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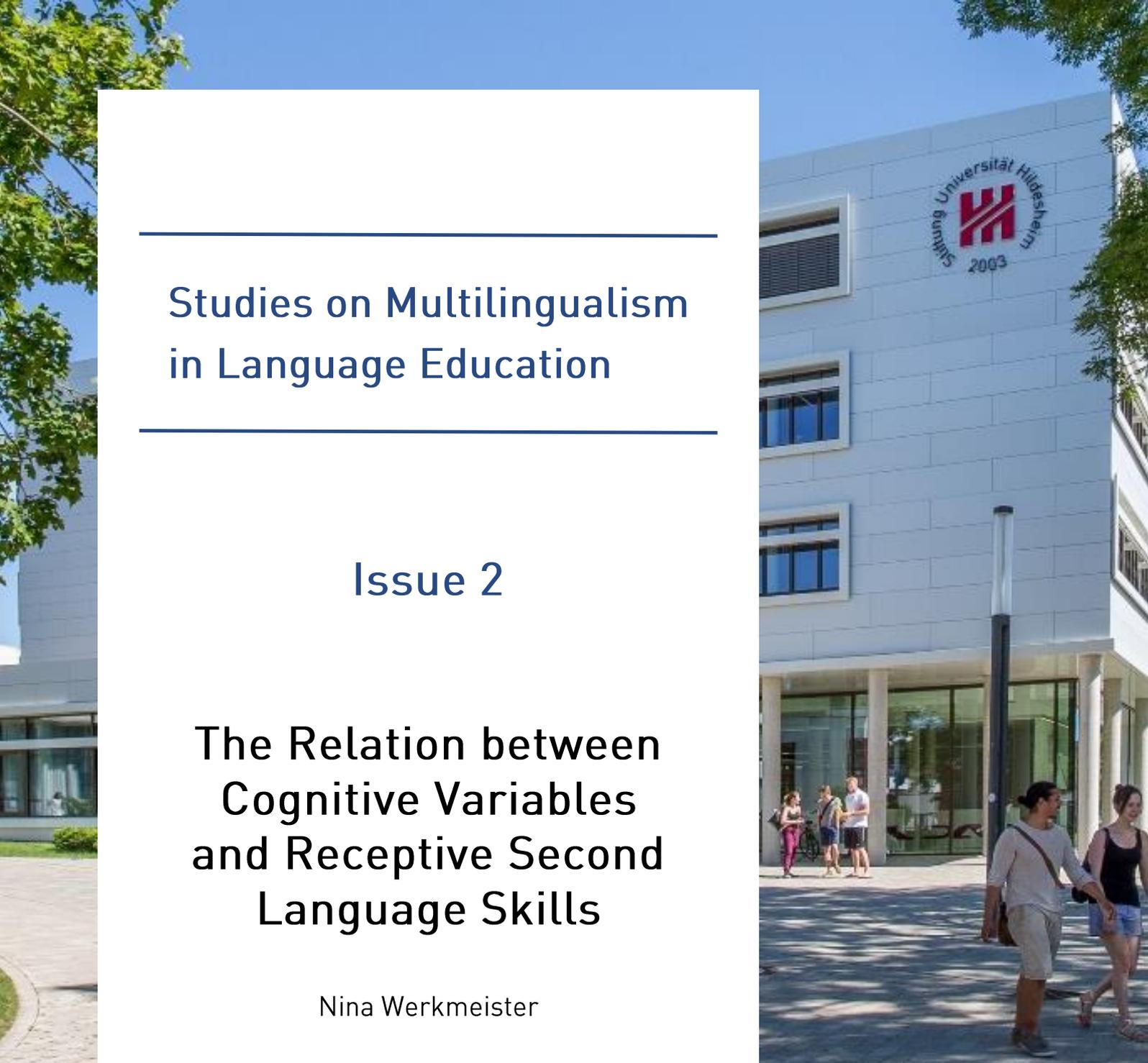
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The Relation between Cognitive Variables and Receptive Second Language Skills

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List of Abbreviations

BPVS = British Picture Vocabulary Scale

BUEGA = Basisdiagnostik Umschriebener Entwicklungsstörungen im Grundschulalter

ELIAS = Early Language and Intercultural Acquisition Studies

L1 = first language

L2 = second language

L3 = third language

NI = nonverbal intelligence

PA = phonological awareness

P-ITPA = Potsdam-Illinois Test für Psycholinguistische Fähigkeiten

PSTM = phonological short-term memory

PPVT = Peabody Picture Vocabulary Test

RPM = Raven Progressive Matrices

SET 5-10 = Sprachstandserhebungstest für Kinder im Alter zwischen 5 und 10 Jahren

SLA = second language acquisition

SMILE = Studies on Multilingualism In Language Education

WISC-IV = Wechsler Intelligence Scale for Children – Fourth Edition

WM = working memory

1 Introduction

Nowadays “in our modern society of large-scale migration [and, N.W.] international markets and finance” (de Groot, 2011:1) the necessity of being able to speak more than one language has become a reality for the majority of the world population (Service, 2006:i). Since “economies, education, and societies grow still more interconnected” (Dale, Harlaar & Plomin, 2012:29), foreign language competencies are considered “part of the core of skills” (Commission of the European Communities, 2003:7) that are necessary “for training, employment, cultural exchange and personal fulfilment” (ibid.). Consequently, for both society and the individual, learning a second language¹ (L2) can be regarded as “an investment for the future” (Service, 2006:i; see also Commission of the European Communities, 2003:3). Thus, great importance should be attached to the promotion of language learning.

What has very often been reported, however, is that – in contrast to first language (L1) acquisition, which usually “leads to native speaker ability” (Robinson, 2002b:122), with relatively little “variation in rate of progress” (ibid.; see also Breen, 2007:2; Dörnyei, 2009:179) – second language acquisition² (SLA) is characterized by great differences in rate of acquisition and ultimate attainment between different individuals (Roberts & Meyer, 2012:1; Robinson, 2002c:ix; Dale et al., 2012:29; van Hell & Tanner, 2012:148; Ortega, 2009:145; Biedroń & Szczepaniak, 2009:55). Even under similar learning conditions, success in learning an L2 varies remarkably (Roberts & Meyer, 2012:1; Dewaele, 2013:624), which leads to the question of what might be the reasons for this variability.

Answering this question not only has important theoretical implications by providing “useful constraints on the theories of L2 learning” (Miyake & Friedman, 1998:339f.) but also is important for practical reasons because a prerequisite for predicting an individual’s language learning development and for optimizing SLA is to understand which individual differences contribute in which way to different learning outcomes (Sawyer & Ranta, 2001:319, 349; Miyake & Friedman, 1998:339f.; Roberts & Meyer, 2012:1). So far, a large number of individual learner variables have been identified in this context (Dewaele, 2013:625ff.; Hufeisen 2003:99ff.; Kempe & Brooks, 2011:15; Sparks & Ganschow, 2001:95ff.; Dörnyei & Skehan, 2003:589ff.). Even though these variables are often classified and labelled differently by different researchers, which makes a comparison and synthesis of different studies difficult, one main domain that has been identified as being influential in SLA is cognition. This might not be a surprise since “to be comprehended, produced and/or acquired, language must be cognitively processed” (Doughty, 2001:211; see also Miyake &

¹Unless stated otherwise, the term *second language* is used synonymously with *foreign language*.

²The term *second language acquisition* refers to both instructed and naturalistic second language acquisition in the present paper.

Friedman, 1998:340). It is less obvious, however, which exact cognitive factors are related to which aspects of language learning and how they are linked exactly. Several studies have investigated this relationship over the last few years, but many questions have remained unanswered and different results have been found (see chapter 2.2.3, 2.2.4, 2.3.3, 2.4.3). Moreover, studies investigating “individual differences in acquisition” (Paradis, 2011:213) have mostly focused on “monolingual child first language learners and adult second language learners” (ibid.), but much less studies have dealt with individual differences in child SLA (ibid.).

In order to shed light on the relation between cognition and child SLA, a quantitative study with German-speaking primary school pupils who learned English as a foreign language at school was conducted and will be presented in the current research paper. As it would go beyond the scope of this work to include all the cognitive factors that have been linked to L2 skills so far, certain cognitive variables which seem to be especially important were chosen for the study. These comprised working memory (WM), phonological short-term memory (PSTM) and phonological awareness (PA) as well as nonverbal intelligence (NI). Furthermore, the study focused on the relation between these cognitive variables and two receptive L2 skills, namely receptive grammar and vocabulary skills, which were operationalized as receptive grammar and vocabulary knowledge as measured by respective tests. Thus, the main objective of this study was to answer the question of whether the four chosen cognitive variables WM, PSTM, PA and NI are related to primary school pupils’ receptive English grammar and vocabulary knowledge and if so, in which way.

Before the findings of the study are presented, firstly, a very brief overview of the subject of cognition in SLA will be given in the following chapter. Afterwards, the four chosen cognitive variables WM, PSTM, PA and NI will be described and reasons for their relevance to SLA will be given. Moreover, previous research findings on the links between these cognitive factors and receptive L2 skills will be reported. In order to give a more comprehensive picture, not only findings on grammar and vocabulary comprehension but also findings on listening and reading comprehension will be included in this part of the paper, especially with regard to WM and PSTM. Following the theoretical overview, the empirical study on the relation between primary school pupils’ receptive English grammar and vocabulary skills and cognitive variables will be presented. Firstly, the hypotheses that underlay the study and that were formulated on the basis of the reported previous research findings are going to be stated. Afterwards, the sample and the research instruments will be described. Moreover, the results of correlational as well as regression analyses that were performed on the data will be presented. Following this chapter, the results will be discussed against the background of the hypotheses and the reported findings of previous studies. At the end a brief conclusion will be drawn.

It should be noted that the study that will be presented is part of a larger research project that not only attempts to gather data about the children's cognitive abilities but also aims to provide a comprehensive picture of the factors that might influence English learning at primary school in Germany. For instance, information about the children's socio-economic status, their motivation as well as about the English input that the children receive at school is gathered.

2 Theoretical Background

2.1 Second Language Acquisition (SLA) and Cognition

According to Long and Richards (2001:vii),

[s]econd language acquisition is first and foremost a mental process – one that occurs in a behavioural and social context, to be sure, but fundamentally a matter of acquiring a new knowledge system.

Consequently, cognition is regarded crucial for SLA (ibid.) and it is assumed that “[t]he learning and use of a second language [...] draws on a range of cognitive processes” (Juffs & Harrington, 2011:137). This view is also related to the fact that SLA “comes at a later stage in life” (Wen, 2014:175) than L1 acquisition and might thus “rely to a greater extent [...] on general learning mechanisms and principles” (Miyake & Friedman, 1998:340).

Originally, in the context of SLA and cognition, a concept termed *foreign language aptitude* received special attention (Dörnyei, 2005:33). In general, the term *foreign language aptitude* does not refer to “a unitary factor but rather a complex of” (ibid.:34) different cognitive factors that determine “the learner’s overall capacity to master a foreign language” (ibid.:33f.)³. Since the 1920s different tests that were supposed to measure language aptitude were developed and on the basis of these tests the constituents of foreign language aptitude were distilled (ibid.:34, 36, 39). Depending on the test and the researcher, the construct of language aptitude could thus contain different abilities even though the constructs that were derived from the foreign language aptitude tests that had received the most attention, the *Modern Language Aptitude Test* by Carroll and Sapon (1959) and the *Pimsleur Language Aptitude Battery* by Pimsleur (1966), shared “some common features” (Dörnyei, 2005:40; ibid.:35, 39, 40). While Pimsleur’s (1966) language aptitude construct consisted of three components, Carroll (1981) identified four factors (Dörnyei, 2005:39, 40): One constituent was phonetic coding ability, which referred to the ability to code, assimilate and remember phonetic material (Dörnyei, 2005:39); another one was grammatical sensitivity, which referred to the capacity to identify “the grammatical functions of words (or other linguistic entities) in sentence structures” (Carroll, 1981:105, cited in Dörnyei, 2005:39). A further factor was rote learning ability, the ability “to

³ It should be noted, however, that different definitions of foreign language aptitude exist (Dewaele, 2013:625) and that some researchers, for instance Pimsleur (1966), included not only cognitive abilities but also further factors such as motivation (Dörnyei, 2005:40). The inclusion of such factors, however, has received criticism (ibid.).

form links in memory” (Skehan, 2002:71), and the fourth component was inductive language learning ability, which was the ability to induce rules or patterns from language input (Dörnyei, 2005:40). Some years later Skehan (1989), on the basis of a research project which investigated Carroll’s language aptitude construct, suggested a similar construct of language aptitude. It differed, however, from Carroll’s construct insofar as grammatical sensitivity and inductive language learning ability were conflated into one ability that was termed linguistic ability (Dörnyei, 2005:40f.).

Since then new research directions and perspectives have developed (ibid.:50). What all these directions and perspectives have in common is that “they examine the impact of various *specific* cognitive [...] factors and subprocesses [...] in detail, going thus beyond the use of the language aptitude metaphor as an umbrella term” (ibid., emphasis in original). Cognitive variables that have been investigated in the context of SLA so far include, for instance, NI and PA (e.g. Kempe & Brooks, 2011; Engel de Abreu & Gathercole, 2012). Moreover, WM is considered especially promising (Miyake & Friedman, 1998:339; Skehan, 2002:90). A comparison of the cognitive variables WM, NI and PA with Carroll’s foreign language aptitude construct reveals that these variables are quite similar to the components that Carroll identified. Consequently, it is likely that they are related to L2 learning.

In the following chapters, the aforementioned cognitive variables will be described and after each description of one of the cognitive variables reasons for the relevance of the respective cognitive variable to SLA as well as an overview of previous research findings will be given.

2.2 Working Memory

2.2.1 Definition

One factor that plays a major role in complex cognition is WM (Shah & Miyake, 1999:1; Dörnyei, 2005:55). WM can be defined as

the theoretical construct that has come to be used in cognitive psychology to refer to the system or mechanism underlying the maintenance of task-relevant information during the performance of a cognitive task (Shah & Miyake, 1999:1).

Consequently, “it underpins our capacity for thinking and has important specific implications for language processing” (Dörnyei, 2005:55). The term arose “in the early 1970’s” (French, 2006:12) and “evolved from the earlier concept of short-term memory” (Baddeley, 2012:4). While short-term memory is generally considered “to have a passive storage function” (Sawyer & Ranta, 2001:340), WM is usually considered to comprise “both temporary storage and ongoing processing functions” (ibid.). It should be noted, however, that both expressions are still sometimes used interchangeably (Baddeley, 2012:4) and that several different theoretical models are labelled with the term *working memory* (Hasselhorn & Gold, 2006:73; Shah & Miyake, 1999:1; French, 2006:13). In general, “two broadly separate approaches [...], one British and one North American” (Martin &

Ellis, 2012:380), can be distinguished. The American literature is generally dominated by the idea that attention, short-term memory and long-term memory are closely interlinked (Hasselhorn & Gold, 2006:73; Ortega, 2009:90) and WM is regarded as a unitary “executive system responsible for both storage and processing functions” (French, 2006:14; see also Li, 2013:638). In the European tradition, in contrast, a model of WM as a “more differentiated system with domain-specific” (Dang, Braeken, Ferrer & Liu, 2012:499) sub-components, which was developed by Baddeley and colleagues, has prevailed (Hasselhorn & Gold, 2006:73).

Despite the different models of WM, one aspect that definitions used by different authors in the context of (S)LA often have in common is that WM is regarded as capacity or ability to both mentally store and manipulate or process information simultaneously (Martin & Ellis, 2012:380; Michalczyk, Krajewski, Preßler & Hasselhorn, 2013:410; Wen, 2014:174; Vulchanova, Foyn, Nilsen & Sigmundsson, 2014:87; Li, 2013:637f.; Ortega, 2009:90; Harrington & Sawyer, 1992:25; Osaka & Osaka, 1992:287) and that the respective information is relevant to a cognitive task (Martin & Ellis, 2012:380; Kempe & Brooks, 2011:17; Shah & Miyake, 1999:1). Moreover, there is often a reference to time insofar as it is mentioned that the information is not stored and manipulated permanently but “over short periods of time” (Michalczyk et al., 2013:410; see also Wen, 2014:174; Ortega, 2009:90; Juffs & Harrington, 2011:137). This time limitation is linked to one of the main characteristics of WM (Ortega, 2009:90), which – although often not explicitly stated – underlies most studies that investigate the relation between WM and language acquisition: Unlike long-term memory, “working memory is of limited capacity” (ibid.; see also French, 2006:3, 13; Henry, 2012:2). For instance, “under normal conditions information can be remembered in working memory for about two seconds only” (Ortega, 2009:90) and “if tasks demands exceed the available resources in working memory, storage and processing functions will suffer” (French, 2006:13).

In spite of the popularity of the view of WM as a unitary system in North-America (Hasselhorn & Gold, 2006:73), according to French (2006:14f.) and Kormos and Sáfár (2008:262), “the most widely accepted conceptualization” (ibid.) of WM today is the one by Baddeley and Hitch. This statement seems to be in line with studies and descriptions of WM in the context of language acquisition since these also often seem to refer to a multi-componential system of WM as developed by Baddeley and his colleagues⁴ (Gathercole, Willis, Emslie & Baddeley, 1992:887; Dufva & Voeten, 1999: 332; Martin & Ellis, 2012:380ff.; de Groot, 2011:116).

The original WM model that Baddeley and Hitch proposed in 1974 was comprised of three components: the central executive and two so-called slave systems, namely the phonological loop and the visuospatial sketchpad (French, 2006:15; Dörnyei, 2005:56; Baddeley, 2012:6; de Groot, 2011:116; Gathercole & Baddeley, 1995:4; Kormos & Sáfár, 2008:262). Since then the model has

⁴ The present paper joins this tradition and also assumes that WM is a multi-componential system.

been revised and a further component has been added: the episodic buffer (Dörnyei, 2005:57; Henry, 2012:4; Kormos & Sáfár, 2008:262).

With reference to the two slave systems, it should be noted that the phonological loop is “a relatively modular system” (Baddeley, 2012:7) specialized for the storage of “speech-based information, and possibly purely acoustic information as well” (Henry, 2012:4; see also Gathercole & Baddeley, 1995:8). “It represents the storage system responsible for ‘phonological short-term memory’ (PSTM), the ability of individuals to remember small amounts of heard information over short periods of time” (Henry, 2012:4f.). Furthermore, “[i]t is [...] becoming increasingly clear that the loop can also provide a means of action control” (Baddeley, 2012:11) because it can be used for overt or sub-vocal self-instruction (*ibid.*).

The phonological loop consists of two subcomponents (Hasselhorn & Gold, 2006:77): a phonological store and a subvocal rehearsal mechanism (Hasselhorn & Gold, 2006:77; Gathercole & Baddeley, 1995:8). The phonological store holds verbal or acoustic information for short periods of time (Dörnyei, 2005:56; Gathercole & Baddeley, 1995:8) and is regarded “as ‘passive’, because it simply holds the information” (Henry, 2012:5). Moreover, its capacity is regarded as “limited [...] by how much information can be maintained” (Juffs & Harrington, 2011:139) and it is also time-limited insofar as the stored information decays rapidly: It can only be held for about one and a half to two seconds (Hasselhorn & Gold, 2006:77; Dörnyei, 2005:56). Here the second subcomponent of the phonological loop, the subvocal rehearsal mechanism, comes into play: It serves to refresh the information in the phonological store by reciting it (Henry, 2012:6; Gathercole et al., 1992:887), “in order to prevent this very rapid decay” (Henry, 2012:6). The verbal rehearsal “of the material re-enters it into the phonological store” (*ibid.*) and thus helps to hold information for longer periods of time (Hasselhorn & Gold, 2006:77). This is crucial, for instance, for understanding longer sentences as this requires remembering the beginning of the sentence when the sentence ends (*ibid.*). In addition, holding the information for longer periods of time also makes it available for further processing, which is of great significance as it has been shown “that the phonological loop interacts with long-term memory and plays an important role in the long-term learning of the phonological form of new words” (de Groot, 2011:117). Apart from keeping information in the phonological store, the rehearsal mechanism has a further function: “It is also used to recode non-phonological inputs such as printed words or pictures into their phonological form so that they can be held in the phonological store” (Gathercole & Baddeley, 1995:8).

The second slave system, the visuospatial sketchpad⁵, “is the visual equivalent of the phonological loop” (Dörnyei, 2005:56). It processes and stores “visual and spatial information, and [...]

⁵ As “there is little indication that this component of working memory plays a significant role in language” (Gathercole & Baddeley, 1995:17), only the main characteristics of the visuospatial sketchpad will be described.

verbal material that is subsequently encoded in the form of imagery” (Gathercole & Baddeley, 1995:17). Furthermore, it has been suggested that the visuospatial sketchpad can be divided “into a passive visual cache and an active spatially based rehearsal system called the inner scribe” (Baddeley & Logie, 1999:30). It should be noted, however, that, according to Baddeley (2012:13), “the precise nature of visuo-spatial rehearsal remains unclear.”

Both the described slave systems allow a sophisticated processing of certain types of information (Hasselhorn & Gold, 2006:80). In order to learn successfully, however, this is not enough because the slave systems and their processing capacities also have to be used in an effective manner (ibid.). Consequently, the supervision and control of the inputs and capacities of the whole WM as well as the adaption and regulation of the ongoing processes is necessary (ibid.). This is where the central executive comes into play: The central executive “has overall attentional control of the working memory system” (Henry, 2012:21) and thus “is the most important” (Dörnyei, 2005:59) component. As it is also “the most complex” (Baddeley, 2012:13) one, it was originally little understood (ibid.:6; Henry, 2012:30). Some progress, however, has been made since then and “the wider literature on executive functioning” (ibid.) has helped to promote the understanding of the central executive (ibid.). According to the original model of WM, the central executive was “capable of attentional focus, storage, and decision making” (Baddeley, 2012:13f.). Some years later, however, Baddeley and Logie (1999:30) proposed that the central executive was “a purely attentional system” (Baddeley, 2012:14) and did not have any storage capacity (Baddeley & Logie, 1999:30). Thus, in the revised WM model, the main function of the central executive is the allocation of attention “within the working memory system” (Henry, 2012:21): It is responsible for focusing attention, for dividing “attention between two important targets or stimulus streams” (Baddeley, 2012:14) and for switching attention between tasks (ibid.). In addition, it fulfills a further function as it has “the capacity to interface with LTM [long-term memory, N.W.]” (ibid.): This link between the central executive and the long-term memory is mediated by the newly added component, the episodic buffer (ibid.:15, 16; Henry, 2012:21).

The episodic buffer is “a temporary storage system that is able to combine information from the loop, the sketchpad, long-term memory, or [...] from perceptual input, into a coherent episode” (Baddeley, 2007:148) and it fulfills the storage function that was originally assigned to the central executive (Baddeley, 2012:15; Dörnyei, 2005:57). The fact that the episodic buffer combines information from different sources already points to one of its main characteristic, namely the characteristic that “it does not just store information in one modality [...], but deals with information from many different modalities” (Henry, 2012:31). Consequently, in this respect, it differs from the phonological loop and the visuospatial sketchpad, which are more specialized in certain types of information. Similar to these slave systems, however, the capacity of the episodic buffer is assumed

to be limited (Baddeley, 2012:15). It is further assumed that “retrieval from the buffer occurs through conscious awareness” (ibid.).

2.2.2 The Relevance of Working Memory to SLA

Findings from both the European research camp, which has rather focused on the role of the phonological loop in vocabulary and grammar learning, and the North American research tradition, which has been more concerned with the functions associated with the central executive, support a link between WM and L1 acquisition (Wen, 2014:174; Baddeley, 2012:15; Gathercole & Baddeley, 1989; Gathercole et al., 1992; Alloway, Gathercole, Willis & Adam, 2004). Consequently, it is likely that WM plays a significant role in SLA as well (Miyake & Friedman, 1998:340). Skehan (2002:90), for example, who assumed that WM might be a central component of language aptitude, identified several L2 processing stages during which WM might be required.

One argument for the relevance of WM to SLA is the fact that SLA “comes at a later stage in life” (Wen, 2014:175) than L1 acquisition and proceeds less automatically (ibid.), which suggests that L2 learning “may have to rely to a greater extent than L1 acquisition on general learning mechanisms” (Miyake & Friedman, 1998:340) and thus on “such cognitive resources as WM” (Wen, 2014:175). Consequently, the role that WM plays in SLA might be even greater than the one it plays in L1 acquisition, especially in adult SLA (Harrington, 1992:127). In addition, the importance of WM for SLA is supported by the assumption that “noticing is crucial to learning” (Sawyer & Ranta, 2001:342). A prerequisite for noticing is attention, which in turn “at any moment is limited by WM capacity” (ibid.). This suggests “a close relationship between amount of learning and size of WM” (ibid.) and “under conditions of WM overload, or even simply full capacity, there will be few if any attentional resources available for learning” (ibid.:342f.). A further argument that supports the importance of WM for language acquisition in general is that “[p]roducing and comprehending language requires the processing of sequences of symbols over time” (Miyake & Friedman, 1998:341): “The linearity of language” (ibid.) requires a reader or listener to temporarily store “intermediate and final products of computations” (ibid.) while constructing and integrating “ideas from the stream of successive words in a text or spoken discourse” (ibid.) and it also necessitates “a writer or speaker to produce a sequence of words and sentences out of the less sequentially organized representation of thought” (ibid.). Consequently, both processing and storage are required at the same time, which makes the involvement of WM in producing and comprehending a language very likely (ibid.).

Moreover, when language acquisition is regarded from a connectionist point of view and the acquisition, storage and use of linguistic sequences is considered an essential task (Wen, 2014:175), the phonological loop component of the WM seems to be especially important since “[i]n the

process of chunking these linguistic sequences, [...] [the phonological loop, N.W.] serves to sustain and rehearse [...] their phonological material in immediate consciousness while long-term representations are being constructed” (ibid.). A further reason why PSTM is considered to play a crucial role in SLA is that “learning a new vocabulary” (Gathercole et al., 1992:897) can be regarded as “one of the most important hurdles in mastering a new language” (ibid.). Since learning words in an L2 does usually “not involve significant conceptual development or reorganization, because the learner will already have the word within his or her first-language lexicon” (ibid.) and will rather have to learn “the new phonological form” (ibid.), PSTM seems to be of particularly great significance.

Such assumptions of a link between WM and SLA “have motivated an increasing number of empirical studies exploring the potential effects of WM in various aspects of SLA” (Wen, 2014:175; e.g. Sunderman & Kroll, 2009; Mackey, Adams, Stafford & Winke, 2010). This is why, in what follows, an overview of previous research findings will be given. As many studies distinguish between WM as a whole, as a construct that is responsible for both storing and manipulating information and in which thus the function of the central executive is emphasized, and the phonological loop component of WM, which is often called PSTM and mainly deals with storing processes, findings about the relation between SLA and WM on the one hand and between SLA and PSTM on the other hand will also be reported separately.

2.2.3 Working Memory in SLA

WM seems to play a role in several aspects of L2 performance (French, 2006:21, 22; Skehan, 2002:75f.; Mackey, Philip, Egi, Fujii & Tatsumi, 2002:185f.). There are, however, also some language domains for which a relation with WM has “not been robustly detectable” (Juffs & Harrington, 2011:158; see also Juffs, 2005) and a closer look reveals that the relation between WM and SLA is relatively complex.

One of the earlier studies that investigated the relationship between WM and SLA was conducted by Harrington and Sawyer (1992) and focused on “adult high-intermediate advanced” (Sawyer & Ranta, 2001:342) English learners’ L2 reading comprehension (Harrington & Sawyer, 1992:30). Moderate⁶ positive correlations were found between the subjects’ reading comprehension skills and their WM capacity as measured by a reading span test (ibid.:30f.). It can be criticized, however, that the reading span task was administered in the participants’ L2 and that this task might thus not have provided a pure measure of WM capacity but might have measured L2 skills as well.

⁶ Correlation coefficients are interpreted following Dancy and Reidy’s (2004) categorization of coefficients of 1 as perfect, ± 0.7 to ± 0.9 as strong, ± 0.4 to ± 0.6 as moderate and ± 0.1 to ± 0.3 as weak. An r-value of 0 is a zero correlation and implies that there exists no correlation at all (Sokunbi, 2014:4).

Another study by Kormos and Sáfár (2008:264, 268), however, in which a purer measure of WM was obtained via a backward digit span task that was administered to the participants in their L1, basically seems to confirm Harrington and Sawyer's (1992) results. The study was conducted with Hungarian "secondary school students aged 15-16" (Kormos and Sáfár:261; see also *ibid.*:264) who were in their "first intensive language training year of an [English, N.W.] bilingual education program" (*ibid.*:269) and a significant positive correlation between reading comprehension and WM was found even though it was only weak (*ibid.*:261, 264, 268).

A study by Geva and Ryan (1993) with junior-high pupils who were attending a "bilingual English-Hebrew day school" (*ibid.*:14), however, questions a direct relationship between WM and reading comprehension although the findings by Geva and Ryan (1993) seem to resemble the aforementioned results at first sight: Significant positive correlations were found between WM as measured in the subjects' L1 and L2 and a reading comprehension test (*ibid.*:14, 25, 26). When intelligence and grade level⁷, however, were partialled out, the correlation between L2 reading comprehension and WM as measured in the participants' L1 decreased and lost its significance (*ibid.*:26, 29). Unfortunately, neither Harrington and Sawyer (1992) nor Kormos and Sáfár (2008) controlled for other cognitive factors so that it is unknown whether the correlations that were found in these studies would still have been significant if other cognitive variables had been controlled. It is, however, possible that this would have been the case since the samples of the three different studies differed with regard to language background, age and learning conditions (Geva & Ryan, 1993:14; Harrington & Sawyer, 1992:28; Kormos & Sáfár, 2008:264). As such factors might influence the relationship between WM and SLA outcomes, Geva and Ryan's (1993) findings might not be directly transferable to Harrington and Sawyer's (1992) and Kormos and Sáfár's (2008) studies.

Another study that also investigated the relationship between L2 reading comprehension skills and WM capacity illustrates that a further factor should be taken into account: the subjects' prior knowledge (Leeser, 2007:241, 229, 253). It was found that "learners benefited from higher WM only if they were familiar" (*ibid.*:253) with the topic of the texts.

The above-mentioned study by Kormos and Sáfár (2008) also reported findings on the relation between WM and further receptive L2 skills. For example, weak to moderate correlations between WM capacity and the achievement in the listening comprehension tasks and the use of English (vocabulary and grammar knowledge) tasks of the Cambridge First Certificate Exam were found (*ibid.*:266f., 265), hence confirming the existence of a connection between WM and L2 achievement. Kormos and Sáfár (2008:267) assumed that listening comprehension, for example, requires to store already heard and processed bits of language while simultaneously new bits of language have to be processed. Moreover, it was assumed that WM influences the "acquisition of syntactic

⁷ The term *grade* refers to whether the subjects attended the fifth, sixth or seventh grade.

and vocabulary knowledge also through its” (ibid.:268) function to regulate “attention in cognitive processing” (ibid.). It should be taken into consideration, however, that grammar and vocabulary knowledge were assessed “in an integrated manner” (ibid.). Thus, it is unknown whether vocabulary skills or grammar skills or both types of skills were the decisive factor for the correlation between the use of English task and WM.

When grammar and vocabulary were examined separately, WM was still found to be linked with receptive L2 grammar skills. Miyake and Friedman (1998:350f., 343), for instance, who conducted a study with adult Japanese learners of English, found moderate positive correlations between WM capacity as measured by a listening span task – a method similar to the reading span task (Daneman & Carpenter, 1980:450) – in both the subjects’ L1 and L2 and syntactic L2 comprehension. In addition, a path analysis was used to test “models of possible causal relationships” (Miyake & Friedman, 1998:351) and support “for a causal role for WM capacity in relation to aspects of L2 proficiency” (Sawyer & Ranta, 2001:342) was obtained.

The importance of WM for receptive grammar skills is also supported by a study by Kempe, Brooks and Kharkhurin (2010), which explored how adult English-speakers “generalize grammatical categories such as noun gender” (ibid.:127). WM as measured by reading span was found to predict “gender categorization of [certain] nontransparent nouns” (ibid.:127; see also ibid.:143) and it was assumed that the reason for this result was that the “storage capacity of verbal working memory” (ibid.:145) affected the categorization of nontransparent nouns since the recall of certain “memorized associations between gender categories and lexical information” (ibid.) facilitated the categorization of these nouns (ibid.). Thus, the study by Kempe et al. (2010) supports the existence of a link between WM and receptive grammar learning, even though this connection only seems to exist for certain grammatical phenomena.

A relation between WM and L2 grammar knowledge is also corroborated by a study by Martin and Ellis (2012) with adult “monolingual native English speakers” (ibid.:384) whose “ability to induce [...] grammatical forms and to generalize the forms to novel utterances” (ibid.:379) was tested. The study revealed weak to moderate positive correlations between WM as measured by listening span and receptive grammar skills (ibid.:384, 393, 394). Moreover, regression analyses and causal path analyses were used to test whether or not “the relationship between memory measures and grammatical competency [...] [was, N.W.] mediated by vocabulary” (ibid.:397). It was found that some effects of WM were “mediated by vocabulary and some [...] [were, N.W.] direct effects” (ibid.:405). It should be noted, however, that these results stem “from laboratory artificial language learning” (ibid.) and that their generalizability might thus be limited (ibid.).

Findings from a study with Luxembourgish-speaking “8- to 9-year-olds” (Engel de Abreu & Gathercole, 2012:1) who learned German as L2 and French as L3 at school suggest, however, that

Martin and Ellis's (2012) results might, in general, also be valid for more naturalistic L2 learning contexts. Positive weak correlations were found between WM as measured by counting recall and backward digit span and L2 grammar comprehension, independent of whether or not L1 vocabulary knowledge was partialled out (Engel de Abreu & Gathercole, 2012:8). Moreover, it is remarkably that the relation between WM and L3 grammar knowledge differed from the one between WM and L2 grammar knowledge insofar as a significant positive correlation between WM and L3 grammar comprehension was only found when WM was measured by the counting recall task but not when it was measured by the backward digit span task (ibid.). Furthermore, while the link between L2 grammar and WM "remained significant after controlling for [...] short-term memory and [phonological, N.W.] awareness" (ibid.:9), this was not the case for the relation between WM and L3 grammar knowledge (ibid.:10). It is possible that these differences were due to the fact that the L2 was structurally similar to the children's L1 while the L3 was not (ibid.:11). It should also be noted, however, that the pupils had "learned L2-German substantially longer than L3-French" (ibid.:12) and "had learned to read and write in German but not yet in Luxembourgish and French" (ibid.:4). These differences might also have influenced the relationship between WM and receptive grammar knowledge in the L2 and L3.

The complexity of the relationship between WM and L2 grammar knowledge is also emphasized by results found by Robinson (2002a). In this study the relation between WM and grammar knowledge, which was tested after incidental learning, depended on the format of the grammar tests, on the time that passed between the last training session and the testing session and on the precise rule types of the sentences (ibid.:233f., 235, 240f., 251, 252). In general, WM was found to predict incidental grammar learning, but it did "so most successfully on tests which themselves tap[ped, N.W.] WM capacity" (ibid.:256; see also ibid.:241, 242). Furthermore, the findings suggested that "the effects of WM on incidental learning are most clearly apparent [...] on [...] rules which *can* be learned" (ibid.:256, emphasis in original).

In sum, on the basis of the reported findings, it can be concluded that there seems to exist a link between WM and certain aspects of L2 grammar knowledge but that several further factors also seem to influence this relationship.

With regard to L2 vocabulary learning, the results of the aforementioned study by Kormos and Sáfár (2008) suggest that WM might also play a role in this domain of language learning even though no distinct conclusions can be drawn on the basis of this study since, as was mentioned before, grammar and vocabulary were assessed in an integrated manner. In addition, it was not stated explicitly whether receptive or productive vocabulary knowledge or a combination of both was assessed. The findings of the above-mentioned study by Martin and Ellis (2012) seem to suggest that WM does not play a major role in the comprehension of L2 vocabulary: Martin and Ellis (2012:385,

386, 389, 392, 394), who worked with adult L2 learners, found no significant correlation between WM as measured by a listening span task in the participants' L1 and receptive L2 vocabulary knowledge. As mentioned previously, it should be noted, however, that the results of the study were attained "from laboratory artificial language learning" (ibid.:405) so that "there are limitations to how much the results [...] can be generalized to real-life language-learning situations" (ibid.).

These limitations with regard to generalizability seem to be confirmed by a study by Swanson, Orosco, Lussier, Gerber and Guzman-Orth (2011), which explored naturalistic SLA and yielded results that differed from Martin and Ellis's (2012) findings. 471 primary school pupils whose "first language [...] was Spanish" (Swanson et al., 2011:383) and who were growing up in an English speaking environment in Southern California participated in the study (ibid.:841). Highly significant weak to moderate positive correlations between WM and receptive L2 vocabulary as measured by the *Peabody Picture Vocabulary Test* (PPVT) were found (ibid.:843, 845, 846). This was the case independent of whether WM was measured in the children's L1 or L2 (ibid.:845). In most regression models, however, WM was only a significant predictor for receptive vocabulary knowledge when it was measured in the pupils' L2 (ibid.:846, 850). As mentioned before, it should be noted, however, that WM when measured in an L2 might not only measure WM capacity but might already measure L2 skills as well.

In sum, the reported results suggest that WM might be linked with L2 reading and listening comprehension, at least under certain conditions. Moreover, a robust link between WM and receptive grammar knowledge was found in several studies. In contrast to this, the results about WM and receptive L2 vocabulary knowledge seem to be mixed and relatively few studies seem to have investigated the relation between WM and receptive vocabulary knowledge. Instead, more studies seem to have focused on productive vocabulary skills. The findings of a well-conducted study by Swanson et al. (2011), however, suggest that WM and receptive vocabulary knowledge might be related even though whether or not WM is a significant predictor for vocabulary learning seems to depend, for instance, on which other factors are accounted for. Moreover, the above-mentioned studies illustrate that further factors seem to influence the relation between WM and receptive L2 skills: The test formats that are used to assess the language competencies in question as well as the methods to measure WM seem to play a role. In addition, the learning conditions as well as the learner's prior knowledge and, with regard to grammar, the precise structures that are examined appear to be influential. Besides, it should also be considered that the exact L2 which is examined as well as its relation to the learner's L1 may be important factors. With regard to the methods for measuring WM, in particular, it should be noted that the reading span task, which was employed in many of the reported studies (e.g. Harrington & Sawyer, 1992; Kempe & Brooks, 2008; Kempe

et al., 2010; Robinson, 2002a), has received criticism for several reasons, especially when it is administered in the participants' L2 (Leeser, 2007:234; Ortega, 2009:93; Juffs & Harrington, 2011:142). One problem is, for instance, that this task requires language knowledge and thus might not provide a pure measure of WM (Juffs & Harrington, 2011:142). The same problem occurs when a listening span task is used (*ibid.*). A further important aspect that should be taken into consideration is that most of the above-mentioned studies were conducted with subjects older than primary school pupils. Thus, the transferability of the findings to child SLA might be limited.

Having dealt with the relation between receptive L2 skills and WM as a whole, the following chapter will focus on the link between receptive L2 competencies and PSTM.

2.2.4 Phonological Short-Term Memory in SLA

The relationship between PSTM and receptive L2 skills has been examined in several studies and, similar to the relation between WM and SLA, also seems to be quite complex as the following findings will illustrate.

With regard to the relation between PSTM and L2 reading comprehension, for example, Harrington and Sawyer (1992:28, 31f.), who investigated adult SLA, obtained only weak correlations that did not reach significance. Findings by Kormos and Sáfár (2008:261, 265, 267, 268), whose participants were secondary school pupils, also suggest that PSTM is not significantly related to L2 reading comprehension. Support for the aforementioned results also comes from Geva and Ryan's (1993:5, 14) study with native English fifth to seventh graders who were attending a bilingual English-Hebrew day school. Although significant weak to moderate positive correlations were found between L2 reading comprehension and PSTM as measured by a word span task in the children's L1 and L2 (*ibid.*:25, 26), a regression analysis showed that PSTM "was not a significant predictor of L2 reading comprehension" (*ibid.*:5, 14, 31). Moreover, no significant correlation was found between L2 reading comprehension and PSTM as measured in the participants' L1 when intelligence and grade level were partialled out (*ibid.*:26). It can be criticized, however, that the word span tasks might have measured not only PSTM but also lexical knowledge. Consequently, the findings should be treated with caution.

Another study, which was conducted by Service (1992) with Finnish primary school pupils "over a period of three school years" (Service & Kohonen, 1995:155), seems to have produced different results since a strong correlation between PSTM as measured by a pseudoword task and English reading comprehension was found (Service, 1992:26, 28, 30, 31, 26). Moreover, with regard to further receptive L2 skills, it was found that PSTM was moderately correlated with listening comprehension (*ibid.*:30, 31). In addition, all the correlations "appeared to be unrelated to exposure to teaching, as the correlation coefficients [...] remained largely the same from year to year" (*ibid.*:31). Unfortunately, it is not possible to decide whether or not the findings by Service (1992) on the

relation between PSTM and reading comprehension contradict the aforementioned results by Geva and Ryan (1993) since, unlike Geva and Ryan (1993), Service (1992) did not control for other cognitive variables. However, even if Service (1992) had found significant positive correlations when controlling for other cognitive factors, this does not necessarily mean that such results would have contradicted the findings of the aforementioned studies completely because one of the major aspects of the teaching program which Service's (1992:43) subjects attended was "building up a basic vocabulary". Since "either passive or active vocabulary were at least indirectly measured in all the language proficiency tests" (ibid.) that were used in the study, vocabulary knowledge might have been "the main locus of the effects of individual variation" (ibid.). In an extension of the original study, in which L2 vocabulary knowledge was measured by a combination of productive and receptive tasks (Service & Kohonen, 1995:161), results which support the existence of "a special relationship [...] between phonological memory and foreign language word learning" (ibid.:171) were obtained since PSTM measures correlated moderately to strongly with vocabulary knowledge (ibid.:162, 163). Moreover, the findings corroborated the hypothesis that the robust relationship between PSTM and some English tasks, especially listening comprehension tasks, "may depend on vocabulary knowledge" (ibid.:169) even though the difficulty of the listening comprehension task was also found to have an influence because only a more difficult task depended clearly on vocabulary knowledge (ibid.:170).

Further studies which also examined the relation between PSTM and L2 listening comprehension, however, partially yielded results that do not seem to be completely in line with Service's (1992) and Service and Kohonen's (1995) findings. With regard to listening comprehension, Kormos and Sáfár (2008:267, 268), for instance, found only very weak correlations with PSTM that did not even reach significance. As this study differed in various aspects from the studies by Service (1992) and by Service and Kohonen (1995), it is impossible to decide what might have caused these differences. Possible factors might have been, for instance, differences between the samples with regard to their L1 and age (Kormos & Sáfár, 2008:264; Service & Kohonen, 1995:26).

The assumption that age might at least be one influential factor is supported by findings by Vulchanova et al. (2014:89, 91), for example, who conducted a study with nine- to ten-year-old Norwegian primary school children and – similar to Service (1992) and Service and Kohonen (1995), who had also worked with primary school pupils – also obtained a significant positive correlation between L2 listening comprehension and PSTM. In addition, Vulchanova et al. (2014:91) also found a significant positive correlation between PSTM and receptive L2 vocabulary skills as measured by the *PPVT*. Even though the correlations that were found by Vulchanova et al. (2014) were weaker than the ones found by Service (1992) and Service and Kohonen (1995), Vulchanova

et al.'s (2014) findings seem to support the relevance of PSTM to L2 listening comprehension and receptive vocabulary skills.

Additionally, the existence of a relation between receptive vocabulary knowledge and PSTM is supported by further studies. French (2006:55, 81, 114, 91), for instance, who conducted a study with francophone six-graders who were taking part in an “intensive English program” (ibid.:55) in Quebec, found that PSTM as measured by nonword repetition was significantly and highly linked with receptive vocabulary skills. In addition, the findings supported a causal influence of PSTM on vocabulary knowledge (ibid.:116). A study by Farnia and Geva (2011) corroborates French's (2006) results since “unidirectional concurrent and longitudinal relationships between” (Farnia & Geva, 2011:733) PSTM capacity and children's receptive L2 vocabulary knowledge were found when it was ensured to measure PSTM with a task that did tap L1 or L2 knowledge as little as possible (ibid.:711, 716, 718, 733). It should be noted, however, that the participants in this study had a migration background and that their L2 was also the language of their environment (ibid.:711, 716).

Findings by Cheung (1996:868), in contrast to the aforementioned studies, rather seem to contradict the assumption that PSTM plays a crucial role in receptive L2 vocabulary acquisition since in this study receptive English vocabulary knowledge “was associated with neither nonword span nor simple word span” (ibid.:870). According to Cheung (1996:872), the reasons for these findings are unknown, but two alternative explanations were considered: Firstly, methodological shortcomings might have caused these results (ibid.) or, secondly, it might also be possible that there is “a point in second-language development beyond which phonological memory will just fail to predict vocabulary size” (ibid.). Even though Gathercole et al. (1992), in the context of L1 acquisition, had found results which resembled Cheung's (1996) second explanation, Gathercole et al. (1992:897) had explicitly stated that their findings were probably not transferable to SLA. Moreover, a further study by Gathercole, Service, Hitch, Adams and Martin (1999:65) had yielded results which rather contradicted the idea that there might be a point in language acquisition beyond which PSTM does not predict vocabulary knowledge anymore. Consequently, it seems more likely that Cheung's (1996) findings might have been influenced by methodological shortcomings.

A further factor that might also have contributed to the differences between the different studies was found by Kormos and Sáfár (2008): When testing beginner learners of English, PSTM as measured by an “L1 based non-word repetition test” (ibid.:265) was not found to be significantly related to the use of English task taken from the Cambridge First Certificate Exam (ibid.:265, 267). When testing pre-intermediate English learners, however, significant correlations were found between PSTM and use of English (ibid.:268). These differences may have been caused by “the different nature of learning processes of the two groups of students” (ibid.:269). While the beginner learners

received more explicit instruction, which required “the memorization of rules and their application” (ibid.) and thus might have depended more on “general working memory capacity” (ibid.), the pre-intermediate pupils’ “learning processes were more implicit” (ibid.) and could be characterized by the acquisition of “words through incidental exposure in reading and listening tests” (ibid.). These learning processes might have been facilitated by high PSTM capacity (ibid.). It should be noted, however, that the use of English task measured not only vocabulary knowledge but also grammar knowledge so that it is not clear whether vocabulary knowledge or grammar knowledge or both types of knowledge were responsible for the findings⁸.

Compared with the amount of studies dealing with the relation between PSTM and L2 vocabulary skills, “[c]onsiderably less work has addressed the role of phonological STM” (Ellis & Sinclair, 1996:236) in L2 grammar learning. Moreover, when the relationship between PSTM and grammar was studied, often only one score for grammar that comprised both receptive and productive knowledge was calculated.

The already-mentioned study by French (2006:111) with francophone six-graders attending an “intensive English program” (ibid.:55) at first sight seems to support the assumption that a higher PSTM capacity is related to better L2 grammar comprehension skills since positive correlations between these two variables were found. A closer look reveals, however, that this was only the case for the participants as a whole and for a low proficiency group (ibid.). For high proficiency learners, in contrast to this, correlations between PSTM and receptive grammar knowledge did not reach significance (ibid.). In addition, when vocabulary knowledge was taken into account, the correlations between PSTM and “the grammar measures [for both the high and the low proficiency group, N.W.] decreased dramatically” (ibid.:112) and no significant correlations were obtained anymore (ibid.). This suggests that the relationship between PSTM capacity and grammar skills might “be largely mediated by the strong link between phonological loop function and lexical properties underlying vocabulary knowledge” (ibid.:110). It is also possible, however, that the results of the study were influenced by the tests that had been used to measure grammar knowledge since these might not have provided a pure measure of grammar skills but might have measured vocabulary knowledge as well (ibid.:73, 128). Consequently, French (2006:130) herself pointed out that no clear conclusions could be drawn with regard to the relation between PSTM and L2 grammar learning.

A clearer picture seems to emerge from a further study with “native French-speaking children undergoing a 5-month intensive English program” (French & O’Brien, 2008:464) in Quebec (ibid.:467). In this longitudinal study, “those morphosyntactic structures [...] that receive explicit pedagogical focus in intensive English programs in Quebec” (ibid.) were assessed and in order to

⁸ Moreover, the use of English task seems to have tested not only receptive L2 skills but also productive L2 skills.

receive a relatively pure measure of grammar skills, “French (L1) translations were provided for key words and/or phrases for each item” (ibid.). Significant positive moderate to strong correlations were found between PSTM and grammar knowledge, even when NI and L2 contact were partialled out (ibid.:471, 472). The role of PSTM in grammar learning was investigated further and it was found that “phonological memory made significant, unique contributions to learners’ grammatical development over the course of the study in addition to the contribution made by lexical knowledge” (ibid.:476). Unfortunately, however, French and O’Brien (2008:472, 470) reported only one score for overall grammar knowledge and did not separate receptive grammar skills from productive skills.

Martin and Ellis (2012:402), however, also found support for a connection between PSTM and grammar skills when a separate score for receptive L2 grammar knowledge was calculated: Positive correlations were found between PSTM as measured by nonword repetition and receptive grammar scores (ibid.:394, 396). Moreover, it was found that while some “effects of PSTM” (ibid.:399) were mediated by vocabulary, some were also direct effects (ibid.). It has to be noted, however, that Martin and Ellis (2012) did not investigate child SLA but adult “uninstructed grammar learning” (ibid.:384; see also ibid.:385).

One of the few studies that focused on child SLA and investigated the relation between PSTM and receptive L2 grammar skills was conducted by Engel de Abreu and Gathercole (2012:1, 6) with Luxembourgish-speaking children. On the one hand, the findings of this study also support a connection between PSTM and receptive grammar skills since weak to moderate positive correlations between the participants’ receptive L2 grammar knowledge and PSTM capacity as measured by simple digit recall and L1 nonword repetition were found (ibid.:5, 8). On the other hand, however, it also has to be noted that the correlations decreased when L1 vocabulary knowledge was partialled out (ibid.:8). In addition, in this case the relation between PSTM and L2 grammar knowledge only remained significant when PSTM was measured by nonword repetition but not when it was measured by digit recall (ibid.). Moreover, it was found that the link between PSTM and L2 grammar was “mediated by phonological awareness” (ibid.).

In sum, the reported findings rather seem to contradict a direct relationship between PSTM and reading comprehension and between PSTM and listening comprehension although no clear conclusion can be drawn with regard to these language skills. With reference to receptive vocabulary skills, in contrast to this, the importance of PSTM is supported by several studies although further factors such as the teaching method also seem to have an influence. The results about the relationship between PSTM and receptive grammar knowledge seem to be mixed, but a closer look reveals that in cases in which positive correlations were found these might have been mediated by PA. In addition, whether or not a positive relation is found also seems to depend on the tasks which are

used to assess PSTM. In this respect, it should be noted that particularly nonword repetition tasks have received criticism for a number of reasons (Hu, 2003:451f.; Kormos & Sáfár, 2008:265; Avons, Wragg, Cupples & Lovegrove, 1998:586; Gathercole, 1995:83; Farnia & Geva, 2011:713; French & O'Brien, 2008:48, Vulchanova et al., 2014:88).

2.3 Phonological Awareness

2.3.1 Definition

Another cognitive ability that seems to be relevant to language acquisition is PA. PA is concerned with structural units of language and is one component of meta-language (Fröhlich, Metz & Petermann, 2010:36). It is therefore regarded as a metacognitive ability. In general, PA can be defined as insight into the sound structure of spoken language and as the ability to concentrate one's attention, independent of the content or meaning, on the formal-linguistic sound aspects of language, to recognize and analyse these aspects and to manipulate them (ibid.; Schründer-Lenzen, 2013:86; Hamilton & Gillon, 2006:57; Branum-Martin, Tao, Garnaat, Bunta & Francis, 2012:932).

What exactly is meant by the term *phonological awareness*, however, can vary as PA is a complex construct that is comprised of different aspects of awareness (Schründer-Lenzen, 2013:88; Fröhlich et al., 2010:38; Hug, 2007:22; Fröhlich, 2010:21; Mayer, 2008:56). Two dimensions that are used to describe this construct in more detail are the size of the sound unit and the explicitness of the operation or judgement (Fröhlich et al., 2010:38; Gathercole & Baddeley, 1995:132). With regard to the first dimension – the size of the phonological unit – three different levels can be distinguished: syllables, onset- and rime-units, and phonemes (Fröhlich et al., 2010:38). While syllables are the largest sound units of words and are the easiest to perceive, onsets and rimes are more difficult than syllables but are still easier than phonemes (ibid.). With regard to the second dimension – the explicitness of the operation or judgement – four different stages with increasing explicitness and thus increasing difficulty can be distinguished: identification, analysis, synthesis and manipulation (ibid.:38f.). Identification is the easiest operation and in order to solve identification tasks, it is necessary, for instance, to decide whether two words begin with the same phoneme (ibid.:39). Manipulation is the most difficult operation since linguistic units not only have to be perceived and identified but also have to be changed. Consequently, it is necessary to deal with the linguistic material consciously (ibid.).

In pedagogical contexts, especially in German-speaking literature, PA is often distinguished into PA in the narrower sense and PA in the broader sense (Schründer-Lenzen, 2013:88; Fröhlich et al., 2010:40; Fröhlich, 2010:21). PA in the broader sense is the ability to identify rhymes, to segment words into syllables and to synthesize syllables into a word. These tasks require rather implicit awareness and operations and refer to units larger than phonemes (Fröhlich et al., 2010:40; Bredel,

2007:170; Gathercole & Baddely, 1995:133; Fröhlich, 2010:22). In contrast to this, PA in the narrower sense requires rather explicit knowledge and processes and refers to the phoneme-level (Fröhlich et al., 2010:40).

2.3.2 The Relevance of Phonological Awareness to SLA

PA is considered especially “important for learning to read and spell” (Hu, 2008:40; see also Schründer-Lenzen, 2013:86, 88) and on the basis of studies dealing with L1 acquisition (e.g. Avons et al., 1998), it can be assumed that “phonological awareness also may affect vocabulary learning in the L2” (Hu, 2008:40). One possible reason for the relevance of this cognitive variable, especially to child SLA, is that children with poorer PA process language rather at a holistic level (ibid.). According to Hu (2008:40), “holistic phonological representations are believed to be primitive and underspecified [and, N.W.] heavily tied to phonetic context”, which makes them “more difficult to retain, to recall, and to articulate than fine-grained, more distinctly segmented representations, particularly in the case of phonologically complex items or new phonological contexts”. Consequently, it is likely that poorer PA results in slower vocabulary learning (ibid.). A further problem of holistic representations is that they are not suitable for bootstrapping: Firstly, no “representations of segments” (ibid.) that can be combined “into novel sequences” (ibid.) and would thus support the acquisition of new words are available (ibid.). If a child, for instance, already knows the words *sock*, *rock* and *mock*, but “fails to abstract the sub-lexical unit *-ock* from the already-known words” (Hu, 2014:570), they “will not be able to use it to support the learning of a new word like *dock*” (ibid.) because they will not realize that it contains a familiar component (ibid.).

Furthermore, findings of L1 acquisition studies also suggest that “phonological cues [...] in the input” (ibid.) are used to assign “grammatical categories to new words” (ibid.) and to predict “upcoming word forms during on-line sentence processing” (ibid.). It is likely that SLA follows patterns that are similar to the ones in L1 acquisition and thus good PA might enhance foreign language learning and especially L2 vocabulary acquisition, “at least at the initial stage of constructing fully specified phonological forms for new words” (Hu, 2008:40). It is also sensible to assume that PA might play an even greater role in foreign vocabulary learning than in L1 vocabulary learning since “[f]or foreign words, not only are the individual sounds unfamiliar, but the phonological structures involve novel sound patternings, stress assignments, and syllable configurations” (Hu, 2003:434).

2.3.3 Phonological Awareness in SLA

Although several studies have dealt with PA, relatively few seem to have focused on the relationship between the degree of proficiency in PA and the level of proficiency in L2 skills, particularly the level of proficiency in receptive L2 skills. Instead, the focus has often been put on comparisons

of PA skills between groups that differed in characteristics such as sex or language background (e.g. Bialystok, Majumder & Martin, 2003; Chipere, 2014; Bruck & Genesee, 1995; Kuo & Anderson, 2010). This is why, in what follows, not only studies that focused on receptive grammar and vocabulary skills but also some studies that investigated productive grammar and vocabulary skills will be presented.

One of the few studies that focused directly on the relation between PA and L2 skills was conducted by Hu (2008:42) with Chinese-speaking children. The children's L1 PA was tested in third grade and their ability to learn unfamiliar English words was assessed in fifth grade via a task that required the children to learn to produce four new colour terms and to revise four familiar colour words (ibid.:44, 45). The results suggested that children with "relatively poor phonological awareness" (ibid.:47) learn new words more slowly and less accurately, even when their existing knowledge of semantically related words is comparable to the knowledge of children with relatively high PA (ibid.). However, children with higher PA and lower PA did not differ with regard to their performance on a receptive vocabulary test that took place after the learning phase and assessed the knowledge of the colour terms (ibid.:45f.). A possible reason for these differences might be that "[i]n principle, recognition can proceed on the basis of a less-than-complete phonological representation (Fernald, Swingley, & Pinto, 2001), one that is not sufficient for accurate production" (Hu, 2008:47).

A further very similar study by Hu (2014:579) with Mandarin-speaking children basically confirmed the findings of the aforementioned study. In addition, it was found that children with poorer PA had "difficulty in learning words that contained components to which they had been pre-exposed multiple times" (ibid.:580). A possible reason for these findings is that learning a word that contains "components that recur[...] in many words might be difficult" (ibid.) when having poor PA "as overall distinctiveness" (ibid.) of the word rather reduces than increases (ibid.). Moreover, Hu's (2014:581) results also indicated that "the learning disadvantage resultant of early poor phonological insight" was not compensated by "4 years of exposure" (ibid.) to the L2 English (ibid.).

While both the aforementioned studies support a link between PA and productive vocabulary skills but not between PA and receptive vocabulary skills, findings by McBride-Chang, Cheung, Chow, Chow and Choi (2006) suggest that a connection between PA and receptive vocabulary knowledge might exist. McBride-Chang et al.'s (2006) subjects were Cantonese-speaking kindergarten children of a mean age of approximately five years who had received about "two years of" (ibid.:701) formal English instruction "at the time of testing" (ibid.; see also ibid.:700). PA and receptive vocabulary knowledge measures were taken within about two months and weak to moderate positive correlations between certain aspects of L1 PA, namely Chinese syllable deletion and especially Chinese phoneme onset deletion, and English receptive vocabulary knowledge were

found (ibid.:702, 706). A regression analysis revealed, however, that only the phoneme onset deletion task was a unique predictor of receptive L2 vocabulary (ibid.:708, 709).

Support for McBride-Chang et al.'s (2006) findings comes from a study by Farnia and Geva (2011), which followed Punjabi-, Tamil- and Portuguese-speaking English learners "from Grades 1 to 6" (ibid.:717; see also ibid.:711): Significant weak to moderate positive correlations between existing receptive L2 vocabulary knowledge and PA were found (ibid.:725, 726). The reasons for the differences between the studies by McBride-Chang et al. (2006) and Farnia and Geva (2011) on the one hand and the aforementioned studies by Hu (2008, 2014) on the other hand cannot be clearly identified, but it is striking that the studies by McBride-Chang et al. (2006:701, 702) and Farnia and Geva (2011:718) assessed existing vocabulary knowledge while the studies by Hu (2008:45; 2014:574, 576) tested the knowledge of words that the participants had just learned.

A further study by Hu (2003), which assessed children's vocabulary knowledge at different points in time, supports the view that such differences might play an important role since the findings suggested that PA is not

a good predictor of the ability in young FL [foreign language, N.W.] learners to learn FL words just encountered for the first time, presumably because with novel words, children devote cognitive resources to the processing of the overall shape of the novel words (ibid.:456).

In contrast to this, "[h]owever, when some level of familiarity with the words is achieved, phonological awareness ability may become a significant factor in word learning" (ibid.). It has to be noted, however, that Hu (2003:440f.) tested productive vocabulary knowledge and it is unknown to what extent these findings are transferable to receptive L2 vocabulary knowledge. Moreover, it should also be taken into consideration that the participants of the different studies also differed with regard to their L1 background and that the L2 learning conditions were not identical (Hu, 2003:436f.; Farnia & Geva, 2011:711, 716f.).

While all the aforementioned studies examined the relation between PA and L2 vocabulary, one of the very few studies that dealt with receptive L2 grammar skills was conducted by Engel de Abreu and Gathercole (2012:6). As mentioned before, this study was conducted with 8- to 9-year-old Luxembourgish-speaking primary school pupils (ibid.:1). Positive weak correlations were found between PA and both L2 and L3 grammar comprehension (ibid.:5, 8). Most of these correlations even remained significant when L1 vocabulary knowledge was partialled out (ibid.:8). Moreover, it was found that the relationship between PA and L3 grammar knowledge was stronger than the one between PA and L2 grammar knowledge (ibid.:8, 10). These differences might have been caused by structural differences between the L2 and L3 and by different degrees of similarity of the L2 and the L3 with the children's L1 (ibid.:3). It is also possible, however, that differences in the way the languages were taught and in the length of exposure to the foreign languages might have contributed to the different results (ibid.:12).

In general, the reported findings seem to support a link between PA and SLA. While there seems to be no relation, however, between PA and the comprehension of foreign language words that have just been encountered for the first time, PA seems to be important for receptive vocabulary that is more familiar. It should be noted, however, that the tasks that are used to assess PA seem to influence the strength of the connection between PA and vocabulary skills. In comparison with the amount of studies that have investigated the relation between PA and L2 vocabulary knowledge, very few studies seem to have explored the relation between PA and L2 grammar skills. Nevertheless, it seems likely that a connection between receptive grammar knowledge and PA exists even though further factors such as the respective L1 and L2 and the degree of similarity between these languages as well as the learning conditions might be influential as well.

2.4 Nonverbal Intelligence

2.4.1 Definition

It is assumed that “[l]earning a foreign language involves intellectual abilities referred to as intelligence” (Kristiansen, 1990:35). According to Neubauer and Fink (2006:319) as well as Myers (2008:468), it is well established that intelligence is regarded as a theoretical construct which cannot be observed directly. Apart from this general idea, however, there is no universal definition because several different concepts of intelligence exist (Neubauer & Fink, 2006:321ff.; Myers, 2008:468). One broad definition given by Myers (2008:468) is that intelligence is the ability to learn from experience, to solve problems and to use knowledge in order to adapt to new situations. Based on Sternberg and Salter (1982) and Hamilton (1983), Kristiansen (1990:35) gives a similar general definition: “Intelligence is expressed in terms of adaptive, goal-directed behaviour”. What exactly is considered as intelligent, however, depends on the culture a person lives in (Myers, 2008:468). In scientific contexts, according to Myers (2008:468f.), intelligence is everything that can be measured by intelligence tests.

“The traditional intelligence tests often consist of what is called a verbal part and a nonverbal part” (Kristiansen, 1990:37), but there are also so-called nonverbal intelligence tests such as the Coloured Progressive Matrices (Testzentrale, 2015a). It should be noted, however, that the term *nonverbal intelligence assessment* can be used in different ways: Firstly, it can “be used to describe the process of assessing the construct of intelligence in a nonverbal fashion” (McCallum, 2003:4). Secondly, the term is also used by some test authors “to describe the assessment of a construct called ‘nonverbal intelligence’, ‘nonverbal reasoning’, or ‘nonverbal abilities’” (ibid.). According to

McCallum (2003), however, Bracken and McCallum (2001) argue that “the central construct assessed by most ‘nonverbal intelligence tests’ is in fact general intelligence” (McCallum, 2003:4)⁹. Additionally, a distinction can be made between unidimensional and multidimensional nonverbal tests (ibid.:16): Unidirectional nonverbal intelligence tests “assess a narrow aspect of” (ibid.) intelligence while multidimensional tests are “comprehensive tests of intelligence that assess multiple facets of [...] intelligence” (ibid.). The unidimensional nonverbal intelligence tests are by far more common than comprehensive nonverbal intelligence tests and are usually matrix analogy tests (ibid.:17), which require the ability “to notice and to identify patterns in complex stimuli” (Kempe & Brooks, 2011:18), “to reason and make inferences” (Kristiansen, 1990:43; see also Abargouei et al., 2011:1927). Very common NI tests are the Raven Progressive Matrices (RPM) tests (Raven and Raven, 2003:223; Testzentrale 2015b). They assess “‘meaning making [...]’ ability” (Raven & Raven, 2003:223) and their construction was influenced by “Spearman’s formulations of intelligence” (ibid.:224), who took the view that a “factor of general cognitive ability or *g*”(ibid.) exists. This general cognitive ability is “made up of two very different abilities which normally work closely together” (ibid.): One is “eductive ability – meaning making ability – and the other [is, N.W.] reproductive ability – the ability to reproduce explicit information and learned skills” (ibid.). “Raven developed his RPM tests as measures of eductive ability” (ibid.). In order to solve the test items, “reasoning without any verbal material included” (Kristiansen, 1990:60) is required. It should be noted, however, that language is included indirectly “when reasoning by oneself” (ibid.).

2.4.2 The Relevance of Nonverbal Intelligence to SLA

With regard to L1 acquisition, it has been argued that “one must be able to learn, remember, and use rules” (Kristiansen, 1990:43) “in order to master one’s [...] language” (ibid.). In order to be able to understand the rules, “[r]easoning is required” (ibid.), an ability which is connected with NI (ibid.). As SLA “comes at a later stage in life” (Wen, 2014:175) than L1 acquisition and proceeds less automatically (ibid.), L2 learning may depend to an even greater extent than L1 acquisition on general cognitive abilities (Miyake & Friedman, 1998:340), which suggests that NI might be even more important for the acquisition of an L2 than for the acquisition of an L1. Particularly when foreign language learning is regarded as

an active process in which the learner discovers how the input is segmented, how the segments are used to represent meaning, how units are assembled structurally, and what principles are used to achieve communicative goals (Kristiansen, 1990:118),

the involvement of NI seems likely. A closer look reveals that NI is considered especially important for “general text understanding” (ibid.:43) as well as for “the acquisition of word meanings”

⁹ In the study presented in chapter 3, the term *nonverbal intelligence* is used to refer to a construct that can be assessed by intelligence tests which are mainly language-free and require the ability to reason.

(*ibid.*:44) since these processes often require the “deduction of meaning from the contexts” (*ibid.*), which in turn requires the ability to reason (*ibid.*). In addition, NI has also been associated with regular aspects of grammar since the ability to reason can also facilitate the detection of patterns in linguistic input (Kempe & Brooks, 2011:18). It should be noted, however, that “it has often been suggested that for young learners intelligence may be less strongly correlated with second language acquisition” (Kristiansen, 1990:48f.) than for adolescents or adults.

2.4.3 Nonverbal Intelligence in SLA

Even though the role of intelligence in SLA has been investigated for some time, several studies only measured verbal intelligence (e.g. Leino, 1972 and 1974) or used tests that combined a verbal and a nonverbal part (e.g. Genesee, 1976; Geva & Ryan, 1993). Relatively few studies, in contrast to this, used NI tests, especially in the context of child SLA. In addition, in the few cases where NI was measured, it was often only investigated whether NI was related to overall language proficiency. Because of this scarceness of studies investigating the relation between NI and separate receptive L2 skills, in what follows, the findings of some studies that rather measured overall language proficiency will be reported as well.

One of the earlier studies that investigated the relationship between NI and SLA was conducted by Genesee and Hamayan (1980:95) with English-speaking first graders who attended a French immersion program. Their findings suggested that NI was a predictor of overall L2 proficiency and might also have contributed significantly to listening comprehension (*ibid.*:100, 102, 103). It should be noted, however, that NI was only one part of a factor for which the aforementioned results were found and that – apart from listening comprehension – receptive and productive skills were not measured separately (*ibid.*:100, 101).

A study by d’Anglejan and Renaud (1985:8) supports the aforementioned results and the importance of NI for L2 learning since in this study NI explained about 18% of the variance in overall foreign language proficiency. It has to be noted, however, that – even though other factors such as years of schooling and classroom anxiety were included in the analysis as well – no other cognitive abilities such as WM or PA were accounted for. Furthermore, the participants were adult immigrants taking part in an intensive L2 course (*ibid.*:1, 3, 8). Consequently, the transferability of these results to child foreign language learning that takes place at school might be limited.

One of the few studies that included NI as a distinct separate cognitive ability and at the same time focused on child SLA was conducted by Kristiansen (1990:58f.) with 12- to 13-year-old Finnish and Indian pupils who were studying a foreign language at school. The RPM test was administered as a measure of NI and receptive L2 skills were assessed by a comprehension test consisting of a matching task, a cloze-task and a translation task (*ibid.*:66-71). It is not explicitly stated which

language skills these tasks assessed but they seem to have tested reading comprehension, vocabulary knowledge as well as grammar knowledge. Regression analyses revealed that NI contributed significantly to the comprehension scores of both the Indian and the Finnish children (ibid.:97, 111). Despite the similarities between the Finnish and the Indian participants, some differences were found as well: While NI was the factor that explained most variance of the comprehension scores of the Finnish sample (ibid.:97), NI accounted only for the second-largest amount of variance in the scores of the Indian participants (ibid.:111). In addition, it should be noted that several other factors such as WM, PSTM and PA that might also have had an influence had not been tested. Moreover, similar to the aforementioned studies, different L2 receptive skills were not measured separately but only overall comprehension was assessed.

A study that investigated the relation between NI and a distinct L2 skill, namely L2 grammar comprehension, was conducted by Kempe et al. (2010). They explored the generalization of “grammatical categories such as noun gender” (ibid.:127) and NI was found to affect receptive grammar “performance in nouns containing at least some degree of gender transparency” (ibid.). Based on statements by Kempe and Brooks (2011:18) and on a further study by Brooks and Kempe (2013:281), it can be assumed that higher NI facilitated the learning of regular grammar aspects by supporting the detection of patterns. The study by Brooks and Kempe (2013) also suggests, however, that this mechanism might only work up to a certain point of complexity of the grammar system and that the underlying rules might not “be accessible to explicit representations” (ibid.:293) anymore if the grammar systems becomes too complex. In such cases NI stops being a good predictor of grammar performance (ibid.). In addition, Kempe et al. (2010:142, 144) found that NI was only a significant predictor of grammar as long as age was not included as a predictor variable.

Furthermore, findings by Brooks, Kempe and Sionov (2006) suggest that the role of NI in L2 grammar learning might also be influenced by the input since in their study only individuals with relatively high NI performed well on a grammar task when they received “rich linguistic input” (Kempe & Brooks, 2011:18, see also Brooks et al., 2006:203) while “[i]ndividuals who scored low on pattern detection [...] actually experienced a deterioration of performance when exposed to rich, rather than restricted input” (Kempe & Brooks, 2011:18). It has to be noted, however, that this conclusion was drawn on the basis of a test that required the production and not the comprehension of grammar (Brooks et al., 2006:192).

Even though the studies by Brooks and Kempe (2013:288), Kempe et al. (2010:138) and Brooks et al. (2006:192f.) focused on grammar learning, they investigated the relation between NI and vocabulary knowledge as well. Unfortunately, however, only productive vocabulary knowledge was tested. In this respect, Kempe et al. (2010:142), for instance, found that NI explained some variance when WM and familiarity with gender-transparent languages were the only other factors that were

accounted for. This result was interpreted “as an effect of limitations in general attentional capacity” (ibid.:146): As vocabulary was learned incidentally while learners focused on grammar learning, variables such as NI that assisted grammar learning “may have affected vocabulary recall simply because the more successful gender learning was, the more resources were available to commit the novel strings to memory” (ibid.). Consequently, these findings do rather support a weak and indirect link between L2 vocabulary skills and NI.

In sum, however, the reported findings illustrate that NI might be related to SLA, but as several studies only reported an overall score for language proficiency and/or did not account for other cognitive factors, drawing precise conclusions on the relationship between NI and distinct L2 skills seems to be difficult. In general, previous research findings seem to support a connection between NI and the comprehension of regular aspects of L2 grammar even though this link might also be influenced by several further factors such as language input and the complexity of the grammar system. Unfortunately, the aforementioned studies did not deal with receptive vocabulary skills as a separate variable, but findings on productive vocabulary knowledge support a weak link between vocabulary knowledge and NI. It should be noted, however, that most of the reported results were yielded by studies that investigated adult SLA. The transferability of the reported findings to child SLA might thus be limited.

2.5 Concluding Remarks

The preceding chapters gave some information about the four cognitive variables WM, PSTM, PA and NI and about the relation between these four factors and L2 skills. In general, it can be concluded that several studies suggest that the chosen cognitive variables might be related to certain receptive L2 skills even though the relevance of the cognitive variables to SLA also seems to depend on the exact language domain and on several further factors. Nevertheless, it seems worth to examine whether the cognitive variables WM, PSTM, PA and NI play a role in German-speaking children’s acquisition of English as a foreign language at school, particularly because none of the aforementioned studies were conducted with German-speaking children who learned English as an L2. The study that will be presented in the following chapters thus aimed to contribute to finding an answer to this question.

3 The Study

3.1 Research Questions and Hypotheses

The main objective of the study was to explore the relation between the cognitive variables WM, PSTM, PA and NI and certain receptive English skills of German-speaking primary school pupils who learned English as an L2 at school: The relationship between the aforementioned cognitive

variables and the comprehension of English grammar and vocabulary as measured by respective receptive tests was investigated. The following research questions and hypotheses, which were formulated on the basis of the research findings that were reported in the chapters 2.2 to 2.4., underlay the study.

Question 1: Are the cognitive variables WM, PSTM, PA and NI related to German-speaking primary school pupils' receptive English vocabulary knowledge and if so, in which way?

Hypothesis 1a: WM capacity correlates positively with the pupils' receptive English vocabulary knowledge.

This hypothesis is primarily based on the study by Swanson et al. (2011) since the participants of this study were about the same age as the subjects of the present study. Several other studies focused rather on secondary school students or adult L2 learners (e.g. Kormos & Sáfár, 2008; Martin & Ellis, 2012) and/or did not measure vocabulary and grammar separately (e.g. Kormos and Sáfár, 2008) so that they did not seem to be comparable to the present study. It has to be noted, however, that the study by Swanson et al. (2011) was conducted with children who learned an L2 because it was the language of their environment. Consequently, the transferability of the findings of this study to SLA which only takes place in a school context might also be limited.

Hypothesis 1b: PSTM capacity correlates positively with the pupils' receptive English vocabulary knowledge.

This hypothesis is based on findings from studies by Service and Kohonen (1995), Vulchanova et al. (2014), French (2006) and Farnia and Geva (2011) since these studies also investigated child SLA. It should be noted, however, that the participants of French's (2006) and Farnia and Geva's (2011) studies learned their L2 under conditions which differed quite strongly from the circumstances under which the participants of the present study learned English. Further studies that also dealt with vocabulary knowledge seem to be even less comparable to the present study since they were conducted with older pupils and did not measure grammar and vocabulary separately (e.g. Kormos & Sáfár, 2008).

Hypothesis 1c: PA correlates positively with the pupils' receptive English vocabulary knowledge.

This hypothesis is based especially on findings by McBride-Chang et al. (2006) and by Farnia and Geva (2011) since they related PA to existing receptive vocabulary knowledge. Several other studies, in contrast to this, rather measured the ability to learn new words or to comprehend words that had just been learned (e.g. Hu, 2008; Hu, 2014). It should be noted, however, that McBride-Chang et al.'s (2006) subjects were younger than the pupils who participated in the present study.

Furthermore, Farnia and Geva's (2011) participants learned their L2 under circumstances that differed from the ones under which the subjects of the present study learned their L2 English.

Hypothesis 1d: NI correlates positively with the pupils' receptive English vocabulary knowledge.

None of the studies mentioned in chapter 2.4 dealt with receptive L2 vocabulary knowledge as a distinct, separate variable. As findings of several studies support, however, a relation between NI and overall L2 comprehension and between NI and productive vocabulary knowledge, it seems likely that NI might be related to receptive L2 vocabulary knowledge.

Question 2: Are the cognitive variables WM, PSTM, PA and NI related to German-speaking primary school pupils' receptive English grammar knowledge and if so, in which way?

Hypothesis 2a: WM correlates positively with the pupils' receptive English grammar knowledge.

This hypothesis is based particularly on the study by Engel de Abreu and Gathercole (2012) because it is one of the few studies that investigated L2 grammar learning that took place in a school context, was conducted with children instead of adults and focused on receptive instead of productive grammar knowledge. The findings of this study are corroborated by further studies which investigated adult SLA (e.g. Kempe et al., 2010; Martin & Ellis, 2012; Miyake & Friedman, 1998). It should be noted, however, that even though the study by Engel de Abreu and Gathercole (2012) and the present study have several aspects in common, they also differ from one another in several aspects. For instance, the pupils that participated in Engel de Abreu and Gathercole's (2012) study had started to learn their L2 at an earlier age than the subjects of the present study.

Hypothesis 2b: PSTM correlates positively with the pupils' receptive English grammar knowledge.

This hypothesis is mainly based on the findings by Engel de Abreu and Gathercole (2012) for the same reasons that were mentioned in the context of Hypothesis 2a. Further studies also investigated the relation between PSTM and L2 grammar knowledge, but they did not provide a pure measure of receptive grammar knowledge (e.g. French, 2006; French & O'Brien, 2008; Kormos & Sáfár, 2008), were conducted with adults (e.g. Martin & Ellis, 2012; Ellis & Sinclair, 1996) and/or investigated language learning under laboratory conditions (e.g. Martin & Ellis, 2012).

Hypothesis 2c: PA correlates positively with the pupils' receptive English grammar knowledge.

This hypothesis is also based on the findings by Engel de Abreu and Gathercole (2012) since – as was mentioned in the context of Hypothesis 2a – this study and the present study have several aspects in common. Moreover, there seem to be very few further studies that examined the relation between children's receptive L2 grammar knowledge and PA.

Hypothesis 2d: NI correlates positively with the pupils' receptive English grammar knowledge.

This hypothesis is based on findings by Kristiansen (1990) and by Kempe et al. (2010). It should be noted, however, that Kristiansen (1990) did not focus on receptive grammar skills in particular but on L2 comprehension in general and that Kempe et al. (2010) investigated adult SLA. The other studies that were mentioned in chapter 2.4.3 in the context of NI, however, seem to be even less suitable for serving as a basis for a hypothesis about the relation between NI and children's receptive L2 grammar knowledge since these studies linked NI only to an overall language proficiency score that combined productive and receptive L2 skills, for instance (e.g. Genessee & Hamayan, 1980; d'Anglejan & Renaud, 1985).

Question 3: Which of the four cognitive variables WM, PSTM, PA and NI have/has the biggest impact on German-speaking primary school pupils' receptive English vocabulary knowledge?

No hypothesis is formulated with regard to this question since many of the studies that have been presented in the preceding chapters (see 2.2.3, 2.2.4, 2.3.3 and 2.4.3) included only some of the four cognitive variables or they included further factors so that no well-founded assumption is possible on the basis of the reported results. The same is true for the following question.

Question 4: Which of the four cognitive variables WM, PSTM, PA and NI have/has the biggest impact on German-speaking primary school pupils' receptive English grammar knowledge?

With regard to the research questions, it should be noted that the term *German-speaking pupils* in the present study refers to children who either speak German as L1 or who speak German as L2 or L3 but whose competencies in German are so good that they can participate in age-appropriate everyday conversations without problems and can read and write in German. The concepts of WM, PSTM, PA and NI as well as the concepts of receptive English grammar and vocabulary knowledge are defined via the tests that were used to measure these variables.

3.2 Participants

The initial sample of the present study consisted of 62 German-speaking primary school pupils who learned English at school. The pupils attended the fourth grade of either a primary school in Garbsen with a total of about 435 pupils or a primary school in Göttingen with about 200 pupils. Both schools were located in Lower-Saxony, Germany. The pupils of one class of the primary school in Garbsen and of three classes of the primary school in Göttingen were tested. The data of the children attending the school in Göttingen, however, had to be excluded because firstly, the objectivity of administration is likely to have been affected with regard to one of the cognitive tests and secondly, the test which measures PA was not administered to any of the pupils in Göttingen.

The remaining sample consisted of 20 pupils and contained 10 boys and 10 girls with a mean chronological age of about 9 years; 9 months (range = 9;1 to 10;5). The pupils had been learning English for about one year and two months at the date of testing and received two English lessons a week of about 45 minutes each. Even though 13 children had a migration background, their language competencies in German as measured by the *Sprachstandserhebungstest für Kinder im Alter zwischen 5 und 10 Jahren (SET 5-10)* were comparable to those of the children who spoke German as L1. One pupil of the sample had been attested an intellectual disability.

Further information about the pupils' cultural and social background can be found in Schilder (2015).

3.3 Instruments

3.3.1 Tests of Cognitive Variables

Working memory (WM)

WM was assessed with a backward digit span task and a letter-number sequencing task taken from WM subtests of the *Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV)* since both these tasks “require to process and store information simultaneously” (Engel de Abreu & Gathercole, 2012:2, see also Petermann & Petermann, 2011a:25) and complex span tasks are commonly used to assess WM capacity (Engel de Abreu & Gathercole, 2012:2). The *WISC-IV* was chosen as it is based on the established Wechsler-tradition and at the same time integrates current results of psychological research (Testzentrale, 2015b). Furthermore, it is one of the most often used test instruments in German-speaking countries and world-wide (Petermann & Petermann, 2011a:5).

The backward digit span test consists of eight tasks with two trials each (ibid.:25). For each trial the child hears a sequence of spoken digits and has to repeat them in the reverse order (Petermann & Petermann, 2011b:63). Both trials of the same task consist of the same amount of digits. The first two tasks require the backward repetition of two digits, the third task consists of three digits and then each task contains of one digit more than the preceding task so that both trials of the eighth task are comprised of eight digits (ibid.:64). If both trials of the same task are not answered correctly, the backward digit span test is discontinued (ibid.:61).

The letter-number sequencing test consists of ten tasks with three trials each (Petermann & Petermann, 2011a:26). For each trial the child hears a combination of spoken letters and digits in a random order (Petermann & Petermann, 2011b:99, 102, 103). The child has to repeat the letters and digits according to a predetermined order which the child is told when the instructions for the letter-number sequencing test are given (ibid.:101). All trials of the same task are comprised of the same amount of items (letters and digits) (ibid.:102, 103). While all trials of the first two tasks are comprised of two items, all trials of the third, fourth and fifth task consist of three items (ibid.).

For each trial of the sixth task four items have to be repeated in the correct order and then every following task consists of one item more than the preceding task so that eight items have to be repeated in the correct order for the tenth task (ibid.:103). Testing is discontinued when all three trials of the same task are not answered correctly (ibid.:99).

Phonological short-term memory (PSTM)

PSTM was assessed by a forward digit span task taken from the digit span subtest of the *WISC-IV*. A simple digit span task was chosen since it is “the most often-used measure of PSTM in the literature” (Henry, 2012:38). The forward digit span part of the digit span subtest of the *WISC-IV* consists of eight tasks with two trials each (Petermann & Petermann, 2011b:63). For each trial the child hears a sequence of spoken digits and has to repeat this sequence in exactly the same order (ibid.:61). Both trials of each task consist of the same amount of digits (ibid.:63). The test begins with two digits for each trial of the first task. Both trials of the second task are comprised of three digits and it goes on with each task consisting of one digit more than the task before so that each trial of the eighth task is comprised of nine digits (ibid.:63). Testing is discontinued when both trials of the same task are not answered correctly (ibid.:61).

Phonological awareness (PA)

PA was assessed by a subtest of the *Potsdam-Illinois Test für Psycholinguistische Fähigkeiten (P-IITPA)*. The *P-IITPA* can be used to assess linguistic abilities of children between 4;00 and 11;5 and was chosen as it allows a differentiation in both the lower and the upper ability range (Esser & Wyszkon, 2001a:27, 33). Moreover, both its objectivity of administration and its objectivity of interpretation have been classified as very high (ibid.:33).

The subtest that assesses PA consists of three parts with an increasing level of difficulty (ibid.:127). The first part is a rhyming task, the second part requires vowel substitution and the third part deals with consonant deletion. School children start with the second part, the vowel substitution task (ibid.).

The vowel substitution part consists of 22 items and requires the child to substitute certain vowel phonemes of a word through other vowel sounds (ibid.:128). This procedure generates new words, some of which have an existing meaning in German and some of which are nonsense words (ibid.). All the items are presented orally to the child (ibid.). Testing is discontinued when the child gives four false answers in a row (ibid.:129). If the child fails to produce at least five correct answers during the whole vowel substitution test, the rhyming task is administered to the child, which is usually only used for kindergarten children (ibid.:127).

The rhyming task consists of 20 items (ibid.:129). For each item the child hears a word for which a rhyming word has to be found (ibid.:127). Then the child is shown a page with three to four pictures (ibid.; Esser & Wyszkon, 2001b:25). One of the terms that describe the pictures rhymes

with the target word. The test administrator names all the pictures, points at the corresponding pictures simultaneously and after a short pause repeats the word for which a rhyming word has to be found (Esser & Wyschkon, 2001a:127). Then the child gives an answer by naming the word that he/she thinks rhymes with the target words (ibid.). The task is discontinued when a child gives four false answers in a row (ibid.:129). School children who have managed to give at least five correct answers in the second part, the vowel substitution test, receive the full score for the rhyming task automatically (ibid.:129, 130).

The last part, the consonant deletion task, is administered to all school children, regardless of their performance in the other parts (ibid.:129). The task contains 22 items and requires the deletion of certain consonant phonemes in words (ibid.). This procedure generates new words and while the first newly-generated words have a meaning in German, the deletion of the consonants in the last items results in the generation of nonsense words (ibid.). All the items are presented orally to the child and the child also has to form the new words orally (ibid.). Testing is discontinued when the child gives four false answers in a row (ibid.).

An analysis of the demands of the different parts shows that the rhyming task tests PA in the broader sense, while the vowel substitution and the consonant deletion part assess PA in the narrower sense.

Nonverbal intelligence (NI)

NI was assessed by a subtest of the *Basisdiagnostik Umschriebener Entwicklungsstörungen im Grundschulalter (BUEGA)* as the *BUEGA* provides high objectivity of administration and interpretation as long as the instructions are followed precisely (Esser, Wyschkon & Ballaschk, 2008:24). In addition, its economy of administration is considered high (ibid.), which was also an important aspect since the children who participated in the present study had to complete several different tests.

The subtest that assesses NI measures the child's nonverbal ability to reason logically (ibid.:21). It consists of 38 items and for each item the child is presented a coloured matrix in which one picture is missing (ibid.:84, 86). The child is required to complete the matrix by choosing the correct picture from several given alternatives (ibid.:84). While only five alternatives are presented for each item at the beginning, the last items require the child to choose between eight alternatives (ibid.:21). In order to be able to select the right answer, shapes, colours and structures as well as their relations with one another have to be recognized (ibid.).

3.3.2 Tests of Receptive English Skills

Receptive English vocabulary knowledge

Receptive English vocabulary knowledge was assessed by the *British Picture Vocabulary Scale: Third Edition (BPVS III)*, which “is an individually administered, norm-referenced, test of hearing (receptive) vocabulary for Standard English” (Dunn et al., 2009:1) and is suitable for testing pupils of an age between “3 years to 16 years 11 months” (ibid.). The *BPVS III* “is a substantial revision of the first and second editions” (ibid.) and one main difference between the previous versions and the *BPVS III* is that the test items of the *BPVS III* “are in colour” (ibid.). It was chosen since it can be used with individuals who learn English as an additional language (ibid.:3). Moreover, “[i]t is used regularly by practitioners in a variety of fields” (ibid.:2) and is easy and “not time-consuming to administer” (ibid.:3, see also ibid.:4). In addition, “[t]he *BPVS* is strongly linked with the *Peabody Picture Vocabulary Test (PPVT; Dunn, 1959)*, which has been well-established and generally accepted in the USA since 1959” (Dunn et al., 2009:1).

The *BPVS III* comprises four training items, “followed by 14 sets of 12 test items” (ibid.). “Each item in the test consists of four simple colour illustrations [...], arranged in a two-by-two array” (ibid.). For each item the pupil has to look at the respective pictures and hears a word. The pupil’s “task is to select the picture that best illustrates the meaning of [...] [the, N.W.] stimulus word” (ibid.).

According to Dunn et al. (2009:1) “[t]he items are arranged so that each successive set is more difficult than the preceding one”. Most of the targets words are “‘operational’: that is, they are functional in the context of everyday life” (ibid.:23). The words that are tested by the *BPVS III* cover a wide range of different categories and are classified in categories such as “actions; adjectives; [...] books; stationery, school and office equipment; [...] emotions and expressions; [...] fruit and vegetables; [...]; musical instruments; [...] vehicles and their parts; and workers” (ibid.). It should be noted, however, that words that are easy for children and adolescents living in an English-speaking environment might not necessarily be easy for children who learn English as a foreign language at school.

Receptive English grammar knowledge

Receptive grammar knowledge was assessed by the *ELIAS (Early Language and Intercultural Acquisition Studies) Grammar Test II*, which “is a picture pointing task” (Steinlen, Håkansson, Housen & Schelletter, 2010:70). It tests “the ability to process L2 utterances morpho-syntactically rather than the ability to semantically comprehend L2 utterances” (Steinlen et al., 2010:74). Consequently, receptive grammar knowledge as assessed by the *ELIAS Grammar Test* “refers to the bottom-up processing of linguistic constructions in which attention to form and a detailed structural analysis are crucial” (ibid.).

The grammar test consists of two parts, an A-version and a B-version, both of which assess the comprehension of the same following grammatical phenomena: subject-verb agreement for copula verbs in singular and plural forms, subject-verb agreement for full verbs in singular and plural forms, the possessive case, affirmative and negative sentences, plural morpheme -s, possessive pronouns in the singular form, personal pronouns in the singular form in the objective case, personal pronouns in the singular form in the subjective case, word order, passive and two types of relative clauses (Kersten et al., [no date]; Steinlen et al., 2010:77). It should be noted, however, that the grammar test does not exclusively assess “morpho-syntactic comprehension because the children need to know the words in the phrases and sentences as well in order to demonstrate their grammatical abilities” (ibid.).

Each version contains three items for each of the twelve grammatical phenomena so that each version comprises 36 items and both versions together consist of 72 items (Kersten et al., [no date]). For each item the child has to look at three pictures and hears a sentence or word in English that corresponds to “one of the pictures” (Schelletter & Ramsey, 2010:105). The child’s task is to select the picture that best illustrates the stimulus word or sentence. The three pictures that are presented for each item differ “in the following way” (ibid.): Two pictures differ only “in the target grammatical dimension (e.g. absence/presence of the plural inflectional marker -s: cat/cats)” (ibid.). The other picture, in contrast, is a distractor and shows something completely different (ibid.).

3.4 Data Elicitation Procedure¹⁰

As stated in chapter 1, the present study is part of a larger research project – the SMILE¹¹ (Studies on Multilingualism in Language Education) – that aims to provide a comprehensive picture of the factors that might influence English foreign language learning at German primary schools. The data that are reported in the present paper were collected during the pilot phase of this research project. The cognitive data were gathered in cooperation with the university outpatient department *KiM (Kind im Mittelpunkt)* of the University Hildesheim. Before the testing sessions started, the pupils’ parents received a form which gave information about the research project and asked for consent for their children to participate in the study.

Both the cognitive tests and the language tests were administered in October and November 2014 and the testing always took place during the first four lessons. While the cognitive tests were

¹⁰ This chapter only refers to the collection of the data of the children who attended the school in Garbsen since the data of the pupils who attended the school in Göttingen were not included in the study.

¹¹ For further information see <https://www.uni-hildesheim.de/fb3/institute/institut-fuer-englische-sprache-und-literatur/mitglieder/prof-dr-kristin-kersten/smile/>

administered to the children only by the author of this paper, the language tests were administered to the children by the author, a bachelor student and a PhD student.

All the cognitive tests were presented in German. The measures of WM (*WISC-IV*), PSTM (*WISC-IV*) and PA (*P-ITPA*) were administered individually to each child according to the test instructions of the respective manuals in a relatively quiet room of the school. The *WISC-IV* and the *P-ITPA* were not tested at the same dates, but firstly all the children took the *WISC-IV* during a period of time from October 9th to October 16th and then the *P-ITPA* was administered from October 16th to October 23rd. Each of these two testing sessions lasted about 20 to 25 minutes per child¹².

The *BUEGA*, which is originally an individual test, was administered to the pupils in groups of about ten children in a quiet classroom in November 2014. Each child received a coloured booklet with the test items. After the instructions had been given and after it had been checked that all children understood the task, the children had to indicate their answers on their own by crossing the number of the pictures that they regarded as correct. For answering the items of the *BUEGA*, the pupils were allowed as much time as they needed, but no child took longer than half an hour.

The English language tests (*BPVS III* and *ELLAS Grammar Test*), which are both originally individual tests, were administered to the pupils in groups of about ten children in a quiet room of the school in October 2014. For the administration of the *BPVS III* the children received a coloured booklet with the pictures of the test items of the first seven sets of the test and, similar to the procedure used for administering the *BUEGA*, had to indicate their answers by crossing the number of the picture that they regarded as correct. The administration of the *BPVS III* differed from the one of the *BUEGA*, however, insofar as the children had to wait after each item until all the other children had made their choice since for each item a word was presented by the test administrator (see chapter 3.3.2). Moreover, during the administration of the *BPVS III* the test items were also presented via a PowerPoint-presentation so that the children could check if they had opened their booklet at the correct page. Furthermore, the presentation helped to make sure that the pupils could recognize what the pictures showed since the pictures in the booklet were quite small. The *ELLAS Grammar Test* was presented in identical fashion, apart from the fact that the pictures were not coloured but were line-drawings. The administration of each language test took about 20 minutes.

¹² In addition to the WM subtest of the *WISC-IV*, a further subtest of the *WISC-IV* was administered. However, the data of this subtest were not included in the present study.

3.5 Data Analysis

After the administration of the tests raw scores for all tests were calculated. The raw scores for the subtests of the *WISC-IV*, the *P-ITPA* and the *BUEGA* were calculated according to the corresponding manuals. It should be noted, however, that the raw scores for the forward digit span task and the raw scores for the backward digit span task were not added up because the forward digit span task was regarded as a measure of PSTM only, while the backward digit span task was considered a measure of overall WM capacity. The raw scores that the children had received for the backward digit span task were added to the raw scores for the letter-number sequencing task.

Raw scores were calculated for the language tests as well. One point was given for each correct answer. With regard to the *BPVS III*, it has to be noted that neither a basal nor a ceiling set was established. Instead all correct answers of the first seven sets were added up.

The collected data were then analyzed statistically. Firstly, descriptive statistics were calculated in order to get an overview of the collected data. Afterwards, in order to test the hypotheses and to answer the research questions, a Pearson's correlational analysis on the pupils' test scores was run to test for relations between the different variables. In addition, a stepwise regression analysis was performed to test which cognitive factors best explained the variance in the pupils' receptive English grammar and vocabulary knowledge.

3.6 Results

3.6.1 Descriptive Statistics

Descriptive statistics for all the cognitive and language variables are listed in Table 1. The data show that the pupils received on average about 52% of the full points of the WM test and about 45% of the highest possible score of the PSTM test, while the mean score of the PA test was about 90% and the mean score of the NI measure was about 68% of the perfect score. Furthermore, the data show that the mean score of the grammar test was about 55% of the full points and the mean score of the vocabulary test was approximately 59% of the maximum score.

	M	SD	Min	Max	Possible
WM	24.10	2.90	17.00	28.00	46
PSTM	7.25	1.25	5.00	11.00	16
PA	57.40	2.90	53.00	63.00	64
NI	25.85	5.73	7.00	35.00	38
Grammar	39.85	4.83	32.00	51.00	72
Vocabulary	50.30	6.55	39.00	64.00	84

Table 1. *Descriptive Data for Variables of Interest*

$N = 20$. WM = working memory; PSTM = phonological short-term memory; PA = phonological awareness; NI = nonverbal intelligence; Grammar = grammar comprehension; Vocabulary = vocabulary comprehension. M = mean; SD = standard deviation; Min = the lowest score that a pupil received; Max = the highest score that a pupil received; Possible = the highest possible score.

3.6.2 The Relations between Cognitive and Language Variables

A set of simple correlations with Pearson-coefficients was performed on the four cognitive and two language variables. The resulting matrix is presented in Table 2 and shows that no negative correlations were found. All the correlations were positive. Five correlation coefficients were significant at the .01-level and four correlation coefficients were significant at the .05-level. In what follows, the correlation matrix will be described in more detail. Correlation coefficients are interpreted following Dancey and Reidy's (2004) categorization of coefficients of 1 as perfect, $\pm .7$ to $\pm .9$ as strong, $\pm .4$ to $\pm .6$ as moderate and $\pm .1$ to $\pm .3$ as weak. An r -value of 0 is a zero correlation and implies that there exists no correlation at all.

	WM	PSTM	PA	NI	Grammar	Vocabulary
WM	-					
PSTM	.225	-				
PA	.575**	.564**	-			
NI	.400	.182	.364	-		
Grammar	.509*	.442	.593**	.281	-	
Vocabulary	.483*	.684**	.734**	.471*	.496*	-

Table 2. *Correlations amongst all Variables*

$N = 20$. WM = working memory; PSTM = phonological short-term memory; PA = phonological awareness; NI = nonverbal intelligence; Grammar = grammar comprehension; Vocabulary = vocabulary comprehension.

** $p < .01$.

* $p < .05$.

Relations amongst cognitive variables

The PA measure correlated moderately with the WM measure ($r = .575$, $p < .01$) as well as with the PSTM measure ($r = .564$, $p < .01$). Both these correlations were highly significant. Even though

both the WM and the PSTM measures correlated with the PA scores, WM and PSTM did not correlate significantly with each other.

Relations amongst receptive English skills

A significant moderate correlation was found between the grammar comprehension measure and the vocabulary comprehension measure ($r = .496, p < .05$).

Relations between cognitive variables and receptive English grammar knowledge

The grammar test scores correlated significantly and moderately with the WM measure ($r = .509, p < .05$) and highly significantly and moderately with the PA score ($r = .593, p < .01$). A lower but still moderate association was found between the grammar measure and the PSTM score ($r = .442, p > .05$). However, it narrowly failed to reach significance. The link between grammar scores and NI scores was weak and not significant.

Relations between cognitive variables and receptive English vocabulary knowledge

The vocabulary test scores were related significantly and highly significantly to all the cognitive measures. A moderate, almost strong, correlation was found between the vocabulary measure and the PSTM measure ($r = .684, p < .01$) and a strong correlation was found between the vocabulary test scores and the PA test scores ($r = .734, p < .01$). Both these correlations were highly significant. In addition, vocabulary correlated moderately with WM ($r = .483, p < .05$) and with NI at a significant level ($r = .471, p < .05$).

3.6.3 The Impact of Cognitive Variables on Receptive English Skills

The impact of cognitive variables on receptive English vocabulary knowledge

The impact of WM, PSTM, PA and NI on receptive English vocabulary knowledge was investigated with the help of a stepwise multiple regression analysis. The regression model which best explained the variance in vocabulary knowledge contained the two cognitive variables PA and PSTM and was reached in two steps (see Table 3). The model was highly significant ($F(2, 17) = 15.512, p < .001$) and accounted for approximately 65% of the variance of receptive vocabulary knowledge ($R^2 = .646, \text{Adjusted } R^2 = .604$). It explained about 10.7% more variance than a model that only contained PA as predictor variable ($R^2 = .539, \text{Adjusted } R^2 = .513$). Both PA and PSTM had a significant positive impact on receptive vocabulary knowledge. PA had the strongest weight in the model ($\beta = .511, p < .05$) and PSTM had the second strongest weight ($\beta = .396, p < .05$).

Model	B	SE	β	T	Sig.
Constant	-30.673	19.632		-1.562	.137
PA	1.149	.393	.511	2.922	.010
PSTM	2.074	.914	.396	2.269	.037

Table 3. *Stepwise Regression Analysis Results for Receptive English Vocabulary Knowledge*

The dependent variable is receptive English vocabulary knowledge as measured by the BPVS. $N = 20$. $R^2 = .646$; Adjusted $R^2 = .604$. Sig. = significant. PA = phonological awareness; PSTM = phonological short-term memory.

The impact of cognitive variables on receptive English grammar knowledge

The impact of WM, PSTM, PA and NI on receptive English grammar knowledge was investigated with the help of a stepwise multiple regression analysis. The regression model which best explained the variance in receptive English grammar knowledge contained only one of the four cognitive variables, namely PA, and was reached in one step (see Table 4). The model was statistically significant ($F(1, 18) = 9.765$, $p < .01$) and accounted for approximately 35% of the variance of receptive English grammar knowledge ($R^2 = .352$, Adjusted $R^2 = .316$). PA had a significant positive impact on receptive English grammar knowledge ($\beta = .593$, $p < .01$).

Model	B	SE	β	T	Sig.
Constant	-16.622	18.094		-.919	.370
PA (<i>P-ITPA</i>)	.984	.315	.593	3.125	.006

Table 4. *Stepwise Regression Analysis Results for Receptive English Grammar Knowledge*

The dependent variable is receptive English grammar knowledge as measured by the ELIAS Grammar Test. $N = 20$. $R^2 = .352$; Adjusted $R^2 = .316$. Sig. = significant. PA = phonological awareness.

3.7 Discussion

3.7.1 The Relation between Working Memory and Receptive English Skills

The results of the study support Hypothesis 1a and 2a, according to which WM capacity is positively related to receptive English vocabulary knowledge and to receptive English grammar knowledge. Thus, the results are in line with the findings of other studies that corroborate a link between WM and receptive L2 vocabulary skills (e.g. Swanson et al., 2012) or between WM and receptive L2 grammar skills (e.g. Miyake & Friedman, 1998; Kempe et al. 2010; Martin & Ellis, 2012; Engel de Abreu & Gathercole, 2012). Furthermore, the results of the present study suggest that Swanson et al.'s (2012) findings on the relation between WM and vocabulary knowledge, which were obtained in the context of rather naturalistic SLA and served as a basis for Hypothesis 1a, might be transferable to SLA that takes place in a school context.

Moreover, the results seem to support the statements by Miyake and Friedman (1998) and by Sawyer and Ranta (2007) (see chapter 2.2.2) that explain why WM might be linked to SLA: The acquisition of both receptive grammar skills and receptive vocabulary skills seems to require the ability to simultaneously store and process language. It seems likely, for instance, that learning new words or grammatical units such as morphemes requires the language learner to store bits of language and to simultaneously assign meaning to the words or grammatical units. Furthermore, in order to understand a familiar word or a familiar grammatical structure in spoken language, language learners have to hold the respective language bit in mind while they simultaneously try to activate the meaning of the linguistic unit that has been stored in long-term memory. Such processes are likely to require attentional control and might thus be related to functions which are fulfilled by the central executive as the allocation of attention is regarded as the main function of the central executive (Henry, 2012:21; Baddeley, 2012:14; see chapter 2.2.1).

Particularly with regard to the relation between WM and receptive grammar skills, however, the possibility that the findings might also be partially due to the format of the grammar test has to be considered (Robinson, 2002a:256; see chapter 2.2.3). The grammar test required the pupils to store a sentence or word that they were presented orally and to decide which of the presented pictures belonged to the respective word or sentence. Whereas storing a single word while selecting a picture might still be manageable for children with a relatively low WM capacity, holding in mind a whole sentence while selecting a picture might benefit from higher WM capacity. Consequently, in order to test whether the relation that was found between WM and receptive grammar skills was mainly due to the format of the grammar test, this association should be investigated further with the help of a grammar test that does not depend so much on WM capacity. It should be noted, however, that it seems unlikely that receptive grammar skills can be assessed without drawing on WM capacity at all since as soon as something has to be stored temporarily while a decision has to be made simultaneously, WM seems to be involved.

In addition, it should also be noted that the positive correlation between receptive English vocabulary knowledge and receptive English grammar knowledge scores suggests that the relation between WM and receptive English grammar skills might have been mediated or influenced by vocabulary knowledge: Firstly, it is likely that receptive grammar and vocabulary acquisition correlate with each other because “[v]ocabulary is thought to provide the foundation for grammatical knowledge” (Dunn et al., 2009:2). Secondly, the possibility that the test format influenced the results should also be considered since, according to Steinlen et al. (2007:77), the *ELLAS Grammar Test* does not exclusively measure grammar skills, but “the children need to know the words in the phrases and sentences as well in order to demonstrate their grammatical abilities” (ibid.). Consequently, the role that vocabulary knowledge might play with regard to the relation between WM

and receptive English grammar skills should be investigated further and further studies should aim to obtain a relatively pure measure of receptive grammar skills in order to be able to draw more precise conclusions.

3.7.2 The Relation between Phonological Short-Term Memory and Receptive English Skills

The findings of the study support Hypothesis 1b since a highly significant moderate (almost strong) correlation was found between PSTM and the pupils' receptive English vocabulary knowledge. Therefore, the results corroborate several other studies that also found support for a link between PSTM and children's L2 vocabulary skills (e.g. Service & Kohonen, 1995; Vulchanova et al., 2014; French, 2006; Farnia & Geva, 2011; see chapter 2.2.4). In addition, the results are also in line with the statement that the phonological loop component of WM is particularly relevant to L2 vocabulary learning (Gathercole et al., 1992; Wen, 2014:175 see chapter 2.2.1.2) since apart from PA, no other cognitive variable correlated more strongly with receptive vocabulary skills than PSTM. A possible reason why vocabulary knowledge seems to have been more strongly linked to PSTM than to WM – even though this observation should also be analyzed statistically in more detail – might be that the most important aspect in learning a new word in an L2 is the acquisition of a “new phonological form” (Gathercole et al., 1992:897).

In contrast to receptive vocabulary skills, receptive grammar skills were not significantly related to PSTM capacity so that the results found in the present study rather seem to contradict Hypothesis 2b and thus do not seem to be in line with Engel de Abreu and Gathercole's (2012) findings, which had served as a basis for the hypothesis. The differences between Engel de Abreu and Gathercole's (2012) findings and the findings of the present study might be due to the different L2 learning conditions of the respective samples as the pupils who participated in Engel de Abreu and Gathercole's (2012) study had probably received a more intensive L2 input than the participants of the present study. Moreover, it is also possible that the lack of a significant relation between PSTM and grammar in the present study might have been caused by the small sample size: The correlation might have reached significance if more pupils had been tested (Juffs & Harrington, 2011:145). This explanation seems quite likely since, despite the small sample size, the relation between PSTM and receptive grammar knowledge only narrowly failed to reach significance. On the other hand, however, the possibility that the correlation between PSTM and grammar skills might seem stronger than it actually was should also be considered: As was said above, the grammar test also partially measured vocabulary knowledge. It is possible that the correlations between PSTM and receptive grammar knowledge would have been weaker if a purer measure of receptive grammar knowledge had been obtained. Thus, no clear conclusion can be drawn with regard to the relation

between PSTM and the pupils' receptive grammar knowledge on the basis of the findings of the conducted study.

3.7.3 The Relation between Phonological Awareness and Receptive English Skills

The results of the study support Hypothesis 1c and 2c because highly significant positive correlations between PA and the pupils' receptive vocabulary skills and between PA and the children's receptive grammar skills were obtained. The ability to recognize, identify and manipulate sound units seems to be crucial for the acquisition of both receptive grammar and vocabulary skills. The findings thus seem to corroborate Hu's (2008, 2003) statements about possible reasons for the relevance of PA to SLA (see chapter 2.3.2), particularly since PA was the cognitive variable that correlated more strongly with receptive vocabulary and grammar skills than all the other cognitive variables. Hu (2008:40) explained, for instance, that better PA skills help to develop "more distinctly segmented representations", which are easier "to retain, to recall and to articulate" than "holistic phonological representations" and that holistic representations are not suitable for bootstrapping (*ibid.*). In addition, PA also seems to be a prerequisite for identifying certain patterns in words (*ibid.*). For instance, in order to understand how the regular plural is formed in English, the language learner has to recognize the difference between the phonological forms of a singular and a plural noun and/or has to be able to recognize the similarity between the phonological forms of different plural nouns. If a learner is not able to perceive such phonological differences, identifying grammatical morphemes seems to be very difficult.

Moreover, PA seems likely to be of special importance when the language learner acquires the L2 mostly via hearing it. This might also explain why the correlations between PA and receptive English skills in the present study were stronger than the relations found between PA and L2 skills in several other studies (e.g. McBride-Chang et al., 2006; Engel de Abreu & Gathercole, 2012; Farnia & Geva, 2011; Hu, 2003): The participants of the present study had probably mainly encountered spoken English. The aforementioned studies by McBride-Chang et al. (2006:701) and Engel de Abreu and Gathercole (2012:12), in contrast, were conducted with children who had also encountered their L2 in written form. Furthermore, as mentioned in chapter 2.3.3, Engel de Abreu and Gathercole (2012) also investigated the relation between PA and an L3 and their findings also pointed to the possibility that the strength of the relation between PA and the achievement in a foreign language might be weaker if the pupils learn to read and write in the foreign language. Since several further factors, however, might also have had an influence, no clear conclusion can be drawn with regard to the question of why the relations between PA and receptive L2 skills were so strong in the present study. Further factors that should be considered, however, are the degree of similarity between the L1 and the L2 and the length of exposure to the L2. Besides, it should be noted that the small sample size of the study might have been responsible for the relatively strong

correlations between PA and receptive English skills since “[t]he smaller the sample size, the greater the likelihood of obtaining a spuriously-large correlation coefficient” (Hole, 2012:1).

In addition, the positive correlations between PA and WM and between PA and PSTM suggest that the correlations between PA and receptive English skills might also have been influenced by further cognitive factors. It seems likely that the test that assessed PA might also have partially measured PSTM and WM because processes that require PA also seem to require functions that are fulfilled by PSTM and WM: It might be possible, for instance, that PSTM capacity and PA are linked because storing the phonological form of a word or a structure in PSTM seems to be a prerequisite for being able to identify sound units and patterns and for being able to manipulate these units since if they cannot be held in PSTM properly, then there is just nothing that can be analyzed and manipulated. Moreover, WM might be linked to PA because tasks that require PA also seem to require the coordination of different processes. As the central executive is responsible for attentional control, higher WM capacity might support PA. It should be noted, however, that all these explanations are only assumptions and that a precise investigation of the relation between PA and PSTM as well as between PA and WM is necessary in order to be able to make any reliable statements.¹³ Future studies should thus investigate in more detail how the different cognitive variables are linked with each other and how such relations influence the connection between PA and L2 skills.

In addition, with regard to the correlation between PA and receptive grammar skills, the influence of vocabulary or the possibility that the grammar test might not have provided a pure measure of grammar knowledge should also be considered. It is likely that the association between PA and grammar skills would not have been as strong as it was if vocabulary knowledge had been partialled out.

3.7.4 The Relation between Nonverbal Intelligence and Receptive English Skills

The results support Hypothesis 1d since NI was related significantly and positively to receptive English vocabulary skills. Thus, the findings seem to corroborate the statement by Kristiansen (1990:44), according to which higher NI might facilitate vocabulary learning by supporting the deduction of the meaning of words from the context (Kristiansen, 1990:44; see chapter 2.3.2): Since the participants of the present study received English lessons that were probably mainly taught in English and in which the translation of English into German was avoided, it seems likely that the ability to infer the meaning of words from the context might have been required in order to learn new words and to understand what was said.

¹³ It is also possible not only that higher WM and PSTM capacity support PA but also that better PA supports WM and PSTM.

In addition, the results suggest that the role of NI in child SLA might not be completely different from the role of NI in adult SLA since the findings of several studies which were conducted with adults also support the existence of a relation between NI and SLA (e.g. Brooks & Kempe, 2013; Kempe et al., 2010; Brooks et al., 2006; see chapter 2.4.3). Despite the association of NI with receptive vocabulary skills, it should be noted that NI was the cognitive variable that was connected the least strongly with vocabulary skills. On the other hand, it should also be considered that the strength of the link between NI and vocabulary knowledge differed only very slightly from the strength of the link between WM and vocabulary skills and it might be possible that this difference was not even statistically significant.

In contrast to Hypothesis 1d, Hypothesis 2d does not seem to be supported by the findings of the study since only a weak correlation between NI and receptive grammar skills that did not reach significance was found. On the basis of a study by Brooks and Kempe (2013) (see chapter 2.4.3), it can be assumed that a possible reason for these findings might be that the English input that the children had received had been little structured with regard to grammar as the focus had probably been on vocabulary learning most of the time. Consequently, the grammatical input had probably often been too complex for the pupils to deduce grammatical patterns even if they had a relatively high NI. Thus, it is possible that the study would have yielded different results if the children had received different language input. It should be noted, however, that a careful analysis of the pupils' English lessons is necessary in order to draw any conclusions with regard to the question of whether or not the lack of a relation between receptive grammar skills and NI in the present study might have been due to the pupils' English input. Furthermore, it should not be forgotten that the subtest of the *BUEGA* that assessed NI had not been administered according to the instructions insofar as it had been administered in groups even though it is an individual test. Consequently, the possibility that the deviation from the standard procedure might have influenced the results cannot be ruled out completely.

3.7.5 The Impact of Cognitive Variables on Receptive English Vocabulary Skills

With regard to Research Question 3, it was found that the variance in the pupils' receptive English vocabulary knowledge was best explained by PA and PSTM capacity. PA was the cognitive variable that had the biggest impact and PSTM was the cognitive variable that had the second biggest impact. The two factors together explained quite a large amount of variance (ca. 64%). As these two cognitive variables were also the ones that correlated most strongly with receptive vocabulary knowledge, the results of the study support the importance of these cognitive factors for L2 vocabulary acquisition. Since the other two cognitive variables WM and NI correlated less strongly with vocabulary knowledge, it is not surprising that they did not explain any additional variance, especially since PA and WM also correlated positively with each other: The amount of variance

that WM would have explained on its own might already have been covered by the amount of variance that PA explained. These results thus support the claim made in chapter 3.7.3: The PA test might also have drawn on WM capacity. Such an explanation seems natural since in order to solve the PA tasks, the pupils had to temporarily store the instructions as well as the phonological forms of the words that they had to change while they had to manipulate the words in the required manner at the same time.

In addition, the results also point to the possibility that the cognitive processes that were involved in solving the PA tasks were more complex than the ones that were involved in solving the WM tasks, for instance. Thus, PA might have best resembled the cognitive processes that had been involved in the participants' acquisition of new English vocabulary at school. As was mentioned above, it is likely that the English instruction that the children had received had been mostly in English and that the focus had been on spoken L2 skills. Consequently, higher PA might have supported the identification of words and patterns in the sound continuum of the spoken L2, for instance, which might have facilitated word learning. Moreover, the cognitive variable PSTM, which had the second biggest impact on receptive vocabulary skills, might have been needed during English lessons for storing the phonological forms of the new words, for example, and WM as a whole – which might also have been partially tested by the PA measure – might have been involved as well since the new phonological forms also had to be transferred to long-term memory. In addition, WM might have been needed for coordinating the different cognitive processes. As it goes beyond the scope of this work to analyse these processes further, no clear conclusion can be drawn with regard to the question of why PA and PSTM were the cognitive variables that best explained receptive vocabulary skills. Future studies, however, should address this question in more detail and should try to analyse the L2 input that the children receive during English lessons as well as the teaching methods in more detail in order to be able to draw more precise conclusions with regard to the question of why a certain cognitive variable might be linked to a certain L2 skill.

3.7.6 The Impact of Cognitive Variables on Receptive English Grammar Skills

With regard to Research Question 4, it was found that the variance in the pupils' receptive English grammar skills was best explained by the cognitive variable PA. It is not surprising that PSTM and NI did not explain any variance beyond the amount of variance that was accounted for by PA since, as was stated in chapter 3.6.2, they did not correlate significantly with the pupils' receptive English grammar knowledge and seem to have been less strongly linked to the pupils' receptive grammar skills than PA. It is quite striking, however, that WM did not explain any variance beyond the amount of variance that was accounted for by PA since WM seems to have correlated almost as strongly with the pupils' receptive grammar skills as PA. As was mentioned in chapter 3.7.3 and 3.7.5, one possible reason for this result might be that PA also requires processes that are fulfilled

by WM. In addition, PA might be the cognitive variable that best resembled not only the cognitive processes that had been involved in the children's acquisition of English vocabulary but also the cognitive processes that had been involved in the children's acquisition of receptive grammar skills. This seems to be quite likely since the processes that are involved in solving PA tasks seem to be relatively complex and the acquisition of grammar skills seems to be a complex process as well (see chapter 3.7.3). Furthermore, better PA might also have facilitated vocabulary learning, which in turn might have supported the acquisition of grammar skills (Dunn et al., 2009:2).

Additionally, it should be noted, however, that the chosen cognitive variables explained considerably less variance with regard to the pupils' receptive grammar skills than with regard to their receptive vocabulary skills. Consequently, it might make sense to think about further cognitive variables that might play a role in grammar learning.

3.7.7 Concluding Remarks

In general, all the results of the present study as well as the conclusions that have been drawn on the basis of the results should be treated with caution due to the small sample size, which may have influenced the strength of the correlations as well as their significance (Juffs & Harrington, 2011:145), for instance. In addition, it should be investigated in detail whether the data that were collected fulfill the conditions for a regression analysis (Bühner and Ziegler, 2010:672). In this context, special attention should be put on the fact that some of the cognitive measures correlated with each other, which might have influenced the results of the regression analyses. A further aspect that should be taken into consideration and that might have influenced the results is the procedure of administering the tests: Neither the grammar and the vocabulary test nor the NI test were administered according to the standards since all these tests are individual tests but were administered in groups. Furthermore, it should be taken into consideration that the grammar test might not have provided a pure measure of receptive grammar skills but might have measured WM capacity and vocabulary skills as well. Unfortunately, however, it seems extremely difficult, if not impossible, to construct a receptive grammar test that does not draw on WM at all since as soon as a task requires simultaneous storing and processing, WM seems to be involved.

3.8 Conclusion

The main objective of the study was to investigate the relation between the cognitive variables WM, PSTM, PA and NI and children's receptive L2 skills: Firstly, the study aimed to answer the question of whether correlational relations existed between the chosen cognitive variables and children's receptive L2 vocabulary and grammar skills. On the basis of the findings of previous studies, hypotheses were formulated. It was expected that all the cognitive variables would correlate positively with both receptive vocabulary and receptive grammar skills. Secondly, the study aimed to

answer the question of which of the four cognitive variables had the biggest impact on the children's receptive L2 grammar and vocabulary skills.

In order to answer these questions and to test the hypotheses, a study with 20 German-speaking fourth graders who attended a primary school in Lower-Saxony and learned English as an L2 was conducted. Most of the expectations were met since all the cognitive variables correlated positively with the children's receptive vocabulary skills. Moreover, receptive grammar skills were found to correlate positively with WM and PA. The correlations between grammar skills and PSTM and between grammar skills and NI, however, failed to reach significance. In addition, it should be noted that PA was the cognitive variable that correlated most strongly with both receptive vocabulary and grammar skills. Furthermore, with regard to the impact of the cognitive variables on the children's receptive English skills, it was found that PA and PSTM best explained the variance in receptive vocabulary knowledge. With regard to receptive grammar skills, PA had the strongest impact and neither PSTM and NI nor WM could explain any additional variance. Consequently, the results of both the correlational analyses and the regression analyses seem to suggest that PA might be especially important for German-speaking children's receptive English grammar and vocabulary skills. Possible explanations for these findings were discussed in the preceding chapters.

It has to be noted, however, that all the findings of the study have to be treated with caution as some of the cognitive variables correlated with each other, as the study was conducted with a very small sample size and as further methodological factors might have influenced the results. Consequently, further investigations are necessary in order to be able to draw reliable conclusions with regard to the relation between the cognitive variables WM, PSTM, PA and NI and German-speaking children's receptive English vocabulary and grammar skills.

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