

The Effects of Nine-Week Summer Vacation: Losses in Mathematics and Gains in Reading

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Summer vacations interrupt the rhythm of learning and may result in a loss of knowledge and skills. This study investigates summer learning losses in an Austrian sample with nine-week summer vacations. The results show losses as well as gains for students in lower secondary education (182 students between 10 and 12 years old). Students experienced losses in arithmetic problem solving (measured by the HAWIK IV intelligence test) and spelling (measured by the standardized spelling test HSP 5-9), but gains in reading (measured by the Salzburg Reading-Screening, SLS-8). Losses or gains in a knowledge domain appear to depend on the degree of practice during the summer vacation. Contrary to American studies, students could make up for their losses within nine weeks following the re-start of school. In addition, socio-economic variables such as the mother's educational background had a small impact on summer learning losses in arithmetic problem solving.

Keywords: arithmetic problem solving, reading, summer learning loss, spelling

INTRODUCTION

After summer vacation, teachers may return to school feeling recharged and eager to reconnect with equally invigorated students – only to find themselves confronted with students who clearly did not spend their vacation reviewing math and reading and who seem to have forgotten most of their previous knowledge. This phenomenon has been investigated in the USA as “summer learning loss”. Various studies dating from 1908 (White, 1908) all the way to the present (Alexander, Entwisle, & Olson, 2012) show that the summer break may disturb the daily rhythm of learning, and may even lead to losses in knowledge and skills (Cooper, Nye, Charlton, Lindsay, & Greathouse, 1996). In a meta-analysis by Cooper et al. (1996), summer learning losses amounted to one tenth of a test score standard deviation,

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which is equivalent to about one month of schooling. This decline was mainly attributable to losses in mathematics and to a smaller degree to losses in spelling and reading.

Despite its overall importance, the phenomenon of summer learning loss has nearly exclusively been investigated in the USA. Against this background, the present study investigates in an Austrian sample to what degree students' knowledge and skills may suffer from a nine-week summer break and to what degree changes are moderated by family-related variables.

Summer learning loss in mathematical knowledge and skills

An overwhelming majority of surveys that were reviewed for this article found summer learning losses in mathematics (e.g., Alexander, Entwisle, & Olson, 2001; Allinder, Fuchs, Fuchs, & Hamlett, 1992; Cooper et al., 1996; Moore, 2010; Pelavin & David, 1977). However, the extent of learning losses varied depending on the domains and existing skills in mathematics as well as family-related variables. Altogether, previous surveys suggest that summer vacations do not lead to losses in knowledge and skills per se, but that their effects are instead moderated by other variables.

Most of the American surveys researched for this article measured knowledge and skills in mathematics via nationally standardized achievement tests that reflect the content of textbooks used nationwide (e.g., the Comprehensive Test of Basic Skills CBTS (NIE, 1978), the Metropolitan Achievement Test MAT (Hawn, Ellett, & DesJardines, 1981), or the California Achievement Test CAT (Entwisle & Alexander, 1992, 1994; Alexander, Entwisle, & Olson, 2001). In these studies, a compound score was calculated which included knowledge of mathematical concepts and their application (e.g., solving computations; Romberg & Wilson, 1992). Here, students' achievement scores generally decreased over the course of the summer vacation.

Studies that calculated test scores for different areas of mathematics show a more detailed picture. They found summer learning losses for mathematical computation in particular, and fewer losses for other fields such as math concepts (Grenier, 1975; Wintre, 1986).

The direction and the strength of cognitive changes over the summer vacation largely appear to be influenced by the parents' socio-economic background and their educational level. Students from families with a low socio-economic status consistently suffered much more from a decline in knowledge and skills than students from families with a high socio-economic status. The latter could in some cases actually increase their skills over the course of the summer vacation (Alexander, Entwisle, & Olson, 2001, 2007; Downey, von Hippel, & Broh, 2004; Entwisle & Alexander, 1992; Moore, 2010; NIE, 1978). A low socio-economic status often was related to a minority status. In their long-term study "Beginning School Study", Alexander, Entwisle, and Olson (2001, 2007) investigated students'

State of the literature

- American studies showed that the summer vacation may lead to losses in knowledge and skills, the so-called summer learning loss (Alexander, Entwisle, & Olson, 2012).
- There are hardly any studies on summer learning loss in European and Asian countries (Wiseman & Baker, 2004).
- Students from families with a low socio-economic status suffered much more from a decline in knowledge and skills over the summer vacation compared to students from families with a high socio-economic status (Moore, 2010).

Contribution of this paper to the literature

- For the first time, the phenomenon of summer learning loss was investigated in a sample of Austrian students with nine-week summer vacations.
- In this study students' development of knowledge and skills in arithmetic problem solving, spelling, and reading were observed at three points in time: nine weeks before the summer vacation, immediately after and nine weeks after the vacation.
- Students experienced losses in arithmetic problem solving and spelling but improved in reading over the summer vacation. Losses in arithmetic problem solving depended on the parent's (mother's) educational background.

developments from grades 1 to 5. Every year in the spring and fall, students completed a test on mathematical concepts and applications. Summer vacation changes were calculated as the differences between test scores in the fall and previous spring. From grades 1 to 3, the results showed strong losses in mathematics for students from families with a low socio-economic status, whereas students from families with a higher socio-economic status experienced gains. Only in grade 4 did all students experience gains in mathematical skills. This suggests that during early elementary years, out-of-school time has a strong impact on children's cognitive development. Depending on the parents' educational level and their socio-economic background, children gain or lose skills during summer vacation. With this in mind, the summer break contributes to a widened knowledge gap between children, even if they start school with the same knowledge and skills (Alexander & Entwisle, 1996; Bormann & Dowling, 2006).

Studies which investigated only students with a low socio-economic status also found declines in knowledge. For instance, in the study by Hawn et al. (1981), students in grade 2 from families with a low socio-economic background experienced losses in their overall MAT mathematics scores. Pelavin and David (1977) found losses in overall CTBS mathematics scores for students from families with a low socio-economic status who were making the transition from grade 7 to 8 (CTBS = Comprehensive Test of Basic Skills).

Summer learning losses do not depend on the age and grade of students. Declines in abilities were found from grade 1 throughout grade 8 (e.g., grade 1 to 4 studies by Alexander et al., 2001; Moore, 2010; Allinder et al., 1992; grade 7, 8 in a study by Pelavin & David, 1977).

Gershenson (2013) attempted to identify reasons for the different development of children during summer vacation. To do this, she investigated children's and parents' time use during school and in the summer vacation in two samples of 600 and 1200 children. A large gap was found between children from households with a low and high socio-economic status when it came to the time spent watching TV. Children from households with a low socio-economic status increased their TV viewing time during the summer vacation, watching nearly two hours more per day than children from households with a high socio-economic status. The former children also spent significantly less time interacting with adults. The study however did not include achievement tests, meaning that it could not be determined to which degree recreational activities were related to losses or gains over the summer vacation.

The phenomenon of summer learning loss has been mostly investigated in the USA. In our literature review we found no studies from Asian countries. Research in Europe also seems to be merely at its beginning. In a Turkish study by Şahin (2004) students in grade 2 and 3 experienced losses in Turkish language as well as in mathematics. In Sweden, which has a ten-week summer vacation, Lindahl (2001) found losses in mathematical knowledge in grade 6. The author however gives no information regarding what aspects of mathematical knowledge were measured, only that the test consisted of selected parts of the test of the Swedish National Agency for Education. Losses did not vary with children's socio-economic background. Coelen and Siewert (2008a, 2008b) investigated a similar age group in Germany with students in grades 5 to 7 (Siewert, 2010). The mathematics test employed reflected the curriculum of the respective grades. Altogether, 60 % of the students experienced losses in mathematics abilities over the course of the six-week summer vacation. The authors explain the decline in abilities as being a result of the lack of practice with curriculum content during the summer vacation. The parents' socio-economic status had no influence on the degree of loss. In a Belgian study, Verachtert, Van Damme, Ongehna, and Ghesquiere (2009) investigated changes in

basic mathematical skills in a sample of kindergarten students changing to the first grade of elementary school. They found no summer vacation effects. It can however be argued to what degree changes can be expected when formal schooling has not yet started.

Summer learning loss in other knowledge domains

Other knowledge domains commonly investigated in summer learning loss studies are reading and spelling (e.g., Pelavin & David, 1977; NIE, 1978; Heyns, 1978, 1987; Gastright, 1979). Research results on spelling resemble those on mathematics skills. Most studies found decreases in students' skills, which were moderated by the family's socio-economic status (Allinder et al., 1992).

In contrast to spelling, results for reading were equivocal. While some studies found summer learning losses (Pelavin & David, 1977; Gastright, 1978; Johns & Vacca, 1984) others even found gains (Klibanoff & Haggart, 1981; McCormick & Mason, 1981; Shaw, 1982). Also, the moderating effect of the family's socio-economic status was less distinct than for mathematics or spelling (NIE, 1978; Alexander et al., 2001).

Similar to mathematics, in Europe the investigation of summer learning losses for reading and spelling is in its infancy. In Germany, Becker, Stanat, Baumert, and Lehmann (2008) investigated children from families with a migration background. They found a small yet significant summer learning loss. Furthermore, these children generally had lower reading skills than children from non-immigrant families. In a German sample of students with different socio-economic backgrounds, Coelen and Siewert (2008a, 2008b) found no summer learning losses in reading. These results concur with those of Stanat, Becker, Baumert, Lüdtke, & Eckhardt (2012) who investigated the effects of a reading intervention on grammar, reading, and vocabulary: The control group which did not take part in the intervention but was also measured before and after the summer break showed steady values in grammar and even increases in reading and vocabulary over the summer vacation.

Even though most studies concentrated on knowledge and skills in mathematics, reading, and spelling, summer learning losses even seem to play a role in children's general intelligence. Jencks (1972) as well as Heyns (1978) found small yet significant decreases in twelve- to thirteen-year-old children's intelligence quotient. Again, decreases were more significant for children from families with a low socio-economic status.

Need for international research on summer learning loss

As mentioned above, research studies have found effects of summer vacation in different knowledge domains. Summer learning loss is more pronounced for mathematics and spelling than for reading. Both mathematics and spelling are areas which involve the ongoing acquisition of factual and procedural knowledge. Findings in cognitive psychology suggest that without practice, facts and procedural skills are most susceptible to being forgotten if they are not trained (e.g., Cooper & Sweller, 1987). So here, summer learning losses can mainly be attributed to a lack of practice.

Present surveys on summer learning losses are not without their limitations. Nearly all American studies cited in this article can be criticized for their methodological design. Using a spring-to-fall design, summer learning losses are calculated as the difference between testing in fall and in the previous spring. Here, a large amount of instructional time is included in the difference values, and it cannot be precisely determined which amount of learning losses (or gains) can be attributed to summer vacation time. Also, these studies vary with regard to the

amount of instructional time included in the difference scores. Cooper et al. (1996; p. 264) found no study that tested students on the final day of school in the spring and the first day of school in the fall, leading them to emphasize the “need for studies that estimate the ‘pure’ effect of summer vacation by employing test dates that more accurately capture the vacation interval.”

There is a strong need for studies outside the USA because results from American studies cannot necessarily be generalized to other countries with different social structures, school systems, and/or summer vacation durations. Researchers and authors such as Wiseman and Baker (2004) and Stanat et al. (2012) have expressed their regret about the lack of studies in Europe.

Research questions

The following study investigates the effects of the nine-week summer vacation on mathematics, reading, and spelling in an Austrian sample of students in lower secondary education (This means grades 5 and 6). These grades were selected because according to the studies by Cooper et al. (1996), summer break effects should be more pronounced for this age group. The following research questions were addressed in this study:

1. How do students’ achievements in mathematics, reading, and spelling change from the start of the summer vacation, to the re-start of school, and nine weeks after that?
2. To what degree may moderating variables influence changes in students’ achievements?

METHOD

Sample, research design, and research process

A total of 182 students from rural areas in Austria took part in the study. 87 boys and 95 girls participated. The children were between 10 and 12 years old ($M = 11.14$, $SD = 0.57$) and in grade 5 or 6 in lower secondary education.

All children were assigned to one of two research groups: the “vacation-effect group” or the control group (see Figure 1). The vacation-effect group took part in three test sessions: A few days before the summer vacation (t1), a few days after the re-start of school (t2), and nine weeks after that (t3). The control group only took part in t2 and t3.

This design was chosen for two reasons: First, with three measurements for the vacation-effect group it could be determined to which degree changes in test performance can be attributed to the summer vacation and to which degree possible losses in abilities can be compensated in the ongoing school year. Second, comparing the test values of the vacation-effect group and the control group allowed us to determine to what degree achievements might be attributed to learning by taking a test several times.

	Point in time		
	Before summer vacation (t1)	Immediately after vacation (t2)	Nine weeks after the re- start of school (t3)
Vacation-effect group	($n = 110$)	($n = 110$)	($n = 110$)
Control group	---	($n = 72$)	($n = 72$)

Figure 1. Research Design

In the vacation-effect group, 110 children completed the tests on reading, spelling, and arithmetic problem solving (60 girls, 50 boys); 72 children were allocated to the control group. Classes were randomly assigned to the vacation-effect group or the control group. The children came from twelve different school classes. To ensure comparability of schools and students' background, schools from rural areas and different school districts were selected. Always all classes in grade 5 and 6 in a school and all students of a class took part in the study. The organization of the study required that a whole class was always allocated to the vacation-effect group or the control group.

Variables

Arithmetic problem solving

Arithmetic problem solving was measured using the respective subtest of the HAWIK IV intelligence test (Petermann & Petermann, 2008) which consists of a maximum of 23 problems which are similar to those encountered in elementary math courses, e.g., "Tom achieved 17 points in one game and 15 points in another one. How many points did he achieve altogether?" Students' test scores were calculated as the number of problems solved correctly. The problems were administered orally and had to be solved without paper and pencil. In addition to math knowledge, the test measured concentration and systematic problem-solving ability.

The HAWIK IV can be regarded as a highly reliable and valid measurement instrument. Reliability and norm values were determined in a representative sample of 1650 children in Germany, Austria, and Switzerland. All subtests showed good to acceptable split-half reliabilities between $r = .79$ and $r = .91$ (Petermann & Petermann, 2008). Structural validity is regarded as being high; criterion-related validity was investigated by a comparison with similar intelligence tests. In our sample the re-test reliability was $r = .80$.

In the Austrian educational standards for mathematics, arithmetic problem solving is defined as a basic mathematical competence for lower secondary education. It includes the sub-skills of applying basic mathematical computations (addition, subtraction, multiplication, division) and adequate problem solving strategies without paper and pencil (Bifie, 2011). The knowledge that students acquire in arithmetic forms an important basis for students' mathematical development in lower and upper secondary education and later learning contexts. For example, knowledge of arithmetic as well as numeric and algebra are needed to understand contents in analysis (Vollrath & Roth, 2012). Banerjee (2011) regards arithmetic as an important starting point for introducing students to algebraic thinking. Furthermore, wrong conceptions in arithmetic are seen as one of the core reasons for problems in later school years, e.g., problems in learning algebra (Booth, 1984; Matz, 1980; Linchevski & Livneh, 1999).

Reading

Reading was investigated by the "Salzburg Reading-Screening" instrument (Salzburger Lese-Screening, SLS-8; Auer, Gruber, Mayringer, & Wimmer, 2005) for grades 5 to 8. The SLS assesses students' reading skills by the reading rate. In the SLS, sentences are presented to the children, and they have to decide whether a sentence is right or wrong. The children have to assess as many sentences as possible within three minutes of testing time. The obtained test score is the number of sentences that were assessed correctly. Altogether, a maximum of 70 sentences is presented.

There are two parallel versions of the SLS 5-8 (A and B) with two subversions (A1, A2; B1, B2). The subversions use the same sentences, only in a different order.

The parallel versions contain sentences with different vocabulary but that are comparable with regard to their complexity. Re-test reliability of the versions is high with $r = .91$ (Mayringer & Wimmer, 2014). In this study, the vacation-effect group first received version A1 (t1), then version B1 (t2) followed by version A2 (t3). The control group first received A1 (t2), followed by.

In our sample the re-test reliability was $r = .87$.

Spelling

Spelling skills were assessed using the standardized spelling test HSP 5-9 (Hamburger Schreibprobe; May, Vieluf, & Malitzky, 2000) for grades 5 to 9. In the HSP, words and sentences are dictated by the researcher and have to be written next to a corresponding picture that illustrates the respective words or sentences. The HSP measures basic orthographic knowledge and the use of spelling strategies. The latter measure was used in this study because it provides a more precise measure of spelling ability. In the present study a maximum of 339 correctly spelled graphemes could be achieved. The internal consistency (reliability) of the HSP is high with values between $r = .92$ und $r = .99$ (May, Vieluf, & Malitzky, 2000). In our sample the re-test reliability was $r = .96$.

Demographic variables and personal assessments

All students additionally answered questions on gender, age, their mother's educational background (coded as 1 = university entrance exam and 0 = no university entrance exam; a coding often used for assessment of socio-economic status and parents' educational level; McElvany, Becker, & Lüdtke, 2009), and an assessment of how inspiring and stimulating students experienced their summer vacation as being (1 = stimulating and 0 = not stimulating).

RESULTS

Comparison of the test values in the vacation-effect group and the control group

As a first step, the research investigated whether merely taking the test may have led to learning effects (e.g., that students remembered answers on the test or developed routines in dealing with the test format). Therefore, for each of the three cognitive domains measured at t2, t-tests were carried out and the values between the vacation-effect group and the control group were compared to each other. A significant difference between both groups could be observed for none of the variables ($p = .267$ to $p = .884$). The same applies for the comparison of the groups at t3. None of the t-tests yielded a significant difference ($p = .359$ to $p = .941$). These results indicate that taking the test did not lead to learning effects that might have influenced later test results.

Research question 1: Do students' achievements change from the start of the summer vacation to the re-start of school and nine weeks after that?

A univariate analysis of variance with repeated measurements (three points in time) was carried out for each knowledge domain for the investigation of research question 1 (i.e., three analyses of variance). By analyses of variance it was investigated how students' achievements in arithmetic problem solving, in spelling, and in reading change over the three points in time. The analysis of variance had to consider the hierarchical structure of the data, i.e. that individual children are nested within classrooms. This is why the affiliation to a class was regarded as an independent variable in the variance analysis. Thus it could be considered that

students' test values might be influenced by individual characteristics as well as by the affiliation to a specific class (Cohen, Cohen, West, & Aiken, 2003).

To assess to which degree the values within the school classes are homogeneous or different from each other, intraclass coefficients ICC2 were calculated for each achievement variable (mathematics, spelling, and reading) at all three points in time. Intraclass coefficients were rather low, with values between 0.001 and 0.215, indicating a low influence of the school class on individual achievement values (Cohen et al., 2003).

Table 1 shows the means and standard deviations for achievement in each cognitive domain and the three points in time. Table 1 shows significant changes in students' achievements in arithmetic problem solving over the three points in time, $F(2, 108) = 56.14, p < .01, \eta^2 = .51$. Achievements deteriorated significantly over the summer vacation from t1 to t2, $d = -1.55, t(109) = -8.45, p < .01$. The interaction between the factors class and time was not significant ($p \geq .05$) which means that the loss in skills is not determined by the affiliation to a specific school class. However, the loss in skills was only temporary, and nine weeks after the re-start of school, students' achievement in arithmetic problem solving significantly exceeded achievements at t1, $d = 0.44, t(109) = 2.45, p = .02$.

The development of cognitive abilities is similar for spelling, with significant differences between the three points in time, $F(2, 108) = 51.93, p < .01, \eta^2 = .49$. Skills in spelling deteriorated significantly from t1 to t2, $d = -3.32, t(109) = -8.89, p < .01$. Again, the interaction class x time was not significant ($p \geq .05$). However, nine weeks after the re-start of school, students could make up for losses in spelling, and achievements at t3 even slightly exceed those at t1, $d = 1.51, t(109) = 3.08, p < .01$.

Contrary to arithmetic problem solving and spelling, skills in reading improved over the course of the summer vacation, $F(2, 108) = 25.21, p < .01, \eta^2 = .32$. Students improved significantly from t1 to t2, $d = 2.13, t(109) = 5.70, p < .01$, and showed further improvements nine weeks after the re-start of school, comparison of t1 to t3: $d = 3.18, t(109) = 6.80, p < .01$. The interaction class x time became significant, $F(4, 214) = 4.08, p < .01, \eta^2 = .07$. The significant interaction can be attributed mainly to one school class which showed no improvements over the three points in time.

Research question 2: Influence of moderating variables

By multivariate regression analysis it was investigated to which degree four variables (mother's educational background, student's gender, stimulating potential of the summer vacations, and achievements before the summer vacation) can predict achievement immediately after the summer vacation at the re-start of school. Three regression analyses were carried out, one for each achievement variable (arithmetic problem solving, spelling, reading).

Regression analyses with random intercepts were applied in order to consider the multi-level structure of the data for this analysis. Random intercept models allow the mean values between classes to differ; they consider that the intercept may vary across school classes. Random coefficient regression models were also

Table 1. Achievements of the Vacation-Effect Group at the Three Points in Time (M, SD; n = 110)

	Before summer vacation (t1)		Immediately after vacation (t2)		Nine weeks after the re-start of school (t3)	
	M	SD	M	SD	M	SD
Arithmetic problem solving	15.02	2.13	13.47	2.67	15.45	2.14
Spelling	327.71	8.66	324.39	10.51	329.22	8.32
Reading	39.60	9.16	41.73	9.12	42.78	9.28

Table 2. Achievement at t2 Regressed on Mother's Educational Background, Gender, Stimulating Summer Vacation, and Achievement at t1, R²

	Education mother		Gender		Stimulating summer vacation		Achievement at t1		R ²
	β	p	β	p	β	p	β	p	
Arithmetic problem solving	.15	≤ .01	--	--	--	--	.63	≤ .01	.55
Spelling	--	--	--	--	--	--	.92	≤ .01	.87
Reading	--	--	.09	≤ .05	.09	≤ .05	.84	≤ .01	.84

Note: Only significant β -values are listed

Table 3. Achievement at t3 Regressed on Mother's Educational Background, Gender, and Achievement at t2, R²

	Education mother		Gender		Achievement at t2		R ²
	β	p	β	p	β	p	
Arithmetic problem solving					.66	< .01	.44
Reading					.88	< .01	.82
Spelling					.83	< .01	.71

Note: Only significant β -values are listed

calculated, allowing for the intercept as well as for the slope of the regression functions to differ across classes. The data however showed that slopes did not differ across classes, so only different intercepts had to be considered (Cohen et al., 2003).

For each achievement variable, a regression analysis with random intercepts was calculated. Achievement at the re-start of school (t2) was regressed on the mother's educational background, student's gender, assessment of whether the summer vacation had been inspiring and stimulating, and achievement before the summer vacation (t1).

Table 2 shows that the mother's educational background contributes with a small but significant regression weight to achievement in arithmetic problem solving after the summer vacation. The regression analysis for arithmetic achievement shows an advantage of children with mothers having a university entrance exam. The strongest predictor for achievement after the summer vacation was prior knowledge and achievement before the start of the vacation.

Contrary to arithmetic problem solving, the mother's educational background had no impact on achievement after the summer vacation for spelling and reading. Gender contributed to reading, i.e. girls did better. Also, the degree of stimulation in the summer vacation contributed to reading achievements. Again, prior knowledge was the strongest predictor for achievement at t2. In contrast, spelling achievements could only be explained by previous achievement.

Furthermore, it was investigated to which degree achievements nine weeks after the re-start of school can be explained by moderating variables. Again, three regression analyses were carried out, one for each achievement variable (arithmetic problem solving, spelling, reading). Predictor variables were the mother's educational background, student's gender, and achievements immediately after the summer vacation.

As Table 3 indicates, of the three variables of mother's educational background, gender, and prior achievement, only achievement at the re-start of school had an impact on achievement nine weeks later.

DISCUSSION

Research question 1: Students' achievements changes from the start of the summer vacation to the re-start of school and nine weeks after that

In the present study, cognitive development over the course of the summer vacation was measured a few days before and after the summer vacation and nine weeks after the re-start of school. This allowed a very precise assessment regarding which amount of gains or losses in knowledge and skills can be attributed to summer vacation.

Summer learning losses were found for two of the three investigated domains: arithmetic problem solving and spelling. In contrast, achievements in reading actually increased over the course of the summer vacation. According to Cooper et al. (1996) as well as Siewert (2010), these results can be explained by the amount of practice in the different domains. Reading is practiced both at home and in school while mathematics and spelling are mostly practiced in formal school settings. The arithmetic word problems that were used in this study require the identification and execution of mathematical operations from textual information. Students are seldom confronted with this type of problem in daily life. In contrast, improvements in reading can be explained by students' reading activities during summer vacation. The comparison of achievements before the summer vacation and nine weeks after the re-start of school shows that the children could compensate the losses in mathematics and spelling. Nevertheless, the first weeks in school are negatively affected by summer learning loss, and children first have to catch up to accommodate lost knowledge and skills.

Research question 2: Influence of moderating variables

Studies on moderating variables for summer learning losses show equivocal results. In nearly all American studies, students' cognitive developments were moderated by parent's socio-economic status and their educational level. Depending on these moderating variables, children's knowledge and skills deteriorated or improved over the course of the summer vacation (e.g., Allinder et al., 1992; Cooper et al., 1996; Cooper, Valentine, Chariton, & Melson, 2003; Alexander et al., 2001, 2007, 2012). In contrast, the few European studies that exist found limited evidence for moderating variables. Lindahl (2001) and Coelen and Siewert (2008a, 2008b) reported summer learning losses in mathematical skills but no influence of parent's socio-economic status. For reading and spelling, only one study found an influence of the children's background. Here, children from immigrant families suffered learning losses (Becker et al., 2008; Stanat et al., 2012).

In order to investigate the impact of moderating variables in the present study, variables such as the mother's educational background, student's gender, stimulating potential of the summer vacations, and former achievements before the summer vacation had been measured. Regression analyses had been carried out to investigate the impact of moderating variables. The present study found a small yet significant influence of the mother's educational background for mathematics (but no influence for spelling and reading). An intellectually stimulating home environment may offer more opportunities to practice mathematical skills and attenuate summer learning losses. Achievements in reading were influenced by gender (girls did slightly better) and stimulating summer vacation. The slight advantage of girls probably expresses their higher preferences for reading. Results of the PISA (Programme for International Student Assessment) study show that in Austria girls generally spend more time reading than boys and more often read "just for fun" (Schwantner, Toferer, & Schreiner, 2013). Altogether, the results affirm a

small influence of moderating variables such as the socio-economic background for achievement after the vacation.

However, the strongest predictor of achievement at the beginning of school and also nine weeks after the re-start of school is children's prior achievement. It also is the only predictor that explains achievement nine weeks after the start of school. In the sense of Vygotsky's "zone of proximal development," prior knowledge can be understood as a starting point that determines to which degree students will be able to acquire new knowledge (Tzur & Lambert, 2011).

The results of the present survey and the general results of European surveys differ from the American ones insofar as summer learning losses were smaller and parents' educational level had much less influence (Alexander & Entwisle, 1996; Alexander et al., 2001, 2007, 2012; Cooper et al., 1996). These effects might be explained by differences in social structures and the school systems. Moreover, the children who took part in this study were mainly recruited from rural areas in Austria. Here, children's and young adults' recreational behavior is much more homogeneous, and there is much less social segregation than in urban areas (Leßmeister, 2008). In rural Austria, students with different social backgrounds are much more likely to attend the same schools than in urban areas. Therefore, differences in the parents' educational level and their socio-economic status might have had much less impact than in a sample of the same age group in an urban area. The results from the PISA studies confirm this assumption. Here for example, students' achievement scores were much more homogeneous in rural areas in Austria (Bruneforth, Weber, & Bacher, 2012).

Implications for mathematics education

The decline of knowledge and skills in mathematics over the summer vacation has major implications for teachers and teaching. Teachers cannot rely on their students' knowledge from the previous school year, but instead need to identify students' ability levels and start the new school year with a review of last year's learning contents. For the identification of students' skills and cognitive concepts, mathematical tasks should be employed that go beyond the execution of terms and that require explanations from the learners (Hußmann, Leuders, & Prediger, 2007). This kind of diagnosis of students' cognitive concepts may then form the basis for a systematic and focused review of learning content. School book publishers have recognized the need for teachers to repeat learning content at the beginning of the new school year. For arithmetic, school books with special modules for a focused repetition of learning content have been developed. These modules start with tests by which learners can identify their knowledge level; learners then work on the respective tasks and can assess their increase in knowledge and abilities via another test. Doing this allows the repetition of learning contents to be adapted to a student's specific knowledge deficit(s) (Prediger, Hußmann, Leuders, & Barzel, 2011).

School book publishers also offer training books that review the learning content of the previous school year while preparing for the next one (Lewisch, 2009). These kinds of training books may be helpful for individual students. The results from this study would suggest that students with an intellectually stimulating home environment and students who have parents with a higher educational level will probably have access to such learning materials, whereas students with less concerned parents start the new school year without this type of preparation. In this case, the gap in knowledge between students would widen over the course of the summer vacation.

A variety of summer school programs have been developed in the United States, partly in response to these kinds of unequal chances for children. These programs

differ along various dimensions. For instance, special programs are designed for poorly performing students and provide remedial instruction, focusing on knowledge and skills that students did not master in the previous school year. These programs mainly focus on mathematics, reading, and spelling. Other programs prepare students for the coming school year, focusing on school material from the subsequent year (McCombs et al., 2011). Participation in programs may be mandatory for poorly performing students, or voluntary. In a meta-analysis with 93 summer school evaluations, Cooper, Charlton, Valentine, Muhlenbruck, and Borman (2000) found that summer programs focusing on remedial instruction had a positive impact on participants' knowledge and skills. Programs led to more favorable outcomes on mathematics assessments than on reading assessments. Evaluations of mandatory summer programs also found higher effect sizes in mathematics than in reading (Jacob & Lefgren, 2004; Matsudaira, 2008).

In German-speaking countries (Austria, Germany, Switzerland), the implementation of and research on summer school programs is in its infancy. Remedial programs in reading and spelling were mostly developed for children from immigrant families (e.g., Knifka, 2008; Spinner, 2008; Stanat et al., 2012). The few programs in mathematics that do exist mostly focus on highly motivated and/or highly talented students (OEMG, 2014). In Austria, the majority of summer school programs is offered by private institutions and in some cases they are rather expensive. When such programs are mainly booked by parents with a higher socio-economic status and/or a higher educational level, the differences in students' cognitive abilities in a classroom might be even further enlarged over the course of a summer vacation. In comparison, free programs that benefit all students, regardless of their parents' socio-economic background, are socially more just.

Conclusions, limitations of the study

In the present study, children's cognitive development in arithmetic problem solving, spelling, and reading was measured before and after the summer vacation and nine weeks after the re-start of school. The results of the present study shows that mathematical abilities and spelling deteriorated over the course of the summer vacation, while reading skills actually improved. A main reason for these kinds of summer learning losses appears to be a lack of practice. Also, an influence of parents' background was found. Children with parents with a higher educational level and children who experience their summer vacation as stimulating are less influenced by potential summer learning losses. This is an important result for teachers as well as parents. However, losses could be compensated within the first nine weeks after the re-start of the school year.

This study is not without limitations, the main one of which concerns the sample itself, which only included children from mainly rural areas in Austria. Nevertheless, the results of the study point out important implications for teachers and teaching, especially in mathematics. Teachers should be aware of their students' summer learning losses and adapt instruction accordingly to allow students to compensate for losses in knowledge.

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