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Cross-lagged relations between task motivation and performance in arithmetic and literacy in kindergarten

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Abstract

To examine the cross-lagged relationships between children's task motivation in mathematics and literacy, and their related performance, 139 children aged 5–6 years were examined twice during their kindergarten year. The results showed that only math-related task motivation and arithmetic performance showed cross-lagged relationship: the higher the math-related task motivation children reported in the beginning of the kindergarten year the higher the level of their arithmetic performance at the end of the kindergarten year. Moreover, the higher the level of children's arithmetic performance the more the interest in mathematics children reported later on. Literacy-related task motivation and literacy performance did not show a similar pattern of relations.

Keywords: Motivation; Motivation change; Arithmetic; Literacy; Kindergarten

1. Introduction

Motivation plays an important role at school. For example, a high level of intrinsic motivation and subjective task values has been shown to be associated with high levels of academic performance and achievement (Eccles, Wigfield, & Schiefele, 1998; Murphy & Alexander, 2000). Students' motivation concerning different school subjects also predicts their choices of different academic activities, such as course enrollment intentions (Eccles et al., 1983; Meece, Wigfield, & Eccles, 1990; Wigfield & Eccles, 2000). However, research on task value and intrinsic motivation has several limitations. First, there are only few studies in the field that have examined the direction of influence between motivation and academic performance (Aunola, Leskinen, & Nurmi, 2006). Second, most studies have focused on older elementary school children or adolescents, and only a few studies have examined task motivation and academic skills among children in the beginning of their school career (Aunola et al., 2006; Gottfried, 1990; Nurmi & Aunola, 2005). Third, no studies have examined task motivation before formal academic instruction has started. Consequently, the present study examined, first, changes in math-related and literacy-related task motivation among children during their kindergarten year, and, second, the lagged associations between their math-related and literacy-related task motivation and their academic performance in these school subject areas.

1.1. Task motivation

Motivation in academic environments has been conceptualized in many ways. One of the first efforts was Atkinson's (1964) expectancy-value theory in which academic motivation was described in terms of achievement motive that involves expectancy for success and incentive value. Two decades later Weiner's (1985) attribution theory suggested that it is the interpretation of one's achievement outcomes that determines

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subsequent achievement strivings rather than previous motivation and expectancies. More recent conceptualizations of academic motivation include achievement goal theory (Ames & Archer, 1988; Pintrich, 2000), according to which there are different kinds of goals that direct students' engagement in achievement tasks. Such goals, that is, mastery, performance-approach and performance-avoidance goals, have also been found to be related to students' academic achievement (Pintrich, 2000). Some other studies in the field have described motivational patterns in academic environments by using many other concepts, such as achievement beliefs (Cantor, 1990; Pintrich & De Groot, 1990) and motivational strategies (Aunola, Nurmi, Lerkkanen, & Rasku-Puttonen, 2003; Onatsu-Arvilommi & Nurmi, 2000).

One widely used framework in this research field is how interested students are in different school subjects. For example, Eccles' expectancy-value model of achievement motivation (Eccles et al., 1983) emphasizes two theoretical concepts: beliefs and expectancies related to academic situations, and subjective task value (Eccles & Wigfield, 1995; Wigfield & Eccles, 2000). Studies on the expectancy aspects of motivation (Murphy & Alexander, 2000) have shown that children who anticipate success in academic situations and who have high ability beliefs use adequate achievement strategies and perform in academic situations better than those who expect failure and show low ability beliefs (Murphy & Alexander, 2000; Zimmerman, 2000). However, expectancy by itself is not enough to bring forth success at school, because even if children's beliefs in their abilities in a specific task are high, they may not involve themselves in that task if they do not value it (Ryan & Deci, 2000). According to Eccles et al. (1983), such value aspect of academic motivation includes three components: *Attainment value* (the importance of doing well on a task in terms of self-schema), *utility value* (the instrumentality of a goal for reaching other goals), and *intrinsic* or *interest value* (the enjoyment one gets from engaging in an activity). Other concepts used to refer to motivation in a particular subject are intrinsic motivation (Deci, Vallerand, Pelletier, & Ryan, 1991; Gottfried, 1990; Harter, 1981) and interest (Schiefele, 1996). In the present study, we will use the concept task motivation (Nurmi & Aunola, 2005) to refer to how much a person enjoys or likes a certain school subject or a task.

Previous studies have shown that in the beginning of their school career children are typically highly motivated in different academic subjects but this motivation tends to decline with age (Gottfried, Fleming, & Gottfried, 2001; Wigfield & Eccles, 2000, 2002; for a review, see Eccles, Wigfield, et al., 1998). For example, Jacobs, Lanza, Oswood, Eccles, and Wigfield (2002) found that the mean level of valuing of mathematics and languages was the highest during the first grades of school but declined as children got older. Wigfield et al. (1997) found a similar decline for interest in reading, Gottfried et al. (2001) for intrinsic motivation in mathematics and reading, and Harter (1981) for intrinsic interest in overall school learning.

Task motivation also begins to get differentiated across the various school subjects early on in the school career (Eccles, Wigfield, Harold, & Blumenfield, 1993; Nurmi & Aunola, 2005; Wigfield et al., 1997). Such inter-individual differences in motivation become also increasingly stable during the first school years (Aunola et al., 2006; Gottfried et al., 2001). Nurmi and Aunola (2005), for example, found that in the beginning of primary school four different kinds of student groups could be identified on the basis of their motivation and that membership in a particular group showed stability across the first two school years: (a) students high in school motivation, (b) students low in reading motivation, (c) students low in math motivation, and (d) students high in math motivation. Previous research has also shown that girls value languages more than boys, while boys value mathematics and sciences more than girls (Eccles, Barber, & Jozefowicz, 1998; Eccles, O'Neill, & Wigfield, 2005). As all previous research has focused on children's task motivation at school, the present study examined how children's math-related and literacy-related task motivations start to develop already during the kindergarten year.

1.2. Learning to read and learning mathematics

Reading and mathematics form the basis for later academic success, but their development unfolds as different skills. Reading skill is a combination of both decoding and reading comprehension skills (Gough, Hoover, & Peterson, 1996; Vellutino & Scanlon, 1991). It is well known that the most important factors behind the decoding skills are letter knowledge (Adams, 1990; Leppänen, Aunola, Niemi, & Nurmi, 2008; Lonigan, Burgess, & Anthony, 2000) and phonological awareness (Bradley & Bryant, 1991; Wagner, Torgesen, & Rashotte, 1994). Moreover, reading comprehension is heavily influenced by word reading skills in the early phases of reading acquisition (Adams, 1990; Stanovich, West, Cunningham, Cipielewski, & Siddiqui, 1996). As soon as children become more fluent readers, reading comprehension emerges more clearly as a closely related but nevertheless separate skill from decoding ability (Catts, Hogan, & Fey, 2003; Nation, 2005). Compared to many other languages, Finnish is relatively easy to learn to read, as it has a highly regular orthography and simple syllabic structure (Seymour, Aro, & Erskine, 2003). At least 25% of Finnish children can read before they enter formal education (Holopainen, Ahonen, Tolvanen, & Lyytinen, 2000; Lerkkanen, Rasku-Puttonen, Aunola, & Nurmi, 2004) and the large majority of them achieve an accurate and fluent word reading skill before the end of the first school year (Aunola, Nurmi, Niemi, Lerkkanen, & Rasku-Puttonen, 2002; Seymour et al., 2003).

Performance in mathematics, in turn, involves many components, such as number knowledge, memory for arithmetical operations, conceptual understanding, reasoning, and procedural knowledge (Christou & Papageorgiou, 2007; Dowker, 1998; Rittle-Johnson & Siegler, 1998). Learning mathematical skills progresses in a hierarchical manner: learning basic skills is necessary foundation for mastering more complex skills and procedures (Entwisle & Alexander, 1990; Karmiloff-Smith, 1995). However, already during their kindergarten year prior to formal instruction around one half of Finnish children are able to do basic addition calculations (Lerkkanen & Poikkeus, 2006).

Both reading and mathematical performance show substantial inter-individual stability over the early school years (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004; Aunola, Leskinen, Onatsu-Arvilommi, & Nurmi, 2002; Leppänen, Niemi, Aunola, & Nurmi, 2004). For example, Leppänen et al. (2004) found that, even though the differences in reading performance between children decreased during Grade 1, those children who showed good reading performance in the beginning of Grade 1 outperformed other children also at the end of Grade 1. The results for mathematical skills show, in turn, that, children who enter school with good skills improve their performance over time more than children who enter with poorer skills (Aunola et al., 2004), indicating again that inter-individual differences in mathematical performance are stable over time.

1.3. Task motivation and academic performance

Children's motivation in a particular task can be assumed to play a positive role in supporting their cognitive engagement in learning (Ryan & Deci, 2000). A motivated student is likely to attend the task and to show high levels of effort and persistence, even when faced with a challenging task. By contrast, a student who is not interested in a task or school subject is likely to show low level of attention, effort and persistence, particularly when faced with difficulties. Task motivation has been suggested to play a particularly important role in mathematics. For example, Eccles, Adler, and Meece (1984) suggested that, because mathematics is perceived to be more difficult and demanding than many other school subjects (see also, Stodolsky, Salk, & Glaessner, 1991), successful learning of mathematics requires a high degree of intrinsic motivation (Gottfried, 1990). However, more recent studies have suggested that academic motivation plays an important role also in learning to read (Lepola, Poskiparta, Laakkonen, & Niemi, 2005; Lepola, Salonen, & Vauras, 2000; Wigfield, 1997).

Many studies have shown that subject-specific motivation is associated with actual academic achievement. For example, high levels of intrinsic (Gottfried, 1990) or task motivation towards mathematics (Aunola et al., 2006) are associated with high performance in mathematics. Intrinsic motivation in learning to read, in turn, has been shown to be associated with reading performance (Wigfield, 1997). However, the results concerning the cross-lagged relationships between subject-specific task motivation and academic performance have been somewhat contradictory. Some studies have found that it is task motivation that predicts subsequent academic performance (Gottfried, Fleming, & Gottfried, 1994), whereas others have shown that it is rather previous achievement that predicts subsequent motivation (Deci et al., 1991; Gottfried, 1990). Other studies have suggested that there are reciprocal relationships between motivation and skill development (Aunola et al., 2006).

However, previous research on the associations between task motivation and academic performance has at least three limitations. First, there are only few cross-lagged longitudinal studies (Aunola et al., 2006), and consequently little is actually known about the direction of influence between task motivation and academic performance. Direction of influence can be analyzed, for example, by using longitudinal data to examine whether some variable (X) at time T predicts (cross-lagged relation) another variable (Y) at time $T+1$, after controlling its value at time T. Second, previous findings concerning the cross-lagged associations (that is, direction of influence) between task motivation and academic performance are contradictory (cf., Deci et al., 1991; Gottfried et al., 1994). Third, most studies carried out so far have focused on older children or adolescents (for a review, see Murphy & Alexander, 2000), and no efforts have been made to examine their relationship before the start of formal education. Consequently, the present study made an effort to examine the cross-lagged relationships (direction of influence) between math-related and literacy-related task motivation and relevant academic performance, as well as the changes in literacy-related and math-related task motivation during kindergarten. These are important research questions because they may provide a basis for developing kindergarten curriculum and pedagogy as positive learning environments before the entrance into primary school.

The Finnish school system differs from schooling in many European countries and the United States. Primary school with formal teaching begins in the year children become 7 years old; however, the vast majority of 6-year-olds spend a year in kindergarten before entrance into primary school (Finnish Office of Statistics, 2006). In the Finnish kindergarten children's literacy and arithmetic skills are promoted by various play-like methods and materials, although more formal instruction begins only at school (Lerkkanen, 2007). It might be assumed, however, that these very first experiences of literacy-related and math-related play-like tasks have an important impact on the development of task motivation. Thus, the aim of the present study was to examine the cross-lagged associations between math-related task motivation and arithmetic performance, on one hand, and literacy-related task motivation and literacy performance, on the other hand, during children's kindergarten year.

1.4. Research questions – hypotheses

The present study examined the following research questions:

(a) Do children's math-related and literacy-related task motivation show stability already during the kindergarten year? This is an important question, because the stability in task motivation suggests that children have started to formulate values and interests that extend over a longer time period. As task motivation was assumed to evolve in the context of feedback children receive from their learning, we expected that task motivation should not show stability during the kindergarten year (Hypothesis 1).
(b) Does children's task motivation concerning a particular subject (arithmetic or literacy) contribute to their performance

during kindergarten year, or is it rather the performance that predicts subsequent task motivation? We expected that a high level of task motivation should contribute to children's performance in a particular subject (Hypothesis 2a). We also expected that good progress in arithmetic and literacy performance, and related positive feedback, would increase children's motivation to the particular school subject (Hypothesis 2b).

(c) Does the level of children's math-related and literacy-related task motivation change during the kindergarten year? As no previous research has been done among children during their kindergarten year, no hypothesis was formulated.

(d) Is math-related and literacy-related task motivation associated with each other? As children's academic motivation has been suggested to be relatively non-specific in the beginning of their school career (Harter, 1983; Jacobs et al., 2002), and their performance in literacy and arithmetic to be closely associated (Koponen, Aunola, Ahonen, & Nurmi, 2007; Lerkkanen, Rasku-Puttonen, Aunola, & Nurmi, 2005), we also assumed that math-related and literacy-related task motivation should be also related (Hypothesis 3).

2. Method

2.1. Participants − procedure

The present study is part of The First Steps Pilot Study (Poikkeus & Lerkkanen, 2005). A total of 139 children (73 girls, 66 boys) aged 5−6 years ($M = 76$ months, $SD = 3.53$ months) from 13 kindergartens from one small semi-rural commune in Central Finland participated in the study. In Finland, the kindergarten programs are arranged either in day-care centres or in primary schools. In the sample of the present study, six kindergartens were situated in day-care centres and seven in primary schools. Teaching methods and curricula do not typically show substantial variation across kindergarten classrooms. The sample was homogeneous in terms of race and cultural background which is typical for school population in this part of Finland. The sample can be considered as a representative of children living in Finland.

The children were examined twice, in October (Time 1) and in April (Time 2), during the kindergarten year. At both time points, the children were tested on their academic performance (e.g., literacy and arithmetic performance), and interviewed concerning their task motivation. All the tests were carried out either by trained investigators (phonological awareness) or by children's own teacher (letter knowledge, arithmetic performance), who were trained to do the testing. The interviews were done by investigators. All the tests and interviews took place in suitable rooms in kindergartens. To identify the participants at Time 1 and Time 2 ID-numbers were used.

At the very beginning of the kindergarten year 8.8% and at the end of the kindergarten year 27.5% of these children accurately read a word list of 20 word with no more than one mistake ($M = 8.3$, $SD = 8.5$).

2.2. Measures

2.2.1. Task motivation

Children's task motivation was assessed at both time points in an interview using the Task Value Scale for Children (TVS-C; Nurmi & Aunola, 1999; see also Aunola et al., 2006; Nurmi & Aunola, 2005). This scale is based on the ideas presented by Eccles et al. (1983) concerning the value or interest that children show related to particular school subjects (task value). This particular scale measures only the interest value component, whereas utility and attainment values were not included. The scale consisted of items measuring children's task motivation (i.e., interest in or liking for a particular task) in literacy tasks (3 items: "How much do you like letter tasks?"; "How much do you like doing letter tasks at school?"; "How much do you like doing letter tasks at home?") and in number and counting tasks (3 items: "How much do you like number and counting tasks?"; "How much do you like doing number and counting tasks at school?"; "How much do you like doing number and counting tasks at home?").

In the testing procedure, the children were first read each question. They were then shown a set of five faces drawn to depict an evaluative scale running from very positive to very negative. The children were then asked to point out the picture which most describes their liking for a particular task, namely from a picture of unhappy face scored with 1 ("I do not like it at all/I dislike doing those tasks") to a picture of happy face scored with 5 ("I like it very much/I really enjoy doing those tasks"). A sum score for task-specific motivation was calculated as the mean of the three items. Cronbach's alpha reliabilities were 0.63 and 0.68 for Math-related Task Motivation, and 0.61 and 0.68 for Literacy-related Task Motivation at Time 1 and Time 2, respectively.

2.2.2. Arithmetic performance

Children's arithmetic performance was assessed by 8 visual addition tasks from the BANUCA test battery (Räsänen, 2005). The test was group administered by children's own teacher and given as a calculus on a paper sheet. The children were given 4 min to write down the answers on these 8 addition tasks (e.g., $2 + 3 = ?$; $9 + 7 = ?$). The scoring for the Arithmetic Performance variable was based on the number of correct items (maximum value 8). The Kuder−Richardson reliabilities (Kaplan & Saccuzzo, 2001) assessed for Arithmetic Performance were 0.88 at Time 1 and 0.83 at Time 2.

2.2.3. Literacy performance

Children's literacy performance was assessed by using two subtests.

2.2.3.1. Letter knowledge

2.2.3.1. Letter knowledge. The children were shown 29 uppercase letters divided into three rows in random order from the ARMI test material (Lerkkanen, Poikkeus, & Ketonen, 2006). The children were asked to name the letters, one row at a time, while the other rows were covered. The test was administered individually to each child by the child's own teacher with a time limit of 7 min. The scoring for the Letter Knowledge variable was based on the number of correctly identified letters (maximum value 29).

2.2.3.2. Phonological awareness. In Time 1 the initial phoneme identification test from the ARMI test material (Lerkkanen et al., 2006) was used. In the test the child was shown 10 sets of four pictures, one at a time. The children were instructed as follows: "Here are pictures of *omena*, *sukka*, *reppu* and *lintu* [apple, sock, bag, bird]. Listen carefully: which word starts with the sound /o/: *omena*, *sukka*, *reppu*, *lintu*?". Because the children obviously became more skilled in phoneme identification during the kindergarten year, we used a more difficult test in Time 2. This test was the Initial Phoneme Naming test from The Diagnostic Tests 1 (Poskiparta, Niemi, & Lepola, 1994). In this test 10 words were said to the child one by one and the child was asked to say aloud the first sound of the word (e.g., Tell me the sound which is in the beginning of the word ASUU?). The scoring for both of these tests was based on the number of correct answers (max 10). The test was administered individually to each child by an investigator with a time limit of 5 min.

The sum scores for Letter Knowledge and Phonological Awareness tests were firstly standardized. Then, a sum score for literacy performance was calculated as the sum of these two scores. The Kuder–Richardson reliabilities (Kaplan & Saccuzzo, 2001) for literacy performance were 0.64 and 0.65 at Time 1 and Time 2, respectively.

2.3. Analytic strategy

The statistical analyses were performed in two steps. First, path analysis was used to investigate the stability of both the math-related and literacy-related motivation, on one hand, and the cross-lagged associations between math-related task motivation and arithmetic performance and between literacy-related task motivation and literacy performance, on the other. Second, the associations between math-related task motivation and literacy-related task motivation were investigated by using multivariate latent change analysis. All the analyses were performed using the Mplus statistical package (Muthén & Muthén, 1998–2004). The parameters of the models were estimated using the maximum likelihood robust (MLR) procedure and missing data method. The means, standard deviations, and correlations between the observed variables are shown in Table 1.

3. Results

3.1. Path analyses

Intra-class correlations were first calculated for all measured variables in order to examine whether classrooms differed in these variables, and whether a multilevel approach would be needed for further analyses. The results showed, however, that all the intra-class correlations were close to zero.

The first aim of the present study was to investigate the stabilities and cross-lagged relationships between math-related task motivation and arithmetic performance. To examine this a path model was constructed that included the stabilities of math-related task motivation and arithmetic performance at Times 1 and 2, as well as path from math-related task motivation to subsequent arithmetic performance, and a path from arithmetic performance to subsequent math-related task motivation. Only statistically significant paths were included in the final model, $\chi^2(2, N = 138) = 3.34$, $p = 0.19$; CFI = 0.98; TLI = 0.94; RMSEA = 0.07, SRMR = 0.07. The standardized solution for this model is presented in Fig. 1.

The results showed, first, that individual differences in arithmetic performance were stable from Time 1 to Time 2 (performance at Time 1 predicted performance at Time 2). However, math-related task motivation did not show such stability (task motivation at Time 1 did not predict task motivation at Time 2). Second, children's math-related task motivation at Time 1 was positively associated with their arithmetic performance at the same time point. Third, the cross-lagged analysis showed that children's math-related task motivation at Time 1 predicted their arithmetic performance at Time 2; that is, the higher the math-related task motivation children reported at Time 1 the better their arithmetic performance at Time 2. Moreover, arithmetic performance at Time 1 contributed to math-related task motivation at Time 2, that is, the better the children's arithmetic performance at Time 1 the higher their math-related task motivation at Time 2.

To examine whether there were gender differences in either math-related task motivation or arithmetic performance gender was added to the model as a predictor. In other words, a dummy coded (1 = girl, 2 = boy) gender variable was included in the equation to predict math-related motivation and arithmetic performance. However, no gender differences were found.

Our next aim was to examine the stabilities of, and cross-lagged relations between literacy-related task motivation and literacy performance (Fig. 2). The results showed, first, that both literacy-related task motivation and literacy performance showed stability, $\chi^2(6, N = 139) = 5.76$, $p = 0.45$; CFI = 1.00; TLI = 1.00; RMSEA = 0.00, SRMR = 0.04. However, no cross-lagged relations between literacy-related task motivation and literacy performance were found. When gender was added to the model, the results showed that boys reported both lower literacy-related task motivation and lower literacy performance than girls at Time 1.

3.2. Latent change model

The next aim of the study was to investigate the changes in math-related and literacy-related task motivation, and whether such changes would be associated during the kindergarten year. Consequently, a multivariate latent change model was created for the task motivation measurements at Time 1 and Time 2 (see Fig. 3).

The saturated model included four components, that is, (a) the Levels and (b) the Changes (Slopes) of math-related and

Table 1
Correlation matrix, means, and standard deviations for observed variables.

Variables	1	2	3	4	5	6	7	8
1. Math-related task motivation (T1)	1.00							
2. Math-related task motivation (T2)	0.18*	1.00						
3. Literacy-related task motivation (T1)	0.56***	0.20*	1.00					
4. Literacy-related task motivation (T2)	0.13	0.54***	0.20*	1.00				
5. Arithmetic performance (T1)	0.26**	0.18*	0.14	0.05	1.00			
6. Arithmetic performance (T2)	0.30***	0.21*	0.06	0.05	0.57***	1.00		
7. Literacy performance (T1)	0.17*	0.11	0.12	−0.01	0.52***	0.35***	1.00	
8. Literacy performance (T2)	0.22*	0.10	0.09	0.11	0.43***	0.45***	0.72***	1.00
M	3.71	3.90	3.43	3.76	3.08	5.26	25.33	32.51
SD	1.08	1.04	1.09	1.03	2.61	2.50	10.23	7.48

T1 = Time 1 (October: at the beginning of the kindergarten year); T2 = Time 2 (April: at the end of the kindergarten year).
$*p < 0.05$; $**p < 0.01$; $***p < 0.001$.

literacy-related task motivation, as well as their relations. The results at the mean level showed, first, that the mean of the Change of math-related task motivation was positive, but not statistically significant ($M = 0.19$, $SE = 0.12$, ns.). The results for literacy-related task motivation showed that the mean of the Change was positive and statistically significant ($M = 0.32$, $SE = 0.11$, $p < 0.01$), indicating that literacy-related task motivation increased across time. In other words, although the path models showed that inter-individual differences in literacy-related task motivation were stable, there was an increase in the mean level of such task motivation over time.

The results further showed that there was statistically significant variance in the Level (1.16, $p < 0.001$) and Change (1.82, $p < 0.001$) of math-related task motivation, as also in the Level (1.18, $p < 0.001$) and Change (1.80, $p < 0.001$) of literacy-related task motivation. The results presented in Fig. 3 showed further that the relationship between the level of math-related task motivation and the level of literacy-related task motivation was positive and statistically significant, as was the relation between the change of math-related task motivation and the change of literacy-related task motivation; that is, the higher the math-related task motivation the higher was also the literacy-related task motivation, and the more math-related task motivation increased the more the literacy-related task motivation also increased.

4. Discussion

The present study examined the changes in children's math-related and literacy-related task motivation during the kindergarten year, as well as their cross-lagged relations with arithmetic and literacy performance. The results showed that, although both math-related and literacy-related task motivation were positively related, only math-related task motivation and arithmetic performance showed recursive cross-lagged relationships. At the mean level, literacy-related task motivation increased, but math-related task motivation did not.

The results of the present study showed, first, that math-related task motivation and arithmetic performance showed recursive cross-lagged relationships. On one hand, the higher the math-related task motivation children reported at Time 1 (October), the higher the level of arithmetic performance was at Time 2 (April), even after controlling for initial level of performance (Hypothesis 2a). As has been suggested previously, motivation seems to play an important role in the development of arithmetic skills (Aunola et al., 2006; Gottfried, 1990). This finding of the present study is in accordance with previous findings among primary school children. For example, Aunola et al. (2006) found that a high level of math-related task motivation at the end of Grade 1 contributed to a later better performance in mathematics. Similarly, Aunola

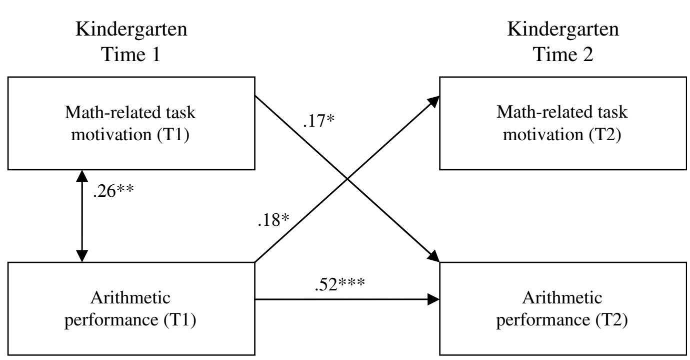

Fig. 1. Path model for math-related task motivation and arithmetic performance. Standardized solution, only the significant paths included. T1 = Time 1 (October: at the beginning of the kindergarten year); T2 = Time 2 (April: at the end of the kindergarten year). $*p < 0.05$; $**p < 0.01$; $***p < 0.001$.

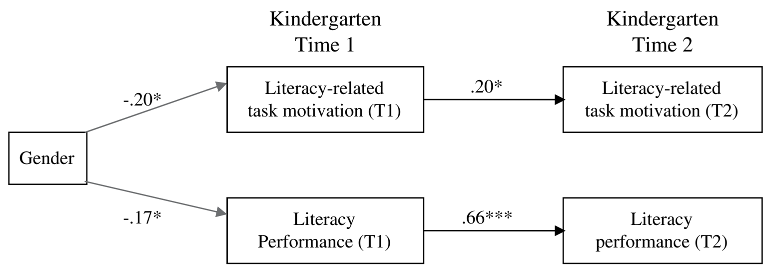

Fig. 2. Path model for literacy-related task motivation and literacy performance. Standardized solution, only the significant paths included. T1 = Time 1 (October: at the beginning of the kindergarten year); T2 = Time 2 (April: at the end of the kindergarten year). *$p < 0.05$; ***$p < 0.001$.

et al. (2006) found that performance in mathematics among children in Grade 1 predicted their later math-related task motivation, which then contributed to their later performance. Gottfried et al. (1994), in turn, found that intrinsic motivation in mathematics at age 9 predicted mathematical performance at age 10. The results of the present study also showed that the better children's arithmetic performance was at Time 1 the more math-related task motivation they showed at Time 2, again after controlling for the initial level of motivation (Hypothesis 2b). This finding provides support to the claim of Deci et al. (1991) according to which school performance is likely to contribute to subsequent task motivation. Our finding is also similar to those of Gottfried (1990) who showed that previous achievement in mathematics among elementary school children predicted their subsequent intrinsic motivation. Overall, the findings of the present study suggest that math-related task motivation and arithmetic performance form cumulative cycles: high motivation leads to improved performance, which again contributes to increase in motivation. The findings of the present study concerning mathematics indicate that the basis for these kinds of cumulative patterns of performance and motivation start to develop already in kindergarten.

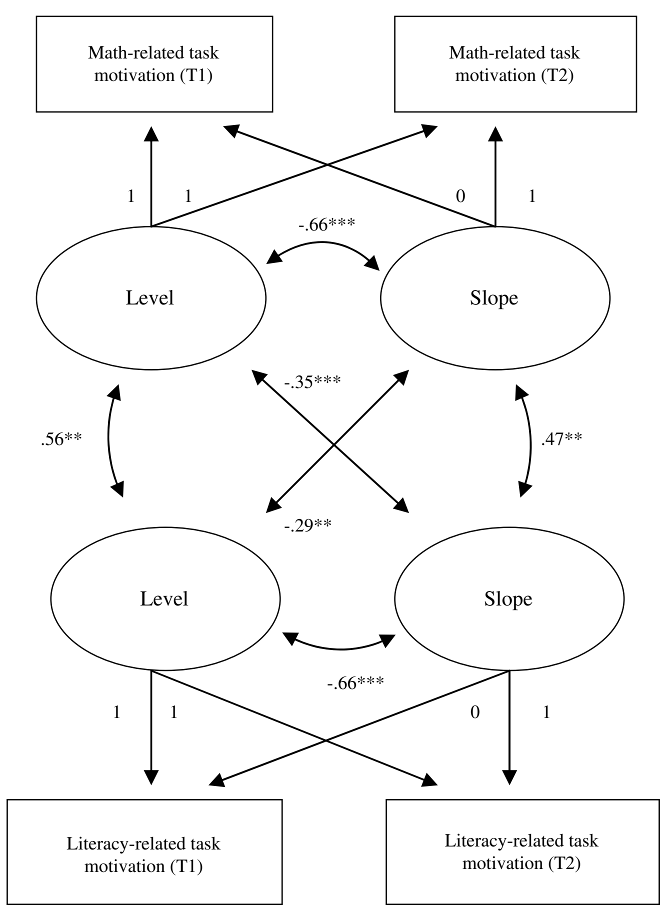

Fig. 3. Multivariate latent change model for the math-related task motivation and literacy-related task motivation variables. T1 = Time 1 (October: at the beginning of the kindergarten year); T2 = Time 2 (April: at the end of the kindergarten year). **$p < 0.01$; ***$p < 0.001$.

When examining the relationship between literacy-related task motivation and literacy performance, however, no concurrent or cross-lagged relations were found. This finding is similar to some previous studies. For example, Nurmi and Aunola (2005) found that neither previous reading performance predicted later task motivation among students of Grades 1 and 2 nor task motivation contributed to the development of reading skills. One possible explanation for the findings of the present study and the one by Nurmi and Aunola (2005) is the nature of the Finnish language. At least 25% of Finnish children are able to read before Grade 1 (Holopainen et al., 2000; Lerkkanen et al., 2004), and most children are accurate readers before they move up to Grade 2 (Aunola, Nurmi, et al., 2002). It may be that literacy-related task motivation only starts to play an important role later on when the focus moves towards more advanced performance, such as reading fluency and text comprehension skills.

The results of the present study showed further that children's math-related task motivation during the kindergarten year was not stable in terms of individual differences (Hypothesis 1). This result is similar to another Finnish study (Aunola et al., 2006) showing low inter-individual stability of math-related task motivation during Grade 1 but an increase in it later on. Overall, this finding concerning lack of inter-individual stability is in accordance with some other earlier findings suggesting that task motivation is not yet stable in the beginning of the school career, but the stability increases during the first school years (Gottfried, 1990; Gottfried et al., 2001; Wigfield et al., 1997) when children receive more systematic feedback on their performance (see, e.g., Stipek & Mac Iver, 1989). The results of the present study showed, however, that literacy-related task motivation showed some stability, although the stability was relatively low. One possible explanation for the different results for literacy and arithmetic is that, although the aim of the kindergarten year is not to actually teach reading and writing, the curriculum is more language-based than focused on numbers and arithmetic skills (Lerkkanen, 2007). Many children also learn to read spontaneously during the kindergarten year (Lerkkanen & Poikkeus, 2006). Consequently, children may receive more systematic feedback about their literacy performance than about their arithmetic performance, which may then provide a basis for developing certain literacy-related task motivation, in particular.

Other findings of the present study showed that math-related and literacy-related task motivations were highly related (Hypothesis 3), that is, the higher the math-related task motivation is the higher the literacy-related task motivation also is. Furthermore, the more the increase in math-related task motivation during kindergarten year was the more the increase was also in literacy-related task motivation. Earlier studies have shown that task motivation in different school subjects starts to get differentiated already during the very first school years (Nurmi & Aunola, 2005). The findings of the present study, however, suggest that during the kindergarten year children's math-related and literacy-related task motivation are relatively undifferentiated. This finding is in accordance with other studies suggesting that children's academic motivation is non-specific at the beginning of the school career (Harter, 1983; Jacobs et al., 2002). It looks as if it is only later on, when children move to the primary school and receive systematic instruction, that their interest in school subjects starts to get differentiated. However, the findings of the present study showed also that children's both math-related and literacy-related task motivation were relatively high in kindergarten. Moreover, literacy-related task motivation increased during the kindergarten year, although no change in the level of math-related task motivation was evident in the present study. This result might be due to the fact that less emphasis is invested in learning mathematics during Finnish kindergarten as compared to providing a basis for literacy.

We also examined whether any gender differences in children's task motivation would be found as early as in kindergarten. The results showed that girls had higher literacy-related task motivation than boys, which is in accordance with many earlier studies suggesting that the motivation and intrinsic value placed on languages are higher among girls than boys (Eccles et al., 1993; Jacobs et al., 2002; Wigfield et al., 1997). However, no gender differences in relation to math-related task motivation were found. This matches well with the findings of previous studies suggesting that there are no gender differences in math-related task motivation among younger children (Jacobs et al., 2002; Wigfield et al., 1997).

There are some limitations in the present study that should be taken into account. First, the sample size of the present study was relatively small ($N = 139$). This may have influenced the power of detecting statistically significant effects. Second, the time the participants were followed up was short, only half a year. Consequently, there is an evident need of studies in which children's motivation and skills are followed from kindergarten to primary school. Third, the measure of children's performance in arithmetic was relatively narrow, including only addition tasks. Fourth, the reliabilities of some of the task motivation scales could have been higher, which may have influenced our possibility to find all the predicted cross-lagged paths. Finally, one should be cautious in generalizing the results to countries with a different schooling system.

Overall, the results of the present study showed that already during the kindergarten year math-related task motivation and arithmetic performance showed cross-lagged relations indicating that the basis for cumulative patterns of skill development and task motivation may start to develop already before the start of formal instruction. Our results have also some practical significance. Although it has been widely accepted that motivation to different topics begins to develop already during the first school years, it is important to understand that this development starts even before the entrance into primary school and systematic instruction. Since math-related task motivation was found in this study to influence arithmetic performance, it is important for adults to be aware of this fact and pay attention to children's math-related learning motivation at home and in the kindergarten. Although Finnish kindergarten introduces children to academic skills in a playful manner without emphasis on achievement and grading, this kindergarten year nevertheless seems to play an important role in the development of children's task motivation. The finding suggesting that girls were more interested than boys in literacy-related tasks is noteworthy. Consequently, it might be important to develop new materials and activities related to literacy that also attract boys and provide them motivating and inspiring experiences related to letters and phonemes.

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References

Adams, M. J. (1990). *Beginning to read. Thinking and learning about print*. Cambridge, MA: MIT Press.

Ames, C., & Archer, J. (1988). Achievement goals in the classroom: students' learning strategies and motivation processes. *Journal of Educational Psychology, 80*, 260–267.

Atkinson, J. W. (1964). *An introduction to motivation*. Princeton, NJ: Van Nostrand.

Aunola, K., Leskinen, E., Lerkkanen, M.-K., & Nurmi, J.-E. (2004). Developmental dynamics of math performance from preschool to Grade 2. *Journal of Educational Psychology, 96*, 699–713.

Aunola, K., Leskinen, E., & Nurmi, J.-E. (2006). Developmental dynamics between mathematical performance, task motivation, and teachers' goals during the transition to primary school. *British Journal of Educational Psychology, 76*, 21–40.

Aunola, K., Leskinen, E., Onatsu-Arvilommi, T., & Nurmi, J.-E. (2002). Three methods for studying developmental change: a case of reading skills and self-concept. *British Journal of Educational Psychology, 72*, 343–364.

Aunola, K., Nurmi, J.-E., Lerkkanen, M.-K., & Rasku-Puttonen, H. (2003). The roles of achievement-related behaviors and parental beliefs in children's mathematical performance. *Educational Psychology, 23*, 403–421.

Aunola, K., Nurmi, J.-E., Niemi, P., Lerkkanen, M.-K., & Rasku-Puttonen, H. (2002). Developmental dynamics of achievement strategies, reading performance, and parental beliefs. *Reading Research Quarterly, 37*, 310–327.

Bradley, L., & Bryant, P. (1991). Phonological skills before and after learning to read. In S. A. Brady, & D. P. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 37–45). Hillsdale, NJ: Erlbaum.

Cantor, N. (1990). From thought to behavior: "Having" and "doing" in the study of personality and cognition. *American Psychologist, 45*, 735–750.

Catts, H. W., Hogan, T. P., & Fey, M. E. (2003). Subgrouping poor readers on the basis of individual differences in reading-related abilities. *Journal of Learning Disabilities, 36*, 151–164.

Christou, C., & Papageorgiou, E. (2007). A framework of mathematics inductive reasoning. *Learning and Instruction, 17*, 55–66.

Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and education: the self-determination perspective. *Educational Psychologist, 26*, 325–346.

Dowker, A. (1998). Individual differences in normal arithmetical development. In C. Donlan (Ed.), *The development of mathematical skills* (pp. 275–302). Hove, England: Psychology Press.

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L., et al. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75–146). San Francisco: Freeman.

Eccles, J. S., Adler, T. F., & Meece, J. L. (1984). Sex differences in achievement: a test of alternate theories. *Journal of Personality and Social Psychology, 46*, 26–43.

Eccles, J. S., Barber, B., & Jozefowicz, D. (1998). Linking gender to educational, occupational, and recreational choices: applying the Eccles, et al. model to achievement-related choices. In W. B. Swann, J. H. Langlois, & L. A. Gilbert (Eds.), *Sexism and stereotypes in modern society: The gender science of Janet Taylor Spence* (pp. 153–192). Washington, DC: American Psychological Association.

Eccles, J. S., O'Neill, S. A., & Wigfield, A. (2005). Ability self-perceptions and subjective task values in adolescents and children. In K. Anderson Moore, & L. H. Lippman (Eds.), *What do children need to flourish? Conceptualizing and measuring indicators of positive development* (pp. 237–249). New York: Springer.

Eccles, J. S., & Wigfield, A. (1995). In the mind of the actor: the structure of adolescents' achievement task value and expectancy-related beliefs. *Personality and Social Psychology Bulletin, 21*, 215–225.

Eccles, J. S., Wigfield, A., Harold, R. D., & Blumenfield, P. (1993). Age and gender differences in children's self- and task perceptions during elementary school. *Child Development, 64*, 830–847.

Eccles, J. S., Wigfield, A., & Schiefele, U. (1998). Motivation to succeed. In W. Damon (Ed.) (5th ed.).. In Eisenberg, N. (Ed.), *Handbook of child psychology, Vol. 3* (pp. 1017–1095) New York: Wiley.

Entwisle, D. R., & Alexander, K. L. (1990). Beginning school math competence: minority and majority comparisons. *Child Development, 61*, 454–471.

Finnish Office of Statistics. (2006). *Oppilaitostilastot 2005*. [*Statistics for education institutes 2005*]. Helsinki: Author.

Gottfried, A. E. (1990). Academic intrinsic motivation in young elementary school children. *Journal of Educational Psychology, 82*, 525–538.

Gottfried, A. E., Fleming, J. S., & Gottfried, A. W. (1994). Role of parental motivational practices in children's academic intrinsic motivation and achievement. *Journal of Educational Psychology, 86*, 104–113.

Gottfried, A. E., Fleming, J. S., & Gottfried, A. W. (2001). Continuity of academic intrinsic motivation from childhood through late adolescence: a longitudinal study. *Journal of Educational Psychology, 93*, 3–13.

Gough, P. B., Hoover, W. A., & Peterson, C. A. (1996). Some observations on a simple view of reading. In C. Cornoldi, & J. Oakhill (Eds.), *Reading comprehension difficulties: Processes and intervention* (pp. 1–14). Mahwah, NJ: Erlbaum.

Harter, S. (1981). A new self-report scale of intrinsic versus extrinsic orientation in the classroom: motivational and informational components. *Developmental Psychology, 17*, 300–312.

Harter, S. (1983). Developmental perspectives on the self-system. In P. H. Mussen (Ed.), *Handbook of child psychology, Vol. 4* (pp. 275–385). New York: Wiley.

Holopainen, L., Ahonen, T., Tolvanen, A., & Lyytinen, H. (2000). Two alternative ways to model the relation between reading accuracy and phonological awareness at preschool age. *Scientific Studies of Reading, 4*, 77–100.

Jacobs, J. E., Lanza, S., Oswood, D. W., Eccles, J. S., & Wigfield, A. (2002). Changes in children's self-competence and values: gender and domain differences across grades one through twelve. *Child Development, 73*, 509–527.

Kaplan, R. M., & Saccuzzo, D. P. (2001). *Psychological testing: Principle, applications and issues* (5th ed.). Belmont, CA: Wadsworth.

Karmiloff-Smith, A. (1995). *Beyond modularity: A developmental perspective on cognitive science* (2nd ed.). London: The MIT Press.

Koponen, T., Aunola, K., Ahonen, T., & Nurmi, J.-E. (2007). Cognitive predictors of single-digit and procedural calculation skills and their covariation with reading skill. *Journal of Experimental Child Psychology, 97*, 220–241.

Lepola, J., Salonen, P., & Vauras, M. (2000). The development of motivational orientations as a function of divergent reading careers from preschool to the secd grade. *Learning and Instruction, 10*, 153–177.

Lepola, J., Poskiparta, E., Laakkonen, E., & Niemi, P. (2005). Development of and relationship between phonological and motivational processes and naming speed in predicting word recognition in Grade 1. *Scientific Studies of Reading, 9*, 367–399.

Leppänen, U., Aunola, K., Niemi, P., & Nurmi, J.-E. (2008). Letter knowledge predicts Grade 4 reading fluency and reading comprehension. *Learning and Instruction, 18*(6), 548–564.

Leppänen, U., Niemi, P., Aunola, K., & Nurmi, J.-E. (2004). Development of reading skills among preschool and primary school pupils. *Reading Research Quarterly, 39*, 72–93.

Lerkkanen, M. -K (2007). The beginning phases of reading literacy instruction in Finland. In P. Linnakylä, & I. Arffman (Eds.), *Finnish reading literacy When quality and equity meet* (pp. 155–174). Jyväskylä: University of Jyväskylä Institute for Educational Research.

Lerkkanen, M.-K., & Poikkeus, A.-M. (2006). Lukemisvalmiuksien ja matemaattisten taitojen kehityksen riskitekijät esiopetusvuonna. [The developmental risk factors in pre-reading and math skills during the kindergarten year]. *Niilo Mäki Instituutti-Bulletin, 16*, 4–12.

Lerkkanen, M.-K., Poikkeus, A.-M., & Ketonen, R. (2006). *ARMI – Luku- ja kirjoitustaidon arviointimateriaali 1. luokalle*. [*ARMI – The test material of reading and writing skills for the first grade*]. Helsinki: WSOY.

Lerkkanen, M.-K., Rasku-Puttonen, H., Aunola, K., & Nurmi, J.-E. (2004). Reading performance and its developmental trajectories during the first and the second grade. *Learning and Instruction, 14*, 111–130.

Lerkkanen, M.-K., Rasku-Puttonen, H., Aunola, K., & Nurmi, J.-E. (2005). Mathematical performance predicts progress in reading comprehension among 7-year olds. *European Journal of Psychology of Education, 10*, 121–137.

Lonigan, C. J., Burgess, S. R., & Anthony, J. L. (2000). Development of emergent literacy and early reading skills in preschool children: evidence from a latent-variable longitudinal study. *Developmental Psychology, 36*, 596–613.

Meece, J., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its consequences for young adolescents' course enrollment intentions and performance in mathematics. *Journal of Educational Psychology, 82*, 60–70.

Murphy, P. K., & Alexander, P. A. (2000). A motivational exploration of motivation terminology. *Contemporary Educational Psychology, 25*, 3–53.

Muthén, L. K., & Muthén, B. O. (1998–2004). *Mplus user's guide*. Los Angeles, CA: Muthén & Muthén.

Nation, K. (2005). Children's reading comprehension difficulties. In M. J. Snowling, & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 248–265). Oxford, UK: Blackwell.

Nurmi, J. -E., & Aunola, K. (1999). Task-value scale for children (TVS-C). Unpublished manuscript, University of Jyväskylä, Finland.

Nurmi, J.-E., & Aunola, K. (2005). Task-motivation during the first school years: a person-oriented approach to longitudinal data. *Learning and Instruction, 15*, 103–122.

Onatsu-Arvilommi, T., & Nurmi, J.-E. (2000). The role of task-avoidant and task-focused behaviors in the development of reading and mathematical skills during the first school year: a cross-lagged longitudinal study. *Journal of Educational Psychology, 92*, 478–491.

Pintrich, P. R. (2000). An achievement goal theory perspective on issues in motivation terminology, theory, and research. *Contemporary Educational Psychology, 25*, 92–104.

Pintrich, P. R., & De Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*, 33–40.

Poikkeus, A.- M., & Lerkkanen, M.- K. (2005). Alkupolku Pilot Study [The First Steps Pilot Study]. Unpublished manuscript, University of Jyväskylä, Finland.

Poskiparta, E., Niemi, P., & Lepola, J. (1994). *Diagnostiset testit 1: Lukeminen ja kirjoittaminen*. [*Diagnostic tests 1: Reading and spelling*]. Finland: University of Turku, The Centre for Learning Research.

Räsänen, P. (2005). *BANUCA – Basic numerical and calculation abilities*. Jyväskylä, Finland: Niilo Mäki Institution.

Rittle-Johnson, B., & Siegler, R. S. (1998). The relation between conceptual and procedural knowledge in learning mathematics: a review. In C. Donlan (Ed.), *The development of mathematical skills* (pp. 75–110). East Sussex, UK: Psychology Press.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivation: classic definitions and new directions. *Contemporary Educational Psychology, 25*, 54–67.

Schiefele, U. (1996). Topic interest, text representation, and quality of experience. *Contemporary Educational Psychology, 2*, 237–244.

Seymour, P. H. K., Aro, M., & Erskine, J. M. (2003). Foundation literacy acquisition in European orthographies. *British Journal of Psychology, 94*, 143–174.

Stanovich, K. E., West, R. F., Cunningham, A. E., Cipielewski, J., & Siddiqui, S. (1996). The role of inadequate print exposure as a determinant of reading comprehension problems. In C. Cornoldi, & J. Oakhill (Eds.), *Reading comprehension difficulties. Processes and intervention* (pp. 15–32). Mahwah, NJ: Erlbaum.

Stipek, D., & Mac Iver, D. (1989). Developmental change in children's assessment of intellectual competence. *Child Development, 60*, 521–538.

Stodolsky, S., Salk, S., & Glaessner, B. (1991). Student view about learning math and social studies. *American Educational Research Journal, 28*, 89–116.

Vellutino, F. R., & Scanlon, D. M. (1991). The preeminence of phonologically based skills in learning to read. In S. A. Brady, & D. P. Shankweiler (Eds.), *Phonological processes in literacy: A tribute to Isabelle Y. Liberman* (pp. 237–252). Hillsdale, NJ: Erlbaum.

Wagner, R. K., Torgesen, J. K., & Rashotte, C. A. (1994). Development of reading-related phonological processing abilities: new evidence of bi-directional causality from a latent variable longitudinal study. *Developmental Psychology, 30*, 73–87.

Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review, 92*, 548–573.

Wigfield, A. (1997). Reading motivation: a domain-specific approach to motivation. *Educational Psychologist, 32*, 59–68.

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25*, 68–81.

Wigfield, A., & Eccles, J. S. (2002). Students' motivation during the middle school years. In J. Aronson (Ed.), *Improving academic achievement: Impact of psychological factors on education* (pp. 159–184). Amsterdam: Academic.

Wigfield, A., Harold, R. D., Freedman-Doan, C., Eccles, J. S., Suk Yoon, K., Arbreton, A. J. A., et al. (1997). Change in children's competence beliefs and subjective task values across the elementary school years: a 3-year study. *Journal of Educational Psychology, 89*, 451–469.

Zimmerman, B. J. (2000). Self-efficacy: an essential motive to learn. *Contemporary Educational Psychology, 25*, 82–91.