount of verbal expressions and the length of maternal utterances.

2 Theoretical background

2.1 Vocabulary development

Vocabulary development is a complex challenge for children who have to accomplish various milestones in this regard in the first years of their life. Overall, three different phases of vocabulary growth can be differentiated (Weinert and Grimm 2018). In the first phase, vocabulary growth is rather slow. Infants are already able to differentiate different features, such as stress patterns or word segments in the first months of their life (e.g., Weber et al. 2004). However, they only begin to understand first words at around 8 months of age, before expanding their receptive vocabulary up to approximately 200 words at around 18 months of age (Grimm and Weinert 2002). At the same age, the second phase of vocabulary growth starts, with word learning accelerating significantly, resulting in a rapid increase in chil-

dren's vocabulary (Hoff 2008). From the second to third year of life, the third phase follows, as children expand their comprehension and production of varied sentences of increasing length. From understanding short, simple sentences during their second year of life, children expand their knowledge, with them understanding longer and increasingly more complex sentences when they are about 3 years old (Bockmann et al. 2020). Furthermore, their growing grammatical knowledge and understanding of increasingly complex sentences support word acquisition, facilitating the acquisition of unknown verb meanings in particular (Gleitman 1990). In addition, children at this age learn to understand more abstract nonvisible entities or internal states. However, they still have problems understanding and using cognitive internal state words such as *may, guess*, or *mean* (Bretherton and Beeghly 1982; Ebert 2011). Johnson and Maratsos (1977) showed that 4-year-olds begin to understand the words *know* and *guess* correctly. In general, understanding abstract nonvisible entities—including mental words—is a challenge throughout preschool years (Johnson and Wellman 1980; Moore et al. 1989; Papafragou et al. 2007). At the age of 4, children increasingly understand in-depth facts and tasks from their immediate environment as well as longer stories (Bockmann et al. 2020).

Parallel to vocabulary acquisition, children extend their knowledge about categories and concepts as well as about the meanings and relations between different words and categories, which in turn is related to further vocabulary development (Borovsky and Elman 2006). More specifically, children expand their conceptual knowledge by building hierarchically organized knowledge about different objects/entities and their relationships (Murphy and Lassaline 1997), including taxonomic categories (Markman 1989). As their vocabulary increases, this conceptual knowledge becomes increasingly specific and broad, facilitating the learning of new word meanings (Weinert 2000, 2020). Overall, there is empirical evidence that the two domains—vocabulary and conceptual knowledge—although separable in principle, are bidirectionally related and mutually beneficial (Borovsky and Elman 2006; Gopnick and Meltzoff 1987; Weinert in press).

In sum, the empirical literature shows that there is a general pattern of vocabulary development across early childhood. After children have learned their first words, there is a rapid increase in their repertoire of vocabulary with a spurt at the age of about 18 months, after which general vocabulary growth slows down (Weinert and Grimm 2018). This pattern has been empirically confirmed, in particular by longitudinal studies. For example, Rowe et al. (2012) showed that the initial increasing vocabulary growth rate is followed by a deceleration of general vocabulary growth. These results are in line with other recent longitudinal studies which have demonstrated similar patterns of progression using latent growth curve modeling (Farkas and Beron 2004; MacLeod et al. 2018). Despite these generalized patterns of vocabulary development, vocabulary growth can vary substantially (Bates et al. 1994; Fenson et al. 1994). Therefore, one of the main goals in this field of research is to identify relevant factors and their impact on vocabulary development.

2.2 Variability of vocabulary growth

Vocabulary development has a trajectory which is affected by numerous factors (Bornstein et al. 1998; Ebert et al. 2013; Hoff 2008) including internal child characteristics and external environmental influences (Aktas 2020).

One of the most important child characteristics affecting vocabulary growth is the individually different capacity of *phonological working memory*. More precisely, phonological working memory is important for correctly storing sound sequences, which is relevant for learning new words (Baddeley et al. 1998). The association between phonological working memory and vocabulary has already been empirically demonstrated (see Gathercole 2006, for an overview). In particular, longitudinal studies support the relational direction between phonological working memory and vocabulary development. For example, Gathercole et al. (1992) demonstrated a unidirectional cross-lagged association between phonological working memory and vocabulary acquisition in children between 4 and 5 years of age. This result is in line with other longitudinal studies that used latent growth curve modeling and showed a positive association between phonological memory and a latent growth factor, particularly in the earlier phases of vocabulary development (Ebert et al. 2013; Weinert et al. 2012).

Gender is another child characteristic that is related to vocabulary development. Some studies have shown that girls are slightly more advanced in their development than boys of the same age (Bornstein et al. 2004; Huttenlocher et al. 1991; Zhang et al. 2008). However, these effects are not consistent (Klann-Delius 1981).

In addition to child characteristics, environmental factors play a major role in vocabulary development. In this view, the bioecological model of development (Bronfenbrenner and Morris 2006) assumes that the home learning environment is an especially important factor for child development. Furthermore, structural characteristics of the family, such as parental education or family income, have an impact on the home learning environment (Kluczniok et al. 2013) which, in turn, is associated with child development. Thus, there is substantial empirical evidence that the *socioeconomic status* (SES) of a family is significantly associated with child vocabulary development (Hoff 2006; Schneider and Linberg 2022; Vasilyeva and Waterfall 2011). The majority of studies have shown that children from families with lower socioeconomic backgrounds show slower rates of language development than children from higher socioeconomic strata (Arriaga et al. 1998; Hart and Risley 1995; Weinert et al. 2012). The main mechanism that is assumed to mediate the association between SES and vocabulary growth is language input by more highly educated mothers. According to this, mothers with a higher SES use a more extensive lexical repertoire in their language, which is associated with better child vocabulary development (Hoff 2003).

Furthermore, *bilingualism* is another factor that contributes to children's vocabulary development (Byers-Heinlein and Fennell 2014). For children learning more than one language, researchers have found less advanced vocabulary in each of the languages compared to children growing up monolingually (Bialystok et al. 2010; Fennell et al. 2007). These differences in majority language development have also

been confirmed by longitudinal studies (Ebert et al. 2013; Mancilla-Martinez and Lesaux 2011; Weinert and Ebert 2013).

With respect to external factors, the *language input* to which a child is exposed is considered to be one of the most important factors that has a lasting effect on child vocabulary development. In this vein, various properties of maternal language input and how they are associated with child vocabulary development have been examined (see Hoff 2006 for an review). For example, studies have shown that a higher quantity of maternal speech (Hart and Risley 1995; Huttenlocher et al. 1991), longer maternal utterances (Hoff and Naigles 2002; Huttenlocher et al. 2002), a higher lexical diversity (Pan et al. 2005), or more sophisticated maternal speech (Weizman and Snow 2001) are positively associated with child vocabulary development. In addition to these linguistic properties of maternal speech, social-communicative aspects of maternal speech are positively correlated with child vocabulary development (Hoff and Naigles 2002). Accordingly, responsive maternal behavior (Tamis-LeMonda et al. 2001), contiguous and contingent maternal behavior (Tamis-LeMonda et al. 2014) or joint attention (Carpenter et al. 1998) are factors that are associated with and predictive for child vocabulary development.

Overall, there are many different internal and external variables that have a significant impact on vocabulary development. However, maternal language input represents a particularly important factor for further child development. For this reason, the present study concentrates on cognitively stimulating maternal language as a predictor for vocabulary growth.

2.3 This study

One characteristic of maternal input that has received less attention in previous research is the cognitive component of maternal linguistic stimulation as a predictor for vocabulary development. Cognitive linguistic stimulation includes, for example, *distancing language* which has been shown to be a positive factor for a child's cognitive development (Sigel 2002; Sigel et al. 1980). This form of distancing language includes statements and questions that challenge children to shift from a concrete situation to a more abstract conception. One example of such cognitively stimulating language is the use of open wh-questions which, in contrast to closed yes- or no-questions, challenge children to recall, organize, and express information, fostering the development of representational thoughts, which underpin vocabulary development (Seidl et al. 2003; Sigel 2002). In the literature, some studies have demonstrated positive effects of wh-questions on vocabulary development (Hoff-Ginsberg 1985; Rowe et al. 2017). Similarly, exposing children to alternative point of views can help them to build mental representations as they are encouraged to think about and compare different scenarios or situations (Heath 1982). Another form of cognitively stimulating language is mental state language, which contains words for describing thoughts, desires, feelings, and beliefs, such as *mean, think*, or *believe* (Bartsch and Wellman 1995). Furthermore, decontextualized language is also characterized by longer utterances and a more complex syntax (Curenton and Justice 2004).

Although there are already some studies that have researched the association between stimulating interaction behavior and vocabulary development, there are very few studies that have investigated vocabulary growth longitudinally using latent growth curve modeling (e.g., Ebert et al. 2013; Weinert et al. 2012). Interestingly, only positive associations have been found between the quality of stimulation and the latent intercept, but not with the latent growth factor.

Rather than examining cognitive-verbal stimulation behavior, the majority of previous studies have used linguistic quantity measures of maternal input such as the mean length or number of utterances (e.g., Hoff 2003; Hoff and Naigles 2002) and/or the number of different word types (e.g., Huttenlocher et al. 1991). Some studies have found that quantitative measurements are positively associated with a child's language and, particularly, grammar acquisition (Huttenlocher et al. 2010), whereas cognitive stimulation has been found to be only associated with vocabulary development and not with grammar acquisition (Anderka 2018; Lehrl et al. 2012). Furthermore, Rowe (2015) proposed that greater attention should be paid to examining the qualitative properties of maternal language, going beyond quantitative measures of input to gain more knowledge about vocabulary acquisition. In the same vein, Huttenlocher et al. (2010) argued that quantitative measures cannot distinguish between whether the same elements are used repeatedly or whether different elements are used. Rowe (2015) also stated that outcomes are best predicted by examining quality measures of maternal input and controlling for quantity properties. Therefore, this study examines both aspects: qualitative aspects, in particular cognitive language stimulation, and quantitative aspects of maternal input.

The main aim of the study was to investigate the influence of a particularly cognitively stimulating language on vocabulary development. In contrast to previous research, we a) used a broader latent construct to measure cognitively stimulating language, b) controlled for other relevant internal child characteristics and external environmental factors, c) used a nationally representative sample of German children, and d) implemented latent growth curve modeling to investigate vocabulary growth in children aged between 3 and 7 years. We hypothesized that a higher level of maternal cognitively stimulating language input for 2-year-olds would be positively associated with later vocabulary growth.

The second aim of the study was to compare the effect of cognitively stimulating language with a more standard measurement of quantity and quality of maternal input on vocabulary development in order to identify specific effects of cognitive language predictors.

3 Method

3.1 Sample and procedure

The present study used data from the Newborn Cohort Study of the German National Educational Panel Study (NEPS; Weinert et al. 2016). It examined data from four different waves of the study which included measures of child vocabulary in the assessments. At the first measurement time point used in the present study, the

children were 26 months old (T1); at the second measurement time point considered in the analyses, the children were 38 months old (T2); at the third measurement time point, they were 5 years old (T3); at the last measurement time point considered in the present analyses, the children were 7 years old (T4). To assess maternal cognitive stimulation behavior, we used data from mother-child interaction that took place at the first measurement time point when the children were 2 years of age. To investigate vocabulary growth, we analyzed the data from T2–T4, i.e., for children aged 3 to 7 years, using latent growth curve modeling.

As part of the Newborn Cohort Study of the NEPS, when the children were 26 months old (T1), mother-child interaction was videotaped for 10 min during a semi-standardized toy play situation in their homes (Linberg et al. 2019) where mothers were instructed to play as naturally as possible with their child. In addition, in each wave of the Newborn Cohort Study of the NEPS, the mothers participated in an interview where demographic data and other relevant variables were collected. To measure receptive vocabulary, the German version of the Peabody Picture Vocabulary Test was administered at the ages of 3 (T2), 5 (T3), and 7 years (T4) at home.

Overall, we included $N = 1127$ families in the analysis. For each of the families complete data were available on the mother-child interaction at the age of 2 years and child vocabulary outcome measures at the age of 3 years. Families were excluded if the children achieved fewer than five points in the PPVT to ensure that only children who understood the task correctly were included in the analysis. We chose five as the cut-off value because all children who scored less than five had answered too many items incorrectly on the first set of pictures and thus the test was terminated early. Moreover, we only analyzed the data of mothers and their children, as the number of fathers in the sample was very small.

3.2 Measures

3.2.1 Dependent variable

To measure the children's *receptive vocabulary*, a German version of the Peabody Picture Vocabulary Test was administered (see Lenhard et al. 2015 for the German adaptation of the PPVT-4). The PPVT is a commonly used measure of receptive vocabulary where children hear a word and are asked to point to the picture (out of four options) that matches the word they heard. The test contains a maximum of 228 items (19 sets of 12 items) which become increasingly difficult. If the children answer too many items within a set incorrectly, the test is terminated prematurely. The test was carried out on tablet computers at home. The internal consistency of the German adaptation of the PPVT-4 was 0.97 (Lenhard et al. 2015).

3.2.2 Independent variables

To assess maternal interaction behavior, trained raters watched the videos and coded different aspects of maternal and child behavior using a micro-analytic coding

procedure[1]. To perform the micro-analytic coding, the 10-minute videos were split into 40 intervals of 15 s. For each of the 40 sequences, the coders were asked to rate different items, leading to a repeated measurement design. To calculate the interrater reliability of the micro-analytic coding, a second rater coded 10% of all videos. The weighted percentages of interrater agreement for maternal interaction behavior were high (ranging between 82.3% and 97.1%).

To create indicators for maternal stimulation behavior, we used a two-step approach. In the first step, we calculated frequency indicators for each behavior, taking into account the repeated measurement design of the micro-analytic coding system. For this purpose, we calculated the share of sequences out of all valid intervals in which a certain behavior was shown (e.g., the mother asking why-questions or not). The resulting value of these indicators ranged between 0 (indicating that a certain behavior was shown in 0% of all intervals) and 1 (indicating that a certain behavior was shown in 100% of the intervals). Then, in a second step, we used these frequency indicators and confirmatory factor analyses to identify appropriate measurement models.

To measure maternal *cognitive stimulation* (see Table 1), specific levels of the following items were used: level of abstraction, sense-making words, alternative viewpoints, kind of questions asked, and hypotheses/speculations. *The Quantity and quality* of maternal language input was measured based on the amount of verbal expression, level of sentence complexity, kind of questions asked, and level of abstraction. Here, it must be noted that the items "level of abstraction" and "kind

Table 1 Coding and Definitions for all Items of *Cognitive Stimulation*

Item	Coding (binary)	Definition
Level of abstraction	0 = no verbal expression or marginally abstract 1 = somewhat abstract or very abstract	The mother includes not visible characteristics of objects and not visible objects. She refers strongly to objects which are not present but imagined, to concepts which are not situation related and to the past or future (beyond the game situation)
Making-sense words	0 = no making-sense words 1 = at least one making sense-word	The mother's utterances contain at least one word that articulates thoughts, opinions, or beliefs
Offering alternative viewpoints	0 = no alternative viewpoints 1 = at least one offer of an alternative viewpoint	The mother encourages the child to think about alternative points of view, to adopt a different perspective, or asks the child to form their own hypotheses
Kind of asked questions	0 = closed questions (yes/no or one-word answers) 1 = open-ended questions	The mother asks a question that allows a large number of (mostly longer) answers (this type of question often suggests more than one sentence as an answer and leaves room for creative suggestions)
Hypotheses/ Assumptions	0 = no hypotheses/ speculations 1 = hypotheses/speculations	The mother expresses at least one own hypothesis/ assumption. Compared to a description there is uncertainty, or the statement can be recognized as the mother's opinion

[1] While the NEPS coding used a macro-analytic coding system (see Linberg et al. 2019), the micro-coding was conducted in the project ViVA (**Vi**deo-Based **V**alidity **A**nalyses of Measures of Early Childhood Competencies and Home Learning Environment) funded by the German Research Foundation (grant to S. Weinert).

Table 2 Coding and Definitions for all Items of *Quantity and Quality of Maternal Language Input*

Item	Coding (binary)	Definition
Amount of verbal expressions	0 = few verbal expressions 1 = some or many expressions	*Some*: The mother speaks repeatedly or for several seconds *Many*: The mother speaks noticeably a lot, more than half of the observed interval. She speaks in at least 7 of the 15 s
Level of complexity	0 = simple 1 = moderate or complex	*Moderate*: The mother uses comprehensible sentences with few subordinate clauses and only short nominal phrases *Complex*: The mother uses longer, more complex sentences with several subordinate clauses, long nominal phrases
Kind of questions asked	0 = yes/no questions 1 = more open or open-ended questions	The mother asks a question that cannot be answered by yes/no but affords at least a short answer or allows for longer answers
Level of abstraction	0 = no verbal expression or marginally abstract 1 = somewhat abstract or very abstract	The mother includes not visible characteristics of objects and not visible objects. She refers strongly to objects which are not present but imagined, to concepts which are not situation related and to the past or future (beyond the game situation)

of questions asked" were used for both latent indicators. However, for the quantity and quality of maternal language, we used a different binary coding for the item "kind of questions asked" (yes/no questions, others) than for cognitive stimulation (closed, open questions; see Tables 1 and 2). We used the same items for both latent indicators because these items represent important aspects for both latent indicators. For example, the level of abstraction or distancing is often used to characterize, in particular, the quality of maternal language input in mother-child interaction situations. In addition, the level of abstraction is important for measuring cognitive stimulation since more abstract language characterizes a higher level of cognitive stimulation. However, it should be noted that this is conservative with respect to our hypothesis as we expected the two indicators to have different effects on child vocabulary development. Tables 1 and 2 show all items and corresponding levels that were used for the latent indicators "cognitive stimulation" and the "quantity and quality" of maternal language.

3.2.3 Control variables

As control variables, we considered various internal child characteristics and external environmental factors because theses variables are typically associated with vocabulary growth.

Age and gender We controlled for the gender of the child and the age (in days) when the children were about 2 years old (T1).

Initial vocabulary level To control for the initial vocabulary level of the children at the age of 2 years, i.e., before the PPVT was assessed for the first time, we used the ELFRA2 (Grimm and Doil 2006), a validated well-known language check-list. For the present study, we used the subscale vocabulary which contains a German vocabulary checklist of 260 words and phrases which the parent fills out. The raw

scores of the sum score of this checklist were z-standardized to obtain a stable measure.

Phonological working memory The children's phonological working memory was measured using the digit span task which was adapted from the German version of the "Kaufman Assessment Battery for Children" (Melchers and Preuß 2009). The digit span task measures the child's ability to immediately reproduce a verbally presented sequence of digits in the correct order. The task consists of two learning items at the beginning, where children receive brief feedback, and 13 test items. Overall, there are five sets, each consisting of three items. In the first set, the items contain two digits; the number of digits increases by one digit per set (the last set contains six digits). Up to the third set, the test stops when all items within a set are answered incorrectly. After that, the test stops after one incorrect answer. As an indicator for phonological working memory, we used the number of correctly reproduced digit sequences (the maximum was 15).

Maternal education Maternal education was measured using an adapted version of the international standard classification of education 1997 (ISCED; United Nations Educational, Scientific, and Cultural Organization (UNESCO), 2012) which ranges from 0 = "no school leaving qualification" to 10 = "PhD/Habilitation."

Table 3 Descriptive Statistics of all Study Variables

	Mean/%	(SD)	Minimum	Maximum
Child Language				
Vocabulary (ELFRA2) at 2 years	159.60	56.34	4	260
Vocabulary (PPVT) at 3 years	58.04	21.27	5	118
Vocabulary (PPVT) at 5 years	86.54	21.28	16	177
Vocabulary (PPVT) at 7 years	94.16	19.22	42	173
Maternal Stimulation Behavior (Frequency) – T1 (child age: 2 years)				
Level of abstraction	0.26	0.17	0.00	0.90
Making-sense words	0.10	0.10	0.00	0.48
Offering alternative viewpoints	0.02	0.04	0.00	0.30
Kind of questions asked[a]	0.04	0.07	0.00	0.80
Hypotheses/assumptions	0.05	0.05	0.00	0.40
Kind of questions asked[b]	0.39	0.15	0.00	0.83
Level of complexity	0.69	0.31	0.00	1.00
Amount of verbal verbal expressions	0.85	0.15	0.00	1.00
Controls				
Age children (T1, in days)	1170.27	27.00	1107	1259
Gender: boys	51.3%	–	–	–
Working memory (age 3; T2)	3.47	2.33	0	10
Maternal education	7.18	2.38	0	10
Household income (log, in Euro)	8.21	0.46	5.70	9.62
Bilingualism: only German	87.5%	–	–	–

[a] Yes/no or one-word answers vs. open-ended questions
[b] Yes/no questions vs. more open or open-ended questions

Household income The income of each household served as another indicator for SES. Household income was log transformed to improve the distribution and skewness for the structural equation modeling.

Bilingualism To capture bilingualism, we used information from the mother on whether their child was learning another native language other than German or whether their child was learning only German.

The descriptive statistics for all study variables are presented in Table 3.

3.3 Statistical analyses

To analyze the effects of maternal cognitively stimulating behavior on vocabulary development, we conducted regression analyses via structural equation modeling using Mplus 8.4 (Muthén and Muthén 1998–2017).

More specifically, we used a three-step approach. In the first step, we computed latent growth curve modeling using three measurement points (T2–T4) to identify an appropriate growth curve model for vocabulary growth. In the second step, we examined the effects of the control variables on the latent intercept and slope factors of vocabulary growth. Finally, we specified two separate models which included the latent variables "cognitive stimulation" and "quantity and quality" in the analysis to examine the specific effects of maternal stimulation behavior on vocabulary growth.

The models were estimated using the robust maximum likelihood (MLR) method, which uses parameter estimates with standard errors and chi-square statistics that are robust to non-normality and non-independence of observations. The missing data were managed with a full-information maximum likelihood approach (FIML). We evaluated the model fit using the comparative fit index (CFI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). We applied the conventional cut-off criteria proposed by Hu and Bentler (1999): 0.95 or higher for CFI, 0.08 or lower for SRMR, and 0.06 or lower for RMSEA.

4 Results

Table 4 presents the correlation matrix with all relevant study variables.

4.1 Modeling vocabulary growth

To identify an appropriate measurement model for vocabulary growth, we used a set of different growth curve models. Table 5 presents the model fit indices of these models. In the first model, we modeled a classical growth curve model with a linear change from T2 (when the children were 3 years old) to T4 (when the children were

Table 4 Correlations of all Study Variables

	Variables	1	2	3	4	5	6	7	8	9	10	11
1	Age	–	–	–	–	–	–	–	–	–	–	–
2	Gender	–0.03	–	–	–	–	–	–	–	–	–	–
3	Education	0.01	0.02	–	–	–	–	–	–	–	–	–
4	Household income	0.04	0.04	0.42*	–	–	–	–	–	–	–	–
5	Bilingualism	–0.04	–0.06*	0.15*	0.08*	–	–	–	–	–	–	–
6	Working Memory (T2)	0.07*	–0.04	0.08*	0.13*	–0.03	–	–	–	–	–	–
7	ELFRA (age 2; T1)	0.01	0.10*	0.18*	0.16*	0.01	0.56*	–	–	–	–	–
8	PPVT (age 3; T2)	0.06	0.03	0.17*	0.17*	0.14*	0.26*	0.32*	–	–	–	–
9	PPVT (age 5; T3)	–0.02	–0.12*	0.21*	0.19*	0.18*	0.15*	0.22*	0.31*	–	–	–
10	PPVT (age 7; T4)	–0.05	–0.19*	0.23*	0.19*	0.17*	0.17*	0.21*	0.32*	0.46*	–	–
11	Cognitive stimulation (T1)	–0.02	–0.04	0.18*	0.17*	0.04	0.08	0.17*	0.12*	0.19*	0.13*	–
12	Quantity and quality (T1)	0.06	0.03	0.18*	0.22*	0.06	0.08	0.23*	0.19*	0.07	0.09*	–0.60*[a]

* $p < 0.05$. $N = 1127$. Gender: 0 = female. 1 = male. Bilingualism: 0 = bilingual German, 1 = monolingual German. Household income was logarithmized. Cognitive stimulation and quantity and quality were modeled as latent variables

[a] It should be noted, that we used one item that was exactly the same for both constructs. Moreover, we used two different and mutually exclusive codings of the item "Kind of questions asked" for both constructs.

Table 5 Model Fit Indices for Latent Growth Curve Models for Vocabulary Growth

Model	χ^2	Df	$p <$	CFI	RMSEA	SRMR
M1: Intercept, slope	228.761	5	0.00	0.292	0.199	0.128
M2: Intercept, slope, quadratic factor	3.264	2	0.19	0.996	0.024	0.013
M3: Freely estimated growth parameter	21.345	4	0.00	0.945	0.062	0.111

7 years old). In Model 2, we added an additional latent quadratic factor[2]. Model 3 consisted of a freely estimated shape of vocabulary growth.

Of the three models, Model 2 showed the best model fit, followed by Model 3 and Model 1. To test whether the differences in model fit were significant, we calculated the Satorra-Bentler scaled χ^2-difference test (Satorra and Bentler 2001). The χ^2 test statistic of Model 2 was significantly better than for Model 3 (M2–M3: $\Delta\chi^2(2) = 8.07$, $p < 0.05$). Therefore, we decided to use a latent growth curve model in-

[2] It must be noted, that three measurement points are not enough to specify a latent growth curve model including latent linear slope and quadratic factors. Therefore, we added the age and gender of the child to the model and regressed both variables on the latent intercept and slope factors to calculate more model parameters. Otherwise, the model would be saturated and no model fit indices could be calculated in order to evaluate the model.

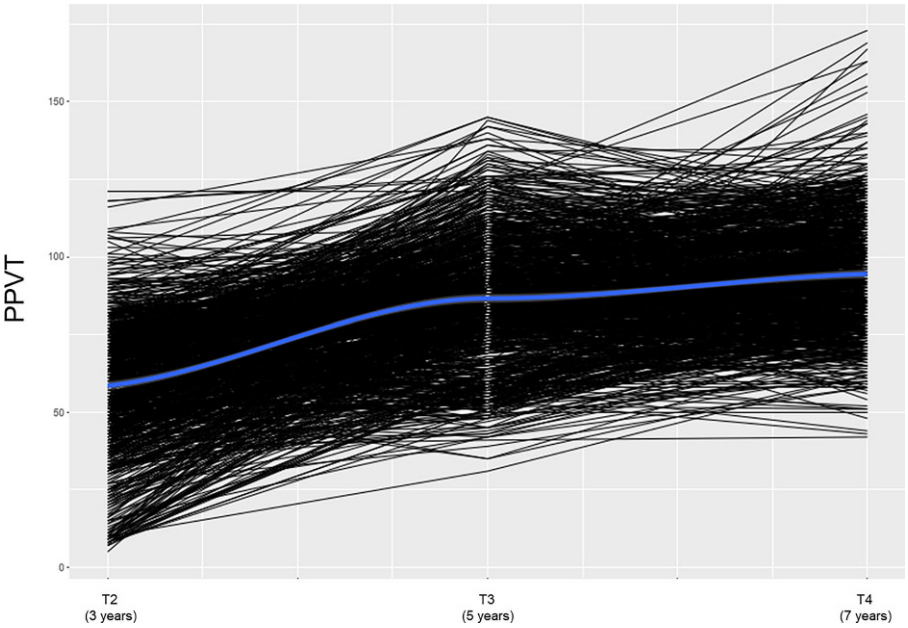

Fig. 1 Empirical Growth Plot for Vocabulary Growth. Development of vocabulary from three to seven years based on the PPVT. The *blue line* based on local trend analysis representing the average vocabulary development

cluding a linear and a quadratic growth factor which also fitted the empirical data well (see Fig. 1 for the empirical growth plot). This model showed that vocabulary growth was steeper between T2 (3 years) and T3 (5 years) before slowing down between the ages of 5 and 7 years (T4). Therefore, the model included an additional negative quadratic factor which decelerated the linear growth. The latent intercept and slope factors were allowed to correlate but did not show any significant correlation.

4.2 Modeling of maternal input

Before including the latent indicators of maternal interactional behavior as predictors for vocabulary growth in the analyses, we conducted confirmatory factor analyses to identify appropriate measurement models for the maternal interaction indicators. The model fit indices showed acceptable values for cognitive-verbal stimulation (CFI = 0.939; SRMR = 0.035; RMSEA = 0.060) and for the quantity and quality of maternal language (CFI = 0.948; SRMR = 0.029; RMSEA = 0.060). In addition, we tested whether a two-factor model fitted the data better than an alternative one-factor model where all items loaded on only one factor. The results showed that a model with two factors (CFI = 0.927; SRMR = 0.039; RMSEA = 0.065) fitted the data significantly better than the one-factor model (CFI = 0.820; SRMR = 0.056; RMSEA = 0.097).

Table 6 Standardized Regression Coefficients for Vocabulary Growth (Model 4 and Model 5)

	Model 4[a]		Model 5[b]	
Predictors	Intercept	Slope	Intercept	Slope
Child characteristics				
Age of child at T2	0.065 (0.04)	–0.185 (0.13)	0.066 (0.04)	–0.192 (0.13)
Gender	–0.010 (0.04)	–0.208 (0.05)*	0.000 (0.04)	–0.206 (0.04)*
Working memory	0.301 (0.06)*	–0.351 (0.15)*	0.294 (0.06)*	–0.361 (0.15)*
Initial vocabulary level (ELFRA)	0.444 (0.05)*	–0.186 (0.15)	0.407 (0.05)*	–0.207 (0.14)
Environmental characteristics				
Maternal education (ISCED)	–	–	0.103 (0.05)*	0.208 (0.15)
Household income (log, in Euro)	–	–	0.097 (0.05)	0.129 (0.15)
Bilingualism	–	–	0.203 (0.04)*	0.110 (0.13)
	$R^2 = 0.360$*	$R^2 = 0.278$*	$R^2 = 0.436$*	$R^2 = 0.355$*

$n = 1127$. Standard errors are shown in brackets
* $p < 0.05$. Gender: 0 = female, 1 = male. Bilingualism: 0 = bilingual German, 1 = monolingual German
[a] Model fit indices: CFI = 0.972, SRMR = 0.023, RMSEA = 0.055
[b] Model fit indices: CFI = 0.971, SRMR = 0.019, RMSEA = 0.047

4.3 Effects of control variables on vocabulary growth

In order to examine the effects of maternal stimulation behavior on children's vocabulary growth, we conducted four different models. In Model 4, we regressed internal children characteristics as control variables on the latent intercept and slope factors. In Model 5, we added external environmental factors as control variables in the analysis. The results of these analyses are presented in Table 6.

The results of Model 4 showed that the latent intercept at the age of 3 was significantly positively associated with the children's phonological working memory at the age of 3 and the initial vocabulary level (ELFRA) one year earlier. Thus, children who performed better on the digit span task also had a more advanced vocabulary level. Similarly and as expected, children who had a higher vocabulary at the age of 2 years also performed better on the PPVT when they were 3 years old. With respect to the latent slope factor, gender and working memory were significantly negatively correlated. In other words, children with a better working memory and boys showed a slower vocabulary growth between the ages of 3 and 7 years. In Model 5, maternal education and bilingualism showed a significantly positive association with the intercept factor. That is, children whose mothers had a higher level of education and who only spoke German with them had a larger vocabulary at the age of 3 years. For the latent slope factor, there were no significant associations.

4.4 Maternal stimulation as predictor for vocabulary growth

Model 6 and Model 7 considered maternal cognitive-verbal stimulation behavior and the quantity and quality of maternal language input (see Table 7). The re-

Table 7 Standardized Regression Coefficients for Vocabulary Growth (Model 6 and Model 7)

	Model 6[a]		Model 7[b]	
Predictors	Intercept	Slope	Intercept	Slope
Child characteristics				
Age of child at T2	0.068 (0.04)	–0.161 (0.12)	0.060 (0.04)	–0.173 (0.12)
Gender	0.027 (0.04)	–0.379 (0.11)*	0.027 (0.04)	–0.378 (0.11)*
Working memory	0.294 (0.05)*	–0.360 (0.13)*	0.295 (0.06)*	–0.349 (0.14)*
Initial vocabulary level (ELFRA)	0.394 (0.05)*	–0.199 (0.13)	0.375 (0.05)*	–0.131 (0.14)
Environmental characteristics				
Maternal education (ISCED)	0.096 (0.05)	0.159 (0.13)	0.091 (0.05)	0.211 (0.14)
Household income (log, in Euro)	0.090 (0.05)	0.087 (0.13)	0.076 (0.05)	0.165 (0.14)
Bilingualism	0.202 (0.04)*	0.064 (0.12)	0.199 (0.04)*	0.094 (0.12)
Maternal stimulation behavior				
Cognitive stimulation	0.049 (0.06)	0.344 (0.13)*	–	–
Quantity and quality	–	–	0.140(0.06)*	–0.228 (0.16)
	$\Delta R^2 = 0.073$	$\Delta R^2 = 0.215$	$\Delta R^2 = 0.105$	$\Delta R^2 = 0.016$
	$R^2 = 0.433$*	$R^2 = 0.492$*	$R^2 = 0.452$*	$R^2 = 0.460$*

$n = 1127$. Standard errors are shown in brackets

* $p < 0.05$. Gender: 0 = female, 1 = male. Bilingualism: 0 = bilingual German, 1 = monolingual German

[a] Model fit indices: CFI = 0.961, SRMR = 0.021, RMSEA = 0.030

[b] Model fit indices: CFI = 0.957, SRMR = 0.021, RMSEA = 0.038

sults indicated two interesting opposite associations. While a high level of cognitive stimulation was positively associated only with the latent slope, differences in the quantity and quality of maternal linguistic input were positively associated only with intercept for 3-year-olds. This means that 2-year-old children who had been exposed to comparatively more cognitive-verbal stimulation at the age of 2 years (T1) did not significantly differ regarding their vocabulary development at the age of 3 (T2), but showed faster vocabulary growth between the ages of 3 (T2) and 7 years (T4). In contrast, children who were more frequently exposed to comparatively more complex maternal language input (T1) showed an advanced repertoire of vocabulary one year later (T2; controlling for earlier vocabulary status), but their overall vocabulary growth over the next five years (T3–T4) was not affected by this indicator. The model fit indices indicated an acceptable model fit for all four models. In both models the effect of maternal education lost its significance when the characteristics of maternal interaction behavior were included in the model. Additional path analyses revealed a significant indirect effect of maternal education via the quantity and quality of maternal input on the latent intercept of vocabulary development (B = 0.120; $SE = 0.60$; $p < 0.05$) but no significant indirect effects via cognitive stimulation (B = 0.100; $SE = 0.55$; $p > 0.05$).

As a robustness check, we also calculated the models without working memory to control for possible suppression effects as well as for monolingual children only (i.e., without considering bilingual children). All effects remained stable in these analyses (see supplement).

5 Discussion

This study examined the relation between the cognitive-verbally stimulating interaction behavior of mothers with their 2-years-old children and the children's vocabulary development from preschool until school age, controlling for other relevant internal child characteristics and external environmental factors. The main finding was that a comparatively high level of cognitive stimulation was positively related to the latent slope factor of the growth curve model. This underlined the importance of cognitively stimulating maternal interaction behavior and language input for vocabulary development, beyond pure quantitative characteristics. In contrast, the more quantitative characteristics of maternal language input were associated with the intercept for 3-year-olds, even when controlling for child vocabulary at the age of 2 years. In the following, we will discuss the results of the control variables with respect to vocabulary development. Subsequently, the effects of the different predictors of maternal stimulation behavior regarding vocabulary growth will be discussed.

5.1 Effects of internal and external characteristics on vocabulary growth

In addition to maternal interaction behavior, we controlled for other relevant internal child characteristics as well as external environmental factors as predictors for vocabulary growth. The results showed some expected but also some differential associations with respect to the intercept and slope factors of the growth curve model.

First, gender was significantly associated with the latent slope factor. Boys had a slower vocabulary growth than girls between the ages of 3 and 7 years, which is in line with previous findings (Huttenlocher et al. 1991; Zhang et al. 2008). In the literature, various biological, psychological, and social mechanisms are discussed (see Bornstein et al. 2004, for an overview). One possible biological explanation is that girls generally mature faster than boys, and faster neurological development has a positive effect on language development (Waber 1976). However, we only found a significant association between gender and the slope factor, but not with the intercept, which undermines the biological explanation. Another potential mechanism is the way in which parents talk to their children. There is empirical evidence that parents talk more to girls and in a more conducive way than they do to boys (see Leaper et al. 1998, for a meta-analysis). However, the effects between gender and slope remained stable when we included the indicators for the quantity and cognitive stimulation of maternal input in the analyses. Based on our study, gender does not appear to be relevant for vocabulary until the later years of early childhood, when children are in preschool and start school. Thus, it might be possible that gender differences in vocabulary development are related to different conversation and interaction styles with peers, parents, and teachers. In this vein, Bornstein et al. (2004) hypothesized that girls are more verbal because they identify more with female stereotypes, which results in them engaging in more conversations and developing a better vocabulary. Nevertheless, more data and analyses are needed to gain a better

understanding of which mechanisms cause gender differences regarding vocabulary development.

Second, phonological working memory showed two interesting but opposite results. It was significantly positively associated with the intercept and significantly negatively associated with the slope factor. As expected and in agreement with previous findings, a better phonological working memory performance at the age of 3 years was associated with a larger vocabulary when the children were 3 years old, even when controlling for earlier vocabulary status (Ebert et al. 2013; Weinert et al. 2012). However, contrary to other studies and against our expectations, children with a better phonological working memory showed slower vocabulary growth between the ages of 3 and 7 years. It should be noted, however, that across all measurement points and ages phonological working memory and vocabulary status were positively associated. This association was particularly pronounced at the earlier ages. A potential explanation for the rather counterintuitive negative association found with the growth factor could be that children with a comparatively better phonological working memory reach their fastest vocabulary growth rate earlier and, after that, expand their vocabulary less quickly. In fact, the results show that the intercept and slope factor are negatively related; however, the relationship is not significant, weakening this explanation. In general, the findings underline the importance of working memory for vocabulary acquisition, especially in the earlier phases of vocabulary development, which supports previous findings (Gathercole et al. 1992; Weinert et al. 2012). As the negative effect of working memory could also indicate a suppression effect within the analyses, all analyses were also conducted without including the children's working memory performance. Overall, all other results remained robust.

Third, concerning bilingualism, the results indicate that monolingual German-speaking 3-year-old children have a larger vocabulary than bilingual children, which is consistent with earlier findings (Ebert et al. 2013; Weinert and Ebert 2013). However, we found no significant differences between monolingual and bilingual children in terms of vocabulary growth from preschool to school age. As some older studies found an increasing gap (Ebert et al. 2013), this could be due to a better quality of language promotion in preschool. However, it is not possible to specifically test this assumption with our data.

Fourth, children whose mothers had a higher education showed a greater vocabulary level when the children were 3 years old. These disparities did not seem to change significantly as there was no effect of maternal education on vocabulary growth in the following years. This finding is consistent with other studies that have shown the same pattern for maternal education and vocabulary development (Ebert et al. 2013). Therefore, maternal education seems to be particularly relevant for the earlier stages of vocabulary development. Interestingly and in accordance with family investment models, the effects of maternal education lost its significance when the characteristics of maternal verbal input and maternal interaction behavior were included in the model. This indicated a potential mediation effect; i.e., higher maternal education is associated with a more stimulating home-learning and richer linguistic environment for children, which, in turn, has a positive effect on vocabulary. This mechanism has already been empirically documented by several other

studies (Hoff 2003) and is supported by the results of the present study. In contrast to maternal education, there were no significant effects for household income, which is another SES-related variable with regard to vocabulary growth. This result supports some previous studies that have shown that maternal education is particularly predictive for child development (see Bradley and Corwyn 2002, for a review).

5.2 Effects of specific aspects of maternal input on vocabulary growth

The main aim of this study was to examine the association between cognitive stimulation and children's vocabulary growth and to compare these effects with a more standard measurement of the quantity and quality of maternal language input which focuses more on general linguistic properties.

The results show two interesting but opposite effects for 'cognitive stimulation' and the 'quantity and quality' of maternal input. Whereas cognitive stimulation was associated only with the slope factor but not with the intercept, the pattern of the findings was reversed for the quantity and quality of maternal language input. To acquire a better understanding of this finding, it is important to know how the PPVT is structured. The test contains a maximum of 228 items which become increasingly difficult. At the beginning, the words are relatively simple: nouns and verbs that occur frequently in children's everyday lives and that are associated in particular with visible objects or actions, such as *paint* or *ball*. Subsequently, the words become more abstract and increasingly refer to mental states such as *confused* or *surprised*. In addition, the nouns become more and more specific. Initially, general superordinate category labels are presented, such as *body*. Later items refer to more specific aspects, such as *ankle*. Finally, more difficult items include words that are especially used in the context of adult everyday life, such as *to apply for a job* or *to arrest*. Hence, advanced cognitive skills and extended conceptual knowledge are necessary to correctly solve more difficult items.

The results also demonstrate that exposure to a high amount of verbal expressions as well as a certain level of abstraction and complexity of maternal input have a positive effect on vocabulary development when children are 3 years old. This holds true even when controlling for vocabulary at the age of 2 years and is in line with many previous studies which have also shown that a higher quantity and higher lexical diversity are positively related to children's vocabulary development (Hoff and Naigles 2002; Huttenlocher et al. 1991; Pan et al. 2005). The majority of these studies particularly examined the early stages of vocabulary development in rather young children. The present study considered vocabulary development beyond these stages and did not find a relationship between the indicator for the quantity and quality of maternal input for 2-year-old children and vocabulary *growth* between the ages of 3 and 7 years. This suggests that the relevant interaction behavior that promotes children's vocabulary development changes as children develop, with the amount and length of utterances being particularly relevant for fostering children's acquisition of words describing less abstract, visible entities. This effect seems to be less relevant for the acquisition of more abstract words.

In contrast, a higher level of maternal cognitively stimulating behavior was not related to the initial level of vocabulary when the children were 3 years old (con-

trolling for vocabulary at the age of 2 years), but was a significant predictor for further vocabulary growth. This finding suggests that cognitive stimulation particularly facilitates the learning of more abstract words and specific words that are more relevant for later general vocabulary growth. That assumption is also supported by other findings suggesting a link between vocabulary development and cognitive development (Bowerman and Levinson 2001). Open wh-questions and exposure to alternative perspectives might challenge children to explore their environment more and to build associations between objects, actions, and, for example, mental states, resulting in more elaborate conceptual knowledge and more sophisticated word meanings (Weinert 2000). In addition, there are other—possibly related—potential mechanisms linking cognitive stimulation and vocabulary. It is possible that mothers who are more cognitively stimulating use rare words more often, which may have a positive effect on later vocabulary growth. Furthermore, it is also possible that conversations with a higher level of cognitive stimulation, including open-ended questions or hypotheses, are also more interactive and lead to more pronounced dialogues, which are associated with better cognitive linguistic development (Sigel 2002). Thus, it is also conceivable that children learn to hold a more constructive dialogue, which could have a positive effect on their vocabulary in preschool years. It should be noted that these effects cannot be attributed to a suppressor effect of the control variables, as shown by the reported robustness checks.

5.3 Implications

The results of the present large-scale study carry several theoretical and practical implications. Overall, they underline the specificity principle, according to which specific experiences affect specific outcomes at specific times in specific individuals (Bornstein 2017). Vocabulary development is a complex and multidimensional process, with specific aspects of maternal interaction behavior and linguistic input assuming an important role at different stages of vocabulary development. While general quantitative and qualitative aspects of maternal input matter more in the early stages of child vocabulary development, the importance of cognitive stimulation seems to increase in the later stages of development. Thus, it seems to be positive for later vocabulary development when a child is exposed to cognitively challenging open-ended questions, alternative viewpoints, and especially mental terms such as *think* or *mean*.

Moreover, the results show that this challenging stimulating behavior by mothers, which affects later development, is not detrimental to early child vocabulary development. Such behavior is not associated with the early stage of vocabulary development, implying that it does not impede early learning. It should be noted, however, that other factors might be relevant for children's early grammar acquisition (Weinert and Ebert 2017).

Furthermore, it would be interesting to investigate whether the positive association between maternal cognitively stimulating language and later receptive vocabulary development is also evident for productive vocabulary development (e.g., Conway et al. 2017). Previous studies have found a moderate to high correlation between receptive and productive vocabulary development at preschool age; we would therefore

expect similar effects. However, more research is needed to support this hypothesis, as no information on productive vocabulary development was collected in the present study.

5.4 Limitations and conclusion

This study also has some noteworthy limitations. First, to measure maternal interaction behavior the mothers were instructed to play with their child as naturally as possible. However, it is not clear whether videotaped interaction behavior is a reliable measurement of normal maternal behavior in everyday life or whether the camera influenced their behavior. Second, we only had information on mother-child interaction when the children were 2 years old. Further measurements of mother-child interactions, especially in preschool years, would generate more information about how interaction behavior changes and affects vocabulary development. Third, the variance of maternal education was relatively limited in our sample, and the mean level was high. A sample that is characterized by a lower SES level might provide more information on how SES, in particular maternal education, and vocabulary development are related. Fourth, previous studies have shown potential bidirectional associations between maternal interaction behavior and child language (Mimeau et al. 2020; Song et al. 2014), which we considered by controlling for child vocabulary at the age of 2 years. Future research should also explicitly address the possible effects of children's language on later maternal interaction behavior which, in turn, also affects children's further vocabulary development.

In sum, the findings demonstrate differentiated effects of specific aspects of maternal interaction behavior with respect to children's vocabulary development. While general aspects of maternal interaction behavior, such as the quantity and complexity of linguistic stimulation, are relevant in the earlier stages of vocabulary development, cognitively stimulating language input, as a more specific aspect of maternal input, is an important predictor in later stages of vocabulary development. More research is needed to better understand the mechanisms between cognitive stimulation and vocabulary growth in preschool years. Therefore, other relevant variables, such as the interactions of children with their peers, parents, and teachers, should also be considered.

Supplementary Information The online version of this article (https://doi.org/10.1007/s11618-022-01114-y) contains supplementary material, which is available to authorized users.

Funding This research was funded by the grant WE 1478/11 from the German Research Foundation (DFG)—Priority Programme 1646: "*Education as a Lifelong Process. Analyzing Data of the National Educational Panel Study (NEPS)*".

Funding Open Access funding enabled and organized by Projekt DEAL.

Conflict of interest D. Möwisch, K. Konrad-Ristau and S. Weinert declare that they have no competing interests.

References

Aktas, M. (2020). Voraussetzungen und Bedingungen eines erfolgreichen Spracherwerbs. In S. Sachse, A.-K. Bockmann & A. Buschmann (Eds.), *Sprachentwicklung: Entwicklung – Diagnostik – Förderung im Kleinkind- und Vorschulalter* (pp. 45–64). Berlin: Springer.

Anderka, A. (2018). *Elterliches Sprachangebot und vorschulischer Spracherwerb: eine empirische Analyse zu Zusammenhängen und sozialen Disparitäten*. Münster: Waxmann.

Arriaga, R.I., Fenson, L., Cronan, T., & Pethick, S.J. (1998). Scores on the MacArthur Communicative Development Inventory of children from lowand middle-income families. *Applied Psycholinguistics*, *19*(2), 209–223. https://doi.org/10.1017/S0142716400010043.

Baddeley, A., Gathercole, S., & Papagno, C. (1998). The phonological loop as a language learning device. *Psychological Review*, *105*(1), 158–173. https://doi.org/10.1037/0033-295X.105.1.158.

Bartsch, K., & Wellman, H.M. (1995). *Children talk about the mind*. New York: Oxford University Press.

Bates, E., Marchman, V., Thal, D., Fenson, L., Dale, P., Reznick, J.S., Reilly, J., & Hartung, J. (1994). Developmental and stylistic variation in the composition of early vocabulary. *Journal of Child Language*, *21*(1), 85–123. https://doi.org/10.1017/s0305000900008680.

Baumann, J.F. (2008). Vocabulary and reading comprehension: the nexus of meaning. In S.E. Israel & G.G. Duffy (Eds.), *Handbook of research on reading comprehension* (pp. 323–346). New York: Routledge. https://doi.org/10.4324/9781315759609.

Bialystok, E., Barac, R., Blaye, A., & Poulin-Dubois, D. (2010). Word mapping and executive functioning in young monolingual and bilingual children. *Journal of Cognition and Development*, *11*(4), 485–508. https://doi.org/10.1080/15248372.2010.516420.

Bockmann, A.-K., Sachse, S., & Buschmann, A. (2020). Sprachentwicklung im Überblick. In S. Sachse, A.-K. Bockmann & A. Buschmann (Eds.), *Sprachentwicklung: Entwicklung – Diagnostik – Förderung im Kleinkind- und Vorschulalter* (pp. 3–44). Berlin: Springer.

Bornstein, M.H. (2017). The specificity principle in acculturation science. *Perspectives on Psychological Science*, *12*(1), 3–45. https://doi.org/10.1177/1745691616655997.

Bornstein, M.H., Haynes, M.O., & Painter, K.M. (1998). Sources of child vocabulary competence: a multivariate model. *Journal of Child Language*, *25*(2), 367–393. https://doi.org/10.1017/s0305000998003456.

Bornstein, M.H., Hahn, C.-S., & Haynes, O.M. (2004). Specific and general language performance across early childhood: stability and gender considerations. *First Language*, *24*(3), 267–304. https://doi.org/10.1177/0142723704045681.

Borovsky, A., & Elman, J. (2006). Language input and semantic categories: a relation between cognition and early word learning. *Journal of Child Language*, *33*(4), 759–790. https://doi.org/10.1017/S0305000906007574.

Bowerman, M., & Levinson, S.C. (2001). *Language acquisition and conceptual development*. Cambridge: Cambridge University Press.

Bradley, R.H., & Corwyn, R.F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, *53*(1), 371–399.

Bretherton, I., & Beeghly, M. (1982). Talking about internal states: the acquisition of an explicit theory of mind. *Developmental Psychology*, *18*(6), 906–921. https://doi.org/10.1037/0012-1649.18.6.906.

Bronfenbrenner, U., & Morris, P.A. (2006). The bioecological model of human development. In R.M. Lerner (Ed.), *Handbook of child psychology. Theoretical models of human development* 6th edn. (Vol. 1, pp. 793–828). Hoboken: John Wiley & Sons.

Byers-Heinlein, K., & Fennell, C.T. (2014). Perceptual narrowing in the context of increased variation: Insights from bilingual infants. *Developmental Psychobiology*, *56*(2), 274–291. https://doi.org/10.1002/dev.21167.

Carpenter, M., Nagell, K., Tomasello, M., Butterworth, G., & Moore, C. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, *63*(4), 1–174.

Conway, L. J., Levickis, P. A., Mensah, F., McKean, C., Smith, K., & Reilly, S. (2017). Associations between expressive and receptive language and internalizing and externalizing behaviours in acommunity-based prospective study of slow-to-talk toddlers. *International Journal of Language and Communication Disorders*, *52*(6), 839–853. https://doi.org/10.1111/1460-6984.12320.

Curenton, S. M., & Justice, L. M. (2004). African American and Caucasian preschoolers' use of decontextualized language: literate language features in oral narratives. *Language, Speech, and Hearing Services in Schools*, *35*, 240–253. https://doi.org/10.1044/0161-1461(2004/023).

Ebert, S. (2011). *Was Kinder über die mentale Welt wissen – Die Entwicklung von deklarativem Metagedächtnis aus der Sicht der „Theory of Mind"*. Bamberg: Otto-Friedrich-Universität Bamberg.

Ebert, S., Lockl, K., Weinert, S., Anders, Y., Kluczniok, K., & Rossbach, H.-G. (2013). Internal and external influences on vocabulary development in preschool children. *School Effectiveness and School Improvement*, *24*(2), 138–154. https://doi.org/10.1080/09243453.2012.749791.

Farkas, G., & Beron, K. (2004). The detailed age trajectory of oral vocabulary knowledge: differences by class and race. *Social Science Research*, *33*(3), 464–497. https://doi.org/10.1016/j.ssresearch.2003.08.001.

Fennell, C. T., Byers-Heinlein, K., & Werker, J. F. (2007). Using speech sounds to guide word learning: the case of bilingual infants. *Child Development*, *78*(5), 1510–1525. https://doi.org/10.1111/j.1467-8624.2007.01080.x.

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., Tomasello, M., Mervis, C. B., & Stiles, J. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development*, *59*, 1–185. https://doi.org/10.2307/1166093.

Fernald, A., & Marchman, V. A. (2011). Causes and consequences of variability in early language learning. In I. Arnon & E. V. Clark (Eds.), *Experience, variation and generalization: learning a first language* (pp. 181–202). Amsterdam: John Benjamins. https://doi.org/10.1075/tilar.7.11fer.

Gathercole, S. E. (2006). Nonword repetition and word learning: The nature of the relationship. *Applied Psycholinguistics*, *27*(4), 513–543. https://doi.org/10.1017/S0142716406060383.

Gathercole, S. E., Willis, C. S., Emslie, H., & Baddeley, A. D. (1992). Phonological memory and vocabulary development during the early school years: a longitudinal study. *Developmental Psychology*, *28*(5), 887–898. https://doi.org/10.1037/0012-1649.28.5.887.

Gleitman, L. (1990). The structural sources of verb meanings. *Language Acquisition: A Journal of Developmental Linguistics*, *1*(1), 3–55. https://doi.org/10.1207/s15327817la0101_2.

Grimm, H. (2012). *Störungen der Sprachentwicklung: Grundlagen – Ursachen – Diagnose Intervention – Prävention*. Göttingen: Hogrefe.

Grimm, H., & Doil, H. (2006). *Die Elternfragebögen für die Früherkennung von Risikokindern (ELFRA)*. Göttingen: Hogrefe.

Grimm, H., & Weinert, S. (2002). Sprachentwicklung. In R. Oerter & L. Montada (Eds.), *Entwicklungspsychologie: Ein Lehrbuch* (5th edn., pp. 517–550). Weinheim: Beltz.

Gopnick, A., & Meltzoff, A. (1987). The development of categorization in the second year and its relation to other cognitive and linguistic developments. *Child Development*, *58*(6), 1523–1531. https://doi.org/10.2307/1130692.

Hart, B., & Risley, T. R. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore: P. H. Brookes.

Heath, S. B. (1982). What no bedtime story means: narrative skills at home and school. *Language in Society*, *11*(1), 49–76. https://doi.org/10.1017/S0047404500009039.

Heppt, B., Stanat, P., Dragon, N., Berendes, K., & Weinert, S. (2014). Bildungssprachliche Anforderungen und Hörverstehen bei Kindern mit deutscher und nicht-deutscher Familiensprache. *Zeitschrift für Pädagogische Psychologie*, *28*(3), 139–149. https://doi.org/10.1024/1010-0652/a000130.

Hoff, E. (2003). The specificity of environmental influence: Socioeconomic status affects early vocabulary development via maternal speech. *Child Development*, *74*(5), 1368–1378. https://doi.org/10.1111/1467-8624.00612.

Hoff, E. (2006). How social contexts support and shape language development. *Developmental review*, *26*(1), 55–88. https://doi.org/10.1016/j.dr.2005.11.002.

Hoff, E. (2008). *Language development* (4th edn.). Belmont: Wadsworth.

Hoff, E., & Naigles, L. (2002). How children use input to acquire a lexicon. *Child Development*, *73*(2), 418–433. https://doi.org/10.1111/1467-8624.00415.

Hoff-Ginsberg, E. (1985). Some contributions of mothers' speech to their children's syntactic growth. *Journal of Child Language*, *12*(2), 367–385. https://doi.org/10.1017/S0305000900006486.

Hu, L.-T., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118.

Hurtado, N., Marchman, V.A., & Fernald, A. (2008). Does input influence uptake? Links between maternal talk, processing speed and vocabulary size in Spanish-learning children. *Developmental Science*, *11*(6), F31–F39. https://doi.org/10.1111/j.1467-7687.2008.00768.x.

Huttenlocher, J., Haight, W., Bryk, A., Seltzer, M., & Lyons, T. (1991). Early vocabulary growth: relation to language input and gender. *Developmental Psychology*, *27*(2), 236–248. https://doi.org/10.1037/0012-1649.27.2.236.

Huttenlocher, J., Vasilyeva, M., Cymerman, E., & Levine, S. (2002). Language input and child syntax. *Cognitive psychology*, *45*(3), 337–374. https://doi.org/10.1016/S0010-0285(02)00500-5.

Huttenlocher, J., Waterfall, H., Vasilyeva, M., Vevea, J., & Hedges, L.V. (2010). Sources of variability in children's language growth. *Cognitive Psychology*, *61*(4), 343–365. https://doi.org/10.1016/j.cogpsych.2010.08.002.

Johnson, C.N., & Maratsos, M.P. (1977). Early comprehension of mental verbs: think and know. *Child Development*, *48*(4), 1743–1747. https://doi.org/10.2307/1128549.

Johnson, C.N., & Wellman, H.M. (1980). Children's developing understanding of mental verbs: remember, know, and guess. *Child Development*, *51*(4), 1095–1102. https://doi.org/10.2307/1129549.

Klann-Delius, G. (1981). Sex and language acquisition-Is there any influence? *Journal of Pragmatics*, *5*(1), 1–25. https://doi.org/10.1016/0378-2166%2881%2990043-6.

Kluczniok, K., Lehrl, S., Kuger, S., & Rossbach, H.-G. (2013). Quality of the home learning environment during preschool age–Domains and contextual conditions. *European Early Childhood Education Research Journal*, *21*(3), 420–438. https://doi.org/10.1080/1350293X.2013.814356.

Leaper, C., Anderson, K.J., & Sanders, P. (1998). Moderators of gender effects on parents' talk to their children: a meta-analysis. *Developmental Psychology*, *34*(1), 3–27. https://doi.org/10.1037/0012-1649.34.1.3.

Lehrl, S., Ebert, S., Roßbach, H.-G., & Weinert, S. (2012). Die Bedeutung der familiären Lernumwelt für Vorläufer schriftsprachlicher Kompetenzen im Vorschulalter. *Journal of Family Research*, *24*(2), 115–133. https://doi.org/10.20377/jfr-181.

Lenhard, A., Lenhard, W., Segerer, R., & Suggate, S. (2015). *Peabody Picture Vocabulary Test-Revision IV (Deutsche Adaption)*. Frankfurt a. M: Pearson Assessment.

Linberg, A., Mann, D., Attig, M., Vogel, F., Weinert, S., & Roßbach, H.-G. (2019). *Assessment of interactions with the macro-analytic rating system of parent-child-interactions in the NEPS at the child's age of 7, 17, and 26 months*. Bamberg: Leibniz Institute for Educational Trajectories.

MacLeod, A.A.N., Castellanos-Ryan, N., Parent, S., Jacques, S., & Séguin, J.R. (2018). Modelling vocabulary development among multilingual children prior to and following the transition to school entry. *International Journal of Bilingual Education and Bilingualism*. https://doi.org/10.1080/13670050.2016.1269718.

Mancilla-Martinez, J., & Lesaux, N.K. (2011). The gap between Spanish speakers' word reading and word knowledge: a longitudinal study. *Child Development*, *82*(5), 1544–1560. https://doi.org/10.1111/j.1467-8624.2011.01633.x.

Markman, E.M. (1989). *Categorization and naming in children: problems of induction*. Cambridge: MIT Press, Bradford Books.

Melchers, P., & Preuß, P. (2009). *Kaufman Assessment Battery for Children (K-ABC)* (8th edn., German Version). Frankfurt: Pearson Assessment.

Mimeau, C., Cantin, É., Tremblay, R.E., Boivin, M., & Dionne, G. (2020). The bidirectional association between maternal speech and child characteristics. *Journal of Child Language*, *47*(2), 435–456. https://doi.org/10.1017/s0305000919000539.

Moore, C., Bryant, D., & Furrow, D. (1989). Mental terms and the development of certainty. *Child Development*, *60*(1), 167–171. https://doi.org/10.2307/1131082.

Moyle, M.J., Weismer, S.E., Evans, J.L., & Lindstrom, M.J. (2007). Longitudinal relationships between lexical and grammatical development in typical and late-talking children. *Journal of Speech, Language, and Hearing Research*, *50*, 508–528. https://doi.org/10.1044/1092-4388(2007/035).

Murphy, G.L., & Lassaline, M.E. (1997). Hierarchical structure in concepts and the basic level of categorization. In K. Lamberts & D. Shanks (Eds.), *Knowledge, concepts, and categories* (pp. 93–132). Cambridge: MIT Press.

Muthén, L.K., & Muthén, B.O. (2017). *Mplus User's Guide* (8th edn.). Los Angeles: Muthén & Muthén.

Owens, R.E. (2019). *Language development: an introduction.*

Pan, B. A., Rowe, M. L., Singer, J. D., & Snow, C. E. (2005). Maternal correlates of growth in toddler vocabulary production in low-income families. *Child Development*, *76*(4), 763–782. https://doi.org/10.1111/j.1467-8624.2005.00876.x.

Papafragou, A., Cassidy, K., & Gleitman, L. (2007). When we think about thinking: the acquisition of belief verbs. *Cognition*, *105*(1), 125–165. https://doi.org/10.1016/j.cognition.2006.09.008.

Ramey, C. T., & Ramey, S. L. (2004). Early learning and school readiness: Can early intervention make a difference? *Merrill-Palmer Quarterly*, *50*(4), 471–491. https://doi.org/10.1353/mpq.2004.0034.

Rowe, M. L. (2012). A longitudinal investigation of the role of quantity and quality of child-directed speech in vocabulary development. *Child Development*, *83*(5), 1762–1774. https://doi.org/10.1111/j.1467-8624.2012.01805.x.

Rowe, M. L. (2015). Input versus intake—a commentary on Ambridge, Kidd, Rowland, and Theakson's 'The ubiquity of frequency effects in first language acquisition. *Journal of Child Language*, *42*(2), 301–305. https://doi.org/10.1017/S030500091400066X.

Rowe, M. L., Raudenbush, S. W., & Goldin-Meadow, S. (2012). The pace of vocabulary growth helps predict later vocabulary skill. *Child Development*, *83*(2), 508–525. https://doi.org/10.1111/j.1467-8624.2011.01710.x.

Rowe, M. L., Leech, K. A., & Cabrera, N. (2017). Going beyond input quantity: wh-questions matter for toddlers' language and cognitive development. *Cognitive Science*, *41*, 162–179. https://doi.org/10.1111/cogs.12349.

Satorra, A., & Bentler, P. M. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika*, *66*(4), 507–514. https://doi.org/10.1007/BF02296192.

Schneider, T., & Linberg, T. (2022). Development of socio-economic gaps in children's language skills in Germany. *Longitudinal and Life Course Studies*, *13*(1), 87–120. https://doi.org/10.1332/175795921X16233448663756.

Seidl, A., Hollich, G., & Jusczyk, P. W. (2003). Early understanding of subject and object wh-questions. *Infancy*, *4*(3), 423–436. https://doi.org/10.1207/S15327078IN0403_06.

Sigel, I. E. (2002). The psychological distancing model: a study of the socialization of cognition. *Culture & Psychology*, *8*(2), 189–214. https://doi.org/10.1177/13567X02008002438.

Sigel, I. E., McGillicuddy-DeLisi, A. V., & Johnson, J. E. (1980). *Parental distancing, beliefs and children's representational competence within the family context*. Princton: Educational Testing Service. https://doi.org/10.1002/j.2333-8504.1980.tb01215.x.

Song, L., Spier, E. T., & Tamis-LeMonda, C. S. (2014). Reciprocal influences between maternal language and children's language and cognitive development in low-income families. *Journal of Child Language*, *41*(2), 305–326. https://doi.org/10.1017/S0305000912000700.

Tamis-LeMonda, C. S., Bornstein, M. H., & Baumwell, L. (2001). Maternal responsiveness and children's achievement of language milestones. *Child Development*, *72*(3), 748–767. https://doi.org/10.1111/1467-8624.00313.

Tamis-LeMonda, C. S., Kuchirko, Y., & Song, L. (2014). Why is infant language learning facilitated by parental responsiveness? *Current Directions in Psychological Science*, *23*(2), 121–126. https://doi.org/10.1177/0963721414522813.

United Nations Educational, Scientific, and Cultural Organization (UNESCO) (2012). *International standard classification of education ISCED 2011*. Montreal: UNESCO Institute for Statistics.

Vasilyeva, M., & Waterfall, H. (2011). Variability in language development: relation to socioeconomic status and environmental input. In S. B. Neuman & D. K. Dickinson (Eds.), *Handbook of early literacy research* (3rd edn., pp. 358–372). New York: Guilford.

Waber, D. P. (1976). Sex differences in cognition: a function of maturation rate? *Science*, *192*(4239), 572–574. https://doi.org/10.1126/science.1257795.

Weber, C., Hahne, A., Friedrich, M., & Friederici, A. D. (2004). Discrimination of word stress in early infant perception: electrophysiological evidence. *Cognitive Brain Research*, *18*(2), 149–161. https://doi.org/10.1016/j.cogbrainres.2003.10.001.

Weinert, S. (in press). Language and cognition. In J. Law, S. Reily & C. McKean (Eds.), *Language development: individual differences in a social context*. Cambridge: Cambridge University Press.

Weinert, S. (2000). Beziehungen zwischen Sprach- und Denkentwicklung. In H. Grimm (Ed.), *Sprachentwicklung* (Enzyklopädie der Psychologie C/III/3, pp. 311–361). Göttingen: Hogrefe.

Weinert, S. (2004). Wortschatzerwerb und kognitive Entwicklung. *Sprache-Stimme-Gehör*, *28*(01), 20–28. https://doi.org/10.1055/s-2004-815480.

Weinert, S. (2020). Sprachentwicklung im Kontext anderer Entwicklungsbereiche. In S. Sachse, A.-K. Bockmann & A. Buschmann (Eds.), *Sprachentwicklung: Entwicklung – Diagnostik – Förderung im Kleinkind- und Vorschulalter* (pp. 131–162). Berlin: Springer.

Weinert, S., & Ebert, S. (2013). Spracherwerb im Vorschulalter: Soziale Disparitäten und Einflussvariablen auf den Grammatikerwerb. *Zeitschrift für Erziehungswissenschaft*, *16*(2), 303–332. https://doi.org/10.1007/s11618-013-0354-8.

Weinert, S., & Ebert, S. (2017). Verlaufsmerkmale und Wirkfaktoren der frühen kognitiv-sprachlichen Entwicklung – Ergebnisse aus der BiKS-3-10 Studie. In V. Mall, F. Voigt & N. H. Jung (Eds.), *Entwicklungsstörungen und Chronische Erkrankungen: Diagnose, Behandlungsplanung und Familienbegleitung* (pp. 13–33). Lübeck: Schmid-Römhild Verlag.

Weinert, S., & Grimm, H. (2018). Sprachentwicklung. In W. Schneider & U. Lindenberger (Eds.), *Entwicklungspsychologie* (8th edn., pp. 445–470). Weinheim: Beltz.

Weinert, S., Ebert, S., Lockl, K., & Kuger, S. (2012). Disparitäten im Wortschatzerwerb: Zum Einfluss des Arbeitsgedächtnisses und der Anregungsqualität in Kindergarten und Familie auf den Erwerb lexikalischen Wissens. *Unterrichtswissenschaft*, *40*, 4–25.

Weinert, S., Linberg, A., Attig, M., Freund, J.-D., & Linberg, T. (2016). Analyzing early child development, influential conditions, and future impacts: Prospects of a German newborn cohort study. *International Journal of Child Care and Education Policy*, *10*(1), 1–20. https://doi.org/10.1186/s40723-016-0022-6.

Weizman, Z. O., & Snow, C. E. (2001). Lexical output as related to children's vocabulary acquisition: effects of sophisticated exposure and support for meaning. *Developmental Psychology*, *37*(2), 265–279. https://doi.org/10.1037/0012-1649.37.2.265.

Zhang, Y., Jin, X., Shen, X., Zhang, J., & Hoff, E. (2008). Correlates of early language development in Chinese children. *International Journal of Behavioral Development*, *32*(2), 145–151. https://doi.org/10.1177/0165025407087213.