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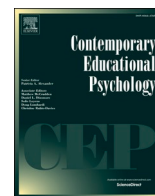
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Reciprocal relations between adolescents' self-concepts of ability and achievement emotions in mathematics and literacy[☆]

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ABSTRACT

This longitudinal study examined cross-lagged relations of self-concepts of ability and achievement emotions (i.e., enjoyment, boredom, anxiety) in two central school subjects (i.e., mathematics and literacy). Adolescents ($N = 848$) reported their achievement emotions and self-concepts of ability four times during Grades 6 and 7. The pattern of results was different for mathematics and literacy subjects. For mathematics the results of random intercept cross-lagged panel models showed a positive reciprocal relationship between self-concepts of ability and enjoyment and a negative reciprocal relationship between self-concept and anxiety. Lower self-concepts of ability in mathematics also predicted higher boredom in mathematics but not vice versa. For literacy, in turn, self-concept of ability did not predict any of the achievement emotions and emotions did not predict literacy self-concept of ability. The results suggest that achievement emotions act as sources as well as consequences of adolescents' self-concepts of ability, particularly in mathematics.

1. Introduction

Self-concept of ability (i.e., how good students evaluate themselves in different subjects domains) is central to adolescents' academic development because, according to robust research evidence, higher evaluations of one's self-concept as a learner predict interest in school subjects, academic choices, success in school, and educational attainment, and can even protect against school drop-out (Durik, Vida, & Eccles, 2006; Guay, Larose, & Boivin, 2004; Marsh, Trautwein, Lüdtke, Köller, & Baumert, 2005; Rumberger & Lim, 2008; Valentine, DuBois, & Cooper, 2004). Besides self-concept, achievement emotions, such as boredom, anxiety, and enjoyment also play a role in academic outcomes (Pekrun, 2017). For example, boredom in learning is thought to relate to off-task behaviors and ineffective learning strategies, thus undermining motivation and achievement. Similarly, anxiety is commonly assumed to be related to task-irrelevant thinking and decreased intrinsic motivation. Enjoyment related to learning tasks, in turn, can facilitate learning and achievement by boosting interest and adaptive learning strategies, fostering future learning and motivation (for reviews, see Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017; Pekrun, 2017). Taken

together, given the effects of self-concept of ability and achievement emotions on adolescents' development, it is important to investigate how they evolve over time in order to support adolescents' academic development and wellbeing.

Theoretical models (e.g., Pekrun 2006; see also Bandura, 1997; Zeidner, 1998) as well as empirical evidence (e.g., Goetz, Cronjaeger, Frenzel, Lüdtke, & Hall, 2010; for a summary, see Pekrun & Perry, 2014) suggest that self-concept of ability and emotions are related. However, the limitation of earlier research is that few attempts have been made to test reciprocal cross-lagged associations between self-concepts of ability and achievement emotions using longitudinal procedures. In particular, only little is known about bidirectional associations between self-concepts of ability and achievement emotions in different achievement domains and including multiple emotions. In order to foster learning and motivation and to better define targets of interventions for this support (e.g., emotion-focused or self-concept enhancement), it is critical to gain knowledge of the developmental dynamics between achievement emotions and their antecedents (e.g., self-concept of ability). Therefore, the aim of the present cross-lagged longitudinal study is to examine reciprocal associations between adolescents' self-concepts of ability and

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achievement emotions in two subject domains (i.e., math and literacy).

1.1. Self-concept of ability and achievement emotions among early adolescents

The present study examined domain-specific emotions and self-concepts of ability in mathematics and literacy (see also Goetz, Frenzel, Hall, Pekrun, & Lüdtke, 2007; Goetz et al., 2010; Raccanello, Brondini, & De Bernardi, 2013). Mathematics and literacy school subjects were chosen because math and literacy skills have shown to play an important role in subsequent academic success (Alexander, Entwistle, & Horsey, 1997; Claessens & Engel, 2013). For example, there is evidence suggesting that early mathematics skills form a central core for learning other subjects (Claessens & Engel, 2013). Moreover, Finnish was the participants' native language and, therefore, their literacy skills in Finnish are likely to form the basis for learning other school subjects.

Self-concept of ability is defined as the beliefs that an individual holds about their competence in a certain domain (e.g., mathematics or literacy) (Wigfield & Eccles, 2000). In the literature, other concepts, such as competence beliefs (Spinath & Spinath, 2005), ability beliefs (Wigfield & Eccles, 2000), and talent perceptions (Watt, 2004), have also been used to refer to perceptions of abilities. Self-concepts of ability tend to decrease during the elementary school years, and thus early adolescents often have less positive self-concepts of ability than younger students (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; Marsh, 1989; Spinath & Spinath, 2005; Stipek & Mac Iver, 1989). However, the changes in self-concepts might vary between domains (Cole et al., 2001; Jacobs et al., 2002), and there is also some evidence of individual differences for when and how extensively self-concepts of ability become more negative (Archambault, Eccles, & Vida, 2010). Moreover, individual differences in self-concept of ability in different subject domains tend to become more stable with increasing age (Cole et al., 2001; see also Wigfield et al., 1997).

In the control-value theory, in turn, achievement emotions are defined as emotions related to achievement outcomes (e.g., anxiety) or as emotions occurring in achievement related activities (e.g., enjoyment or boredom) (Pekrun & Perry, 2014). Outcome-related emotions can be further classified as prospective outcome emotions (e.g., anxiety related to anticipated failing in an exam) or retrospective outcome emotions (e.g., pride after a success). Furthermore, achievement emotions differ from each other also in terms of valence (positive or negative emotions) and a level of physiological activation (activating or deactivating emotions).

Adolescents experience a wide variety of achievement emotions and enjoyment, boredom, and anxiety in learning related activities are salient and frequently experienced emotions (Goetz & Hall, 2014; Pekrun, Goetz, Titz, & Perry, 2002; Raccanello et al., 2013). Due to their central role in adolescents' learning experiences and because they cover all the dimensions of emotions (i.e., negative vs. positive, activating vs. deactivating, outcome vs. activity-related emotions) proposed by the control-value theory (Pekrun & Perry, 2014), the present study focused on enjoyment, anxiety, and boredom.

1.2. The role of self-concepts of ability in subject-specific achievement emotions

The control-value theory of achievement emotions (Pekrun & Perry, 2014) suggests that self-concept of ability affects the way one feels toward learning as it forms a basis for a person's feeling of control over achievement outcomes and activities. The control-value theory also assumes that when students feel that they are competent to master the required tasks, enjoyment is likely to be instigated. Anxiety, in turn, is assumed to be provoked when self-concept is low (Pekrun & Perry, 2014). Lower self-concept of ability might signal that a person is not up to the task demands and anxiety is likely to be triggered (Bandura, 1997; Csikszentmihalyi, Aduhamdeh, & Nakamura, 2005), particularly if the

person evaluates the task as important (Pekrun & Perry, 2014). Furthermore, low ability beliefs may create attentional and interpretive biases in the processing of information. More specifically, low self-evaluations can arouse anxiety by increasing students' vigilance of threats and magnifying their evaluation of the severity of threats. In contrast, higher self-evaluations may facilitate viewing potential threats as more benign and adopting adaptive strategies to cope with threats, which decreases anxiety and results in unaffected or enhanced evaluations of self (Bandura, 1997).

The role that self-concept of ability plays in boredom towards learning has been debated. Traditionally, boredom has been assumed to be triggered if ability level is high and task demands are too low (Csikszentmihalyi et al., 2005; see also Van Tilburg & Igou, 2012). However, the control-value theory of achievement emotions (Pekrun, 2006) suggests that boredom is as likely to occur if subjective control over the activity is low or high. Thus, boredom is likely to be instigated if the demands of the situation exceed a person's ability to cope in the situation or if the task demands are too low in relation to ability level (see also Acee et al., 2010; Daschmann, Goetz, & Stupnisky, 2011; Krannich et al., 2019). However, it has also been suggested that school tasks are typically designed to be difficult enough, and therefore high control situations are not common in the school environment. Thus, it is more likely that overchallenging (rather than underchallenging) situations instigate boredom in school (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010).

The results from cross-sectional studies have shown that self-concepts of ability are positively related to enjoyment and negatively to boredom and anxiety in different academic domains (e.g., Goetz, Bieg, Lüdtke, Pekrun, & Hall, 2013; Goetz et al., 2010; Goetz, Frenzel, Hall, & Pekrun, 2008; Golob, Brunner, Martin, Preckel, & Goetz, 2017; Peixoto, Sanches, Mata, & Monteiro, 2017; Van der Beek, Van der Ven, Kroesbergen, & Leseman, 2017). Furthermore, there is also some cross-sectional evidence showing that the relationship between boredom and self-concept of ability is weaker compared to other emotions (Goetz et al., 2010). Despite the cross-sectional evidence of the relations between self-concepts of ability and emotions, little is known about the longitudinal dynamics of these constructs. The few longitudinal studies that have investigated the associations between self-concept of ability and achievement emotions have typically examined the direction of the effect from self-concept to emotions, but not vice versa. For example, in a longitudinal study, university students' academic control (equivalent to self-concept of ability) was shown to be negatively related to subsequent course-related boredom (Pekrun et al., 2010), whereas in a one-year longitudinal study among students in grades 7–9, math-related self-concept of ability was found to negatively predict math-related anxiety (Meece, Wigfield, & Eccles, 1990). Finally, a more recent longitudinal study by Pekrun, Murayama, Marsh, Goetz, and Frenzel (2019) showed that 5th and 9th Grade math self-concept of ability predicted negatively students' math-related anxiety and positively math-related enjoyment a year later. However, these studies did not examine the cross-lagged longitudinal relations between different achievement emotions and self-concepts of ability in several domains simultaneously and, therefore, were not able to show how different achievement emotions and self-concepts of ability in different domains are developmentally related across time.

1.3. The role of achievement emotions in subject-specific self-concepts

Previous literature has shown that mood affects memory, attention and judgments (for a review, see Forgas, 2017). The mood-congruency hypothesis suggests that people are likely to make negative judgments of their abilities when they experience negative mood and positive judgments when they experience positive mood (for a review, see Sedikides, 1992). As, feelings-as-information theory (Schwarz, 2012; see also Clore & Storbeck, 2006) implies, emotions can affect self-evaluation directly by implicitly giving information about a person's performance

and this emotionally-biased information can downgrade or upgrade beliefs (Bandura, 1997). Therefore, people are likely to make positive evaluations of themselves when they experience positive emotions and negative evaluations if they experience negative emotions. In addition, similar to associative network theory (Bower, 1981), control-value theory of achievement emotions (Pekrun, Frenzel, Goetz, & Perry, 2007) suggests that achievement emotions can affect self-concept of ability indirectly by triggering emotion-congruent memory networks. Therefore, negative emotions may activate past failures in memory, affecting self-evaluation negatively, whereas positive emotions may activate past successes, with a positive impact on self-evaluation (Bandura, 1997).

There is evidence supporting the mood-congruency hypothesis mainly from mood inductions studies that have investigated mood as a source of self-evaluations. According to these studies positive mood is positively related to subsequent self-evaluations while negative mood has an opposite effect (for a review, see Sedikides, 1992; see also Lyubomirsky, King, & Diener, 2005; Usher & Pajares, 2008), although there is also some evidence for mood-incongruency (for a review, see Sedikides & Green, 2001). However, as with the studies that have investigated self-concept of ability as a source for emotions, these studies did not test cross-lagged relations between self-concept of ability and specific emotions in different subject domains while also controlling for previous levels of the constructs, and thus they were unable to answer how these constructs are reciprocally related across time.

1.4. The present study

As suggested by the control-value theory (Pekrun, 2006; Pekrun & Perry, 2014), the present study builds on the assumptions that emotions might act as both a source and consequence of self-concept of ability (see

also, Bandura, 1997; Zeidner, 1998; Marsh, Craven, & Debus, 1999). To our knowledge, only few studies have investigated reciprocal relations between achievement emotions and self-concepts of ability. Ahmed, Minnaert, Kuyper, and Van der Werf (2012) showed in their three-wave cross-lagged longitudinal study that higher mathematics anxiety predicted lower self-concept and lower self-concept predicted higher anxiety among students in Grade 7, whereas a three-wave longitudinal study from 4th to 7th grade in turn, showed that math self-concept of ability did not predict math related enjoyment but enjoyment predicted students' math self-concept of ability (Pinxten, Marsh, De Fraine, Van Den Noortgate, & Van Damme, 2014). Another two-wave longitudinal study of Grade 5 students (Garn et al., 2019) also investigated enjoyment but the focus was on physical activity enjoyment and its relations with physical self-concept and its different facets (e.g., coordination self-concept, endurance self-concept). The study did not find reciprocal relations between physical self-concept and physical activity related enjoyment, but the results showed that previous coordination self-concept predicted subsequent physical activity enjoyment and previous physical activity enjoyment predicted future sport self-concept. In a more recent cross-lagged longitudinal study, Zhang (2020) examined 8 and 10 Grade students' self-concepts of ability and anxiety in three school subjects (i.e., Chinese, English and mathematics) twice in a year and showed that previous self-concepts of ability negatively predicted subsequent anxiety in all three domains. However, previous anxiety also predicted negatively subsequent Chinese and math self-concepts of ability but not English self-concept of ability. Thus far, no previous longitudinal studies have examined the reciprocal relations between self-concept of ability and multiple achievement emotions simultaneously in several school subjects. Hence, the main aim of this study was to broaden the knowledge of the developmental dynamics between self-concepts of ability in two important subject-domains (mathematics and

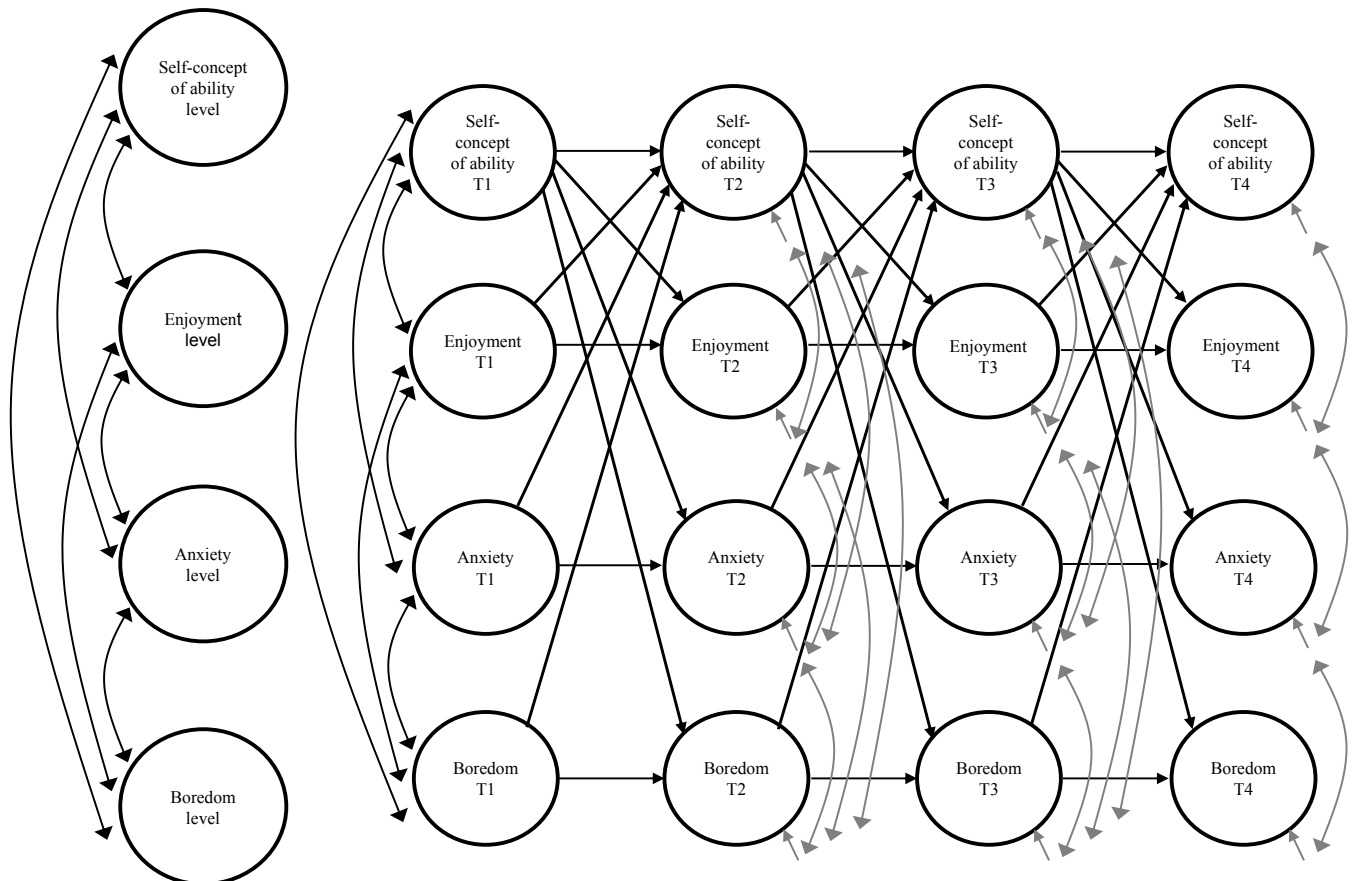


Fig. 1. Schematic model of associations between self-concept of ability and achievement emotions.

literacy) and frequently experienced achievement emotions (enjoyment, boredom, and anxiety) in adolescence.

The research questions and hypotheses were as follows (for the schematic model, see Fig. 1):

- (1) Do math and literacy self-concepts of ability predict adolescents' subsequent subject-specific enjoyment, anxiety, and boredom? H1: We expected prior self-concepts of ability would negatively predict anxiety and positively predict enjoyment (Pekrun, 2006; Pekrun & Perry, 2014; see also, Bandura, 1997; Zeidner, 1998). Because theoretical assumptions and empirical results concerning the relationship between self-concept and boredom have been inconsistent, no specific hypothesis was set concerning boredom.
- (2) Do subject-specific achievement emotions (enjoyment, anxiety, and boredom) predict adolescents' subsequent literacy and math self-concepts of ability? H2: We expected prior enjoyment would positively predict self-concepts of ability and prior anxiety would negatively predict self-concepts of ability (Pekrun, 2006; Pekrun & Perry, 2014; see also, Bandura, 1997; Zeidner, 1998). Again, no specific hypothesis was set for boredom, because theoretical assumptions and empirical results of its role have been inconsistent.

Adolescents' gender and skills were controlled for in all the analyses as previous research has shown that gender and academic skills are related to students' self-concepts of ability (e.g., Marsh & Craven, 2006; Valentine et al., 2004; Wilgenbusch & Merrell, 1999). Furthermore, gender differences in achievement emotions have also been found in previous research (e.g., Hembree, 1990; Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011; Soric, Penezić, & Burić, 2013), and skills have been found to play a role in achievement emotions (e.g., Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017; Pekrun et al., 2019).

2. Method

2.1. Participants

The research is part of an ongoing longitudinal study. Of all families initially contacted, 74% consented to the child's participation. The adolescents were recruited from one large town and one middle-sized town in central Finland, both including also semi-rural areas with smaller schools (for more details about the sample and its recruitment, see Hirvonen, Väänänen, Aunola, Ahonen, & Kiuru, 2018; Mauno, Hirvonen, & Kiuru, 2018). Parental written consent and child assent were required, and teachers also gave written consent for the data collection during their lessons. The research plan was approved by the local ethics committee.

The sample of this study consisted of 848 (457 girls, 54%) adolescents who were examined twice in Grade 6 and twice in Grade 7. Out of the 848 students, a total of 841 (99%) adolescents participated in Grade 6 fall, 836 (96%) participated in Grade 6 spring, 802 (95%) participated in Grade 7 fall and 793 (94%) participated in Grade 7 spring. The adolescents came from 57 classes (class size $M = 21$, $SD = 5.3$) and the average age of the adolescents at the outset was 12.32 years ($SD = 0.36$).

2.2. Procedure

The data was collected during normal school hours in four waves (Grade 6 fall, Grade 6 spring, Grade 7 fall, and Grade 7 spring) between 2014 and 2016. Self-concepts of ability and achievement emotions were measured at each wave, whereas achievement levels and gender were measured in Grade 6 fall. The trained research assistants administered the questionnaires.

2.3. Measures

Self-concept of ability. The questionnaires of self-concepts of

ability in math and literacy were adapted from Eccles and Wigfield (1995) and Spinath and Steinmayr (2008) and included three items for both math and literacy (e.g., *How good are you at math calculation problems / at reading precisely and fast?*) on a 5-point Likert scale (1 = very poor to 5 = very good) (see also Pesu, Aunola, Viljaranta, Hirvonen, & Kiuru, 2018). The reliabilities of the self-concept of ability scales were good or adequate. For the math self-concept of ability Cronbach's alphas were 0.85 (Grade 6 fall), 0.86 (Grade 6 spring), 0.85 (Grade 7 fall), and 0.86 (Grade 7 spring). In turn, for the literacy self-concept of ability, Cronbach's alphas were 0.70 (Grade 6 fall), 0.67 (Grade 6 spring), 0.69 (Grade 7 fall), and 0.68 (Grade 7 spring). In the present study, the term *literacy self-concept of ability* refers to students' self-concepts of ability in the school subject of Finnish language (i.e., students' mother tongue).

Achievement emotions. Enjoyment, boredom, and anxiety toward mathematics and literacy were measured with the Achievement Emotions Questionnaire (AEQ; Pekrun et al., 2011; for validity in the Finnish sample, see Sainio, Eklund, Hirvonen, Ahonen, & Kiuru, 2020). For both math and literacy subjects the AEQ included three items for enjoyment (e.g., *I enjoy acquiring new knowledge*), three items for anxiety (e.g., *I get tense and nervous while studying*), and two items for boredom (e.g., *I get bored while studying*) that were rated on a 5-point Likert scale (1 = disagree to 5 = agree). The reliabilities of the emotion scales in math and literacy were good or adequate. For math-related emotions the Cronbach's alpha's were as follows: 0.77 for enjoyment, 0.64 for anxiety and 0.76 for boredom (Grade 6 fall); 0.78 for enjoyment, 0.70 for anxiety and 0.78 for boredom (Grade 6 spring); 0.77 for enjoyment, 0.71 for anxiety and 0.77 for boredom (Grade 7 fall); 0.78 for enjoyment, 0.72 for anxiety and 0.79 for boredom (Grade 7 spring). In turn, for literacy-related emotions the Cronbach's alpha's were as follows: 0.72 for enjoyment, 0.62 for anxiety and 0.76 for boredom (Grade 6 fall); 0.77 for enjoyment, 0.70 for anxiety and 0.80 for boredom (Grade 6 spring); 0.75 for enjoyment, 0.69 for anxiety and 0.79 for boredom (Grade 7 fall); 0.76 for enjoyment, 0.69 for anxiety and 0.79 for boredom (Grade 7 spring).

Control variables. Adolescents' gender and academic skills in math and literacy were controlled for in the analyses. Gender was coded as 0 = boy and 1 = girl. Literacy skills were measured using three subtests. Two subtests (the error-finding test and the word-chain test) were from *Dyslexia Screening Methods for Adolescents and Adults* by Holopainen, Kairaluoma, Nevala, and Aho (2004; see also Kiuru et al., 2011) and the third test was the short version of Salzburg's reading fluency test (Landerl, Wimmer, & Moser, 1997). A sum score of the subtests was created by computing the mean of the three standardized test scores ($\alpha = 0.87$). Mathematics skills were assessed with the three-minute basic arithmetic test with the test-retest reliability 0.86 (Aunola & Räsänen, 2007; Räsänen, Salminen, Wilson, Aunio, & Dehaene, 2009).

2.4. Analysis strategy

First, we investigated the descriptive information of the data. Second, to answer the research questions we used random intercept cross-lagged panel model (RI-CLPM) for investigating reciprocal relationships between variables within individuals while controlling for differences between individuals (see Hamaker, Kuiper, & Grasman, 2015; for schematic model, see Fig. 1). The analyses were conducted separately for mathematics and literacy with the focus in the longitudinal associations between self-concept of ability, enjoyment, anxiety, and boredom. First, we built between-level factors for each emotion and self-concept that captured adolescents' average levels of emotions and self-concepts across all four measurement points. In these models, the between-level factors were allowed to correlate with each other. Second, we created within-person factors for each emotion and self-concept separately for each time point. The within-person factors and the residuals of the within-person factors were allowed to be correlated within each measurement point. Third, we estimated stability paths and cross-lagged paths between subsequent measurement points for the within-

person factors of self-concepts of ability, and within-person factors of three emotions (enjoyment, anxiety, and boredom; see Fig. 1). Our main interest was in the within-person cross-lagged paths between self-concept of ability and achievement emotions after accounting for between-person differences in the level of self-concept and academic emotions. In these models we also controlled for the effects of gender and academic skill level in the particular school subject.

The analyses were carried out using the complex approach of the statistical package Mplus (Version 7.31, Muthén & Muthén, 1998–2015). When using this method the models are estimated at the level of the whole sample, but possible distortions of standard errors caused by the clustering of observations (classroom differences) are corrected. The proportion of missing data in the observed variables ranged from 0% to 8.6% ($M = 3.88$; $SD = 7.96$). Little's MCAR test (Little, 1988) showed that data in the self-concepts of ability, achievement emotions, and control variables were not missing completely at random: $\chi^2(334) = 632.61$, $p < .001$. Hence, missingness at random (MAR) was assumed, which is a weaker condition for missing data than missingness completely at random (MCAR). In the MAR situation, missingness does not depend on unmeasured variables but can depend on the values of the observed variables included in the analyses (Little, 1988). Assuming MAR, full-information maximum likelihood estimation was used in the analyses to deal with the missing data. Because all of the study variables were not fully normally distributed, we used maximum likelihood robust (MLR) estimation that produces robust standard errors by means of a sandwich estimator and a χ^2 test statistic for non-normal outcomes. Goodness-of-fit of the models was evaluated using the root mean square error of approximation (RMSEA), the comparative fit index (CFI), the Tucker-Lewis Index (TLI), and the standardized root mean square residual (SRMR). RMSEA values below 0.06 and SRMR values below 0.06 indicate a good fit to the data, whereas CFI and TLI values close to 0.95 or above indicate a good fit to the data (see also Hu and Bentler 1999).

3. Results

3.1. Cross-lagged associations between self-concepts of ability and achievement emotions

Table 1 shows means, standard deviations, and correlations between the main variables (correlations for mathematics are presented in the upper diagonal and correlations for literacy are presented in the lower diagonal). Next, we present CLPM models separately for mathematics and literacy.

Mathematics. The final CLPM model for mathematics (see Fig. 2) fit the data well: RMSEA = 0.02, CFI = 1.00, TLI = 0.99 and SRMR = 0.02. Factor loadings of between-level factors for self-concept of ability ranged from 0.76 to 84, for boredom from 0.63 to 0.78, for anxiety from 0.62 to 0.75, and for enjoyment from 0.68 to 0.80. The results showed that interindividual differences in achievement emotions and self-concepts of abilities were relatively stable. The between-level self-concept of ability factor had a moderate positive correlation with the between-level enjoyment factor and a weak negative correlation with the between-level anxiety and boredom factors: the higher the adolescents' self-concept of ability in math was, the more enjoyment, the less anxiety and the less boredom toward math they reported.

The within-person level results showed further that self-concept of ability was reciprocally related with math anxiety and enjoyment even after controlling for between-individual differences in the levels of self-concept of ability and emotions, and after accounting for the effects of the control factors (i.e., gender and skill level). The higher the self-concept of ability in the fall of Grade 6, the more enjoyment and less anxiety a student had toward math in the spring of Grade 6. The more enjoyment and less anxiety a student had in the spring of Grade 6, the higher was self-concept in the fall of Grade 7. Finally, the higher the self-concept in the fall of Grade 7, the less anxiety and more enjoyment a

student had toward mathematics in the spring of Grade 7. Self-concept of ability also predicted boredom: the higher the self-concept in the fall of Grade 6, the spring of Grade 6, and the fall of Grade 7, the less boredom a student had toward math at subsequent measurement points (see Fig. 2). However, boredom did not predict subsequent self-concept of ability. Self-concepts of ability accounted for 8% to 16% of the variance in subsequent emotions at the within-person level. Total variance in self-concepts of ability at the within-person level explained by emotions and control variables ranged from 9% to 12%. Achievement emotions accounted for 8% to 10% of the variance in subsequent self-concepts of ability at the within-person level, whereas the proportion of the variance in emotions at the within-person level explained by control variables and self-concepts of ability ranged from 3% to 7%.

Literacy. The final model of literacy (see Fig. 3) fit the data well: RMSEA = 0.02, CFI = 1.00, TLI = 0.99 and SRMR = 0.03. Factor loadings of the between-level factor for self-concept of ability ranged from 0.79 to 81, for boredom from 0.64 to 0.76, for anxiety from 0.65 to 0.80, and for enjoyment from 0.70 to 0.81. The between-level self-concept of ability factor had a weak positive correlation with the between-level enjoyment factor and a weak negative correlation with the between-level anxiety and boredom factors: the higher the adolescents' self-concept of ability in literacy, the more enjoyment, the less anxiety and the less boredom toward literacy they reported. The within-level results showed that self-concept of ability did not predict subsequent emotions and emotions did not predict subsequent self-concept of ability.

4. Discussion

The main purpose of this study was to investigate to what extent adolescents' self-concepts of ability predict their achievement emotions (enjoyment, boredom, and anxiety) and to what extent these achievement emotions predict self-concepts of ability in mathematics and literacy from grades 6 to 7. Although the relations between domain-specific self-concept of ability and achievement emotions has been well demonstrated in previous research (for a summary, see Pekrun & Perry, 2014), there has been a lack of knowledge on the developmental dynamic of these constructs across time. Particularly, longitudinal studies focusing on multiple achievement emotions in many academic domains simultaneously have been lacking. This study increased our understanding of how self-concepts of ability in two main school subjects (literacy and mathematics) and frequently experienced achievement emotions (enjoyment, anxiety and boredom) influence each other over time among adolescents. The results indicated first that in mathematics higher self-concept of ability was longitudinally and reciprocally related to subsequent higher enjoyment and lower anxiety, when controlling for previous levels of the constructs as well as gender and skill level. For boredom, a lower self-concept of ability in mathematics predicted higher subsequent boredom toward mathematics, but boredom did not predict self-concept of ability. Second, in literacy, no longitudinal cross-lagged predictions between self-concept of ability and achievement emotions were found.

4.1. Associations between self-concepts of ability and emotions in mathematics

Our results regarding developmental dynamics between enjoyment and self-concepts of ability in mathematics were in line with our hypotheses H1 and H2 and theoretical assumptions (Pekrun, 2006; Pekrun & Perry, 2014). Accordingly, the results among early adolescents showed that higher math self-concept of ability predicted higher enjoyment and higher enjoyment predicted better self-concept of ability, creating a positive cycle between self-concept and enjoyment of mathematics. This result is in line with Pekrun et al. (2019) study showing that adolescents' higher self-concept in math was related to higher enjoyment toward studying math a year later and with studies that have

Table 1
Correlations Between the Main Study Variables and Means and Standard Deviations (math at the upper diagonal and literacy at the lower diagonal).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|------|------|
| 1. Literacy/math self-concept of ability T1 | | 0.78*** | 0.71*** | 0.63*** | 0.48*** | 0.50*** | 0.41*** | 0.35*** | -0.30*** | -0.33*** | -0.27*** | -0.19*** | -0.20*** | -0.20*** | -0.19*** | -0.17*** | -0.23*** | 0.47*** | 3.83 | 0.73 |
| 2. Literacy/math self-concept of ability T2 | 0.71*** | | 0.76*** | 0.70*** | 0.46*** | 0.55*** | 0.46*** | 0.38*** | -0.31*** | -0.36*** | -0.29*** | -0.23*** | -0.19*** | -0.24*** | -0.21*** | -0.17*** | -0.20*** | 0.49*** | 3.80 | 0.73 |
| 3. Literacy/math self-concept of ability T3 | 0.67*** | 0.71*** | | 0.76*** | 0.47*** | 0.53*** | 0.57*** | 0.47*** | -0.27*** | -0.35*** | -0.35*** | -0.29*** | -0.19*** | -0.23*** | -0.30*** | -0.26*** | -0.16*** | 0.47*** | 3.81 | 0.73 |
| 4. Literacy/math self-concept of ability T4 | 0.63*** | 0.64*** | 0.69*** | | 0.45*** | 0.47*** | 0.51*** | 0.53*** | -0.24*** | -0.30*** | -0.32*** | -0.26*** | -0.18*** | -0.23*** | -0.26*** | -0.28*** | -0.11** | 0.43*** | 3.73 | 0.80 |
| 5. Enjoyment T1 toward literacy/math | 0.34*** | 0.33*** | 0.33*** | 0.31*** | | 0.69*** | 0.61*** | 0.52*** | -0.31*** | -0.31*** | -0.30*** | -0.23*** | -0.54*** | -43*** | -0.37*** | -0.34*** | -0.04 | 0.23*** | 3.30 | 1.00 |
| 6. Enjoyment T2 toward literacy/math | 0.32*** | 0.38*** | 0.32*** | 0.31*** | 0.67*** | | 0.68*** | 0.56*** | -0.33*** | -0.41*** | -0.33*** | -0.29*** | -0.44*** | -0.52*** | -0.42*** | -0.36*** | -0.06 | 0.29*** | 3.32 | 1.00 |
| 7. Enjoyment T3 toward literacy/math | 0.31*** | 0.31*** | 0.37*** | 0.33*** | 0.61*** | 0.66*** | | 0.64*** | -0.27*** | -0.31*** | -0.38*** | -0.29*** | -0.37*** | -0.43*** | -0.51*** | -0.42*** | -0.03 | 0.25*** | 3.40 | 0.93 |
| 8. Enjoyment T4 toward literacy/math | 0.27*** | 0.29*** | 0.32*** | 0.36*** | 0.44*** | 0.53*** | 0.63*** | | -0.23*** | -0.30*** | -0.29*** | -0.33*** | -0.31*** | -0.35*** | -0.37*** | -0.53*** | 0.03 | 0.22*** | 3.10 | 1.00 |
| 9. Anxiety T1 toward literacy/math | -0.29*** | -0.29*** | -0.29*** | -0.25*** | -0.30*** | -0.32*** | -0.28*** | -0.18*** | | 0.61*** | 0.54*** | 44*** | 0.40*** | 0.27*** | 0.27*** | 0.23*** | 0.05 | -0.16*** | 1.90 | 0.81 |
| 10. Anxiety T2 toward literacy/math | -0.28*** | -0.33*** | -0.32*** | -0.31*** | -0.30*** | -0.39*** | -0.31*** | -0.25*** | 0.61*** | | 0.63*** | 0.49*** | 0.30*** | 0.44*** | 0.31*** | 0.25*** | 0.02 | -0.19*** | 1.82 | 0.83 |
| 11. Anxiety T3 toward literacy/math | -0.26*** | -0.30*** | -0.29*** | -0.31*** | -0.29*** | -0.33*** | -0.34*** | -0.26*** | 0.50*** | 0.62*** | | 0.54*** | 0.27*** | 0.34*** | 0.49*** | 0.30*** | 0.05 | -0.15*** | 1.70 | 0.80 |
| 12. Anxiety T4 toward literacy/math | -0.22*** | -0.24*** | -0.22*** | -0.24*** | -0.21*** | -0.27*** | -0.29*** | -0.30*** | 0.38*** | 0.46*** | 0.51*** | | 0.24*** | 0.31*** | 0.32*** | 0.52*** | -0.07 | -0.09** | 2.01 | 0.90 |
| 13. Boredom T1 toward literacy/math | -0.14*** | -0.13** | -0.17*** | -0.12** | -0.53*** | -0.47*** | -0.39*** | -0.26*** | 0.39*** | 0.31*** | 0.26*** | 0.23*** | | 0.60*** | 0.48*** | 0.43*** | -0.03 | -0.06 | 2.02 | 1.02 |
| 14. Boredom T2 toward literacy/math | -0.12** | -0.15*** | -0.19*** | -0.13** | -0.44*** | -0.55*** | -0.43*** | -0.33*** | 0.28*** | 0.43*** | 0.34*** | 0.25*** | 0.60*** | | 0.59*** | 0.51*** | -0.10** | -0.04 | 1.90 | 1.00 |
| 15. Boredom T3 toward literacy/math | -0.16*** | -0.18*** | -0.20*** | -0.16*** | -0.36*** | -0.44*** | -0.50*** | -0.39*** | 0.28*** | 0.35*** | 0.49*** | 0.31*** | 0.52*** | 0.62*** | | 0.52*** | -0.04 | -0.06 | 1.84 | 1.00 |
| 16. Boredom T4 toward literacy/math | -0.11** | -0.13** | -0.16*** | -0.13*** | -0.30*** | -0.39*** | -0.52*** | -0.52*** | 0.18*** | 0.25*** | 0.28*** | 0.51*** | 0.40*** | 0.50*** | 0.56*** | | -0.10* | -0.04 | 2.31 | 1.13 |
| 17. Gender | 0.10** | 0.12** | 0.13** | 0.11*** | 0.14*** | 0.14*** | 0.18*** | 0.17*** | -0.10** | -0.10** | -0.08* | -0.16*** | -0.14*** | -0.16*** | -0.18*** | 0.19*** | | -0.09** | 0.54 | 0.50 |
| 18. Literacy/math skills | 0.50*** | 0.49*** | 0.43*** | 0.48*** | 0.15*** | 0.15*** | 0.15*** | 0.15*** | -0.18*** | -0.19*** | -0.12*** | -0.12*** | 0.03 | 0.04 | 0.01 | 0.04 | 0.22*** | | 0.10 | 1.00 |
| 19. Literacy/math mean | 4.00 | 3.94 | 4.00 | 3.90 | 3.10 | 3.12 | 3.30 | 3.00 | 1.90 | 1.80 | 1.70 | 2.00 | 2.12 | 2.04 | 1.90 | 2.31 | 0.54 | 0.06 | | |
| 20. Literacy/math standard deviation | 0.54 | 0.53 | 0.54 | 0.60 | 0.90 | 0.90 | 0.90 | 0.90 | 0.80 | 0.80 | 0.80 | 0.84 | 1.03 | 1.10 | 1.02 | 1.14 | 0.50 | 1.01 | | |

shown that positive mood lead to positive self-perceptions (for reviews, see Lyubomirsky et al., 2005; Sedikides, 1992). This result is also similar to Pinxten et al. (2014) results from a 3-year longitudinal study among 4th graders which showed that enjoying math predicted students' math self-concept and Garn et al. (2019) cross-lagged longitudinal study that showed that 5th graders coordination self-concept predicted enjoying physical activities and enjoying these activities, in turn, predicted sport self-concept. However, these studies did not find a positive reciprocal relationship between enjoyment and self-concept of ability as was found in our study. An explanation for this positive cycle can be provided by the broaden-and-build theory of positive emotions (Fredrickson, 2001), which suggests that positive emotions broaden an individual's momentary thought-action repertoires by triggering novel ideas and creative thinking and by urging one to explore and be open to learning new information. This can lead to actions for building personal resources such as self-concept of ability, which in turn can increase positive emotions.

There are also other possible explanations for the reciprocal associations between self-concept of ability and enjoyment in math. First, positive perception of one's abilities in math might signal that one is able to master the required tasks, which instigates enjoyment toward learning (Pekrun & Perry, 2014). Second, enjoyment toward learning mathematics may instigate mood-congruent judgments of one's math abilities by directly acting as source for math self-concept evaluation by interpreting positive math-related emotions as an indication of one's math self-concept of ability (Schwarz 2012; Clore & Storbeck, 2006; see also Bandura, 1997). Third, positive emotions toward math learning may make positive mood-congruent events and math-related memories more accessible from memory, resulting in positive judgments of self-concept of ability (Bower, 1981; see also Bandura, 1997; Pekrun et al., 2007). This may enable adolescents to use positive emotions and memories as a resource to verify or even enhance their self-concept (Kwang & Swann, 2010; Swann & Buhrmester, 2012). To preserve their consistent self-views, adolescents with higher self-concept of ability in math might also strive to maintain their positive learning emotions toward math while adolescents with lower self-concept of ability are less likely to do so (see also Gomez-Baya, Mendoza, Gaspar, & Gomes, 2018; Wood, Heimpel, & Michela, 2003). Overall, there is increasing evidence of positive emotions' power to build capabilities and resources, which further increase positive emotions and over time may lead to emotional wellbeing (for reviews, see Fredrickson, 2005, 2013; see also Aspinwall, 1998).

The findings for the relationship between self-concept and anxiety in mathematics were in line with our hypotheses H1 and H2 and theoretical assumptions (Bandura, 1997; Pekrun, 2006; Pekrun & Perry, 2014; Zeidner, 1998) by showing that lower self-concept of ability predicted higher anxiety toward learning and higher anxiety in turn predicted lower self-concept. These results resemble previous studies that have shown that people are prone to make negative judgments of themselves when in a negative mood (for reviews, see Sedikides, 1992; see also Usher & Pajares, 2008). The results are also in line with the findings of Pekrun et al. (2019) and Meece et al. (1990) showing that adolescents' higher math self-concept of ability predicted lower anxiety related to math studying. Similarly, the results are consistent with the cross-lagged longitudinal studies by Ahmed et al. (2012) and Zhang (2020) who showed that higher anxiety predicted lower self-concept and lower self-concept predicted higher anxiety in mathematics. Zhang (2020) also found similar reciprocal relationship between self-concept and Chinese subject, whereas in English a lower self-concept was related to higher anxiety but not vice versa.

There are several possible explanations for why we found math self-concept of ability and anxiety toward math-learning to be reciprocally related. First, low self-concept of ability in math might give information to the student that one is not up to the task demands thereby triggering anxiety (Bandura, 1997; Csikszentmihalyi et al., 2005). Second, as in the case of enjoyment and self-concept of ability relations, it is possible that

anxiety toward math instigates mood-congruent judgments of one's math abilities (Bower, 1981; Clore & Storbeck, 2006; Schwarz, 2012; see also Bandura, 1997; Pekrun et al., 2007), and thus results in lowered self-concept of ability in math. Furthermore, it is also possible that adolescents with lower self-concept of ability in math are less likely than adolescents with a higher self-concept of ability to lift their negative feelings toward math (see also Heimpel, Wood, Marshall, & Brown, 2002), thus enabling them to verify their math self-concept of ability (Kwang & Swann, 2010; Swann & Buhrmester, 2012). Overall, the found negative reciprocal relations between math anxiety and self-concept of ability indicate a negative cycle. It is possible that lower self-concept of ability in math can heighten vigilance of threats and magnify the severity of threats, leading to an increase in math anxiety, which in turn may feed maladaptive coping behavior and cognitions related to math and further elaborating and maintaining a negative self-concept of ability in math (Bandura, 1997; see also Zeidner & Matthews, 2005). In sum, it seems that as suggested by self-verification theory (Swann & Buhrmester, 2012), adolescents with lower self-concept of ability in math may have a tendency to hang on to their unfavorable view of themselves, whereas adolescents with a higher self-concept of ability may have a tendency to restore their positive self-views.

Because theoretical assumptions and empirical findings concerning the relationship between self-concept and boredom have been inconsistent, no specific hypothesis was set concerning their relations. Our findings for the relationship between boredom and self-concept of ability in mathematics showed that lower self-concept of ability predicted higher boredom but boredom did not predict subsequent self-concept of ability. This result is in line with a previous study among university students showing that academic control (equivalent to self-concept of ability) was negatively related to subsequent course-related boredom (Pekrun et al., 2010). The found negative relationship between self-concept of ability and subsequent boredom in math is also similar to previous cross-sectional studies that have found boredom to be associated with low self-concept of ability (e.g., Goetz et al., 2010; Peixoto et al., 2017). If students with low self-concept of ability feel that they do not have the ability to cope with math tasks, they may start to devalue the subject and this perceived lack of control and low value then creates boredom (Pekrun, 2006). It is likely that students with low self-concept feel overchallenged (see also Krannich et al., 2019) and reporting boredom in overchallenging situations may act as a way to protect their self-worth, as students can thus avoid attributing the difficulty they have with the task to their ability (Acee et al., 2010; see also Covington, 1984). In contrast, although it has been suggested that gifted or high ability students can experience boredom in school because boredom may be triggered when ability level is high and task demands are low (Csikszentmihalyi et al., 2005) or when they feel underchallenged instead of overchallenged (Krannich et al., 2019; Preckel, Götz, & Frenzel, 2010; see also Daschmann et al., 2011), our results suggest that high self-concept of ability was related to low feelings of boredom. Consequently, it is possible that students with high self-concept of ability are generally satisfied with the level of challenge they face at school and they value the tasks they are given, and thus experienced less boredom. However, these explanations are speculative in nature since, to our knowledge, this study was the first that investigated cross-lagged relationships between boredom and self-concept of ability. Future studies are needed to examine more detailed dynamics between self-concept of ability, task demands and value when predicting boredom.

It is also notable that although math self-concept predicted subsequent boredom, boredom toward math, in turn, was not related to subsequent math self-concept of ability. One possible explanation for this result is that when they are bored, students distance themselves from the learning activities and from the chance to evaluate their abilities in action. Boredom has been associated with low motivation and effort and poor study strategies (Pekrun et al., 2010; see also Tze, Daniels, & Klassen, 2016). Disengagement from the tasks and the use of

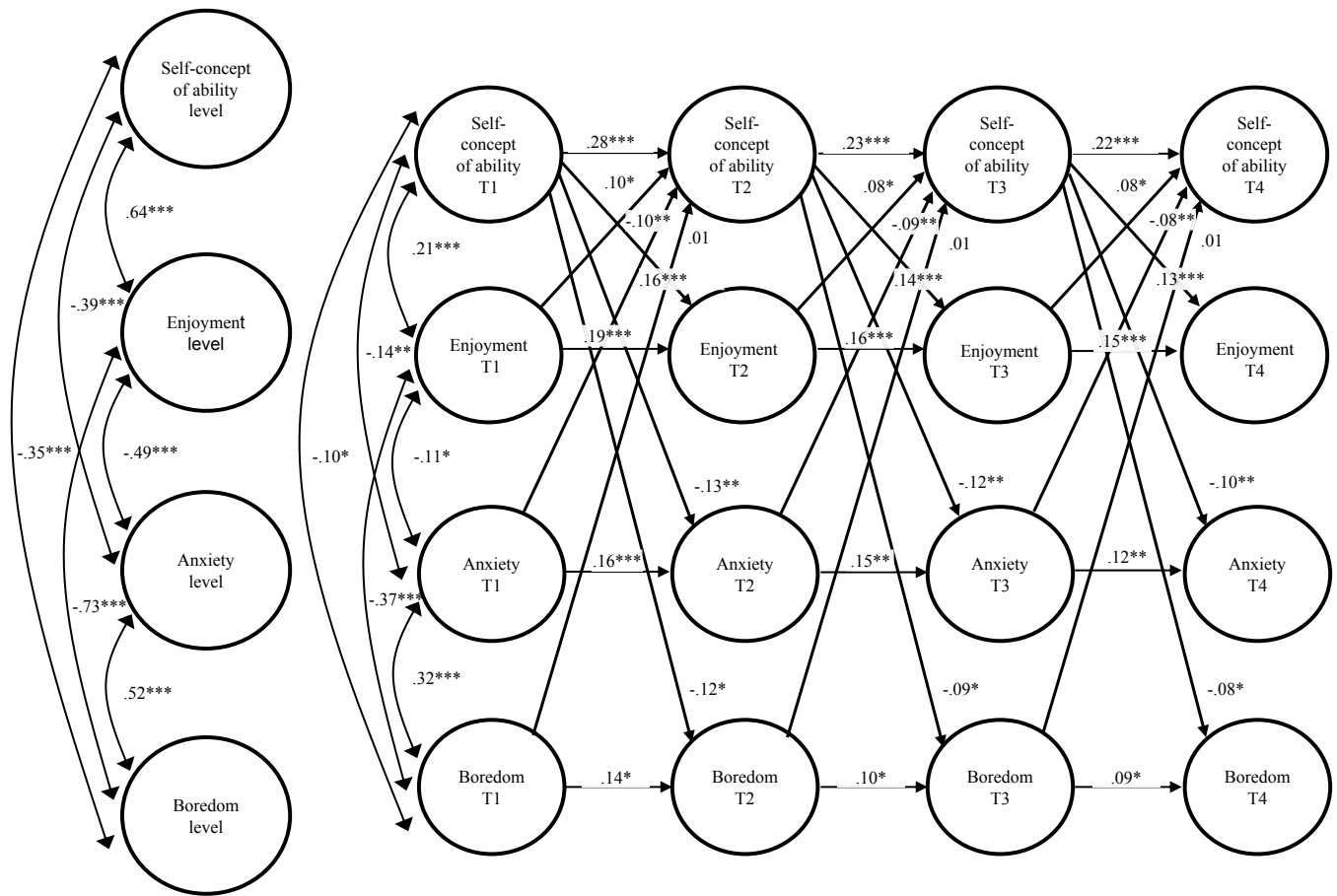


Fig. 2. Final random intercept cross-lagged panel model for mathematics. Standardized estimates are presented, ***p < .001, **p < .01, *p < .05.

ineffective strategies, on the other hand, do not provide students realistic information about the abilities they would need to build their self-concept of math ability.

4.2. Associations between self-concepts and achievement emotions in literacy

Our results regarding developmental dynamics between achievement emotions (enjoyment, anxiety and boredom) and self-concepts of ability in literacy domain did not support our hypotheses H1 and H2 or theoretical assumptions (Pekrun, 2006; Pekrun & Perry, 2014; see also Bandura, 1997; Zeidner, 1998). That is, in literacy (as opposed to mathematics), no predictions between self-concept of ability and achievement emotions were found. In general, our results revealing longitudinal associations in mathematics but not in literacy resemble some previous cross-sectional studies (Clem, Rudasill, Hirvonen, Aunola, & Kiuru, 2020; Goetz et al., 2010) that have shown that relations between self-concept of ability and emotions is stronger in quantitative fields such as mathematics compared to verbal domains, as well as with a recent longitudinal study that also found stronger relations between math self-concept of ability and math-related anxiety compared to language domains (Zhang, 2020).

Goetz et al. (2010) suggest that the stronger relationships in mathematics may be due to mathematics typically having a narrower range of classroom activities than in literacy, therefore having also limited sources for emotions and self-concepts construction. Another possible explanation for the divergent results in mathematics and literacy is that individual differences in maths increase across time (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004) and are wider than in reading (e.g., Lepänen, Niemi, Aunola, & Nurmi, 2004; Parrila, Aunola, Leskinen,

Nurmi, & Kirby, 2005). Therefore, there may be more room in maths (than in literacy) for influences of motivational factors. However, as far as we know the present study was the first to investigate the developmental dynamics between multiple achievement emotions and self-concept of ability in two domains using cross-lagged longitudinal procedure. Therefore future studies should examine in more depth the differences in multiple subject-domains to gain better understanding of the possible differences between different school subjects.

4.3. Strengths, limitations and future directions

Previous longitudinal cross-lagged studies of the relations between self-concept of ability and achievement emotions are rare and have mainly been concerned with single emotions in single achievement domains. The major strength of this study was that we were able to test the theoretical assumptions concerning the relations between self-concept of ability and achievement emotions in a cross-lagged longitudinal study in two important school subjects and three different achievement emotions, thus allowing us to broaden the knowledge of the reciprocal dynamics between self-concept of ability and emotions. More specifically, this study was able to broaden knowledge of developmental dynamics of self-concept of ability and achievement emotions by showing that at least in mathematics achievement emotions are material for self-concept construction, and that self-concept of ability plays a role in the development of enjoyment, anxiety and boredom toward math learning.

As in any research, there are some limitations in the study that need to be taken into account when interpreting the results. First, this study investigated the self-concepts of ability as well as enjoyment, anxiety, and boredom in literacy and mathematics of students in grades 6 and 7.

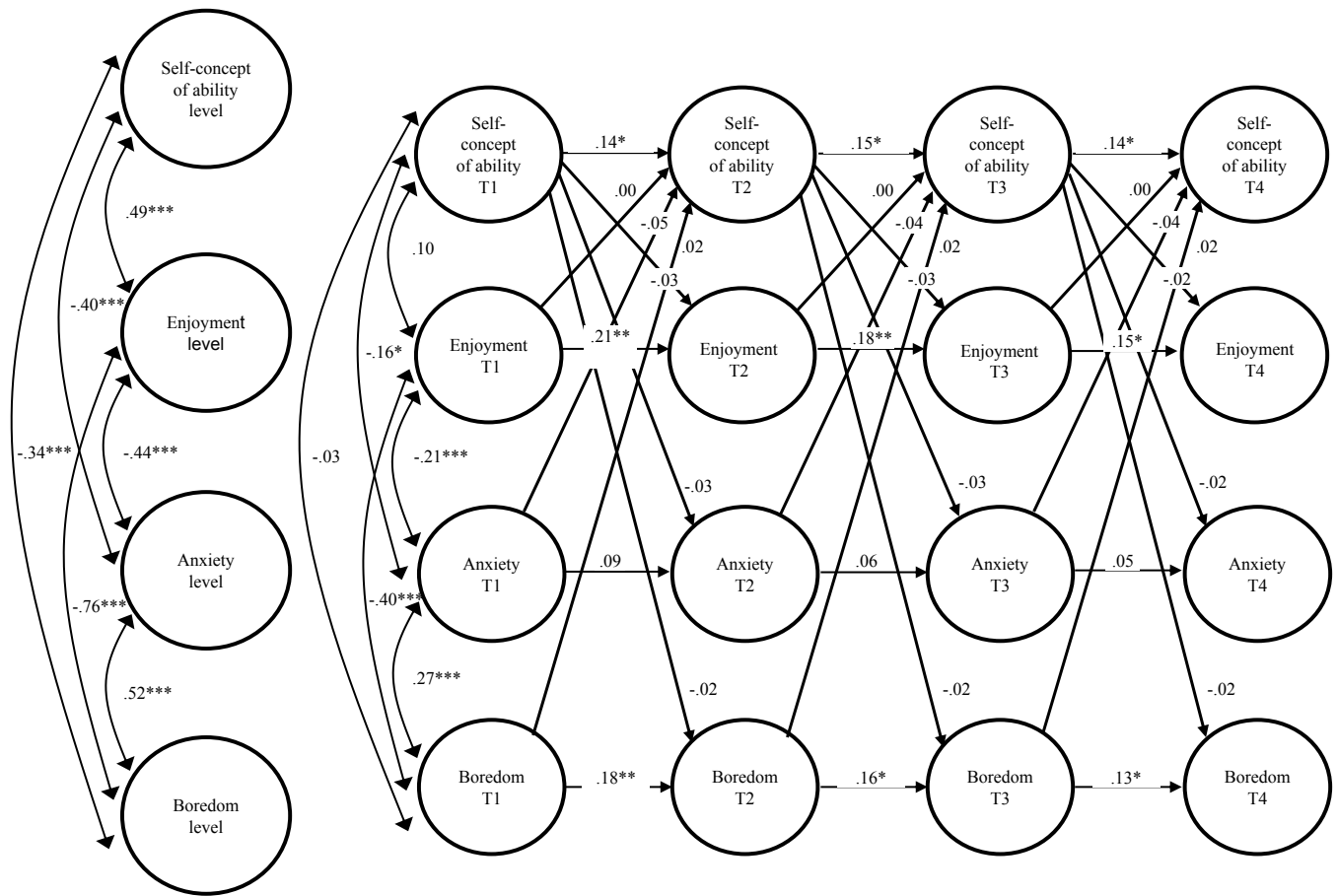


Fig. 3. Final random intercept cross-lagged panel model for literacy. Standardized estimates are presented, ***p < .001, **p < .01, *p < .05.

It is possible that the relations we found could be different in different age groups and in different subject domains (Goetz et al., 2010), and thus, one should be cautious about generalizing the results beyond the population used in this study. Second, although most of the reliabilities of the used scales were good or adequate, some were relatively low, which may partly result from the fact that the scales used to measure self-concepts and emotions were relatively short. Future studies should consider measuring adolescents' self-concepts and emotions more thoroughly with longer scales, although keeping in mind how to motivate adolescent participants to fill the questionnaires carefully. Third, it is notable that in this study the developmental associations between self-concepts of ability and emotions were investigated separately in mathematics and literacy domains. In future studies it would be important to also study spillover effects of self-concepts of ability and emotions between different achievement domains and relate these dynamics to adolescents' achievement. The internal/external frame of reference model of self-concept (I/E model; Marsh, 1986; Marsh et al., 2015) proposes that in addition to social comparisons in regards to achievement, self-concepts are also influenced by internal comparisons, where individuals compare their own relative achievement and abilities between different academic subjects. It would be an intriguing challenge for further research to include achievement emotions in different domains in the same model to investigating the assumptions of the I/E model. In the future, it would also be important to examine more distant antecedents (e.g., teacher-student relationship quality) of emotions and investigate the role of self-concept as a possible mediator between environmental factors and achievement emotions in longitudinal samples. Finally, it would be also important to examine how these dynamics between self-concepts of ability and achievement emotions are related to students' achievement, engagement in school and wellbeing over

time.

4.4. Conclusions and implications

The findings of the current study suggest that achievement emotions and self-concept of ability are developmentally related in a reciprocal manner at least in mathematics. Previous research has shown that low levels of self-concept of ability can impede learning (e.g., Valentine et al., 2004), while there is also evidence that enhancing skills and attribution re-training can promote self-concept of ability (e.g., O'Mara, Marsh, Craven, & Debus, 2006). The findings of the current study added to the literature by showing that math self-concept of ability could also be supported by increasing math enjoyment and reducing math anxiety. Maintenance of enjoyment is vital as a sustaining force in learning activities and has been shown to be positively related to achievement and motivation (for a review, see Pekrun, 2017). Math anxiety can, in turn, have long-term educational implications by leading to avoidance of math, thus affecting math skills negatively and decreasing enrollment in advanced math classes and further affecting future career paths (Ashcraft, 2002; Ashcraft & Ridley, 2005; Hembree, 1990). Furthermore, boredom can distract from learning activities, and thus have deteriorating effects on learning and motivation (for a review, see Pekrun, 2017). One way to reduce boredom and anxiety and increase enjoyment toward math as suggested by findings of this research is to boost self-concept of ability in math. Other ways to reduce boredom and anxiety have been suggested, such as methods for coping with boredom (e.g., Nett, Goetz, & Daniels, 2010), cognitive-behavioral treatment of anxiety (e.g., Hembree, 1990; see also Zeidner, 2014), and creating classrooms that can reduce math anxiety and boredom in school (e.g., Finlayson, 2014; Geist, 2010; Goetz & Hall, 2014). In sum, regarding the practical

implications of the current study, learning motivation and achievement in mathematics, in particular, could be enhanced by enhancing positive emotions, reducing negative emotions, and promoting self-concept of ability.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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