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**Doctoral thesis submitted to  
the Faculty of Behavioural and Cultural Studies  
Heidelberg University  
in partial fulfillment of the requirements of the degree of  
Doctor of Philosophy (Dr. phil.)  
in Psychology**

Title of the publication-based thesis

*One Step Closer to Preschool-aged Children's Self-Regulation:  
Conceptualization and Investigation of its Correlates during Everyday Life*

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year of submission  
2017

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## Acknowledgments

Writing this doctoral thesis has been a journey and has certainly challenged my self-regulation several times. At all times, there were fellow travelers by my side who replenished my resources and from whom I learned a great deal – without them, completing this thesis would not have been possible.

First, I would like to thank my supervisor, Dr. Wolfgang Rauch, whose guidance was most important to me. Wolfgang, you helped me when I once again missed the forest for the trees, and I deeply appreciate your consistent support.

I also would like to thank Prof. Dr. Sabina Pauen, who immediately agreed to review this thesis. Thank you also for inviting me to the familiar EDOS meetings, which helped me to think outside the box.

The completion of projects such as “BeR-Alltag” and “Kiga-BeR” was only possible as a team effort. My deepest thanks go to all our research assistants, whose highly committed work, flexibility, and positivity also made everything easier for me during challenging project phases. I would also like to thank all of the children, parents, and preschool teachers who participated in our research projects.

Special thanks go to my great colleagues Ruth and Lena, who have been there for me from the first day on. Thank you so much for providing professional and moral support – we made it as friends without making an “Eierkuchen”! Also, greatest thanks to Bianca, Lena, Ivan, and Sebastian. We ate ourselves through the Hauptstraße, and chatting and joking with you always made my day. I am also indebted to Sabine and Jan, who completed our “Pavilion circle” and who always had answers and were so supportive.

I also owe many thanks to my friends, who accompanied me not only on this journey but also throughout the years. Elisa, special thanks go to you, this paragraph is not large enough. Your friendship is invaluable, and we go together like summer and Schmelzpunkt! ☺

With all my heart, I also thank my family for encouraging me in all of my pursuits. I am especially grateful to my sister Lena, who is my twin, even more in my mind's eye, and who always understands me. Finally, I am deeply grateful to my husband Thomas, who always kept his sense of humor when I sometimes lost mine. Thank you for your love and ongoing support.

## List of Scientific Publications of the Publication-based Dissertation

This dissertation is based on the following publications, which are attached in the Appendices.

### **Appendix A - Publication 1**

**Ludwig, K.,** Haindl, A., Laufs, R., & Rauch, W. A. (2016). Self-regulation in preschool children's everyday life: Exploring day-to-day variability and the within- and between-person structure. *Journal of Self-Regulation and Regulation*, 2, 99-117. doi: 10.11588/josar.2016.2.34357

### **Appendix B - Publication 2**

**Ludwig, K., & Rauch, W. A.** (2017). *Associations between physical activity, positive affect, and self-regulation during preschoolers' everyday lives*. Manuscript submitted for publication.

### **Appendix C - Publication 3**

**Ludwig, K., & Rauch, W. A.** (2017). *Preschoolers' multi-faceted self-regulation: Relations to the home context and parenting behaviors*. Manuscript submitted for publication.

## 1 Introduction

The acquisition of self-regulation skills during early childhood is essential. Being able to listen to others without interrupting them, to not throw a tantrum when things do not work out as well as expected, or to inhibit distractions in the classroom as well as direct one's attention to the teacher – situations like these are part of children's everyday life, requiring adaptive regulation of one's own inner states such as thoughts, emotions, and behaviors to effectively respond to internal as well as environmental demands (Bridgett, Burt, Edwards, & Deater-Deckard, 2015; Nigg, 2017). However, successful self-regulation is not important only for proximal outcomes, such as school readiness or academic achievement, in childhood (Blair & Raver, 2015; Sawyer et al., 2015). Recent research indicates the predictive power of children's self-regulation skills for adaptive functioning over various contexts throughout their lifespan, such as socio-emotional relations in adolescence (e.g., Holmes, Kim-Spoon, & Deater-Deckard, 2016; Trentacosta & Shaw, 2009) and health and wealth in adulthood (Fergusson, Boden, & Horwood, 2013), and these effects remained unchanged even after controlling for socioeconomic status (SES) or general mental ability (IQ) (Fergusson et al., 2013). Understanding self-regulation and its correlates, particularly in young samples, is therefore essential to prevent negative developmental trajectories associated with self-regulatory deficits (e.g., Hardaway, Wilson, Shaw, & Dishion, 2012). Moreover, early childhood is a sensitive stage for the development of self-regulation, when controlling actions and following rules shift from being externally parent-initiated (i.e., co-regulation) to being self-initiated and internally monitored (Kopp, 1982; Pauen & The EDOS Group, 2016). Within the first three years of life, infants' awareness of social demands, their compliance with caregivers' requests and increasing impulse control emerge as early forms of self-regulation. During the preschool years, children are increasingly able to memorize rules and social standards as well as recall them, to inhibit predominant responses, and to shift their

own attention. That is, there are marked improvements in executive function (i.e., working memory, shifting, and response inhibition; Garon, Bryson, & Smith, 2008), providing the cognitive capacity that is needed for adaptive self-initiated regulatory performances (Barkley, 2001; Hofmann, Schmeichel, & Baddeley, 2012). Thus, the preschool-aged child is increasingly able to act in a goal-oriented and effective manner in the absence of external regulators and to be increasingly flexible and adaptive according to new situational demands. This developmental shift from early compliance and impulse control during infancy to self-control and self-regulation during the preschool years (Kopp, 1982) is empirically affirmed by longitudinal studies (e.g., Feng, Hooper, & Jia, 2017), and this shift implicates that influencing factors seem to be particularly effective during early childhood, either facilitating or limiting children's self-regulation development. Therefore, the empirical studies of this thesis focused on the investigation of self-regulation and its correlates in preschool-aged samples.

### **1.1 Definition of Self-Regulation in the Present Thesis**

In general, there is a lack of clarity and an ongoing debate in conceptualizing the construct of self-regulation (for a recent and elaborated discussion see Nigg, 2017). Over the past several decades, researchers from different fields within the psychological research landscape investigated diverse aspects of self-regulation over varying contexts. As a consequence, self-regulation has become an umbrella term for different aspects of adaptive and self-initiated processes (Nigg, 2017), including temperamental (cf. *effortful control*; Rothbart, 1989), neuropsychological (cf. *executive functions*; Barkley, 2001; Diamond, 2002), affective (cf. *emotion regulation*; Gross, 2014), and motivational (cf. *self-control*; Baumeister & Vohs, 2007) perspectives. Despite these multiple terminologies and conceptualizations, self-regulation refers in general to three processes: cognitive, behavioral, and emotional. *Cognitive self-regulation* refers to the self-initiated modulation of attentional processes to

enhance adaptation or to achieve a goal (Nigg, 2017). To self-direct one's attention and to remain focused is important both during everyday life and, especially, within the school context (e.g., Blair, Ursache, Greenberg, Vernon-Feagans, & The Family Life Project Investigators, 2015). Although executive functions are important in this respect, they should not be equated with cognitive self-regulation: Executive functions are cognitive capacities that enable self-regulation and other mental processes, while self-regulation performances are adaptive changes (modulations) of internal states (Nigg, 2017). For example, reading or solving a math problem requires executive functioning but is not self-regulation per se. Thus, executive functions can be understood as primary (higher-level) mechanisms of self-regulation processes (Blair & Ursache, 2011; Hofmann et al., 2012). *Behavioral self-regulation* refers to the modulation and control of behaviors or actions (e.g., motor, ocular, and vocal responses) that would not suit internal or environmental demands (Denham, Warren-Khot, Bassett, Wyatt, & Perna, 2012; Nigg, 2017). Examples in childhood include: adhering to rules (i.e., compliance in the absence of external regulators; Kopp, 1982), listening to others without interrupting them, and being able to wait one's turn (e.g., during playing games). Thus, behavioral self-regulation is assumed to be linked to social outcomes in particular, such as positive peer relations and socially appropriate behaviors (Eisenberg et al., 1997; Ramani, Brownell, & Campbell, 2010). *Emotional self-regulation* refers to the modulation, experience, and expression of emotions (Gross, 2014; Morris, Silk, Steinberg, Myers, & Robinson, 2007). For instance, children with higher emotional self-regulatory skills are not as easily frustrated when things do not work out as well as expected, thanks to the successful use of adaptive strategies such as self-distraction (Calkins & Howse, 2004; Cole, Dennis, Smith-Simon, & Cohen, 2009; Gross, 2014). From a functionalist perspective, the ability to regulate emotions is also important for building and maintaining social relationships



(cf. behavioral self-regulation) and for children's socioemotional adjustment (Calkins & Howse, 2004; Denham et al., 2003; Thompson, 1994).

According to the taxonomy of Bridgett and colleagues (2015), cognitive, behavioral, and emotional self-regulation belong to top-down self-regulation, in contrast to bottom-up self-regulation. *Top-down self-regulation* refers to deliberate processes (served by cortical structures), while *bottom-up self-regulation* describes automatic, reactive processes (served by subcortical structures). While top-down self-regulation includes the cognitive, emotional, and behavioral self-regulatory processes outlined above, bottom-up self-regulation includes constructs such as fear (behavioral overcontrol) and impulsivity (behavioral undercontrol; Bridgett et al., 2015). This thesis focuses on top-down self-regulation as a more volitional conceptualization of self-regulation that responds to mental representations (Bridgett et al., 2015; Nigg, 2017), which broadens the scope of opportunities to positively influence children's self-regulation skills.

Overall, self-regulation is a complex construct with different meanings according to the researcher's perspective. Therefore, it is important to provide a definition of how self-regulation is understood in this thesis. In accordance with most recent consensus, self-regulation is in the present thesis broadly defined as preschoolers' effective ability to control and modulate their own emotions, attention, and behaviors during their everyday lives (cf. Bridgett et al., 2015; Calkins & Howse, 2004; Nigg, 2017).

## **1.2 Overview and Inner Coherence of the Publications**

The present thesis focused on the investigation of preschoolers' self-regulation skills, complementing previous research in four ways. First, when self-regulation is understood as an adaptive skill as outlined above, daily fluctuations in self-regulation levels should be inherent, yet no study has empirically examined such intra-individual differences in self-regulation while controlling for inter-individual differences. Thus, it was firstly examined whether self-

regulation must not only be considered as a trait but also as a state, with daily variability in self-regulation levels during preschoolers' everyday life (Publication 1). Second, it is so far unclear whether cognitive, behavioral, and emotional self-regulation facets form a unidimensional self-regulation factor or whether those can be empirically separated from each other despite their interrelations. Therefore, in Publication 1, competing factor structures were tested against each other and which factor structure best represents preschoolers' self-regulation at the intra-individual (i.e., within-person) and inter-individual (i.e., between-person) level was investigated. Third, given intra-individual fluctuations in preschoolers' self-regulation levels (see Publication 1), this raises the question which variables can explain this daily variability. Therefore, in Publication 2, daily physical activity and positive affect were considered as two promising child-level factors that are presumed to be beneficial to preschoolers' daily cognitive, behavioral, and emotional self-regulation skills (Becker, McClelland, Loprinzi, & Trost, 2014; Davis & Suveg, 2014). Here, both direct and indirect relations were investigated at the intra-individual and inter-individual level. Finally, besides the characteristics of the child (e.g., physical activity, positive affect), the family is a key influencing factor on children's self-regulation development within this age group (Bridgett et al., 2015), and both contextual and interactional family factors should be taken into account (Bronfenbrenner & Morris, 2006). Therefore, Publication 3 focused on the relations of the home environment (i.e., contextual perspective) and diverse parenting behaviors (i.e., interactional perspective) to preschoolers' distinct behavioral, cognitive, and emotional self-regulation skills. Additionally, preschoolers' self-regulation was multi-informant-assessed to take into account the context dependency of their self-regulation levels. That is, parents observe children in different daily situations than preschool teachers do (e.g., interactions with other children in the preschool setting vs. playing alone or interacting with siblings or parents at home), and these divergent perspectives should be taken into account to obtain a

more complete picture of children's self-regulation skills (De Los Reyes, Thomas, Goodman, & Kunder, 2013). Throughout the three publications, the present thesis focused on preschoolers' typical (in contrast to maximal, as assessed under laboratory conditions; Toplak, West, & Stanovich, 2013) multi-faceted self-regulation skills. In addition, this thesis focused on correlates of preschoolers' self-regulation that, in particular, occur in or are part of preschoolers' everyday lives to increase the ecological validity of findings.

### **1.3 Empirical Framework Projects**

The present thesis was drawn up within the framework of two larger research projects, which investigated potential influences on preschool-aged children's self-regulation and physical activity at the child, family, and preschool (day care center) levels. The data collection of the first project, *BeR-Alltag* (original German title: *Bewegung und Selbst-Regulation im Kindergarten-Alltag*), took place between March 2015 and August 2015. This project focused on daily influencing factors on preschoolers' self-regulation and physical activity, which were consecutively assessed over the course of several days. The data collection of the subsequent project, *Kiga-BeR* (original German title: *Kindergarten, Bewegung, Selbst-Regulation*), took place between October 2016 and March 2017. In addition to the investigation of familial influences on preschoolers' multi-faceted self-regulation skills, this project particularly focused on the relations of inherent conditions of the preschools (e.g., daily routines, play equipment, outside area) to preschoolers' self-regulation and physical activity. The publications of the present thesis use data at the child and family levels, whereas preschool-level data were not included to avoid exceeding the limits of this thesis. Thus, Publications 1 and 2 draw on data from the BeR-Alltag project, while Publication 3 is based upon data from the Kiga-BeR project.

The following chapters of this thesis summarize theoretical considerations, previous research gaps, and the results of the three publications, which can be examined in more detail in the original manuscripts attached in the Appendices. Chapter 2 outlines Publication 1, which investigated daily fluctuations in preschoolers' cognitive, behavioral, and emotional self-regulation levels over the course of several days. It also outlines which factor structure best describes preschoolers' self-regulation at both the within-person (reflecting intra-individual differences) and between-person (reflecting inter-individual differences) levels. Next, Chapter 3 summarizes the results of Publication 2, which examined child-level correlates of preschoolers' multi-faceted self-regulation skills during their everyday lives. In Chapter 4, the findings of Publication 3 are outlined, which focused on family-level correlates of preschoolers' distinct and multi-informant-assessed self-regulation facets. Finally, Chapter 5 relates the findings of the publications to one another.

## 2 Daily Variability in Self-Regulation and Factor Structure (Publication 1)

Ludwig, K., Haindl, A., Laufs, R., & Rauch, W. A. (2016). Self-regulation in preschool children's everyday life: Exploring day-to-day variability and the within- and between-person structure. *Journal of Self-Regulation and Regulation*, 2, 99-117. doi: 10.11588/josar.2016.2.34357

Previous research has examined meaningful inter-individual differences (i.e., between-person effects) in self-regulation, demonstrating that children with higher self-regulation levels typically enjoy higher levels in various beneficial outcomes compared to children with lower self-regulation levels (McClelland, Geldhof, Cameron, & Wanless, 2015). However, research so far is lacking that considers intra-individual differences (i.e., within-person effects) in general within developmental psychology (van Geert & van Dijk, 2002) and, in particular, in preschool-aged children's self-regulation levels. In view of the definition of self-regulation as the adaptive modulation of inner states (Nigg, 2017), intra-individual variability in self-regulation on a daily basis or even within shorter time intervals remains strongly indicated. A couple of previous studies suggest intra-individual variability in related constructs and in older samples, such as day-to-day fluctuations in working memory performances (Dirk & Schmiedek, 2016) and self-regulation failures in adolescents (Berg et al., 2014; Schmid, Stadler, Dirk, Fiege, & Gawrilow, 2016). Identifying variability within children in their daily self-regulation levels would thus contribute to developmental research and also introduce a range of new research questions, aiming at examining everyday correlates of children's self-regulation. For instance, besides asking whether children with typically higher physical activity levels have higher self-regulation levels (inter-individual perspective), one can ask whether an increase in a child's daily physical activity level increases his or her self-regulation level (intra-individual perspective) (cf. Hamaker, 2012).

This distinction is important, since correlates (e.g., beneficial resources) of self-regulation that were identified at a between-person level might not apply to the within-person level (Wang & Maxwell, 2015). Identifying within-person resources for children's daily self-regulation that arise during their everyday lives also would facilitate the implementation of ecologically valid interventions and the child's compliance, enhancing the likelihood for a number of individuals to be on positive trajectories (Lerner, Agans, DeSouza, & Gasca 2013). Thus, investigating within-person variability in children's self-regulation is important for practical and methodological reasons.

Furthermore, there is a lack of consensus regarding the factor structure of self-regulation. Most researchers agree that self-regulation targets cognitive, behavioral, and emotional processes (Nigg, 2017). However, it is still unclear whether those facets are so strongly interrelated that they form a unidimensional self-regulation factor or whether they can be empirically separated from each other despite their interrelation. Thus, there exist competing structural models of preschoolers' self-regulation, including three-factor (e.g., Denham et al., 2012; Jahromi & Stifter, 2008), two-factor (e.g., Bridgett et al., 2015; Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011), and single-factor models (e.g., Allan & Lonigan, 2014; Raffaelli, Crockett, & Shen, 2005). Furthermore, there is as yet no study that has investigated the factor structure of preschool-aged children's self-regulation at a within-person level and whether the hypothesized factor structure differs between the within- and between-person levels. Understanding this conceptualization is, however, important for future research. A differentiated factor structure would implicate that self-regulation facets must be considered as distinct factors, with discriminant predictor variables and likely different underlying mechanisms. Moreover, differing factor structures at the within- and between-person levels would indicate that the construct of self-regulation demands different conceptualizations according to the data level or, respectively, the research question (e.g., the

two-factor structure of self-regulation in inter-individual research questions vs. the three-factor structure of self-regulation in daily/intra-individual research questions).

For these reasons, the purposes of this publication were 1) to investigate day-to-day fluctuations in preschoolers' self-regulation (i.e., conceptualizing self-regulation as a state while controlling for trait effects) and 2) to empirically test which factor structure best reflects preschoolers' typical self-regulation skills at both the within-person (representing intra-individual differences) and between-person (representing inter-individual differences) levels. Three nested models were tested against each other: a single-factor model of global self-regulation, a two-factor model (i.e., cognitive-behavioral vs. emotional self-regulation), and a three-factor model (i.e., cognitive vs. behavioral vs. emotional self-regulation). In total, the sample included 106 children ( $M_{\text{age}} = 4.83$  years) with their parents. The parents rated their child's daily self-regulation skills by questionnaire at the end of the day for seven consecutive days (i.e., diary assessment).

In short, the findings suggested substantive day-to-day variability in preschoolers' parent-reported self-regulation skills (see Fig. 1 for a visualization of one child's daily fluctuations in self-regulation levels), thus extending previous findings of intra-individual variability in similar constructs and in older samples (Berg et al., 2014, Schmid et al., 2016).

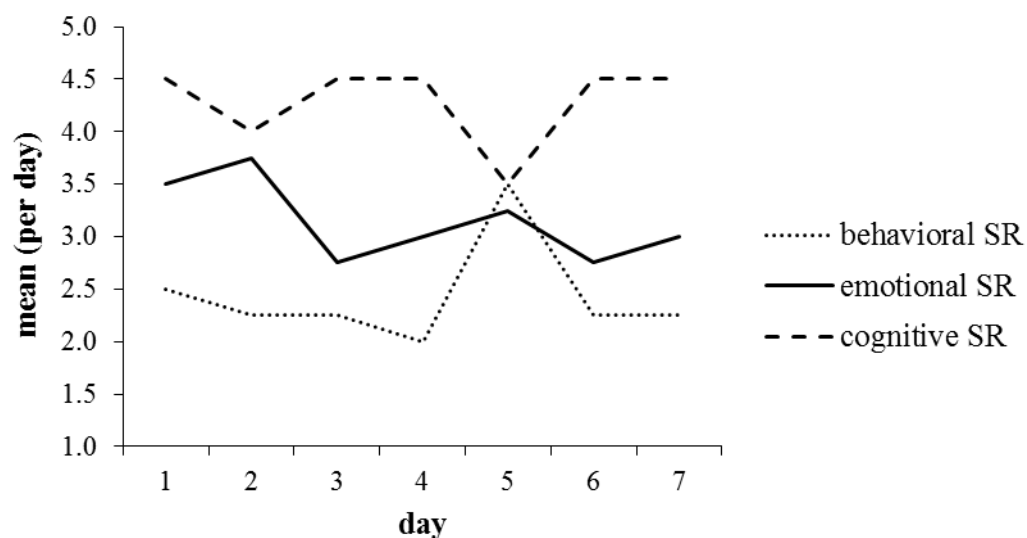


Figure 1. Example of one child's intra-individual variability in daily self-regulation (SR).

For comparison, similar magnitudes of within-person variability were recently shown in children's positive affect, which is a construct well known for its state component (Leonhardt, Könen, Dirk, & Schmiedek, 2016). Hence, by showing day-to-day fluctuations in preschoolers' self-regulation, Publication 1 underlines the dynamic nature of self-regulation. This finding indicates that, besides inter-individual differences (trait perspective), intra-individual differences (state perspective) in self-regulation should be considered in future research (cf. the discussion by van Geert & van Dijk, 2002). In doing so, possible within-person correlates of self-regulation should be included in future studies to test whether self-regulation resources, which so far have been identified at the between-person level (e.g., positive affect; Sirois, 2015), also hold true for the within-person level.

Regarding the factor structure of self-regulation, multilevel confirmatory factor analyses revealed the best fit for a model with three latent factors (i.e., emotional, cognitive, and behavioral self-regulation) at the within- and between-person levels. The present study's three-factor model corresponds to the findings of Daneri, Sulik, Raver, and Morris (2017) and those of Denham and colleagues (2012), who investigated the factor structure of preschool-aged children's self-regulation at a between-person level. Thus, although correlated, self-regulation facets should be considered as empirically distinct factors (i.e., emotional, cognitive, and behavioral self-regulation) that may be uniquely associated with individual predictor and outcome variables. For example, Jahromi and Stifter (2008) provided evidence that children's cognitive self-regulation predicted their understanding of false belief, whereas their behavioral and emotional self-regulation facets were unrelated. Additionally, the study by Eisenberg and colleagues (1997) suggests that while children's cognitive self-regulation seems to be important to their resiliency, their behavioral self-regulation seems to be particularly related to their socially appropriate behavior. Thus, future research should include different self-regulation facets to investigate possible divergent effects.



To conclude, the question that follows from the findings of Publication 1 is: Which variables may explain the within-person variance in children's multi-faceted (i.e., emotional, behavioral, and cognitive) self-regulation skills that occur in their everyday lives? This was the research focus of Publication 2.

### 3 Child-Level Correlates of Preschoolers' Self-Regulation (Publication 2)

Ludwig, K., & Rauch, W. A. (2017). *Associations between physical activity, positive affect, and self-regulation during preschoolers' everyday lives*. Manuscript submitted for publication.

Publication 2 focused on two child-level variables assumed to be beneficial to preschoolers' daily self-regulation during their everyday lives: physical activity and positive affect (Becker et al., 2014; Davis & Suveg, 2014). Specifically, this study investigated direct relations between preschoolers' day-to-day physical activity, positive affect, and self-regulation and also indirect relations between physical activity and self-regulation through positive affect at the inter-individual (i.e., between-subjects effects) and intra-individual (i.e., within-subjects effects) levels (see Fig. 2).

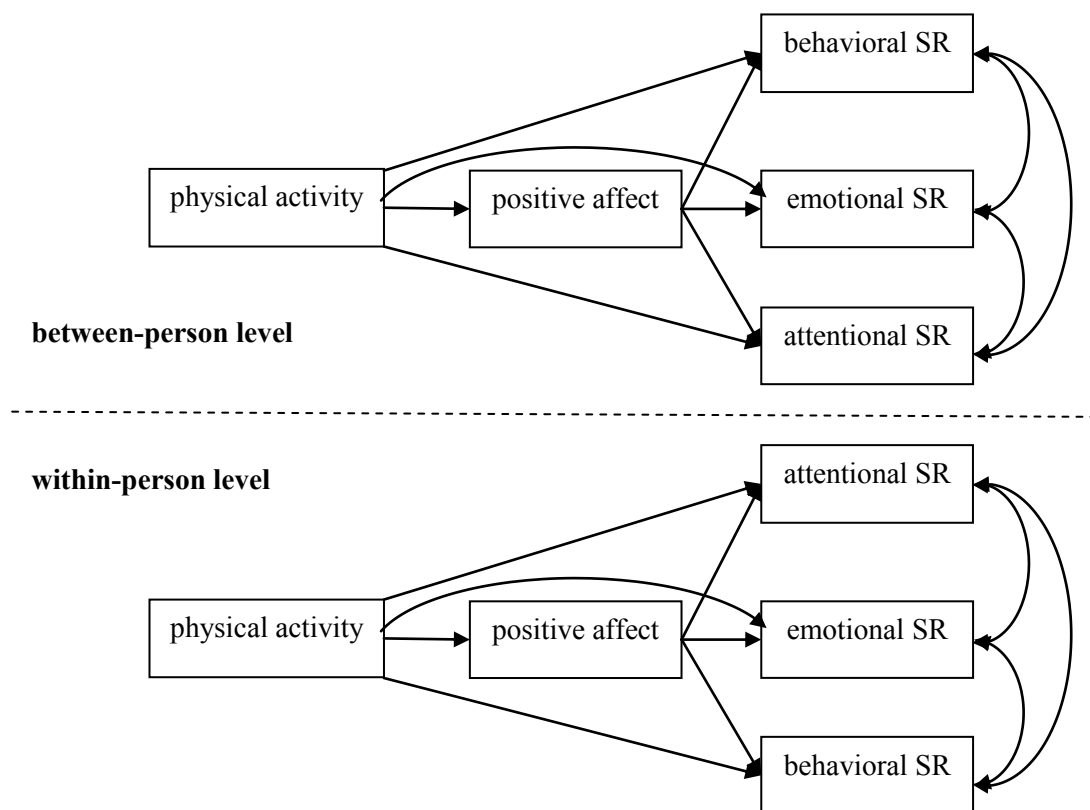


Figure 2. Theoretically assumed model depicting direct and indirect relations between physical activity, positive affect, and self-regulation (SR).

Direct positive effects of physical activity on subsequent positive affect are strongly indicated by prior studies with adult samples. Across several studies, findings have suggested that being more physically active than one's usual level is typically associated with higher subsequent positive affective states (i.e., within-subjects effects; Kanning, Ebner-Priemer, & Schlicht, 2013; Liao, Shonkoff, & Dunton, 2015), and, according to experimental studies, exercise seems to improve subjects' affective states compared to control groups (i.e., between-subjects effects; Arent, Landers, & Etnier, 2000; Ekkekakis, 2015). The underlying mechanisms that explain why physical activity benefits positive affect are still under research, but there is evidence for both physiological (e.g., enhanced aminergic synaptic brain transmission) and psychological (e.g., enhanced self-esteem and self-efficacy) pathways (Lubans et al., 2016; Paluska & Schwenk, 2000; Peluso & Guerra de Andrade, 2005).

Furthermore, direct beneficial effects of physical activity on children's self-regulation are expected, since prior experimental studies have shown improved executive functioning in children after physical exercise compared to non-exercising control children (Best, 2010). Neurobiological processes, such as enhanced monoamine transmission, which evokes better attention (Paluska & Schwenk, 2000), and enhanced brain activation (Davis et al., 2011), seem to explain these relations. Additionally, engaging together with peers in structured physical activity in a playful but cognitive demanding way (e.g., eye-hand coordination, start-stop games) seems to explain the beneficial effects of physical activity on children's executive functions from a psychosocial perspective (Best, 2010; Diamond, 2015). However, a large part of children's everyday physical activity occurs naturally and across various contexts (Ridgers, Stratton, & Fairclough, 2006) – focusing on the effects of physical activity in terms of structured interventions or exercise thus may limit ecological validity. Hence, the question remains whether *habitual* physical activity (i.e., ambulatory-assessed physical activity by accelerometer sensors during daily life; Kanning et al., 2013) is also beneficial to

children's self-regulation. So far, only three studies have investigated the relation between children's habitual physical activity and their self-regulation and only at a between-person level, yet with inconsistent results (Becker et al., 2014; El Nokali, 2012; Schmutz et al., 2017).

In addition to direct relations, indirect links between physical activity and self-regulation facets through positive affect are also expected (see Fig. 2). Again, via physiological processes (e.g., increases in dopamine; Ashby, Isen, & Turken, 1999) and psychological processes (e.g., broadening of the individual's thought-action repertoires; Fredrickson, 2001; positive affect as psychological resource; Davis & Suveg, 2014), positive affect is thought to facilitate successful self-regulation. However, no study has yet tested whether physical activity and self-regulation might be indirectly related through positive affect. Finding evidence for the beneficial effects of young children's physical activity on their positive affect and self-regulation would reveal a great resource within children: Physical activity is relatively easy to implement during their everyday lives, is accompanied by diverse additional health benefits (Ahn & Fedewa, 2011; Ekelund et al., 2012), and is also fun and motivating, fulfilling children's natural urge to be physically active. Therefore, Publication 2 investigated the direct and indirect relations between preschoolers' daily habitual physical activity, positive affect, and multi-faceted (i.e., cognitive, behavioral, and emotional) self-regulation skills.

For seven consecutive days, a total of 98 children aged four to six years wore an accelerometer to assess their moderate-to-vigorous physical activity (MVPA) during their everyday lives. During this week, parents rated their child's daily positive affect and cognitive, behavioral, and emotional self-regulation skills each evening. Direct and indirect relations were tested via multilevel structural equation modeling to distinguish within-person from between-person effects (Wang & Maxwell, 2015).

Results indicated that being more physically active than one's usual level on a given day was associated with higher positive affect on that day (within-person effect). This finding is in line with previous studies that also found beneficial intra-individual effects of physical activity on positive affect in the same order of magnitude in older samples (Dunton et al., 2014; Flueckiger, Lieb, Meyer, Witthauer, & Mata, 2017). Like the results of Dunton and colleagues (2014), this effect was found at the within-person but not the between-person level. Hence, habitual physical activity seems to constitute a natural, at least short-term, psychological resource during preschoolers' daily lives. Regarding preschoolers' self-regulation skills, there were no direct relations of MVPA to behavioral and cognitive (i.e., attentional) self-regulation at the within- and between-person levels; however, an unexpected but small negative association between MVPA and emotional self-regulation was found at the within-person level. On the one hand, the non-significant findings are in accordance with studies that also found no relations between children's accelerometer-assessed MVPA and their self-regulation skills (El Nokali, 2012; Schmutz et al., 2017) and executive functions (Aadland et al., 2017; Carson, Rahman, & Wiebe, 2017). On the other hand, direct positive relations between physical activity and self-regulation were expected, as previous studies have shown beneficial between-subjects effects of exercise on children's executive functioning (Best, 2010) and their cognitive and affective self-regulation facets (Laberge, Bush, Chagnon, 2012; Lakes & Hoyt, 2004). One possible explanation for the non-significant findings could be that the measurable beneficial effects of physical activity seem to depend on the type of physical activity. That is, positive effects seem to be primarily demonstrated immediately after playful but physically and cognitively demanding exercise together with peers (Best, 2010; Diamond, 2015) and not after habitual MVPA accumulated over the course of a day (cf. El Nokali, 2012; Schmutz et al., 2017). The negative effect of daily MVPA on daily emotional self-regulation ran contrary to our expectations and indicates the importance

of taking into account a second meaningful mediator (Zhao, Lynch, & Chen, 2010), such as subjective fatigue (Hagger, Wood, Stiff, & Chatzisarantis, 2010). This assumption should, however, be tested in future research. In addition, positive affect was positively related to all self-regulation facets at the within- and between-person level, with strongest relations to the emotional self-regulation facet at the within-person level and to attentional self-regulation at the between-person level. These latter findings are in line with Davis and Suveg's (2014) transactional model of child positive affect, which considers positive affect as psychological resource needed for self-regulation performances (see also Sirois, 2015). Furthermore, MVPA was indirectly related to all self-regulation facets through positive affect on a daily basis (i.e., within-person level): Engaging in more minutes of MVPA than usual on a given day fostered preschoolers' daily positive affect, which in turn was positively related to their daily behavioral, emotional, and attentional self-regulation facets. Thus, Publication 2 indicates that instead of direct relations between children's habitual physical activity and their self-regulation, the beneficial effects of physical activity on self-regulation rather seem to be effective through positive affect experiences, at least on a daily basis.

In sum, although the findings of the present study must be interpreted in light of certain limitations (e.g., preschoolers' daily positive affect and self-regulation were both assessed by parent reports), first evidence is provided for daily habitual physical activity and positive affect as two important resources of preschool-aged children during their everyday lives. In addition to child-level variables, the family is a key influencing factor on children's self-regulation development in this age group (Bridgett et al., 2015). Thus, Publication 3 focused on family-level correlates that are presumed to be associated with preschoolers' multi-faceted self-regulation skills.

#### 4 Family-Level Correlates of Preschoolers' Self-Regulation (Publication 3)

Ludwig, K., & Rauch, W. A. (2017). *Preschoolers' multi-faceted self-regulation: Relations to the home context and parenting behaviors*. Manuscript submitted for publication.

The purpose of Publication 3 was to examine family-level correlates of preschool-aged children's behavioral, emotional, and cognitive self-regulation skills. According to Bronfenbrenner's bioecological model, the characteristics of the immediate settings children inhabit and the interactions between children and their caregivers shape children's development and should therefore both be taken into account (Bronfenbrenner & Morris, 2006). Prior research suggests family's socioeconomic status (SES) and the amount of household chaos as two factors of the family context and diverse parenting behaviors as indicators of family interactions that are important for children's self-regulation skills (Bridgett et al., 2015). Self-determination theory (Deci & Ryan, 2008) offers an explanation of why the home context and parenting behaviors can be supportive to children's self-regulation development, namely, by providing a sense of autonomy, competence, and relatedness (Grolnick & Farkas, 2002). Highly chaotic homes, however, are family contexts that are noisy, hectic, and lacking in structures (Matheny, Wachs, Ludwig, & Phillips, 1995), thus undermining children's feelings of autonomy or competence and, consequently, their self-regulation development (Evans, 2006; Grolnick & Farkas, 2002). In contrast, family routines and meaningful rituals are shown to positively influence children's mental health (Spagnola & Fiese, 2007). Parenting behaviors that provide clear guidelines and expectations but that are also marked by warmth and responsiveness support children's internalization of rules and behaviors, thus enabling self-regulation development (Grolnick & Farkas, 2002; Kopp, 1982). So far, empirical evidence is mixed regarding the effects of diverse parenting behaviors on children's self-regulation. While inadequate parenting behaviors such as harsh

discipline consistently seem to have negative impacts (Karreman, van Tuijl, van Aken, & Deković, 2006), parental warmth was either positively related (e.g., Eisenberg et al., 2005) or unrelated (Karreman et al., 2006) to children's self-regulation facets. In regard to autonomy- and competence-promoting parenting behaviors, such as child-centered communication or consistent discipline, studies are rare and inconclusive (Lengua & Kovacs, 2005; Karreman et al., 2006; Moilanen, Rasmussen, and Padilla-Walker, 2014).

Overall, previous studies have focused on only one or two parenting aspects and single facets of children's self-regulation, resulting in inconsistent findings (e.g., Eiden, Colder, Edwards, & Leonard, 2009; Lengua, Honorado, & Bush, 2007). Since children's self-regulation should be considered as a multi-faceted construct with distinct emotional, cognitive, and behavioral facets (see Publication 1), it is so far unclear whether divergent findings can be explained by the possibility that different parenting behaviors are differently related to children's distinct emotional, behavioral, and cognitive self-regulation facets. Therefore, Publication 3 investigated the relations between household chaos, family SES, and diverse parenting behaviors (i.e., parental warmth, child-centered communication, harsh discipline, inconsistent discipline) in regard to preschoolers' multi-informant-assessed emotional, behavioral, and cognitive self-regulation facets. Highly chaotic homes and inadequate parenting behaviors (e.g., harsh discipline, inconsistent discipline) were expected to be negatively associated with children's self-regulation (Bridgett et al., 2015; Evans, 2006; Karreman et al., 2006), while adequate parenting behaviors (e.g., parental warmth and child-centered communication) were assumed to be positively related to children's self-regulation (Eisenberg et al., 2005). Specifically, the strongest associations were expected between household chaos and children's behavioral and cognitive self-regulation facets. Harsh discipline and parental warmth were expected to be most strongly related to emotional self-regulation, while child-centered communication and inconsistent discipline were expected to be



particularly related to behavioral and cognitive self-regulation facets. In addition, family SES was presumed to be particularly beneficial to children's cognitive self-regulation because of enhanced educational and financial resources (Raver, Blair, Willoughby, & The Family Life Project Key Investigators, 2013).

The final sample consisted of 176 parents and their children aged four to six years. The parents rated their child's self-regulation (i.e., emotional, behavioral, and cognitive facets) and their own parenting behaviors via questionnaires. Maternal educational background and monthly net income were assessed as two indicators of family SES. The preschool teachers were asked to complete the same questionnaire as the parents did regarding the children's self-regulation skills. Moreover, the children themselves performed two cognitive self-regulation tests with a trained member of our research group. These different perspectives on children's emotional, behavioral, and cognitive self-regulation skills and their relations to parenting, household chaos, and family SES were examined simultaneously in a structural equation model.

In short, the findings of the present study were that the amount of household chaos, the family's SES, and distinct parenting behaviors were differently related to preschoolers' distinct self-regulation skills, over and above each other's influences. Higher levels of household chaos were related to lower emotional and behavioral but not cognitive self-regulation levels, which is in accordance with findings that have linked home chaos to children's poor socioemotional functioning and behavioral inhibition (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005; Fiese, Foley, & Spagnola, 2006). The finding that household chaos was unrelated to children's cognitive self-regulation facet was unexpected, given prior evidence that chaotic home environments jeopardize children's cognitive functioning (Evans, 2006). However, these effects seem to apply particularly to noise exposures as one aspect of chaotic homes (Ackerman & Brown, 2010), while disorganization,

unpredictability, and crowding (cf. CHAOS scale; Matheny et al., 1995) seem to be rather indirectly related to children's cognitive resources through inadequate parent-child interactions (Valiente, Lemery-Chalfant, & Reiser, 2007). Hence, possible mediation effects of household chaos and parenting should be tested in further research, particularly regarding children's distinct self-regulation facets. In addition, family SES was, as expected, positively associated with preschoolers' cognitive self-regulation (see also Evans & Kim, 2013). In regard to parenting behaviors, a negative relationship between harsh discipline and preschoolers' cognitive and emotional self-regulation was found, supporting the assumption that punitive parents may act as negative role models regarding the regulation of emotional responses to conflicts or distress (Morris et al., 2007). Additionally, child-centered communication was positively related to preschoolers' cognitive and behavioral self-regulation. This last finding further supports the idea that opportunities to talk are especially important regarding children's self-regulation skills and can be facilitated by daily routines such as regular mealtimes (see also Martin, Razza, & Brooks-Gunn, 2012). Parental warmth and inconsistent discipline were, however, not related to any self-regulation facet after taking into account the influences of all independent family-level variables (cf. Lengua & Kovacs, 2005). Thus, by the simultaneous consideration of diverse parenting behaviors, Publication 3 indicates that parenting is indeed important to children's self-regulation, over and above the impacts of family SES and household chaos, but it seems to depend on the discrete parenting dimension and self-regulation facet (cf. Lengua et al., 2007).

Overall, the present study underlines the importance of parenting and characteristics of the home context for children's distinct self-regulation facets. Fostering adequate parenting behaviors, especially high levels of child-centered communication and low levels of harsh discipline, thus seems to be promising to prevent negative trajectories. Additionally, adverse

effects of household chaos may be compensated by the implementation of routines in children's everyday lives (Martin et al., 2012; Spagnola & Fiese, 2007).

## 5 General Discussion

The main purpose of this publication-based thesis was to investigate self-regulation in the everyday life of healthy preschool-aged children. Publication 1 focused on the conceptualization of self-regulation in the everyday life of preschoolers; this study was the first that investigated day-to-day fluctuations in preschoolers' self-regulation skills and its factor structure at the within- and between-person levels. Publication 2 aimed at explaining daily variability in preschoolers' self-regulation and investigated two child-level variables presumed to be beneficial to their self-regulation levels during their everyday lives: habitual physical activity and positive affect (Becker et al., 2014; Sirois, 2015). Publication 3 focused on the family context and parenting behaviors as further variables that are part of preschoolers' everyday lives and are presumed to have a strong impact on their self-regulation development (Bridgett et al., 2015; Grolnick & Farkas, 2002). Using diverse informants, methods, and study designs in samples that are comparatively rarely studied but essential (i.e., preschool-aged samples), the present thesis makes a major contribution to the rising field of self-regulation research.

### 5.1 Summary of Main Findings

The main findings of this thesis were as follows: Preschoolers' self-regulation skills showed substantial day-to-day variability (Publication 1), indicating that besides inter-individual (trait) differences in self-regulation, intra-individual (state) differences (i.e., within persons, from day to day) must also be considered. Publication 1 also provides evidence that self-regulation should be considered as a multi-faceted construct with distinct emotional, behavioral, and cognitive self-regulation facets, and this was found at the intra-individual (within-person) and inter-individual (between-person) levels. Furthermore, the findings of Publication 2 indicate that positive affect and physical activity seem to be two beneficial

variables associated with preschoolers' distinct self-regulation skills on a daily basis; engaging in more minutes of moderate-to-vigorous physical activity than usual on a given day fostered preschoolers' positive affect, which in turn was positively related to their daily behavioral, emotional, and cognitive self-regulation facets, with the strongest relations to emotional self-regulation. Thus, physical activity and positive affect are suggested as important resources of preschool-aged children that are important for their adjustment during everyday life. Finally, a family context that offers structure and predictability (as indicated by low levels of household chaos) and also fulfills needs for relatedness, competence, and autonomy (as indicated by low levels of harsh discipline, as well as parenting behaviors such as child-centered communication) seems to be mostly important to preschoolers' successful emotional, behavioral, and cognitive self-regulation in their everyday life (Publication 3).

## **5.2 Methodological and Practical Implications**

The present thesis has several methodological and practical implications. There are three main implications from a methodological perspective. First, day-to-day fluctuations (Publication 1) call into question one-time assessments of self-regulation, as these might represent one of the extreme points (i.e., best or worst performance) rather than typical performance (Toplak et al., 2013). Also, future studies should carefully consider whether the investigated effect is hypothesized at the between-person and/or within-person level, as associations can be considerably different between these two levels (Wang & Maxwell, 2015). For instance, in this thesis, habitual physical activity was positively related to positive affect intra-individually (i.e., at the within-person level) but not inter-individually (i.e., at the between-person level) (Publication 2). Thus, not distinguishing within- from between-person effects of variables that hypothetically could vary within and between persons (e.g., emotional states, daily stressors, working memory performances, and cortisol level) could lead to incorrect conclusions. Second, understanding preschoolers' self-regulation as a construct with

three correlated but empirically distinct facets (i.e., emotional, behavioral, and cognitive self-regulation) implicates that future studies should include more differentiated measures of children's self-regulation. Publications 2 and 3 support this finding of Publication 1. For instance, daily positive affect was most strongly related to preschoolers' daily cognitive (i.e., attentional) self-regulation facet (Publication 2), indicating that positive affect experiences broaden their momentary thought-action repertoires (Fredrickson, 2001). Furthermore, Publication 3 showed different relations of different family-level variables regarding preschoolers' self-regulation facets: For example, while family SES was specifically related to preschoolers' cognitive self-regulation, household chaos was related to their emotional and behavioral facets. Thus, further research is needed investigating the discriminant validity of children's multi-faceted self-regulation skills, with likely different underlying mechanisms. Third, future studies should also include multiple informants to assess preschoolers' self-regulation skills (Toplak et al., 2013). For instance, parents' and preschool teachers' reports of children's self-regulation were only moderately correlated (see Appendix C), indicating that in addition to shared perspectives, there are unique observations that should be taken into account to obtain a more complete picture of children's self-regulation skills.

There are also several implications from a practical perspective. First, showing that self-regulation is a construct with state besides trait differences (Publication 1) implicates that what makes a good day (i.e., successful self-regulation) can be quite different from what makes a self-regulated person (cf. Neubauer & Voss, 2016). For example, habitual physical activity was beneficial to preschoolers' self-regulation through positive affect on a daily basis (within-person level), but being a more (habitually) physically active person compared to other persons does not seem to be a resource for their trait self-regulation (between-person level), which seems to be more associated with other variables, such as the home context (Publication 3). Moreover, getting one step closer to children's self-regulation skills and

investigating their self-regulation levels during their everyday lives introduces a broad range of new research questions, such as which contexts in preschoolers' everyday life are most associated with their self-regulation levels (e.g., structured days vs. chaotic days), which preceding mechanisms underlie self-regulation performances (e.g., working memory fluctuations; Dirk & Schmiedek, 2016), as well as the bidirectionality of findings by investigating lagged and dynamic effects (e.g., do parenting behaviors on the previous day predict children's self-regulation the following day, which in turn predicts parenting behaviors on the subsequent day?). Furthermore, understanding physical activity and positive affect as two promising daily factors, which might indirectly or directly improve children's self-regulation skills in the short run (Publication 2), offers new interventions that can be implemented during their everyday lives. Given the importance of self-regulation for academic achievement (e.g., Sawyer et al., 2015), it is promising that short physical exercises or pedagogical practices, such as positive feedback loops<sup>1</sup> that improve positive affective states, might enhance children's self-regulation skills in the short run; this would likely be particularly beneficial before exams, when self-regulation resources are needed. Of course, future research should first replicate the findings of Publication 2 and do so also in samples with school-aged children. With growing evidence, a resource model of children's self-regulation could be established, with physical activity and positive affect as two components that can comparatively easily be improved during children's everyday lives. Such a model could be further tested using experimental study designs with four groups: one group being physically active, one group with induced positive affect (e.g., by receiving a surprise gift;

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<sup>1</sup> This practice is in German called "Warme Dusche" [hot shower] and is a popular interactional exercise to improve classroom climate: the peers (classmates) write down a number of positive characteristics of a child/classmate, which will then be read to this child to improve his or her well-being (cf. Bleicher & Rapp, 2011).

Tice, Baumeister, Shmueli, & Muraven, 2007), one group with both physical activity and positive affect manipulations, and one waiting-list control group. The participants should perform self-regulation tests before and also after the manipulations. According to the results of this doctoral thesis, the hypotheses would include that all three manipulation groups would show improved self-regulation compared to the control group, with best performances for the combined group (enhanced physical activity and positive affect). Finally, in light of Bronfenbrenner's bioecological model (Bronfenbrenner & Morris, 2006), Publication 3 emphasizes the importance of both the home context and parenting behaviors for children's self-regulation facets. Specifically, fostering adequate parenting behaviors (i.e., particularly high levels of child-centered communication and low levels of harsh discipline) and implementing structure and routines (i.e., reducing household chaos) seem to be most promising, according to Publication 3. From a practical perspective, these findings underline the importance of socio-pedagogical family assistants (e.g., social workers) who perform capacity building, specifically in poor families, within their home context by structuring daily routines and providing educational support (among other tasks).

### **5.3 Limitations and Future Perspectives**

Despite several strengths, the empirical studies of the present thesis also have limitations that offer starting points for future research. A main limitation is the cross-sectional nature of the findings, implicating that reverse effects are also possible (e.g., Hofer, Busch, & Kärtner, 2011; Lengua, 2006; Liao et al., 2015; Michie, Abraham, Whittington, McAteer, & Gupta, 2009), which need to be investigated in future longitudinal studies. Additionally, longitudinal study designs would provide the opportunity to investigate intra-individual differences during the course of development (cf. Lerner et al., 2013; van Geert & van Dijk, 2002), examining questions such as: When and at which time points in children's development are intra-individual variabilities strongest? To what extent are there inter-



individual differences in intra-individual variability and why? Furthermore, Publication 2 indicated the beneficial effects of preschoolers' habitual (moderate-to-vigorous intense) physical activity on their positive affect, but there is also evidence for the impairing effects of physical activity (Peluso & Guerra de Andrade, 2005). As reviewed by Peluso and Guerra de Andrade (2005), physical activity can also have detrimental effects on mood and mental health, especially when inappropriately performed in a very intense way (e.g., excessive exercise, overtraining syndrome). This indicates the possibility of a non-linear relationship, such as an inverse U-curved relation, between physical activity and self-regulation and positive affect. Thus, future research should investigate possible non-linear relationships between children's physical activity and their adjustment (e.g., positive affect, self-regulation) as a function of intensity. Additionally, future studies may also include bottom-up self-regulation (e.g., reactivity, impulsivity) in addition to measures of top-down self-regulation (cf. Publication 2), in particular when examining the beneficial effects of physical activity, as research in adults indicates that physical activity seems to benefit not only cortical (top-down) but also subcortical (bottom-up) areas (Erickson, Leckie, & Weinstein, 2014; Luft et al., 2008). Moreover, the samples were self-selected, with a medium-to-high socioeconomic background. Findings should be replicated with more heterogeneous samples that might enhance individual variation and would improve the generalizability of findings.

Nevertheless, it must be noted that the effects of socioeconomic status were obvious despite limitations in variance (see Publication 3), and the findings of the present thesis's studies, which were observed in German samples, complement previous research that mostly consisted of studies with U.S. samples (e.g., Denham et al., 2012; Eiden et al., 2009; Lengua et al., 2007). Furthermore, since there was a lack of self-regulation measures on a daily basis, a parent-reported diary of children's diverse self-regulation facets was developed within our research group. Publication 1 and 2 indicate good psychometric properties (see Appendices A

and B), but future studies should further validate this measure<sup>2</sup>. In addition to daily fluctuations, future research should examine variability within shorter time intervals, that is, from occasion to occasion (e.g., morning, noon, and afternoon), as such fluctuations were recently shown by Dirk and Schmiedek (2016) regarding children's working memory performances. Moreover, according to Bronfenbrenner's model (Bronfenbrenner & Morris, 2006), another important microsystem of preschool-aged children is the preschool (or day care center). However, the investigation between preschool-level variables and preschoolers' self-regulation was not included in the present thesis's studies. Thus, a future research aim could be the investigation of the preschools' settings, which are important to children's self-regulation development (e.g., teacher autonomy support, routines and rituals, opportunities for pretend play; Carlson, White, & Davis-Unger, 2014; Joussemet, Landry, & Koestner, 2008; Spagnola & Fiese, 2007). Furthermore, Publication 3 draws on self-determination theory (Deci & Ryan, 2008) to explain the relations between parenting and children's self-regulation. However, the concrete mechanisms were not explicitly tested; thus, future research should include direct measures of children's need fulfilment. So far, self-report questionnaires assessing need fulfilment exist for adults or third-graders as the earliest age (e.g., Joussemet et al., 2008; Neubauer & Voss, 2016). Hence, in studies with preschool-aged children, observational methods could be the method of choice (for a short overview, see Joussemet et al., 2008). In doing so, it would be further enlightening whether there are divergent relations among need fulfilment of competence, autonomy, and relatedness and preschoolers' distinct emotional, behavioral, and cognitive self-regulation facets.

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<sup>2</sup> In addition to that, a reviewer raised the question whether the emotional self-regulation measure is conceptually different from the positive affect measure. This assumption was empirically tested via confirmatory factor analyses. Results indicated strong evidence for two correlated ( $r_{L1} = .50$ ;  $r_{L2} = .31$ ) but empirically distinct factors.

## 6 Conclusion

The ability to self-regulate one's own attention, behavior, and emotions is essential for healthy trajectories. The present thesis complements previous research by providing first evidence that preschoolers' self-regulation should be considered as a multi-faceted construct, with intra-individual variability (i.e., daily fluctuations) in addition to inter-individual differences and divergent relations. There is first evidence that daily variability in preschoolers' successful self-regulation seems to be directly explained by their daily positive affective states and indirectly by habitual physical activity through positive affect, indicating that these child-level variables may constitute promising psychological resources for children's successful self-regulation, occurring in their everyday life. In addition, different parenting behaviors and facets of the home context seem to be differently related according to preschoolers' self-regulation facet. By investigating preschoolers' multi-faceted self-regulation skills and their correlates during their everyday lives, the present thesis gets one step closer and contributes to the mosaic of the rising field of self-regulation research.

## References

- Aadland, K. N., Moe, V. F., Aadland, E., Anderssen, S. A., Resaland, G. K., & Ommundsen, Y. (2017). Relationships between physical activity, sedentary time, aerobic fitness, motor skills and executive function and academic performance in children. *Mental Health and Physical Activity, 12*, 10-18. doi: 10.1016/j.mhpa.2017.01.001
- Ackerman, B. P., & Brown, E. D. (2010). Physical and psychosocial turmoil in the home and cognitive development. In G. W. Evans & T. D. Wachs (Eds.), *Chaos and its influence on children's development: An ecological perspective* (pp. 35-47). Washington: American Psychological Association.
- Ahn, S., & Fedewa, A. L. (2011). A meta-analysis of the relationship between children's physical activity and mental health. *Journal of Pediatric Psychology, 36*, 385-397. doi: 10.1093/jpepsy/jsq107
- Allan, N. P., & Lonigan, C. J. (2014). Exploring dimensionality of effortful control using hot and cool tasks in a sample of preschool children. *Journal of Experimental Child Psychology, 122*, 33-47. doi: 10.1016/j.jecp.2013.11.013
- Arent, S. M., Landers, D. M., & Etnier, J. L. (2000). The effects of exercise on mood in older adults: A meta-analytic review. *Journal of Aging and Physical Activity, 8*, 407-430. doi: 10.1123/japa.8.4.407
- Ashby, F. G., Isen, A. M., & Turken, U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106*, 529-550.
- Barkley, R. A. (2001). The executive functions and self-regulation: An evolutionary neuropsychological perspective. *Neuropsychology Review, 11*, 1-29.
- Baumeister, R. F., & Vohs, K. D. (2007). Self-regulation, ego-depletion, and motivation. *Social and Personality Psychology Compass, 1*, 115-128. doi: 10.1111/j.1751-9004.2007.00001.x

- Becker, D. R., McClelland, M. M., Loprinzi, P., & Trost, S. G. (2014). Physical activity, self-regulation, and early academic achievement in preschool children. *Early Education & Development, 25*, 56-70. doi: 10.1080/10409289.2013.780505
- Berg, C. A., Wiebe, D. J., Suchy, Y., Hughes, A. E., Anderson, J. H., Godbey, E. I., ... King, P. S. (2014). Individual differences and day-to-day fluctuations in perceived self-regulation associated with daily adherence in late adolescents with type 1 diabetes. *Journal of Pediatric Psychology, 39*, 1038-1048. doi: 10.1093/jpepsy/jsu051
- Best, J. R. (2010). Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise. *Developmental Review, 30*, 331-351.
- Blair, C., & Raver, C. C. (2015). School readiness and self-regulation: a developmental psychobiological approach. *Annual Review of Psychology, 66*, 711-731. doi: 10.1146/annurev-psych-010814-015221
- Blair, C., & Ursache, A. (2011). A bidirectional model of executive functions and self-regulation. In K. D. Vohs & R. F. Baumeister (Eds), *Handbook of self-regulation: Research, theory, and applications* (2nd ed., pp. 300-320). New York, NY: The Guilford Press.
- Blair, C., Ursache, A., Greenberg, M., Vernon-Feagans, L., & The Family Life Project Investigators (2015). Multiple aspects of self-regulation uniquely predict mathematics but not letter-word knowledge in the early elementary grades. *Developmental Psychology, 51*, 459-472. doi: 10.1037/a0038813
- Bleicher, M., & Rapp, A. (2011). *Trainingsprogramm zum sozial-emotionalen Lernen für Klasse 5+6 (SEL 5+6)* [Training program for social-emotional learning for classes 5+6 (SEL 5+6)]. Tübingen: Regierungspräsidium.

- Bridgett, D. J., Burt, N. M., Edwards, E. S., & Deater-Deckard, K. (2015). Intergenerational transmission of self-regulation: A multidisciplinary review and integrative conceptual framework. *Psychological Bulletin, 141*, 602-654. doi: 10.1037/a0038662
- Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology, volume 1: theoretical models of human development* (pp. 793-828). New Jersey: John Wiley & Sons.
- Calkins, S. D., & Howse, R. B. (2004). Individual differences in self-regulation: Implications for childhood adjustment. In P. Philippot & R. S. Feldman (Eds.), *The regulation of emotion* (pp. 307-332). New Jersey: Lawrence Erlbaum Associates.
- Carlson, S. M., White, R. E., & Davis-Unger, A. C. (2014). Evidence for a relation between executive function and pretense representation in preschool children. *Cognitive Development, 29*, 1-16. doi: 10.1016/j.cogdev.2013.09.001
- Carson, V., Rahman, A. A., & Wiebe, S. A. (2017). Associations of subjectively and objectively measured sedentary behavior and physical activity with cognitive development in the early years. *Mental Health and Physical Activity, 13*, 1-8. doi: 10.1016/j.mhpa.2017.05.003
- Cole, P. M., Dennis, T. A., Smith-Simon, K. E., & Cohen, L. H. (2009). Preschoolers' emotion regulation strategy understanding: Relations with emotion socialization and child self-regulation. *Social Development, 18*, 324-352. doi: 10.1111/j.1467-9507.2008.00503.x
- Daneri, M. P., Sulik, M. J., Raver, C. C., & Morris, P. A. (2017). Observers' reports of self-regulation: Measurement invariance across sex, low-income status, and race/ethnicity. *Journal of Applied Developmental Psychology*. Advance online publication. doi: 10.1016/j.appdev.2017.02.001

- Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N., ... Naglieri, J. A. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized controlled trial. *Health Psychology, 30*, 91-98. doi: 10.1037/a0021766
- Davis, M., & Suveg, C. (2014). Focusing on the positive: A review of the role of child positive affect in developmental psychopathology. *Clinical Child and Family Psychology Review, 17*, 97-124. doi: 10.1007/s10567-013-0162-y
- De Los Reyes, A., Thomas, S. A., Goodman, K. L., & Kunder, S. M. A. (2013). Principles underlying the use of multiple informants' reports. *Annual Review of Clinical Psychology, 9*, 123-149. doi: 10.1146/annurev-clinpsy-050212-185617
- Deci, E. L., & Ryan, R. M. (2008). Facilitating optimal motivation and psychological well-being across life's domains. *Canadian Psychology, 49*, 14-23. doi: 10.1037/0708-5591.49.1.14
- Denham, S. A., Blair, K. A., DeMulder, E., Levitas, J., Sawyer, K., Auerbach-Major, S., & Queenan, P. (2003). Preschool emotional competence: Pathway to social competence? *Child Development, 74*, 238-256. doi: 10.1111/1467-8624.00533
- Denham, S. A., Warren-Khot, H. K., Bassett, H. H., Wyatt, T., & Perna, A. (2012). Factor structure of self-regulation in preschoolers: testing models of a field-based assessment for predicting early school readiness. *Journal of Experimental Child Psychology, 111*, 386-404. doi: 10.1016/j.jecp.2011.10.002
- Diamond, A. (2002). Normal development of prefrontal cortex from birth to young adulthood: Cognitive functions, anatomy, and biochemistry. In D. Stuss & R. Knight (Eds.), *Principles of frontal lobe function* (pp. 466-503). NY: Oxford University Press.

- Diamond, A. (2015). Effects of physical exercise on executive functioning: Going beyond simply moving to moving with thought. *Annals of Sports Medicine and Research*, 2(1), 1011.
- Dirk, J., & Schmiedek, F. (2016). Fluctuations in elementary school children's working memory performance in the school context. *Journal of Educational Psychology*, 108, 722–739. doi: 10.1037/edu0000076
- Dunton, G. F., Huh, J., Leventhal, A. M., Riggs, N., Hedeker, D., Spruijt-Metz, D., & Pentz, M. A. (2014). Momentary assessment of affect, physical feeling states, and physical activity in children. *Health Psychology*, 33, 255-263. doi: 10.1037/a0032640
- Eiden, R. D., Colder, C., Edwards, E. P., & Leonard, K. E. (2009). A longitudinal study of social competence among children of alcoholic and nonalcoholic parents: Role of paternal psychopathology, parental warmth, and self-regulation. *Psychology of Addictive Behaviors*, 23, 36-46. doi: 10.1037/a0014839
- Eisenberg, N., Guthrie, I. K., Fabes, R. A., Reiser, M., Murphy, B., Holgren, R., ... Losoya, S. (1997). The relations of regulation and emotionality to resiliency and competent social functioning in elementary school children. *Child Development*, 68, 295-311. doi: 10.1111/j.1467-8624.1997.tb01941.x
- Eisenberg, N., Zhou, Q., Spinrad, T. L., Valiente, C., Fabes, R. A., & Liew, J. (2005). Relations among positive parenting, children's effortful control, and externalizing problems: A three-wave longitudinal study. *Child Development*, 76, 1055-1071. doi: 10.1111/j.1467-8624.2005.00897.x
- Ekelund, U., Luan, J., Sherar, L. B., Esliger, D. W., Griew, P., & Cooper, A. (2012). Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *The Journal of the American Medical Association*, 307, 704-712. doi: 10.1001/jama.2012.156



- Ekkekakis, P. (2015). Honey, I shrunk the pooled SMD! Guide to critical appraisal of systematic reviews and meta-analyses using the Cochrane review on exercise for depression as example. *Mental Health and Physical Activity*, 8, 21-36.  
10.1016/j.mhpa.2014.12.001
- El Nokali, N. E. (2012). *The intersection of physical activity, self-regulation and academic achievement: Implications for educational success* (Doctoral dissertation). Retrieved from <http://d-scholarship.pitt.edu/10487/>
- Erickson, K. I., Leckie, R. L., & Weinstein, A. M. (2014). Physical activity, fitness, and gray matter volume. *Neurobiology of Aging*, 35, S20-S28. doi:  
10.1016/j.neurobiolaging.2014.03.034
- Evans, G. W. (2006). Child development and the physical environment. *Annual Review of Psychology*, 57, 423-451. doi: 10.1146/annurev.psych.57.102904.190057
- Evans, G. W., Gonnella, C., Marcynyszyn, L. A., Gentile, L., & Salpekar, N. (2005). The role of chaos in poverty and children's socioemotional adjustment. *Psychological Science*, 16, 560-565. doi: 10.1111/j.0956-7976.2005.01575.x
- Evans, G. W., & Kim, P. (2013). Childhood poverty, chronic stress, self-regulation, and coping. *Child Development Perspectives*, 7, 43-48. doi: 10.1111/cdep.12013
- Feng, X., Hooper, E. G., & Jia, R. (2017). From compliance to self-regulation: Development during early childhood. *Social Development*, 26, 981-995. doi: 10.1111/sode.12245
- Fergusson, D. M., Boden, J. M., & Horwood, L. J. (2013). Childhood self-control and adult outcomes: Results from a 30-year longitudinal study. *Journal of the American Academy of Child & Adolescent Psychiatry*, 52, 709-717. doi:  
10.1016/j.jaac.2013.04.008

- Fiese, B. H., Foley, K. P., & Spagnola, M. (2006). Routine and ritual elements in family mealtimes: Contexts for child well-being and family identity. *New Directions for Child and Adolescent Development, 111*, 67-89. doi: 10.1002/cd.156
- Flueckiger, L., Lieb, R., Meyer, A. H., Witthauer, C., & Mata, J. (2017). Day-to-day variations in health behaviors and daily functioning: Two intensive longitudinal studies. *Journal of Behavioral Medicine, 40*, 307-319. doi: 10.1007/s10865-016-9787-x
- Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist, 56*, 218-226. doi: 10.1037/0003-066X.56.3.218
- Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134*, 31-60. doi: 10.1037/0033-2909.134.1.31
- Grolnick, W. S., & Farkas, M. (2002). Parenting and the development of children's self-regulation. In M. H. Bornstein (Ed.), *Handbook of parenting, vol. 5. Practical issues in parenting* (2nd ed., pp. 89-110). Mahwah, NJ: Erlbaum.
- Gross, J. J. (2014). Emotion regulation: Conceptual and empirical foundations. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (2nd ed., pp. 3-20). New York, NY: Guilford Press.
- Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: A meta-analysis. *Psychological Bulletin, 136*, 495-525. doi: 10.1037/a0019486
- Hamaker, E. L. (2012). Why researchers should think "within-person". A paradigmatic rationale. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (pp. 43-61). New York, NY: Guilford Press.

- Hardaway, C. R., Wilson, M. N., Shaw, D. S., & Dishion, T. J. (2012). Family functioning and externalizing behaviour among low-income children: Self-regulation as moderator. *Infant and Child Development, 21*, 67-84. doi:10.1002/icd.765
- Hofer, J., Busch, H., & Kärtner, J. (2011). Self-regulation and well-being: The influence of identity and motives. *European Journal of Personality, 25*, 211-224. doi: 10.1002/per.789
- Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences, 16*, 174-180. doi: 10.1016/j.tics.2012.01.006
- Holmes, C. J., Kim-Spoon, J., & Deater-Deckard, K. (2016). Linking executive function and peer problems from early childhood through middle adolescence. *Journal of Abnormal Child Psychology, 44*, 31-42. doi: 10.1007/s10802-015-0044-5
- Jahromi, L. B., & Stifter, C. A. (2008). Individual differences in preschoolers' self-regulation and theory of mind. *Merrill-Palmer Quarterly, 54*, 125-150. doi: 10.1353/mpq.2008.0007
- Joussemet, M., Landry, R., & Koestner, R. (2008). A self-determination theory perspective on parenting. *Canadian Psychology, 49*, 194-200. doi: 10.1037/a0012754
- Kanning, M. K., Ebner-Priemer, U., & Schlicht, W. M. (2013). How to investigate within-subject associations between physical activity and momentary affective states in everyday life: A position statement based on a literature overview. *Frontiers in Psychology, 4*, 1-16. doi: 10.3389/fpsyg.2013.00187
- Karreman, A., van Tuijl, C., van Aken, M. A. G., & Deković, M. (2006). Parenting and self-regulation in preschoolers: A meta-analysis. *Infant and Child Development, 15*, 561-579. doi: 10.1002/icd.478
- Kopp, C. B. (1982). Antecedents of self-regulation: A developmental perspective. *Developmental Psychology, 18*, 199-214.

- Laberge, S., Bush, P. L., & Chagnon, M. (2012). Effects of a culturally tailored physical activity promotion program on selected self-regulation skills and attitudes in adolescents of an underserved, multiethnic milieu. *American Journal of Health Promotion, 26*, e105-115. doi: 10.4278/ajhp.090625-QUAN-202.
- Lakes, K. D., & Hoyt, W. T. (2004). Promoting self-regulation through school-based martial arts training. *Applied Developmental Psychology, 25*, 283-302. doi: 10.1016/j.appdev.2004.04.002
- Lengua, L. J. (2006). Growth in temperament and parenting as predictors of adjustment during children's transition to adolescence. *Developmental Psychology, 42*, 819-832. doi: 10.1037/0012-1649.42.5.819
- Lengua, L. J., Honorado, E., & Bush, N. R. (2007). Contextual risk and parenting as predictors of effortful control and social competence in preschool children. *Journal of Applied Developmental Psychology, 28*, 40-55. doi:10.1016/j.appdev.2006.10.001
- Lengua, L. J., & Kovacs, E. A. (2005). Bidirectional associations between temperament and parenting and the prediction of adjustment problems in middle childhood. *Applied Developmental Psychology, 26*, 21-38. doi:10.1016/j.appdev.2004.10.001
- Leonhardt, A., Könen, T., Dirk, J., & Schmiedek, F. (2016). How differentiated do children experience affect? An investigation of the within-and between-person structure of children's affect. *Psychological Assessment, 28*, 575-585. doi: 10.1037/pas0000195
- Lerner, R. M., Agans, J. P., DeSouza, L. M., & Gasca, S. (2013). Describing, explaining, and optimizing within-individual change across the life span: A relational developmental systems perspective. *Review of General Psychology, 17*, 179-183. doi: 10.1037/a0032931

- Liao, Y., Shonkoff, E. T., & Dunton, G. F. (2015). The acute relationships between affect, physical feeling states, and physical activity in daily life: A review of current evidence. *Frontiers in Psychology, 6*, 1-7. doi: 10.3389/fpsyg.2015.01975
- Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., ... Biddle, S. (2016). Physical activity for cognitive and mental health in youth: A systematic review of mechanisms. *Pediatrics, 138*, e20161642. doi: 10.1542/peds.2016-1642
- Luft, A. R., Macko, R. F., Forrester, L. W., Villagra, F., Ivey, F., Sorkin, J. D., ... Hanley, D. F. (2008). Treadmill exercise activates subcortical neural networks and improves walking after stroke. A randomized controlled trial. *Stroke, 39*, 3341-3350. doi: 10.1161/STROKEAHA.108.527531
- Martin, A., Razza, R., & Brooks-Gunn, J. (2012). Specifying the links between household chaos and preschool children's development. *Early Child Development and Care, 182*, 1247-1263. doi:10.1080/03004430.2011.605522
- Matheny, Jr., A. P., Wachs, T. D., Ludwig, J. L., & Phillips, K. (1995). Bringing order out of chaos: Psychometric characteristics of the confusion, hubbub, and order scale. *Journal of Applied Developmental Psychology, 16*, 429-444. doi: 10.1016/0193-3973(95)90028-4
- McClelland, M. M., Geldhof, G. J., Cameron, C. E., & Wanless, S. B. (2015). Development and self-regulation. In W. F. Overton & P. C. M. Molenaar (Eds.), *Handbook of child psychology and developmental science. Volume 1: Theory and method* (7th ed., pp. 523-565). New Jersey: John Wiley & Sons.
- Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: A meta-regression. *Health Psychology, 28*, 690-701. doi: 10.1037/a0016136

- Moilanen, K. L., Rasmussen, K. E., & Padilla-Walker, L. M. (2014). Bidirectional associations between self-regulation and parenting styles in early adolescence. *Journal of Research on Adolescence, 25*, 246-262. doi: 10.1111/jora.12125
- Morris, A. S., Silk, J. S., Steinberg, L., Myers, S. S., & Robinson, L. R. (2007). The role of the family context in the development of emotion regulation. *Social Development, 16*, 361-388. doi: 10.1111/j.1467-9507.2007.00389.x
- Neubauer, A. B., & Voss, A. (2016). The structure of need fulfillment: Separating need satisfaction and dissatisfaction on between- and within-person level. *European Journal of Psychological Assessment*. Advance online publication. doi: 10.1027/1015-5759/a000326
- Nigg, J. T. (2017). Annual research review: On the relations among self-regulation, self-control, executive functioning, effortful control, cognitive control, impulsivity, risk-taking, and inhibition for developmental psychopathology. *Journal of Child Psychology and Psychiatry, 58*, 361-383. doi: 10.1111/jcpp.12675
- Paluska, S. A., & Schwenk, T. L. (2000). Physical activity and mental health: Current concepts. *Sports Medicine, 29*, 167-180. doi: 10.2165/00007256-200029030-00003
- Pauen, S., & The EDOS Group (2016). Understanding early development of self-regulation and co-regulation: EDOS and PROSECO. *Journal of Self-Regulation and Regulation, 2*, 2-16. doi: 10.11588/josar.2016.2.34350
- Peluso, M. A. M., & Guerra de Andrade, L. H. S. (2005). Physical activity and mental health: The association between exercise and mood. *Clinics, 60*, 61-70. doi: /S1807-59322005000100012
- Raffaelli, M, Crockett, L. J., & Shen, Y.-L. (2005). Developmental stability and change in self-regulation from childhood to adolescence. *The Journal of Genetic Psychology, 166*, 54-76. doi: 10.3200/GNTP.166.1.54-76

- Ramani, G. B., Brownell, C. A., & Campbell, S. B. (2010). Positive and negative peer interaction in 3- and 4-year-olds in relation to regulation and dysregulation. *The Journal of Genetic Psychology, 171*, 218-250. doi: 10.1080/00221320903300353
- Raver, C. C., Blair, C., Willoughby, M., & The Family Life Project Key Investigators (2013). Poverty as predictor of 4-year-olds' executive function: New perspectives on models of differential susceptibility. *Developmental Psychology, 49*, 292-304. doi: 10.1037/a0028343
- Ridgers, N. D., Stratton, G., & Fairclough, S. J. (2006). Physical activity levels of children during school playtime. *Sport Medicine, 36*, 359-371. doi: 10.1186/1479-5868-4-19
- Rothbart, M. K. (1989). Temperament in childhood: A framework. In G. A. Kohnstamm, J. E. Bates, & M. K. Rothbart (Eds.), *Temperament in childhood* (pp. 59-73). Chichester, England: John Wiley & Sons.
- Sawyer, A. C. P., Chittleborough, C. R., Mittinty, M. N., Miller-Lewis, L. R., Sawyer, M. G., Sullivan, T., & Lynch, J. W. (2015). Are trajectories of self-regulation abilities from ages 2-3 to 6-7 associated with academic achievement in the early school years? *Child: Care, Health and Development, 41*, 744-754. doi:10.1111/cch.12208
- Schmid, J., Stadler, G., Dirk, J., Fiege, C., & Gawrilow, C. (2016). ADHD symptoms in adolescents' everyday life fluctuations and symptom structure within and between individuals. *Journal of Attention Disorders*. Advance online publication. doi: 10.1177/1087054716629214
- Schmutz, E. A., Leeger-Aschmann, C. S., Radtke, T., Muff, S., Kakebeeke, T. H., Zysset, A. E., ... Kriemler, S. (2017). Correlates of preschool children's objectively measured physical activity and sedentary behavior: A cross-sectional analysis of the SPLASHY study. *International Journal of Behavioral Nutrition and Physical Activity, 14*, 1-13. doi: 10.1186/s12966-016-0456-9

- Sirois, F. M. (2015). A self-regulation resource model of self-compassion and health behavior intentions in emerging adults. *Preventive Medicine Reports, 2*, 218-222. doi: 10.1016/j.pmedr.2015.03.006
- Spagnola, M., & Fiese, B. H. (2007). Family routines and rituals: A context for development in the lives of young children. *Infants & Young Children, 20*, 284-299. doi: 10.1097/01.IYC.0000290352.32170.5a
- Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. *Monographs of the Society for Research in Child Development, 59*(2-3), 25-52. doi: 10.1111/j.1540-5834.1994.tb01276.x
- Tice, D. M., Baumeister, R. F., Shmueli, D., & Muraven, M. (2007). Restoring the self: positive affect helps improve self-regulation following ego depletion. *Journal of Experimental Social Psychology, 43*, 379-384. doi:10.1016/j.jesp.2006.05.007
- Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, 54*, 131-143. doi:10.1111/jcpp.12001
- Trentacosta, C. J., & Shaw, D. S. (2009). Emotional self-regulation, peer rejection, and antisocial behavior: Developmental associations from early childhood to early adolescence. *Journal of Applied Developmental Psychology, 30*, 356-365. doi: 10.1016/j.appdev.2008.12.016
- Valiente, C., Lemery-Chalfant, K., & Reiser, M. (2007). Pathways to problem behaviors: chaotic homes, parent and child effortful control, and parenting. *Social Development, 16*, 249-267. doi: 10.1111/j.1467-9507.2007.00383.x
- van Geert, P., & van Dijk, M. (2002). Focus on variability: New tools to study intra-individual variability in developmental data. *Infant Behavior & Development, 25*, 340-374. doi: 10.1016/S0163-6383(02)00140-6



- Wang, L. P., & Maxwell, S. E. (2015). On disaggregating between-person and within-person effects with longitudinal data using multilevel models. *Psychological Methods, 20*, 63-83. doi: 10.1037/met0000030
- Willoughby, M., Kupersmidt, J., Voegler-Lee, M., & Bryant, D. (2011). Contributions of hot and cool self-regulation to preschool disruptive behavior and academic achievement. *Developmental Neuropsychology, 36*, 162-180. doi: 10.1080/87565641.2010.549980
- Zhao, X., Lynch, J. G. Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and truths about mediation analysis. *Journal of Consumer Research, 37*, 197-206. doi: 10.1086/651257

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## Appendix A – Publication 1

Ludwig, K., Haindl, A., Laufs, R., & Rauch, W. A. (2016). Self-regulation in preschool children's everyday life: Exploring day-to-day variability and the within- and between-person structure. *Journal of Self-Regulation and Regulation*, 2, 99-117. doi: 10.11588/josar.2016.2.34357

Self-Regulation in Preschool Children's Everyday Life: Exploring Day-to-Day Variability  
and the Within- and Between-Person Structure

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Katja Ludwig, Amelie Haindl, Ruth Laufs and Wolfgang A. Rauch are at the University of Heidelberg. This research was part of the BeR-Alltag project at the Junior Research Group: Development of Self-Regulation, and partially funded by Field of Focus 4, University of Heidelberg. We thank our student research assistants for their highly committed work as well as the parents and children for their participation and interest in our research.

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## Abstract

**Objective:** Self-regulation - the ability to regulate one's own behavior, emotions, and cognition - is fundamental for achieving personal goals and successful socio-emotional adaptation. Individual differences in self-regulation and associations with correlates important in early childhood (e.g., school readiness) are well studied at a between-person level. This is the first study investigating intra-individual variation in self-regulation in the everyday life of a sample of preschool children using an intensive longitudinal design. Moreover, the study explores the dimensionality of self-regulation at both the between- and within-person level.

**Method:** Over a period of seven consecutive days including weekend days, 106 parents (84.3% mothers) rated their preschool children's self-regulation every evening either by an online questionnaire or via a phone interview. **Results:** Preschoolers' self-regulation varied substantially within persons over the measurement period as indicated by intra-individual standard deviations and intraclass correlation coefficients. Multilevel confirmatory factor analyses revealed best model fit for a model with three correlated but empirically distinct factors at both the within- and between-person level that can be labeled as "emotional self-regulation", "behavioral self-regulation", and "attentional self-regulation". **Conclusion:** The study is the first demonstrating that self-regulation varies within, and not only between, individuals from day to day in a sample of healthy preschool children. Preschoolers' self-regulation can be described by three related but distinct factors at the within- and between-person level, supporting the conceptualization of self-regulation as a construct with multiple interrelated but separable facets.

*Keywords:* self-regulation, daily, preschool, intensive longitudinal design, within-person

Self-regulation in preschool children's everyday life: Exploring day-to-day variability  
and the within- and between-person structure

### **Introduction**

Self-regulation is the ability to adaptively regulate one's own emotions, cognition, and behavior in order to respond effectively to internal as well as environmental demands (McClelland & Cameron, 2012; Raffaelli, Crockett, & Shen, 2005). Early childhood is a sensitive stage for the development of self-regulation. In longitudinal studies, self-regulation increases substantially during infancy and the preschool years, with individual variability in growth rates (e.g., Fuhs & Day, 2011; Moilanen, Shaw, Dishion, Gardner, & Wilson, 2009; Raffaelli et al., 2005; Raikes, Robinson, Bradley, Raikes, & Ayoub, 2007). Inter-individual differences in self-regulation in early childhood are predictive of numerous outcomes across the lifespan (Fergusson, Boden, & Horwood, 2013; Moffitt et al., 2011), including school readiness (Blair & Raver, 2015; Suchodoletz et al., 2013), literacy and math skills (Becker, McClelland, Loprinzi, & Trost, 2014; Sawyer, Chittleborough et al., 2015), behavioral problems in the classroom (Sawyer, Miller-Lewis, Searle, Sawyer, & Lynch, 2015), and building as well as maintaining positive peer relationships (Holmes, Kim-Spoon, & Deater-Deckard, 2016). The present study is the first investigating whether there is also *intra*-individual, day-to-day variability in preschoolers' self-regulation besides inter-individual differences, and how the factor structure of self-regulation can be described at the within-person (intra-individual) and between-person (inter-individual) level.

### **Within- and Between-Person Variability in Self-Regulation**

So far, research on self-regulation in childhood has concentrated on inter-individual differences. However, some studies have already demonstrated intra-individual variability in related constructs: Miller, Seifer, Crossin, and Lebourgeois (2015) experimentally investigated the relationship between acute sleep restriction and different self-regulation

strategies during an unsolvable puzzle task in a sample of two- and three-year old children. The experimental group was deprived of sleep by not having their usual afternoon nap, while the children of the control group were allowed to sleep. During the unsolvable puzzle task, the experimental group showed significantly less adaptive, self-regulatory behaviors (e.g., insistence on completing an unsolvable puzzle, self-soothing behaviors) compared to the control group. Even if these findings have to be interpreted with caution due to the small sample size ( $n = 12$ ), the study provides first evidence for the influence of factors subjected to change from day to day (i.e., sleep time) on self-regulation in early childhood. Using an intensive longitudinal design with ambulatory-assessed (i.e., smartphone-based) working memory tasks three times a day over four consecutive weeks, Dirk and Schmiedek (2016) demonstrated substantial day-to-day fluctuations, as well as fluctuations throughout the day in elementary school children's working memory. Likewise, two studies with adolescent samples within the clinical context recently showed substantial day-to-day fluctuations in self-regulation failures (Berg et al., 2014; Schmid, Stadler, Dirk, Fiege, & Gawrilow, 2016). Thus, besides the fact that some children generally show better self-regulation skills compared to other children (inter-individual differences or between-person level), day-to-day fluctuations in self-regulation should be present in younger samples as well; the individual child might also intra-individually experience days on which his or her self-regulation is better or worse compared to other days (within-person level). This dynamic nature of self-regulation was already mentioned by Thompson (1994), who concluded in his basic review about emotional self-regulation that "there is no necessary reason why individuals should exhibit deficiencies in all aspects of emotion regulation or in all situations" (p. 45) and highlighted the need for future research to focus on (emotional) self-regulation "much less globally and in a manner that is far more situationally specific" (p. 47). The present study addresses Thompson's challenge and contributes to closing this research gap by empirically

investigating whether within-person variability in self-regulation is also present in the everyday life of healthy preschool children, as it was previously shown in older and clinical samples (Berg et al., 2014; Dirk & Schmiedek, 2016; Schmid et al., 2016). For this purpose, the study applies an intensive longitudinal design over a measurement period of seven consecutive days, enabling us to differentiate between within- (intra-individual) and between-person (inter-individual) effects.

### **The Structure of Self-Regulation**

Present theories about the structure of self-regulation in children are built on assumptions at the between-person level. Many researchers from multiple research fields have addressed (inter-individual) self-regulation; yet have emphasized slightly different aspects, such as effortful control (Rothbart, Ahadi, Hershey, & Fisher, 2001), self-control (Moffitt et al., 2011), emotion regulation (Carlson & Wang, 2007), or executive functioning (Miyake & Friedman, 2012).

Summarizing the different approaches and perspectives on children's self-regulation by independent researchers, self-regulation integrates three processes: cognitive, behavioral, and emotional regulation. Cognitive self-regulation refers to executive functions such as updating (working memory), inhibition, and flexible attentional shifting (Garon, Bryson, & Smith, 2008; Miyake & Friedman, 2012). To concentrate one's attention and to stay focused is an important self-regulation skill in children's everyday life, especially with regards to academic performance (Blair, Ursache, Greenberg, & Vernon-Feagans, 2015; McClelland & Wanless, 2012). From a cognitive perspective, executive functions constitute the underlying, higher-order neurocognitive ("top down") process subserving cognitive self-regulation (Blair & Ursache, 2011; Bridgett, Burt, Edwards, & Deater-Deckard, 2015; Hofmann, Schmeichel, & Baddeley, 2012). Behavioral regulation refers to self-control abilities and compliance, that is, the ability to internalize rules and standards as well as to inhibit predominant behavioral



responses that do not conform to those rules and standards or that do not fit the demands of the environment (Denham, Warren-Khot, Bassett, Wyatt, & Perna, 2012; Tangney, Baumeister, & Boone, 2004). Children's behavioral self-regulation describes behaviors such as adhering to rules, listening to others without interrupting them, or being able to wait until one's turn. Thus, behavioral self-regulation is linked to positive and desired social outcomes, such as positive peer relations (Ramani, Brownell, & Campbell, 2010) and socially appropriate behavior (Eisenberg et al., 1997). Emotional regulation refers to the experience and expression of emotions (Gross, 2014). Emotional regulation emerges in early childhood as the employment of regulation strategies shifts more and more from an extrinsic (i.e., parent-monitored) to an internal (i.e., self-monitored) process during the preschool years (Bridgett et al., 2015). During development, children acquire an increasing number of emotion-regulation strategies: from early strategies such as regulation of visual attention by two or three months of age or physical self-soothing behaviors (e.g., thumb sucking) between four and ten months of age (Bridges & Grolnick, 1995) to more complex strategies such as cognitive reappraisal (Gross, 2014; Gullone, Hughes, King, & Tonge, 2010). From a functionalist perspective, the ability to regulate emotions is important for building and maintaining social relationships as well as meeting situational demands and social expectations (e.g., in the school context) or achieving goals (Thompson, 1994). For instance, children with good emotional self-regulation skills would not be easily frustrated when things did not work out as well as expected (i.e., starting crying, tossing toys, etc.).

However, it is still unclear whether cognitive, behavioral, and emotional self-regulation are so strongly interrelated that they form a unidimensional self-regulation factor or whether they can be empirically separated from each other despite their interrelation. Therefore, up to now there exist different, competing structural models of preschoolers' self-regulation, including three-factor, two-factor, and single-factor models. According to Bridgett

and colleagues (2015), a two-factor structure of self-regulation is assumed with a conglomerate of cognitive and behavioral self-regulation on the one hand and emotional self-regulation on the other hand. A conceptually similar two-factor structure of preschoolers' self-regulation is also assumed by researchers who differentiate between "hot" versus "cool" self-regulation (e.g., Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011). While hot self-regulation describes affective and motivational processes (i.e., self-regulation in the presence of emotionally arousing and/or appetitive demands), cool self-regulation describes cognitive, emotionally neutral regulatory processes (i.e., executive functions). Besides a two-factor structure of self-regulation, past research found also evidence for the conceptualization of self-regulation as a global, single-factor construct and – in contrast – as a rather differentiated, three-factor construct. Studies supporting a three-factor model argue that the regulation of cognition, emotion, and behavior describes three related but empirically distinct constructs (Denham et al., 2012; Jahromi & Stifter, 2008). Studies supporting a unidimensional, single-factor model of self-regulation argue that the factor correlations between the two or three latent factors are so high that a global self-regulation factor is most appropriate (Allan & Lonigan, 2014; Raffaelli et al., 2005).

In sum, there is no consensus about whether preschoolers' self-regulation is best described by a unidimensional construct or whether self-regulation consists of related but empirically distinct subcomponents. Overall, few studies have investigated the factor structure at a between-person level in samples of preschool children, and there is no study yet investigating the factor structure of children's self-regulation at a within-person level and testing whether the factor structure differs between the within- and between-person levels.

### **The Present Study**

The aim of the present study was twofold: a) to investigate the amount of daily fluctuations in self-regulation within individuals over the course of several days and b) to

explore which factor structure best describes preschoolers' self-regulation at both the within- and between-person level. The current lack of research in this area might be mostly due to a lack of instruments assessing daily self-regulation. We therefore developed a short parental questionnaire capturing self-regulation in preschool children on a daily basis (see below). This questionnaire was then applied to a larger sample in the present study to investigate the two research aims.

Since there is no prior research investigating self-regulation in preschool children on a daily basis, our approach to examine the second research question is grounded on model assumptions obtained in past between-level studies. Therefore, three nested models were tested against each other: a global single-factor model (i.e., global self-regulation), a two-factor model (i.e., cognitive-behavioral self-regulation vs. emotional self-regulation), and a three-factor model (i.e., cognitive vs. behavioral vs. emotional self-regulation). Multilevel confirmatory factor analyses (CFA) were conducted in order to test the assumed factor structures at both the within- and between-person level.

## Method

### Participants

The present study was part of a larger research project investigating potential influences on self-regulation at the individual, family, and preschool levels. The sample consisted of 106 parents with their children aged four to six years ( $M_{\text{age}} = 4.83$ ,  $SD_{\text{age}} = 0.72$ ) from eight different preschools in the south of Germany. Gender was almost equally distributed (44.3% female children). On average, participants' socio-economic status was in the middle-to-upper regions as indicated by education and income: The highest maternal school qualifications were 60% who had qualified for university entrance, 31.8% middle school, and 4.7% lower secondary school (3.5% missing values). The average net family income per month was distributed as follows: 17.9% above €5,000, 15.1% between €4,000-

€5,000, 18.9% between €3,000-€4,000, 12.3% between €2,000-€3,000, 4.7% between €1,000-€2,000, and 0.9% below €1000 (30.2% missing values). 73.6% of the sample spoke German as their mother tongue at home, 9.4% spoke German at home most of the time, and 12.3% spoke German at home at least part of the time (4.7% missing values). Parents and their children were recruited by flyers and information letters in different preschools; parents gave written informed consent to participation. The study was approved by the local research ethics committee.

### **Procedure**

When completing the parental consent form to participate in the study, the parents had to indicate whether they wished to answer the daily questions about their child's self-regulation by phone or by an online questionnaire. 41.5% chose the telephone interview. For seven consecutive days, the parents were called every evening about 7pm and were asked about their child's self-regulation on the particular day. The parents who chose the online questionnaire received an email, every evening at about 7pm, with an individualized link to the questionnaire of the particular day. Out of the persons who answered the daily questions 84.3% were mothers. Families received €50 for their participation in the complete study.

### **Daily Self-Regulation Measure**

The child's daily self-regulation was assessed with a short parental questionnaire developed in a preliminary study within our research group. The initial questionnaire was developed in two steps. First, an initial item pool was built based on the definition of self-regulation as the ability to control or direct one's attention, thoughts, emotions, and behaviors (McClelland & Cameron, 2012). According to McClelland and Cameron (2012), instruments measuring self-regulation should capture aspects of self-regulation that are relevant in the context of interest. We aimed at creating a measure that captures self-regulation on a daily basis in the everyday life of preschool children. Hence, the items of the questionnaire should

imply behaviors that can be observed in children aged four to six in their natural environments. For this purpose, we selected items from preexisting, validated parental questionnaires measuring general self-regulation in normal preschool children. These were the Behavior Rating Inventory of Executive Function – Preschool Version (BRIEF-P, German version by Daseking & Petermann, 2013), the effortful control scale of the Children's Behavior Questionnaire (CBQ, Rothbart et al., 2001), and the Child Behavior Rating Scale (CBRS, Bronson, Goodson, Layzer, & Love, 1990). We also created several additional items in an attempt to capture all facets (i.e., cognitive, behavioral and emotional) of self-regulation equally well. The initial item pool consisted of 22 items. Since the purpose was to measure day-to-day self-regulation, the item wording was adjusted so that the parents were asked to what extent their child showed the self-regulatory behaviors *on the particular day*. This item pool was empirically tested (administered in German) in a sample of 20 parents with children aged four to six years ( $M_{\text{age}} = 4.65$ ,  $SD_{\text{age}} = 0.81$ ) who took part in an unrelated study at our laboratory. In the evening after the laboratory visit, parents were contacted by phone and responded to each item using a 5-point rating scale ranging from 1 “this is not true” to 5 “this is very true”. At the end there was also one open question where the parents were asked to make critical comments to the items in order to adapt the wording of the questions if necessary. Next, items with item selectivity less than .30, item difficulty less than .20 or greater than .80, and items which had been indicated as difficult to understand were excluded. This procedure resulted in 10 items selected and partially adapted for use in the main study. All items with descriptive statistics can be seen in Table 1 (see below).

### **Data Analyses**

The data gathered for our two research questions are hierarchically structured: Repeated measurements (level 1 or L1) are nested within persons (level 2 or L2) in our study. As the children were nested in eight different preschools, we tested whether there was the

need to account for dependency at a third level (i.e., the preschool). However, the design effect (i.e., a function of both the intraclass correlation coefficient (ICC) and cluster size:  $\text{design effect} = 1 + (\text{average cluster size} - 1) * \text{ICC}$ ) for the preschool level (L3) was smaller than 2 (Lai & Kwok, 2015; Muthén & Satorra, 1995), indicating that there is no data dependency on a third level.

To answer the first research question whether preschoolers' self-regulation varies from day to day, the average intra-individual standard deviation (ISD) and the ICC were calculated for each item. The ISD reflects each participant's individual standard deviation in self-regulation responses across the seven assessment days. The average ISD is the mean intra-individual standard deviation for each item across all participants. The ICC refers to the proportion of between-person variance relative to overall variance (Snijders & Bosker, 2012). Thus, small values can be seen as an indicator for substantial within-person variability.

To answer the second research question concerning the within- and between-person factor structure of self-regulation in preschool children, several multilevel CFAs were conducted. We started with one global self-regulation factor at the within- and between-person level (Model 1). Next, in Model 2, two latent factors were differentiated at each level, namely emotional self-regulation (with factor loadings from items 1, 3, 5, 9) versus cognitive-behavioral self-regulation (with factor loadings from items 2, 4, 6, 7, 8, 10). Finally, a further differentiated model with three latent factors at each level (i.e., four items measuring emotional self-regulation: items 1, 3, 5, 9; four items measuring behavioral self-regulation: items 2, 7, 8, 10; and two items measuring cognitive self-regulation: items 4, 6; also see Figure 1 below) was tested (Model 3). Only two items capturing cognitive aspects of self-regulation met the criteria to be included in the final questionnaire during item development. However, these two items reflect in particular the attentional aspect of executive function (i.e., cognitive self-regulation) but not cognitive shifting and inhibition (Miyake & Friedman,

2012). Therefore, in the following, we refer to this factor as *attentional* self-regulation instead of cognitive self-regulation. The factor loadings of the first indicator per factor were fixed to one; no other constraints were imposed. In order to evaluate model fit, several fit indices were used with regards to the criteria proposed by Schermelleh-Engel, Moosbrugger, and Müller (2003): the Root Mean Square Error of Approximation (RMSEA: good fit:  $\leq .05$ , acceptable fit:  $\leq .08$ ), the Comparative Fit Index (CFI: good fit:  $\geq .97$ , acceptable fit:  $\geq .95$ ), and the Standardized Root Mean Square Residual for the within- and between-person level (SRMR<sub>w</sub>/SRMR<sub>b</sub>: good fit:  $\leq .05$ , acceptable fit:  $\leq .10$ ). However, it has to be noted that these fit indices were established for single-level factor analyses and their application to two-level models is questionable (Hsu, 2009). To compare the models,  $\chi^2$ -difference tests were calculated (Satorra & Bentler, 2001); Akaike's Information Criterion (AIC) was additionally used as a descriptive index with lower values indicating better model fit. All models were estimated with Mplus 7 (Muthén & Muthén, 1998-2012) using a maximum likelihood estimation with robust standard errors (MLR). Reliability of the final retained factor(s) was considered separately for the within- and between-person level using the reliability coefficients by Cranford and colleagues (2006) (based on variance decomposition within the framework of multilevel models) as well as two-level alpha (based on multilevel CFA) by Geldhof, Preacher, & Zyphur (2014)<sup>1</sup>. While within-person estimates reflect sensitivity to change (i.e., reliability of daily fluctuations in self-regulation), between-person estimates reflect sensitivity to differences between persons across the seven measurement days.

The amount of missing observations per item was small (range: 0.07 to 1.2%). Missing data were managed with a full maximum likelihood approach (FIML) used in Mplus by default. There were no missing data at level 2 (i.e., aggregated responses per person across days). In five cases there were missings on all items. That is, five persons only answered the

questions on six instead of seven days. These (complete) missings could not be managed with FIML and hence could not be included in the analyses.

## Results

### Preliminary Analyses

Since some parents chose the phone interview and some parents the online questionnaire to answer the daily questions, we first tested for differences between these two groups with regards to demographic background. There were no differences in children's gender ( $\chi^2(1) = 1.45, p = .243$ ), age ( $t(104) = -0.69, p = .493$ ), and family net income ( $\chi^2(5) = 6.75, p = .240$ ). However, those who chose the online questionnaire had a significantly higher maternal educational degree ( $\chi^2(3) = 15.05, p = .002$ ). Descriptive statistics of the self-regulation items can be seen in Table 1. Parents mainly used the upper categories of the self-regulation ratings, with item means (L2) ranging from  $M = 3.41$  to  $M = 4.56$ .

### Variability of Daily Self-Regulation

The average ISDs and ICCs for all items are displayed in Table 1. Although parents mainly used the upper categories for rating their child's self-regulation, the ratings still varied considerably from day to day as indicated by the ISDs and ICCs. The ICCs ranged from .21 to .35, that is, between-person variance was two to four times smaller than within-person variance in all items. Values of the average ISDs ranged from .50 to .91, indicating substantial variability of self-regulation within persons from day to day; in fact, ISDs were larger than the between-person SDs for nine out of ten items.

INSERT TABLE 1 HERE

### Within- and Between-Person Factor Structure of Self-Regulation

Model fit results for the series of different models with factor combinations ranging from one to three factors at the two data levels are displayed in Table 2. Model fit was worst in Model 1, implying an undifferentiated, single-factor solution at the within- and between-



person level. With greater differentiation at each level, model fit improved (see Model 2 and 3). The model with three latent factors at both the within- and between-person level (Model 3) showed best model fit compared to the other factor structures. However, the inter-factor correlation between the factors attentional self-regulation and behavioral self-regulation was relatively high at the between-person level ( $r = .87$ ) compared to the within-person level ( $r = .60$ ). Hence a fourth model with three factors at the within-level but two factors at the between-level was tested (Model 4). The multilevel CFA produced a quite similar but slightly worse model fit for Model 4 in comparison to Model 3 with regards to the descriptive fit indices. A  $\chi^2$ -difference test (Satorra & Bentler, 2001) revealed a significantly smaller deviance of Model 3 compared to Model 4 ( $\chi^2(2) = 6.10, p = .047$ ). Hence, Model 3 was finally accepted with three latent factors that can be labeled as “attentional self-regulation”, “behavioral self-regulation”, and “emotional self-regulation”<sup>2</sup>. Factor loadings of the final model can be seen in Figure 1.

INSERT TABLE 2 HERE

Two-level alphas (Geldhof et al., 2014) at the within-/between-person level were .66/.91 for the emotional self-regulation scale, .65/.89 for the behavioral self-regulation scale and .47/.87 for the attentional self-regulation scale. Within-/between-person reliability according to the coefficients by Cranford and colleagues (2006) were .66/.92 (emotional self-regulation), .65/.91 (behavioral self-regulation), and .46/.89 (attentional self-regulation). These values are comparable with multilevel reliability coefficients reported in previous diary studies (e.g., Schmid et al., 2016).

## Discussion

### Day-to-Day Fluctuations

For the first time we showed that self-regulation varies substantially within a sample of healthy preschool children on a daily basis. The ICCs, which indicate the proportion of

between-person variance, ranged between .21 and .35. Thus, between 65% and 79% of the overall variance was due to within-person variance but not to between-person variance. For nine out of ten items of our self-regulation measure, the daily variability of self-regulation as indicated by the averaged ISDs (within-person level; range: .50 to .91) was greater than the standard deviations of the group-means (between-person level; range: .53 to .64). That is, in the present sample, self-regulation varied stronger *intra*-individually than *inter*-individually. Similar values were obtained when studying children's affect – a construct well-known for its state component (Leonhardt, Könen, Dirk, & Schmiedek, 2016). This finding emphasizes the dynamic nature of self-regulation by empirically showing that the ability to self-regulate cognitive, behavioral, and emotional processes in preschool children fluctuates from day to day besides relatively stable differences in average self-regulation abilities between individuals.

The study extends findings from previous research investigating individual differences in preschool children's self-regulation at a between-person level (e.g., Jahromi & Stifter, 2008; Sawyer, Miller-Lewis et al., 2015) and intra-individual variability in similar constructs and older samples (Berg et al., 2014; Dirk & Schmiedek, 2016; Schmid et al., 2016). This result calls into question the results of one-time assessments of self-regulation, because one-time assessments fail to take intra-individual variability into account and in the worst case might represent one of the extreme points (best or worst performance intra-individually) rather than typical performance (cf. Toplak, West, & Stanovich, 2013). Moreover, it is not yet clear whether there are inter-individual differences in intra-individual variability. In emotion research, there is a vivid debate how to measure such inter-individual differences in variability (Wang, Hamaker, & Bergeman, 2012), and different methods of measuring inter-individual differences in variability are differently related to relevant outcomes (Houben, van den Noortgate, & Kuppens, 2015; Wang et al., 2012).

In addition to analyses of inter-individual differences in intra-individual variability, daily correlates of self-regulation using longitudinal study designs could be investigated as a next step. Becker and colleagues (2014) recently found first evidence for the influence of moderate to vigorous physical activity on preschool children's self-regulation skills. Although the study investigated this question at a between-person level, physical activity seems to be a promising influencing factor on children's self-regulation on a daily basis; it varies within individuals from day-to-day (and within shorter time intervals; e.g., Ridgers, Timperio, Cerin, & Salmon, 2015) and is through its motivating nature a fun and relatively simple approach to positively influence children's self-regulation skills in their natural, everyday life. Another promising daily correlate of self-regulation is positive affect. Positive affect enables effective self-regulation by facilitating cognitive processes (i.e., efficient processing of information) and providing psychological resources (i.e., energy, motivation) that are essential for self-regulatory processes (Aspinwall, 1998; Isen, 2000; Muraven & Baumeister, 2000). Since previous research already showed that positive affect varies within children on a daily basis (Leonhardt, Könen, Dirk, & Schmiedek, 2016), the question remains whether daily variations in preschoolers' self-regulation could be explained by preceding variations in positive affect. The identification of within-person correlates and which situations are conducive to preschoolers' self-regulation in their everyday life enables the creation of more specific interventions enhancing preschool children's self-regulation skills. The focus on this young age group is hereby in particular important since an enhancement of self-regulation is advisable before the children transition into school.

### **Factor Structure of Self-Regulation**

Multilevel CFAs revealed that the factor structure of daily self-regulation was best described by a model with three latent factors (i.e., emotional, attentional, and behavioral self-regulation) at both the within- and between-person level. With regards to the measurement of

daily self-regulation in the present study, the factor “attentional self-regulation” consists of items describing cognitive self-regulation, or executive function, such as focusing the attention and staying focused for a while, or being able to concentrate. Attentional self-regulation (cf., executive function) is particularly essential for variables within the school context, such as school readiness and success in school (see for a short review Blair & Raver, 2015). However, the factor “attentional self-regulation” has only two indicators, thus reducing reliability of the scale (Marsh, Hau, Balla, & Grayson, 1998). The factor “behavioral self-regulation” reflects inhibitory, compliant behaviors such as being able to wait for something (i.e., until someone finished speaking, until it is one’s turn etc.) or following the rules. This part of self-regulation is a developmentally important aspect of self-regulation in particular with regards to social interactions (e.g., Eisenberg et al., 1997; Ramani et al., 2010). The factor “emotional self-regulation” describes the regulation of affect and emotions, especially in case of negative emotions (e.g., frustration) when things do not work out as expected. The development of emotional self-regulation also has important implications for social relationships. Both cross-sectional and longitudinal studies showed significant associations between children’s emotional self-regulation (e.g., self-distraction during a delay task) and their popularity with peers (Raver, Blackburn, Bancroft, & Torp, 1999; Spinrad et al., 2006; Trentacosta & Shaw, 2009). With the exception of attentional self-regulation, two-level reliability estimates showed satisfactory coefficients in the present study at both the between- and within-person level for emotional and behavioral self-regulation.

Besides empirical evidence in the present study for the three-factor model in comparison to other factor structures (i.e., single-factor or two-factor models), the conceptualization of self-regulation as a differentiated construct with three distinct processes (i.e., cognitive/attentional, behavioral, emotional) is also in accordance with findings from previous research. On the one hand, there is evidence for discriminant validity of multifaceted

self-regulation in children. That is, different facets of self-regulatory processes uniquely predict different outcome variables, such as cognitive self-regulation being a dominant predictor above behavioral and emotional self-regulation in predicting false belief (Jahromi & Stifter, 2008), or behavioral self-regulation mediating the association between emotional self-regulation and academic achievement (Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003), thus supporting the assumption that self-regulation consists of different interrelated processes. On the other hand, some of the previous factor-analytic studies investigating the latent factor structure of preschoolers' self-regulation (at a between-person level) also received best model fit for a model with three factors similar in content to the factors identified in the present study (Denham et al., 2012; Raffaelli et al., 2005). However, it has to be noted that within the study of Raffaelli and colleagues (2005), a single-factor model was yet accepted because of very high correlations among the three identified latent factors. In the present study, the inter-factor correlation between behavioral and cognitive self-regulation was quite high at the between-person level as well ( $r = .87$ ). This seems to support previous studies postulating a two-factor model of self-regulation such as the segmentation of self-regulation into a "hot" (i.e., emotional) versus "cool" (i.e., cognitive-behavioral) self-regulation factor (Willoughby et al., 2011). However, previous research is only based on data at the between-person level. By disaggregating the within- and between-person level, the present study shows that a more differentiated factor structure is true for both levels while controlling for the respective data level. At the within-person level, the inter-factor correlations are much smaller compared to the between-person level, ranging from .49 to .65 in the present study. The inter-factor correlations at the between-person level range from .43 to .87, but are smaller compared to the study by Raffaelli and colleagues (2005) who also measured preschoolers' self-regulation by parent-report and obtained inter-factor correlations ranging from .74 to .95 at the between-person level. The possibility of a two-factor structure

at the between-person level was empirically tested in the present study: a difference test revealed significant better model fit of the model with three distinct factors at the within- and between-person level compared to the model with three factors at the within- but two factors at the between-person level. However, the inter-factor correlations between behavioral and attentional self-regulation were clearly greater than the respective correlations with emotional self-regulation at the between-person level, indicating that the “cool” processes of cognitive and behavioral self-regulation are more strongly related with one another than each is with the “hot” process of emotional self-regulation (cf., Bridgett et al., 2015).

In sum, the present study contributes to the understanding of self-regulation as a diverse construct whose regulatory processes (i.e., emotional, attentional, behavioral) are related but distinct. However, more research is needed to support this initial finding and provide further insights into the factor structure, for instance by investigating discriminant predictive validity of the three factors (e.g., academic and social relationship outcomes, see above).

### **Limitations and Future Directions**

Some limitations of the present research must be acknowledged: First, daily self-regulation was assessed by parent-report (particularly mothers) rather than by self-report. Within clinical research, several studies only show limited convergence between child- and parent-reported symptoms (Achenbach, McConaughy, & Howell, 1987; De Los Reyes & Kazdin, 2005). However, in research with children under the age of six, parent-reports are nonetheless the method of choice, since applying self-reports is difficult within this young age group as the children have difficulties in representing complex internal experiences (Luby, Belden, Sullivan, & Spitznagel, 2007). Moreover, the problem of convergence between child and parent reports seems to be of more concern in the case of internal processes such as the investigation of children's depressive or anxious symptoms (De Los Reyes & Kazdin, 2005).

Although self-regulation means the self-monitored regulation of different emotional, behavioral, and attentional – and thus internal – processes, the outcome of these regulatory processes (i.e., successful or non-successful self-regulation) is visible for external observers, such as showing *no* frustration reaction when things did not work out as well as expected or being able to complete a game or keep on task. Therefore, we assume the measurement of preschool children's self-regulation by an external person as adequate. However, one could further argue whether the measurement by parent's report or rather by preschool teacher's report is more appropriate. Since the children spend a large part of their waking hours in the preschool, the preschool teacher might see more situations demanding self-regulation, especially in socially interactive situations. However, during the day, one preschool teacher has to supervise multiple children; thus, focusing on one child in order to adequately rate its self-regulation throughout the day is quite difficult in practice. Moreover, the data of the present study also included weekend days where there would be missing data in the case of preschool teacher-reports. We therefore chose parents' reports to measure preschoolers' daily self-regulation. Nevertheless, for future research it would be interesting to combine preschool teachers' reports and parents' reports to get further insights into children's self-regulation in different contexts. In addition, the present study only investigated children's intra-individual self-regulation on a daily basis. Dirk and Schmiedek (2016) already showed that children's working memory performance varies not only from day to day, but also from occasion to occasion (i.e., morning, noon, afternoon). Thus, a study design with multiple measurement bursts throughout the day is recommended to further investigate preschoolers' intra-individual self-regulation within shorter time intervals.

Second, the sample is limited in representativity, as the sample was self-selected with a middle-to-high socio-economic background. The elaborate review by Bridgett and colleagues (2015) underlines the key role that parental influence factors play for children's

self-regulation. Parental (mostly maternal) and children's self-regulatory abilities are usually correlated in part because of intergenerational transmission processes such as parenting behavior (e.g., caregiving), inter-parent relations (e.g., marital conflict), and rearing context (e.g., socio-economic background) (Bridgett et al., 2015). Concerning the ceiling effects in the present study partially represented in the relatively high item means of the aggregated self-regulation scores, a more heterogeneous sample might enhance individual differences in self-regulation thus enhancing between-person variance. To what extent this might affect within-person variance is as yet unclear. Although the children scored relatively high on the self-regulation items on average, there was still substantial variation within and between individuals. Hence, future research is needed including more diverse samples regarding family background and using longitudinal study designs to disaggregate within- and between-person level effects.

Third, it should be noted that while the  $SRMR_{within}$  met Schermelleh-Engel and colleagues' (2003) criteria for good model fit, the RMSEA and CFI of the three-factor model only showed acceptable model fit according to conventional cut-off criteria (e.g., Hu & Bentler, 1999; Schermelleh-Engel et al., 2003). However, it must be remarked that the use of conventional cut-off criteria such as Hu and Bentler (1999) as golden rules for evaluating model fit has been criticized (Marsh, Hau, & Wen, 2004). Marsh and colleagues (2004) instead recommend the comparison of nested models as more adequate. In the present study, besides the comparatively better descriptive fit indices, a difference test revealed a significant smaller deviance of the three-factor model. Therefore the three-factor model was accepted. Moreover, there exist no general cut-off criteria yet for two-(or more)level model fit, and the application of current cut-off criteria for single-level models to multilevel models has to be done with caution (Hsu, 2009; Wagner, 2008) - simulation studies showed that global fit indices are more sensitive to the within-level than the between-level (Hsu, 2009; Wagner,



2008). Here, level-specific model fit evaluations revealed better model fit at the within-person level and worse model fit at the between-person level according to the  $SRMR_{\text{between}}$  provided by Mplus and the partially saturated model approach by Ryu and West (2009). Future research should include more items for further exploration of the source of misfit at the between-person level and the reliability estimates of the scales (i.e., additionally calculating McDonald's omega, see Geldhof et al., 2014).

### **Conclusion**

The present study provides evidence that preschoolers' parent-reported self-regulation skills substantially vary from day to day. Similar results have been found for related constructs in older samples. This finding emphasizes the dynamic nature of self-regulation and highlights the need for a prospective focus on intra-individual (within-person) self-regulatory processes besides common investigations at the between-person level. Here, potential antecedents and consequences of within-person variability in self-regulation should be investigated as a next step as well as variability within shorter time intervals (i.e., morning, noon, afternoon).

By disaggregating the two-level data, the study provides further insights into the factor structure at both the within- and between-person level: Best model fit was found for a three-factor model including behavioral, emotional, and attentional self-regulation. This finding further contributes to the understanding of self-regulation as a diverse construct with distinct but related processes.

### **Declaration of interests and funding**

The author(s) declare no potential conflicts of interest concerning the research, authorship, and/or publication of this article. The present study was supported by Field of Focus 4, University of Heidelberg, Germany, funded by the German Excellence Initiative.

## References

- Achenbach, T. M., McConaughy, S. H., & Howell, C. T. (1987). Child/adolescent behavioral and emotional problems: Implications of cross-informant correlations for situational specificity. *Psychological Bulletin*, *101*, 213-232. doi: 10.1037/0033-2909.101.2.213
- Allan, N. P., & Lonigan, C. J. (2014). Exploring dimensionality of effortful control using hot and cool tasks in a sample of preschool children. *Journal of Experimental Child Psychology*, *122*, 33-47. doi: 10.1016/j.jecp.2013.11.013
- Aspinwall, L. G. (1998). Rethinking the role of positive affect in self-regulation. *Motivation and Emotion*, *22*(1), 1-32. doi: 10.1023/A:1023080224401
- Becker, D. R., McClelland, M. M., Loprinzi, P., & Trost, S. G. (2014). Physical activity, self-regulation, and early academic achievement in preschool children. *Early Education & Development*, *25*, 56-70. doi: 10.1080/10409289.2013.780505
- Berg, C. A., Wiebe, D. J., Suchy, Y., Hughes, A. E., Anderson, J. H., Godbey, E. I., ... White, P. C. (2014). Individual differences and day-to-day fluctuations in perceived self-regulation associated with daily adherence in late adolescents with type 1 diabetes. *Journal of Pediatric Psychology*, *39*, 1038-1048. doi: 10.1093/jpepsy/jsu051
- Blair, C., & Raver, C. C. (2015). School readiness and self-regulation: A developmental psychobiological approach. *Annual Review of Psychology*, *66*, 711-731. doi: 10.1146/annurev-psych-010814-015221
- Blair, C., & Ursache, A. (2011). A bidirectional model of executive functions and self-regulation. In K. D. Vohs & R. F. Baumeister (Eds.), *Handbook of self-regulation: Research, theory, and applications* (2nd ed., pp. 300-320). New York, NY: Guilford Press.

- Blair, C., Ursache, A., Greenberg, M., & Vernon-Feagans, L. (2015). Multiple aspects of self-regulation uniquely predict mathematics but not letter–word knowledge in the early elementary grades. *Developmental Psychology, 51*, 459-472. doi: 10.1037/a0038813
- Bridges, L. J., & Grolnick, W. S. (1995). The development of emotional self-regulation in infancy and early childhood. In N. Eisenberg (Ed.), *Social development* (pp. 185-211). Thousand Oaks: Sage.
- Bridgett, D. J., Burt, N. M., Edwards, E. S., & Deater-Deckard, K. (2015). Intergenerational transmission of self-regulation: A multidisciplinary review and integrative conceptual framework. *Psychological Bulletin, 141*, 602-654. doi: 10.1037/a0038662
- Bronson, M. B., Goodson, B. D., Layzer, J. I., & Love, J. M. (1990). *Child Behavior Rating Scale*. Cambridge, MA: Abt Associates.
- Carlson, S. M., & Wang, T. S. (2007). Inhibitory control and emotion regulation in preschool children. *Cognitive Development, 22*, 489-510. doi: 10.1016/j.cogdev.2007.08.002
- Cranford, J. A., Shrout, P. E., Iida, M., Rafaeli, E., Yip, T., & Bolger, N. (2006). A procedure for evaluating sensitivity to within-person change: can mood measures in diary studies detect change reliably? *Personality and Social Psychology Bulletin, 32*, 917-929. doi: 10.1177/0146167206287721
- Daseking, M., & Petermann, F. (2013). *Verhaltensinventar zur Beurteilung exekutiver Funktionen für das Kindergartenalter-BRIEF-P* [Behavior Rating Inventory of Executive Function – Preschool Version, BRIEF-P]. Bern: Huber.
- De Los Reyes, A., & Kazdin, A. E. (2005). Informant discrepancies in the assessment of childhood psychopathology: A critical review, theoretical framework, and recommendations for further study. *Psychological Bulletin, 131*, 483-509. doi: 10.1037/0033-2909.131.4.483

- Denham, S. A., Warren-Khot, H. K., Bassett, H. H., Wyatt, T., & Perna, A. (2012). Factor structure of self-regulation in preschoolers: Testing models of a field-based assessment for predicting early school readiness. *Journal of Experimental Child Psychology, 111*, 386-404. doi: 10.1016/j.jecp.2011.10.002
- Dirk, J., & Schmiedek, F. (2016). Fluctuations in elementary school children's working memory performance in the school context. *Journal of Educational Psychology, 108*, 722-739. doi: 10.1037/edu0000076
- Eisenberg, N., Guthrie, I. K., Fabes, R. A., Reiser, M., Murphy, B., Holgren, R., ... Losoya, S. (1997). The relations of regulation and emotionality to resiliency and competent social functioning in elementary school children. *Child Development, 68*, 295-311. doi: 10.1111/j.1467-8624.1997.tb01941.x
- Fergusson, D. M., Boden, J. M., & Horwood, L. J. (2013). Childhood self-control and adult outcomes: Results from a 30-year longitudinal study. *Journal of the American Academy of Child & Adolescent Psychiatry, 52*, 709-717. doi: 10.1016/j.jaac.2013.04.008
- Fuhs, M. W., & Day, J. D. (2011). Verbal ability and executive functioning development in preschoolers at head start. *Developmental Psychology, 47*, 404-416. doi: 10.1037/a0021065
- Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin, 134*, 31-60. doi: 10.1037/0033-2909.134.1.31
- Geldhof, G. J., Preacher, K. J., & Zyphur, M. J. (2014). Reliability estimation in a multilevel confirmatory factor analysis framework. *Psychological Methods, 19*, 72-91. doi: 10.1037/a0032138

- Gross, J. J. (2014). Emotion regulation: Conceptual and empirical foundations. In J. J. Gross (Ed.), *Handbook of Emotion Regulation* (2nd ed., pp. 3-20). New York, NY: Guilford Press.
- Gullone, E., Hughes, E. K., King, N. J., & Tonge, B. (2010). The normative development of emotion regulation strategy use in children and adolescents: A 2-year follow-up study. *Journal of Child Psychology and Psychiatry*, *51*, 567-574. doi: 10.1111/j.1469-7610.2009.02183.x
- Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences*, *16*, 174-180. doi: 10.1016/j.tics.2012.01.006
- Holmes, C. J., Kim-Spoon, J., & Deater-Deckard, K. (2016). Linking executive function and peer problems from early childhood through middle adolescence. *Journal of Abnormal Child Psychology*, *44*, 31-42. doi: 10.1007/s10802-015-0044-5
- Houben, M., van den Noortgate, W., & Kuppens, P. (2015). The relation between short-term emotion dynamics and psychological well-being: A meta-analysis. *Psychological Bulletin*, *141*, 901-930. doi: 10.1037/a0038822
- Howse, R. B., Calkins, S. D., Anastopoulos, A. D., Keane, S. P., & Shelton, T. L. (2003). Regulatory contributors to children's kindergarten achievement. *Early Education and Development*, *14*, 101-120. doi: 10.1207/s15566935eed14017
- Hsu, H.-Y. (2009). *Testing the effectiveness of various commonly used fit indices for detecting misspecifications in multilevel structural equation models* (Doctoral dissertation, Texas A&M University). Retrieved from <http://oaktrust.library.tamu.edu/>
- Hu, L.-T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*, 1-55. doi: 10.1080/10705519909540118

- Isen, A. M. (2000). Some perspectives on positive affect and self-regulation. *Psychological Inquiry, 11*, 184-187.
- Jahromi, L. B., & Stifter, C. A. (2008). Individual differences in preschoolers' self-regulation and theory of mind. *Merrill-Palmer Quarterly, 54*, 125-150. doi: 10.1353/mpq.2008.0007
- Lai, M. H. C., & Kwok, O.-M. (2015). Examining the rule of thumb of not using multilevel modeling: The “design effect smaller than two” rule. *The Journal of Experimental Education, 83*, 423-438. doi: 10.1080/00220973.2014.907229
- Leonhardt, A., Könen, T., Dirk, J., & Schmiedek, F. (2016). How differentiated do children experience affect? An investigation of the within-and between-person structure of children's affect. *Psychological Assessment, 28*, 575-585. doi: 10.1037/pas0000195
- Luby, J. L., Belden, A., Sullivan, J., & Spitznagel, E. (2007). Preschoolers' contribution to their diagnosis of depression and anxiety: Uses and limitations of young child self-report of symptoms. *Child Psychiatry and Human Development, 38*, 321-338. doi: 10.1007/s10578-007-0063-8
- Marsh, H. W., Hau, K.-T., Balla, J. R., & Grayson, D. (1998). Is more ever too much? The number of indicators per factor in confirmatory factor analysis. *Multivariate Behavioral Research, 33*, 181-220. doi: 10.1207/s15327906mbr3302\_1
- Marsh, H. W., Hau, K.-T., & Wen, Z. (2004). In search of golden rules: Comment on hypothesis-testing approaches to setting cutoff values for fit indexes and dangers in overgeneralizing Hu and Bentler's (1999) findings. *Structural Equation Modeling, 11*, 320-341. doi: 10.1207/s15328007sem1103\_2
- McClelland, M. M., & Cameron, C. E. (2012). Self-regulation in early childhood: Improving conceptual clarity and developing ecologically valid measures. *Child Development Perspectives, 6*, 136-142.

- McClelland, M. M., & Wanless, S. B. (2012). Growing up with assets and risks: The importance of self-regulation for academic achievement. *Research in Human Development, 9*, 278-297. doi: 10.1111/j.1750-8606.2011.00191.x
- Miller, A. L., Seifer, R., Crossin, R., & Lebourgeois, M. K. (2015). Toddler's self-regulation strategies in a challenge context are nap-dependent. *Journal of Sleep Research, 24*, 279-287. doi: 10.1111/jsr.12260
- Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions four general conclusions. *Current Directions in Psychological Science, 21*, 8-14. doi: 10.1177/0963721411429458
- Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H.-L., ... Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences, 108*, 2693-2698. doi: 10.1073/pnas.1010076108
- Moilanen, K. L., Shaw, D. S., Dishion, T. J., Gardner, F., & Wilson, M. (2009). Predictors of longitudinal growth in inhibitory control in early childhood. *Social Development, 19*, 326-347. doi: 10.1111/j.1467-9507.2009.00536.x
- Muraven, M., & Baumeister, R. F. (2000). Self-regulation and depletion of limited resources: Does self-control resemble a muscle? *Psychological Bulletin, 126*, 247-259. doi: 10.1037/0033-2909.126.2.247
- Muthén, L. K., & Muthén, B. O. (1998-2012). *Mplus User's Guide* (7th ed.). Muthén & Muthén: Los Angeles, CA.
- Muthén, B. O., & Satorra, A. (1995). Complex sample data in structural equation modeling. *Sociological Methodology, 25*, 267-316.

- Raffaelli, M., Crockett, L. J., & Shen, Y.-L. (2005). Developmental stability and change in self-regulation from childhood to adolescence. *The Journal of Genetic Psychology, 166*, 54-76. doi: 10.3200/GNTP.166.1.54-76
- Raikes, H. A., Robinson, J. L., Bradley, R. H., Raikes, H. H., & Ayoub, C. C. (2007). Developmental trends in self-regulation among low-income toddlers. *Social Development, 16*, 128-149. doi: 10.1111/j.1467-9507.2007.00375.x
- Ramani, G. B., Brownell, C. A., & Campbell, S. B. (2010). Positive and negative peer interaction in 3-and 4-year-olds in relation to regulation and dysregulation. *The Journal of Genetic Psychology, 171*, 218-250. doi: 10.1080/00221320903300353
- Raver, C. C., Blackburn, E. K., Bancroft, M., & Torp, N. (1999). Relations between effective emotional self-regulation, attentional control, and low-income preschoolers' social competence with peers. *Early Education and Development, 10*, 333-350. doi: 10.1207/s15566935eed1003\_6
- Ridgers, N. D., Timperio, A., Cerin, E., & Salmon, J. (2015). Within-and between-day associations between children's sitting and physical activity time. *BMC Public Health, 15*(950), 1-7. doi: 10.1186/s12889-015-2291-3
- Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at three to seven years: The Children's Behavior Questionnaire. *Child Development, 72*, 1394-1408. doi: 10.1111/1467-8624.00355
- Ryu, E., & West, S. G. (2009). Level-specific evaluation of model fit in multilevel structural equation modeling. *Structural Equation Modeling, 16*, 583-601. doi: 10.1080/10705510903203466
- Satorra, A., & Bentler, P. M. (2001). A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika, 66*, 507-514. doi: 10.1007/BF02296192



- Sawyer, A. C. P., Chittleborough, C. R., Mittinty, M. N., Miller-Lewis, L. R., Sawyer, M. G., Sullivan, T., & Lynch, J. W. (2015). Are trajectories of self-regulation abilities from ages 2–3 to 6–7 associated with academic achievement in the early school years? *Child: Care, Health and Development, 41*, 744-754. doi: 10.1111/cch.12208
- Sawyer, A. C. P., Miller-Lewis, L. R., Searle, A. K., Sawyer, M. G., & Lynch, J. W. (2015). Is greater improvement in early self-regulation associated with fewer behavioral problems later in childhood? *Developmental Psychology, 51*, 1740-1755. doi: 10.1037/a0039829
- Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online, 8*(2), 23-74.
- Schmid, J., Stadler, G., Dirk, J., Fiege, C., & Gawrilow, C. (2016). ADHD symptoms in adolescents' everyday life fluctuations and symptom structure within and between individuals. *Journal of Attention Disorders*. Advance online publication. doi: 10.1177/1087054716629214
- Snijders, T., & Bosker, R. (2012). *Multilevel analysis. An introduction to basic and advanced multilevel modeling* (2nd ed.). Sage Publications: London.
- Spinrad, T. L., Eisenberg, N., Cumberland, A., Fabes, R. A., Valiente, C., Shepard, S. A., ... Guthrie, I. K. (2006). Relation of emotion-related regulation to children's social competence: A longitudinal study. *Emotion, 6*, 498-510. doi: 10.1037/1528-3542.6.3.498
- Suchodoletz, A. von, Gestsdottir, S., Wanless, S. B., McClelland, M. M., Birgisdottir, F., Gunzenhauser, C., & Ragnarsdottir, H. (2013). Behavioral self-regulation and relations to emergent academic skills among children in Germany and Iceland. *Early Childhood Research Quarterly, 28*, 62-73. doi: 10.1016/j.ecresq.2012.05.003

- Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality, 72*, 271-324. doi: 10.1111/j.0022-3506.2004.00263.x
- Thompson, R. A. (1994). Emotion regulation: A theme in search of definition. *Monographs of the Society for Research in Child Development, 59*, 25-52. doi: 10.1111/j.1540-5834.1994.tb01276.x
- Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, 54*, 131-143. doi:10.1111/jcpp.12001
- Trentacosta, C. J., & Shaw, D. S. (2009). Emotional self-regulation, peer rejection, and antisocial behavior: Developmental associations from early childhood to early adolescence. *Journal of Applied Developmental Psychology, 30*, 356-365. doi: 10.1016/j.appdev.2008.12.016
- Wagner, W. (2008). *Methodenprobleme bei der Analyse der Unterrichtswahrnehmung aus Schülersicht—am Beispiel der Studie DESI (Deutsch Englisch Schülerleistungen International) der Kultusministerkonferenz* [Methodological problems with the analysis of student's perceptions of teaching – on the example of the study DESI (German English student performances international) of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany] (Doctoral dissertation, University of Koblenz-Landau). Retrieved from <http://dnb.info/987591800/34>
- Wang, L., Hamaker, E., & Bergeman, C. S. (2012). Investigating inter-individual differences in short-term intra-individual variability. *Psychological Methods, 17*, 567-581. doi: 10.1037/a0029317
- Willoughby, M., Kupersmidt, J., Voegler-Lee, M., & Bryant, D. (2011). Contributions of hot

and cool self-regulation to preschool disruptive behavior and academic achievement.

*Developmental Neuropsychology*, 36, 162-180. doi: 10.1080/87565641.2010.549980

## Footnotes

<sup>1</sup> An additional two-level reliability estimate (based on multilevel CFA) is McDonald's omega (Geldhof et al. 2014). However, it was not possible to calculate omega since model identification failed for the attentional self-regulation factor due to the small number of indicators.

<sup>2</sup> We thank a reviewer for suggesting Ryu and West's (2009) approach for level-specific model fit evaluation in which each level is separately evaluated by defining partially saturated models. We estimated two partially saturated theoretical models and two partially saturated baseline models for each level. Similar to the  $SRMR_{within}$  and  $SRMR_{between}$  provided by Mplus (Table 2), the  $\chi^2$  estimates and CFIs showed that the model fitted worse on the between-person level.

Table 1

*Descriptive Statistics of Self-Regulation Items*

<i>Items<sup>b</sup></i>	Original item		<i>Average</i>		
	number	Factor <sup>c</sup>	<i>M (SD)<sup>d</sup></i>	<i>ISD (SD)</i>	<i>ICC</i>
Today, my child was frustrated when things did not work out as well as expected. <sup>a</sup>	1	e	3.96 (0.64)	0.91 (0.38)	.21
Today, my child was easily depressed when she/he did not accomplish a task. <sup>a</sup>	3	e	4.39 (0.61)	0.66 (0.47)	.30
Today, my child had strong mood swings. <sup>a</sup>	5	e	4.21 (0.62)	0.84 (0.50)	.21
Today, my child had difficulties shifting between tasks. <sup>a</sup>	9	e	4.56 (0.53)	0.50 (0.42)	.34
Today, my child was able to listen to others without interrupting them.	2	b	3.40 (0.62)	0.76 (0.33)	.29
Today, my child easily waited until his/her turn.	7	b	3.44 (0.58)	0.78 (0.39)	.23
Today, my child had difficulties following rules. <sup>a</sup>	8	b	3.96 (0.62)	0.85 (0.36)	.24
Today, my child blurted out answers without waiting until it was his/her turn. <sup>a</sup>	10	b	3.93 (0.63)	0.84 (0.40)	.25

Today, my child concentrated	6	a	3.80 (0.60)	0.65 (0.33)	.35
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easily.

Today, my child followed a	4	a	4.00 (0.60)	0.69 (0.41)	.29
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task through.

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*Notes.* *ISD* = intra-individual standard deviation (within-person); *ICC* = intraclass correlation coefficient. <sup>a</sup>Items are recoded (higher values mean higher self-regulation). <sup>b</sup>For all items, the full range of scale values (1 to 5) was used. <sup>c</sup>e = emotional, b = behavioral, a = attentional self-regulation. <sup>d</sup>Standard deviation of the group-means of individuals (between-person).

Table 2

*Model fit indices for the measurement models (multilevel CFA)*

<i>Model (factors)</i>	$\chi^2$ ( <i>df</i> )	<i>AIC</i>	<i>RMSEA</i>	<i>CFI</i>	<i>SRMR</i> ( <i>within/between</i> )
1. 1 within-1 between	393.15 (70)	18436.63	.08	.77	.08/.24
2. 2 within-2 between	201.57 (68)	18241.99	.05	.90	.05/.13
3. 3 within-3 between	164.34 (64)	18210.03	.05	.93	.04/.12
4. 3 within-2 between	170.53 (66)	18212.87	.05	.93	.04/.13

*Notes.* CFA = confirmatory factor analysis; *df* = degrees of freedom; *AIC* = Akaike Information Criterion; *RMSEA* = Root Mean Square Error of Approximation; *CFI* = Comparative Fit Index; *SRMR* = Standardized Root Mean Square Residual.

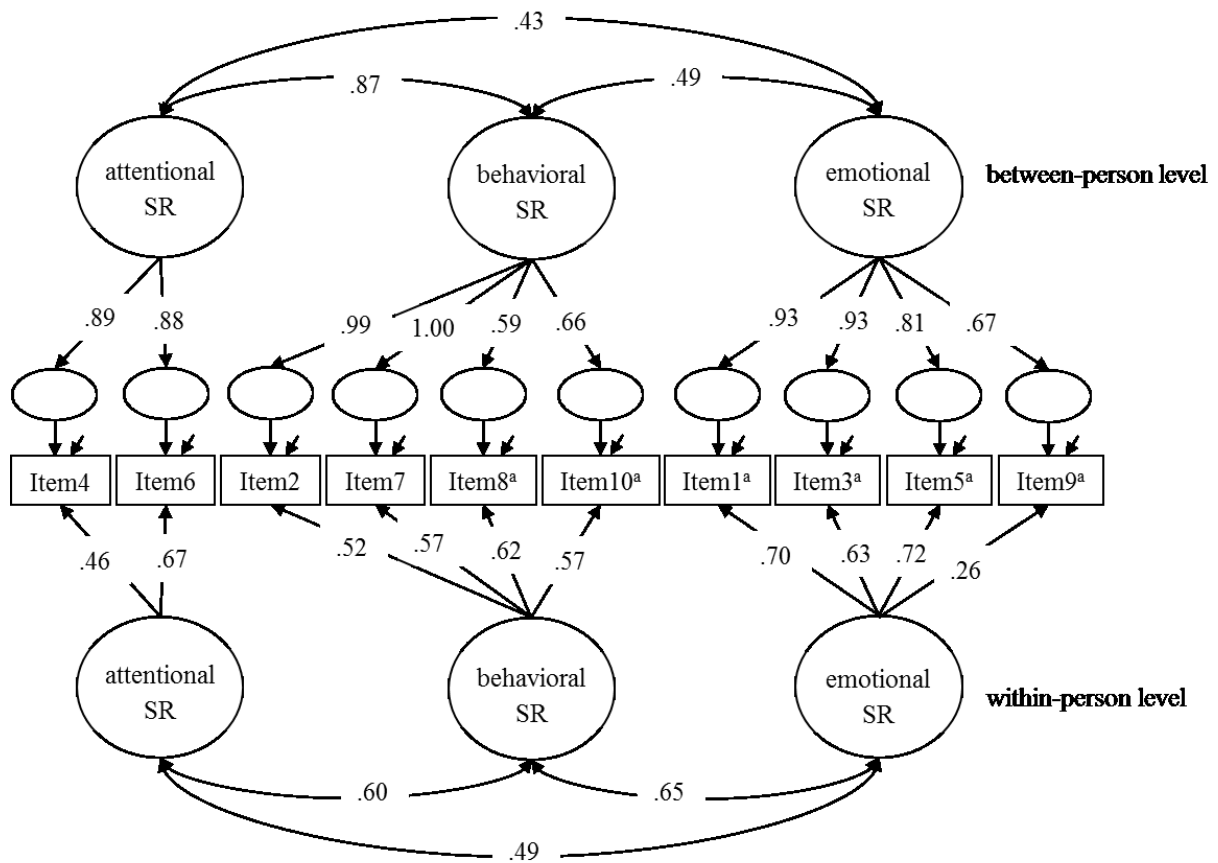


Figure 1. Factor structure, standardized factor loadings, and inter-factor correlations of the final model (Model 3). Short arrows reflect residual variances. All factor loadings are significant ( $p < .001$ ). SR = self-regulation. <sup>a</sup>Items are recoded.



## Appendix B – Publication 2

Ludwig, K., & Rauch, W. A. (2017). *Associations between physical activity, positive affect, and self-regulation during preschoolers' everyday lives*. Manuscript submitted for publication.

Associations between Physical Activity, Positive Affect, and Self-Regulation during  
Preschoolers' Everyday Lives

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This research was part of the BeR-Alltag project at the Junior Research Group: Development of Self-Regulation, and was partially funded by Field of Focus 4, University of Heidelberg. We thank our student research assistants for their highly committed work as well as the parents and children for their interest and participation in our research.

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## Abstract

**Objective:** Previous research on the beneficial effects of physical activity mostly focused on adult samples, although daily physical activity engagement is crucial for children's healthy development. The current study examines associations between preschool-aged children's physical activity, positive affect, and self-regulation during their everyday lives. Both direct and indirect associations between physical activity, positive affect, and self-regulation were investigated. **Methods:** For seven consecutive days, 98 children aged four to six years wore a tri-axial accelerometer (ActiGraph wGT3X-BT) to assess their moderate-to-vigorous physical activity (MVPA). During this week, parents rated their children's daily positive affect and self-regulation every evening either by an online questionnaire or via a phone interview. **Results:** A multilevel structural equation model revealed direct positive associations between daily MVPA and positive affect (within-person level) and between positive affect and self-regulation (within- and between-person levels). There were no direct positive associations between MVPA and self-regulation (within- and between-person level); at the within-person level, a small, unexpected negative association between MVPA and emotional self-regulation was found. MVPA and self-regulation were indirectly related through positive affect on a daily basis. **Conclusions:** Engaging in more MVPA than usual on a given day enhanced preschoolers' daily positive affect, which was associated with higher daily self-regulation levels. Whereas physical activity seems to have short-term effects on a daily basis, positive affect seems to facilitate children's self-regulation skills both intra- and inter-individually. The results emphasize the importance of promoting physical activity in young children for positively influencing their well-being.

*Keywords:* young children; multilevel SEM; accelerometry; diary

Associations between Physical Activity, Positive Affect, and Self-Regulation during  
Preschoolers' Everyday Lives

Physical activity, positive affect, and successful self-regulation are each crucial for children's well-being and healthy development, and there is growing evidence that they are interrelated in a mutually supportive way. Physical activity, defined as body movements by skeletal muscle contractions resulting in energy expenditure (Caspersen, Powell, & Christenson, 1985), has beneficial effects on children's mental and physical development (Ahn & Fedewa, 2011; Ekelund et al., 2012). Early experiences of positive affect (i.e., positively valenced, non-cognitive feeling states; Ekkekakis & Petruzzello, 2000) set the stage for building enduring personal resources such as resilience and psychological well-being (Fredrickson, 2001). Self-regulation, the adaptive modulation of emotion, attention, and behavior by oneself (Nigg, 2017), is demanded in various contexts throughout the lifespan and predictive for important outcomes in childhood and adulthood (Fergusson, Boden, & Horwood, 2013). Executive functions provide the cognitive capacity underlying self-regulatory performances (Hofmann, Schmeichel, & Baddeley, 2012). Children differ in their physical activity, positive affect, and self-regulation levels; deficits should hence be recognized early to prevent negative trajectories, for which early childhood is a sensitive developmental stage (Fredrickson, 2001; Montroy, Bowles, Skibbe, McClelland, & Morrison, 2016; Telama et al., 2014).

In adult samples it is well established that physical activity enhances positive affect inter-individually (i.e., between-subjects effects) and intra-individually (i.e., within-subjects effects, such as day-to-day fluctuations): Meta-analyses showed large benefits for subjects who engaged in exercise compared to subjects who had not been physically active (i.e., between-subjects effects; Ekkekakis, 2015), and recent reviews indicated that being more physically active than one's usual level predicts higher subsequent positive affective states

(i.e., within-subjects effects; Kanning, Ebner-Priemer, & Schlicht, 2013; Liao, Shonkoff, & Dunton, 2015). Evidence in younger samples is to date rare. There are two studies that investigated the relationship between physical activity and positive affect in the everyday life of children; however, results were mixed, as either no effects or only within-subjects effects were found (Dunton et al., 2014; Kühnhausen, Leonhardt, Dirk, and Schmiedek, 2013). Different biological (e.g., increased release of monoamines) and psychological (e.g., social interaction during physical activity, increased feelings of self-efficacy) processes are assumed to underlie the relation between physical activity and positive affect, but are still undergoing research (Paluska & Schwenk, 2000).

Direct beneficial effects of physical activity on children's self-regulation are expected because of experimental (between-subjects) studies that showed improved executive functioning in children who participated in physical exercise compared to non-exercising control children (Best, 2010). So far, three studies focused on the relationship between physical activity and self-regulation (as the integration of executive functions manifested in self-regulated emotional, behavioral, and attentional performances) in preschool-aged samples: Becker, McClelland, Loprinzi, and Trost (2014) found positive associations between preschooler's physical activity and observed self-regulation, while El Nokali (2012) and Schmutz and colleagues (2017) did not find any effects. Hence, more research is needed to clarify the effects of physical activity on children's self-regulation.

In addition to a direct association between physical activity and self-regulation, previous research indicates an indirect link between physical activity and self-regulation through positive affect. Researchers in motivational and social psychology consider positive affect as a psychological resource relevant to successful self-regulation (e.g., Sirois, 2015). In a similar vein, Davis and Suveg's (2014) transactional model of child positive affect stresses that positive affect serves as a regulatory function thus contributing to an adaptive

development. By both physiological (e.g., increases in dopamine; Ashby, Isen, & Turken, 1999) and psychological processes (e.g., broadening of individual's thought-action repertoires; Fredrickson, 2001) positive affect seems to facilitate successful self-regulation. Therefore, physical activity and self-regulation might be indirectly related through positive affect, which needs to be investigated.

### **Limitations of Existing Studies and Contributions of the Present Study**

Previous studies mostly focused on effects of physical activity in terms of structured interventions, trainings, or exercises. However, a large part of children's everyday physical activity occurs naturally and over various contexts (Ridgers, Stratton, & Fairclough, 2006). To capture this habitual physical activity, a continuous assessment is needed in contrast to short and deliberate interventions or exercises (Kanning et al., 2013), ideally by using accelerometer sensors rather than questionnaires. Empirical evidence showed only low-to-moderate correlations between reported and actual physical activity, and reported physical activity was usually overestimated. Also, most previous studies with younger samples typically considered inter-individual differences (i.e., between-person effects) while ignoring intra-individual differences (i.e., within-person effects, day-to-day variations). However, associations at the between-person level can be considerably different from associations at the within-person level (Wang & Maxwell, 2015); it is possible that there are associations at the within-person level but no associations at the between-person level and vice versa.

The present study aims at closing these research gaps. It is the first study that simultaneously investigates associations between physical activity, positive affect, and self-regulation within the same data set in a young, preschool-aged sample. A prospective study design with seven consecutive measurement days was applied to attain a detailed insight into preschool-aged children's everyday life, tracing preschoolers' ambulatory-assessed habitual physical activity, positive affect, and self-regulation on a daily basis. The nested design (i.e.,

days nested within persons) allows for differentiating intra-individual (i.e., within persons) from inter-individual (i.e., between persons) effects. Given previous research reviewed earlier, both direct and indirect associations between children's physical activity, positive affect, and self-regulation are assumed. Specifically, four hypotheses were tested, which were considered at the within-person and between-person levels:

*H1*: Physical activity is positively related to preschoolers' positive affect.

*H2*: Physical activity is positively related to preschoolers' behavioral, emotional, and attentional self-regulation.

*H3*: Positive affect is positively related to preschoolers' behavioral, emotional, and attentional self-regulation.

*H4*: Physical activity is indirectly positively related to preschoolers' behavioral, emotional, and attentional self-regulation through positive affect.

## **Method**

### **Participants**

The present study was part of a larger research project that investigated different influencing factors on preschoolers' self-regulation and physical activity at the individual, family, and preschool levels. Leaflets and information letters were distributed in eight different preschools in the XXX region in Germany. Children had to be between four to six years old and able-bodied (i.e., non-dependent on a wheelchair) to be included in the sample. Parents of 108 children interested in participation gave written informed consent in accordance with the ethical standards in research and publication of the American Psychological Association (APA, 2010). Of these, ten cases had to be excluded from further analyses because of invalid accelerometer wear-time (see below). Thus, the final sample consisted of 98 parents (85% mothers) with their children aged four to six years ( $M_{\text{age}} = 4.86$ ,  $SD_{\text{age}} = 0.71$ ; 43% girls). On average, participants' socio-economic status (SES) was in the

middle to upper range, as indicated by education and income: In total, 60.2% mothers had school qualifications for university entrance and the average net family income per month was €3,959 ( $SD = €1,878$ ). This approximately corresponds to the income distribution in the XXXX region (Statistical Office of the Federal State XXXX, 2016).

### **Design and Procedure**

Data collection took place between March and August 2015 and was carried out by trained members of our research group. Children's height and weight were measured in a separate room provided by each preschool to set the accelerometers. Several days later, data collectors demonstrated the children and a kindergarten teacher how to correctly wear the sensors. The demonstrations were pre-structured and the same for all children. The parents were given information sheets that detailed instructions on the use of the accelerometers and the correct wearing method. The children were asked to wear the accelerometers the whole day during waking hours except during water-based activities for eight days. The first day of monitoring was excluded from further analyses, as the whole waking time was not completely covered and the children familiarized themselves with their accelerometer. Thus, the study included five weekdays (i.e., preschool days) and two weekend days. The parents could choose whether they wished to answer the daily questions about their child's self-regulation and positive affect by phone or by an online questionnaire. 43% chose the telephone interview, which were called every evening at about 7pm and were asked about their child's self-regulation and positive affect on the particular day. The parents who chose the online questionnaire received an email with an individualized link to their online diary every evening at about 7pm. Parent's choice (i.e., telephone interview vs. online questionnaire) was not associated with outcome variables. Most of the daily questions (85%) were answered by mothers; for 19 children, on some days the questions were answered by one parent and on the other days by the other parent. After the last measurement day, accelerometers were handed



back and families received €50 for their participation in the complete study. The study was approved by the ethics committee of the XXXX University (project title: XXXXX).

## Measures

**Physical activity.** Daily physical activity was assessed with tri-axial accelerometers (ActiGraph wGT3X-BT, Pensacola, FL) attached above each child's right hipbone via an elastic belt. The wGT3x-BT measures acceleration in a horizontal, vertical, and perpendicular axis in a dynamic range from  $\pm 8$  g. Sampling rate was set to 100Hz. Data were downloaded and processed using ActiLife software version 6. Only those participants were included who had at least three valid weekdays and one valid weekend day. A valid day contained at least eight hours of wear time. Non-wear time was defined after 20 minutes of consecutive zero counts, which is adequate for this age group (Thiel, Gabrys, & Vogt, 2016). For all valid participants and days, accelerometer's activity counts were categorized into different intensities (i.e., sedentary, light, moderate, and vigorous) by using the cutpoints by Butte and colleagues (2014), specifically developed for tri-axial accelerometers in preschool-aged samples. Physical activity was operationalized as minutes in moderate-to-vigorous physical activity (MVPA) per day. Since data collection took place during summer, swimming activities were additionally taken into account, as indicated by the parents during their diary assessments.

**Positive affect.** Daily positive affect was assessed by parent report, using a short German version of the PANAS-C (Laurent et al., 1999). The original PANAS-C consists of 30 items (Laurent et al., 1999). Using data from a previous study (Laufs, unpublished data) with  $N = 166$  children, a 10-item version suitable for daily diary research was created based on factor loadings ( $> .63$ ), discriminatory power ( $> .56$ ), item difficulty (about  $.50$ ), skewness ( $< .39$ ), kurtosis ( $< .84$ ), and content considerations. The item stem was transferred into the same diary format for all items (i.e., 'today, my child was...'). The positive affect scale

consists of five items (e.g., 'happy'). Parents answered the items using a 5-point Likert scale ranging from 1 'this is not true' to 5 'this is very true'. Two-level reliability coefficients were estimated using Generalizability Theory-based coefficients (Cranford et al., 2006). The reliabilities were satisfactory for the between-person level (reliability across all days,  $R_{KF} = .97$ ) and the within-person level (reliability of within-person changes,  $R_C = .83$ ).

**Self-regulation.** Daily successful self-regulation was assessed with a 10-item questionnaire developed within our research group. Parents answered the items using a 5-point Likert scale ranging from 1 'this is not true' to 5 'this is very true'. The items measured three self-regulation facets, which were previously identified via two-level confirmatory factor analyses (XXX, 2016): four items captured emotional self-regulation (e.g., 'today, my child was frustrated when things did not work out as well as expected (recoded)'), four items captured behavioral self-regulation (e.g., 'today, my child easily waited until his/her turn'), and two items captured attentional self-regulation (e.g., 'today, my child concentrated easily'). The differentiated factor structure is adequate at the within- and between-person levels (XXX, 2016). The two-level reliability coefficients (Cranford et al., 2006) were  $R_{KF} = .90$  (between-person level) and  $R_C = .67$  (within-person level) for emotional self-regulation,  $R_{KF} = .92$  (between-person level) and  $R_C = .66$  (within-person level) for behavioral self-regulation, and  $R_{KF} = .90$  (between-person level) and  $R_C = .46$  (within-person level) for attentional self-regulation.

### Data Analysis

Data were hierarchically structured with repeated daily measurements (L1) nested within persons (L2). Intraclass correlations (ICCs) were calculated to assess the amount of within-person dependency of observations, respectively the need to decompose within- (L1) from between-person (L2) variance. Hypotheses were tested within a multilevel structural equation model (MSEM) framework (Preacher, Zyphur, & Zhang, 2010). It was previously

tested whether time (i.e., day), diary version (online questionnaire vs. telephone interview), children's age and gender needed to be controlled in the model. None of those had significant effects on the endogenous variables; hence they were not included to achieve a parsimonious model. The model (Fig. 1) was estimated using Mplus version 7 (Muthén & Muthén, 1998-2012) with a robust maximum likelihood estimator (MLR). A full information maximum likelihood approach (FIML) was used in Mplus by default to handle missing data. Manifest analyses (i.e., path model) within the MSEM framework were performed since a latent model (i.e., factor analysis) would have had as many parameters (98) as there are observations (persons) at L2. It has to be noted that the confidence intervals (CIs) obtained by Mplus (delta method) are not adequate for significance tests of the indirect effects, as their sampling distribution typically is non-normal (Preacher et al., 2010). Therefore, a web-based Monte Carlo method for assessing multilevel (unstandardized) indirect effects provided by Preacher and Selig (2010) was used to obtain adequate CIs.

## Results

### Preliminary Analyses

**Compliance.** The number of missing diary entries was used as an indicator of parents' compliance over the measurement period. Missings were low for the positive affect and self-regulation ratings: ten out of 98 parents missed their diary entry on one out of seven days for positive affect, behavioral self-regulation, and emotional self-regulation (1.46% missing data); regarding attentional self-regulation, an additional person did not complete the questions on two days (1.75% missing data). Among these missing data, in five cases there were missing values on both exogenous and endogenous variables on the same day; these missing occasions could not be managed by FIML and were excluded from further analyses. With regard to physical activity, the children wore their accelerometers on 6.58 out of seven days ( $SD = 0.64$ ) for at least 480 minutes (inclusion criterion), with an average wear-time of

703.96 minutes per day ( $SD = 88.50$ ). Thus, compliance was high for the parents and the children.

**Descriptives.** Descriptive statistics and correlations between indicators are depicted in Table 1. On 75% of all days, children spent at least 60 minutes per day in MVPA, thus fulfilling the World Health Organization's criterion for a healthy development (WHO, 2010). About a quarter (26.5%) of all children spent at least 60 minutes in MVPA on all seven days during the measurement period. ICCs ranged from .30 (emotional self-regulation) to .42 (positive affect), reflecting non-independent observations (L1) nested in persons (L2). In other words, about 30-42% of the overall variance in positive affect and self-regulation was attributable to inter-individual differences (i.e., between subjects) and about 58-70% to intra-individual differences (i.e., differences from day-to-day within subjects). Additionally, the children were nested in eight different preschools, introducing a third level; hence, it was tested whether there was the need to account for dependency at the preschool level. However, the design effect, which is a function of the ICC and the average cluster size, was smaller than 2 for all four endogenous variables, indicating that there is no data dependency on a third level (Muthén & Satorra, 1995).

INSERT TABLE 1 HERE.

### **Multilevel SEM**

Since MVPA units (i.e., minutes) are much smaller in scale compared to positive affect and self-regulation, standardized effects of the MSEM are reported to facilitate the interpretation of effect sizes (see Fig. 1).

**Direct relations between MVPA and positive affect (H1).** At the within-person level, MVPA throughout the day significantly predicted positive affect in the evening ( $\beta = .168$ , 95% CI [.089, .247]). At the between-person level, MVPA was not significantly associated with positive affect ( $\beta = -.049$ , 95% CI [-.231, .132]).

**Direct relations between MVPA and self-regulation (H2).** At the within-person level, daily MVPA was neither associated with behavioral self-regulation ( $\beta = -.028$ , 95% CI [-.108, .052]) nor attentional self-regulation ( $\beta = -.056$ , 95% CI [-.119, .008]) but there was a significant negative association with emotional self-regulation ( $\beta = -.094$ , 95% CI [-.154, -.033]). At the between-person level, person-averaged MVPA was not significantly related to self-regulation (behavioral:  $\beta = -.131$ , 95% CI [-.346, .083]; emotional:  $\beta = -.097$ , 95% CI [-.299, .105]; attentional:  $\beta = -.060$ , 95% CI [-.213, .093]), indicating that children with a generally higher amount of MVPA did not typically show higher self-regulation levels.

**Direct relations between positive affect and self-regulation (H3).** At the within-person level, daily positive affect was significantly directly associated with all three facets of daily self-regulation (behavioral:  $\beta = .212$ , 95% CI [.131, .294]; emotional:  $\beta = .397$ , 95% CI [.309, .486]; attentional:  $\beta = .269$ , 95% CI [.183, .355]), indicating that on days on which children showed higher positive affect they also showed higher self-regulation levels compared to days with lower positive affect. At the between-person level, positive affect was also significantly associated with all three facets of self-regulation (behavioral:  $\beta = .424$ , 95% CI [.271, .578]; emotional:  $\beta = .336$ , 95% CI [.176, .495]; attentional:  $\beta = .686$ , 95% CI [.537, .836]). That is, children who received on average higher positive affect ratings showed higher mean ratings of behavioral, emotional, and attentional self-regulation in comparison to children with lower positive affect ratings.

**Indirect relations between MVPA and self-regulation through positive affect (H4).** To obtain CIs for the indirect effects, Preacher and Selig's (2010) Monte Carlo method uses the unstandardized path coefficients. In the following, the results for the indirect effects using unstandardized coefficients and their associated CIs and additionally the standardized coefficients will be reported. The indirect within-subjects effects of MVPA via daily positive affect were significant for behavioral ( $b = 0.001$ , 95% CI [0.0002, 0.0012], standardized

effect:  $\beta = .036$ ), emotional ( $b = 0.001$ , 95% CI [0.0004, 0.0022], standardized effect:  $\beta = .067$ ), and attentional self-regulation ( $b = 0.001$ , 95% CI [0.0003, 0.0015], standardized effect:  $\beta = .045$ ). That is, on days where the children engaged in higher MVPA they showed higher positive affect, which was in turn associated with better self-regulatory skills. In contrast, the indirect between-subjects effects through positive affect were not significant for all three self-regulation facets (behavioral:  $b = 0.000$ , 95% CI [-0.0022, 0.0012], standardized effect:  $\beta = -.021$ ; emotional:  $b = 0.000$ , 95% CI [-0.0018, 0.0008], standardized effect:  $\beta = -.016$ ; attentional:  $b = -0.001$ , 95% CI [-0.0040, 0.0021], standardized effect:  $\beta = -.034$ ).

INSERT FIGURE 1 HERE.

Overall, positive affect and MVPA accounted for 5% in behavioral self-regulation, 15% in emotional self-regulation, and 7% in attentional self-regulation at the within-person level. Daily MVPA accounted for 3% of the variance in positive affect. At the between-person level, positive affect and MVPA accounted for 20% of the variance in behavioral self-regulation, 13% in emotional self-regulation, and 48% in attentional self-regulation. Mean MVPA accounted for 0% in mean positive affect (between-person level).

### Discussion

This is the first study that investigated direct and indirect associations between physical activity (i.e., time spent in MVPA throughout the day), positive affect, and successful self-regulation (reported by parents in the evening) in a young sample of healthy preschool-aged children. A prospective study design with seven consecutive measurement days was applied, which allows for differentiating daily intra-individual (within-person level) from inter-individual (between-person level) effects while controlling for each other.

Hypothesis 1 posited a beneficial direct relationship between MVPA and positive affect, and this was confirmed at the within-person but not at the between-person level. This finding extends previous studies that also revealed beneficial intra-individual effects of

physical activity on positive affect in the same order of magnitude in older samples (Dunton et al., 2014; Flueckiger, Lieb, Meyer, Witthauer, & Mata, 2017). Like Dunton and colleagues (2014), this effect was found at the within-person but not at the between-person level. That means, children who had a higher mean MVPA over the whole measurement period did not show a higher mean positive affect compared to children who showed a lower mean MVPA. Nevertheless, it was on average true for all children that on days on which they were more physically active than usual they also had higher positive affect ratings. Hence, physical activity seems to constitute a psychological resource contributing to positive affect primarily on a daily basis. In contrast, at the between-person level, other factors besides physical activity might be more important to person-mean positive affect (e.g., parents' positive affect, parenting; Davis & Suveg, 2014). The divergent effects also indicate rather short-term (state) than trait effects of physical activity on positive affect.

In contrast to our expectations, MVPA was unrelated to behavioral and attentional self-regulation at the within-person level and also to any facet of self-regulation at the between-person level (H2). Moreover, daily MVPA was significantly negatively associated with emotional self-regulation at the within-person level. Therefore, hypothesis 2 assuming beneficial direct effects of physical activity on children's self-regulation was not confirmed. On the one hand, the lack of associations is in accordance with recent results of other studies that also did not find any significant relations between young children's accelerometer-assessed MVPA and their self-regulation skills (El Nokali, 2012; Schmutz et al., 2017). On the other hand, previous research strongly indicates beneficial between-subjects effects of physical activity on children's executive functions as one central aspect of self-regulation (e.g., Best, 2010). This research does, however, mostly consist of experimental studies comparing a group of children who engaged in acute physical exercise with a control group. Best (2010) concluded that beneficial effects of physical activity on cognitive functioning

seem to be primarily demonstrated immediately after cognitively demanding playful physical activities with peers. However, direct positive effects of physical activity on children's self-regulation seem to be rather difficult to find when MVPA is accumulated throughout the day during children's normal everyday lives.

The significant negative effect of daily MVPA on daily emotional self-regulation ran contrary to our expectations. According to Zhao, Lynch, and Chen (2010) such findings are called "competitive mediation" (p. 200), since the indirect effect was positive and the direct effect was negative (i.e., opposite directions). This indicates the possible existence of a second mediator explaining the competitive effect. In such cases, further research is recommended considering omitted negative indirect paths (Zhao et al., 2010). A possible omitted mechanism explaining the negative direct path from MVPA to emotional self-regulation might be subjective fatigue (Hagger, Wood, Stiff, & Chatzisarantis, 2010). Therefore, data were reanalyzed using only vigorous physical activity as predictor, assuming that more intense physical activity would have led to more feelings of fatigue in comparison to MVPA. The results revealed a comparatively stronger negative association with emotional self-regulation ( $\beta = -.106, p < .01$ ), suggesting that engaging in more intense physical activities than usual throughout the day could have led to subjective feelings of physiological fatigue and hence self-regulation resource depletion (Hagger et al., 2010). However, questions asking about children's feelings of fatigue were not included in this study; hence, this assumption needs to be tested in future research.

Hypothesis 3 postulated direct beneficial effects of positive affect on children's self-regulation. This was confirmed at the within-person and between-person levels. That is, on days on which children had higher positive affect ratings than usual they also showed higher behavioral, emotional, and attentional self-regulation (within-person level), and children who displayed higher mean positive affect compared to other children also showed higher mean



self-regulation (between-person level). These findings are in line with Davis and Suveg's (2014) transactional model of child positive affect and with other models that also consider positive affect as kind of a psychological resource needed for self-regulation performances (Sirois, 2015). Hence, the present study provides further evidence for the beneficial function of positive affect for children's adaptive development.

Finally, hypothesis 4 assumed that MVPA has an indirect effect on children's self-regulation through positive affect, and this was partly confirmed (i.e., at the within-person level): Engaging in more minutes of MVPA than usual on a given day fostered positive affect at this day, which in turn was positively associated with children's daily behavioral, emotional, and attentional self-regulation. Likewise, Flueckiger and colleagues (2017) showed in an older sample that positive affect mediated the relationship between day-to-day physical activity and daily learning goal achievement, with similar small but significant coefficients. Therefore, further evidence is added by the present study for positive affect constituting a psychological mechanism, facilitating beneficial effects of physical activity on cognitive and motivational variables.

In sum, the findings of the present study highlight the importance of physical activity and positive affect for children's adaptive development. Day-to-day physical activity seems to be a promising factor influencing children's positive affect, which was associated with children's self-regulation during their everyday life. Since physical activity is fun and motivating and easy to integrate into children's everyday lives, fostering children's physical activity to positively influence their physiological and psychological development is further recommended.

### **Limitations and Future Directions**

Several limitations of the present study should be acknowledged. Positive affect and self-regulation were both assessed by parents' reports, and this is problematic for different

reasons: First, although efforts were made to reduce potential common method variance by using accelerometers instead of questionnaires to assess children's physical activity, using the same informants for mediator (i.e., positive affect) and outcome variables (i.e., self-regulation) could have led to overestimations of the relationships between positive affect and self-regulation. Second, some studies in clinical research indicate a limited convergence between child- and parent-reported symptoms (De Los Reyes & Kazdin, 2005). However, in research with preschool-aged children, parent reports are often the (only) method of choice, since children have difficulties in representing complex internal experiences that are required for self-reports (Luby, Belden, Sullivan, & Spitznagel, 2007) and they cannot yet read or write. However, the question remains whether parents' reports or preschool teachers' reports seem to be more appropriate. Since the children spend a large part of their waking hours in preschools, the preschool teachers might more accurately estimate children's self-regulation and positive affect throughout the day. However, preschool teachers have to supervise multiple children throughout the day; thus, focusing on one child to adequately rate its self-regulation throughout the day is quite difficult in practice. Moreover, the majority of children in the present study left the preschool before 3pm (i.e., about 69%) and the study design also included weekend days – hence there would be missing data in the case of preschool teacher-reports. Therefore, parents' reports were chosen to measure preschoolers' daily positive affect and self-regulation. Nevertheless, for future research it would be interesting to combine preschool teachers' reports and parents' reports to get further insights into children's self-regulation in different contexts and to control for potential informant effects.

Another limitation is that the sample was self-selected; for this reason it could be possible that in particular those parents who were interested in physical activity participated at the study, and the children thus might have displayed more minutes of MVPA per day compared to other samples. Recently, Ravagnani and colleagues (2017) reviewed different

studies that also investigated preschoolers daily MVPA by using hip-worn ActiGraph devices. To increase comparability over the different studies using different accelerometer cutpoints, they transformed the studies' reported means of MVPA (min/day). The adjusted overall mean reported by Ravagnani and colleagues (2017;  $M = 89.35$  minutes of MVPA) was similar to the present study ( $M = 94.50$  minutes of MVPA). Likewise, Schmutz and colleagues (2017) recently reported a mean value of 93 minutes spent in MVPA using the same accelerometer (ActiGraph wGT3X-BT) in a preschool-aged sample, indicating comparability of the present study's sample.

Finally, the mediation analysis implies a causal direction that cannot actually be derived from the present study design as positive affect and self-regulation were measured at the same time. Reverse effects, that is, beneficial effects of positive affect and self-regulation on physical activity or, respectively, self-regulation on positive affect are likewise possible but need further clarification: Regarding the effects of positive affect on subsequent physical activity, Liao and colleagues (2015) reported evidence for beneficial effects of prior positive affect on subsequent physical activity in adult samples, whereas Dunton and colleagues (2014) did not find any effects of children's affective states on their subsequent MVPA. Likewise, beneficial effects of self-regulation on positive affect or well-being seem to be consequential in light of the fact that the ability to managing goal conflicts and resisting impulsive temptations facilitates adaptive responding to different situational demands and mastering developmental tasks (Hofer, Busch, & Kärtner, 2011). Empirically, first beneficial effects of self-regulation on positive affect are indicated in adult samples (Hofer et al., 2011). Likewise, self-regulatory processes enable individuals to overcome intention-behavior gaps, thus increasing health-related behaviors such as physical activity participation (Michie, Abraham, Whittington, McAteer, & Gupta, 2009). Hence, reverse effects between self-

regulation, physical activity, and positive affect are indicated but need to be clarified in future research and particularly in younger samples.

Future studies should also include occasion-to-occasion assessments to better capture the dynamics between physical activity, positive affect, and self-regulation throughout the day. This could further shed light into the assumption that physical activity seems to have rather short-term effects on children's positive affect and self-regulation. Additionally, within a more continuously closely monitored study design it could be possible to assess different contexts the children inhabit, thus considering preceding events that evoke higher positive affect or self-regulation (i.e., event-contingent sampling). However, ambulatory assessments (e.g., via smartphones) of non-physiological indicators such as affective states are quite difficult to carry out in preschool-aged samples. Here, a feasibility study applying, for example, tablets with auditory items and a smiley scale to indicate psychological states could be a next step towards a closer understanding of short-term relations between variables that are important for children's healthy development, such as physical activity, positive affect, and self-regulation.

### **Conclusion**

The present study contributes to a better understanding of the relationships between preschool children's everyday physical activity, positive affect, and self-regulation. On a daily basis, preschoolers' accelerometer-assessed everyday MVPA was positively and directly associated with their daily positive affect, which was positively associated with their daily behavioral, emotional, and attentional self-regulation. Promoting children's habitual physical activity seems to be a promising factor to early positively influence young children's well-being in a natural way during their everyday lives.

### **Declaration of interests and funding**

The author(s) declare no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

## References

- Ahn, S., & Fedewa, A. L. (2011). A meta-analysis of the relationship between children's physical activity and mental health. *Journal of Pediatric Psychology, 82*, 1-13. doi: 10.1093/jpepsy/jsq107
- American Psychological Association (2010). *Ethical principles of psychologists and code of conduct*. Retrieved from <http://www.apa.org/ethics/code/>
- Ashby, F. G., Isen, A. M., & Turken, U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106*, 529-550.
- Becker, D. R., McClelland, M. M., Loprinzi, P., & Trost, S. G. (2014). Physical activity, self-regulation, and early academic achievement in preschool children. *Early Education & Development, 25*, 56-70. doi: 10.1080/10409289.2013.780505
- Best, J. R. (2010). Effects of physical activity on children's executive function: contributions of experimental research on aerobic exercise. *Developmental Review, 30*, 331-351.
- Butte, N. F., Wong, W. W., Lee, J. S., Adolph, A. L., Puyau, M. R., & Zakeri, I. F. (2014). Prediction of energy expenditure and physical activity in preschoolers. *Medicine & Science in Sports & Exercise, 46*, 1216-1226. doi:10.1249/MSS.0000000000000209
- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports, 100*, 126-131.
- Cranford, J. A., Shrout, P. E., Iida, M., Rafaeli, E., Yip, T., & Bolger, N. (2006). A procedure for evaluating sensitivity to within-person change: can mood measures in diary studies detect change reliably? *Personality and Social Psychology Bulletin, 32*, 917-929. doi: 10.1177/0146167206287721

- Davis, M., & Suveg, C. (2014). Focusing on the positive: a review of the role of child positive affect in developmental psychopathology. *Clinical Child and Family Psychology Review, 17*, 97-124. doi: 10.1007/s10567-013-0162-y
- De Los Reyes, A., & Kazdin, A. E. (2005). Informant discrepancies in the assessment of childhood psychopathology: a critical review, theoretical framework, and recommendations for further study. *Psychological Bulletin, 131*, 483-509. doi: 10.1037/0033-2909.131.4.483
- Dunton, G. F., Huh, J., Leventhal, A. M., Riggs, N., Hedeker, D., Spruijt-Metz, D., & Pentz, M. A. (2014). Momentary assessment of affect, physical feeling states, and physical activity in children. *Health Psychology, 33*, 255-263. doi: 10.1037/a0032640
- Ekelund, U., Luan, J., Sherar, L. B., Esliger, D. W., Griew, P., & Cooper, A. (2012). Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *The Journal of the American Medical Association, 307*, 704-712. doi: 10.1001/jama.2012.156
- Ekkekakis, P., & Petruzzello, S. J. (2000). Analysis of the affect measurement conundrum in exercise psychology: I. fundamental issues. *Psychology of Sport and Exercise, 1*, 71-88. doi: 10.1016/S1469-0292(00)00010-8
- Ekkekakis, P. (2015). Honey, I shrunk the pooled SMD! Guide to critical appraisal of systematic reviews and meta-analyses using the Cochrane review on exercise for depression as example. *Mental Health and Physical Activity, 8*, 21-36. doi: 10.1016/j.mhpa.2014.12.001
- El Nokali, N. E. (2012). *The intersection of physical activity, self-regulation and academic achievement: implications for educational success* (Doctoral dissertation). Retrieved from <http://d-scholarship.pitt.edu/10487/>

- Fergusson, D. M., Boden, J. M., & Horwood, L. J. (2013). Childhood self-control and adult outcomes: results from a 30-year longitudinal study. *Journal of the American Academy of Child & Adolescent Psychiatry, 52*, 709-717. doi: 10.1016/j.jaac.2013.04.008
- Flueckiger, L., Lieb, R., Meyer, A. H., Witthauer, C., & Mata, J. (2017). Day-to-day variations in health behaviors and daily functioning: two intensive longitudinal studies. *Journal of Behavioral Medicine, 40*, 307-319. doi: 10.1007/s10865-016-9787-x
- Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: the broaden-and-build theory of positive emotions. *American Psychologist, 56*, 218-226.
- Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2010). Ego depletion and the strength model of self-control: a meta-analysis. *Psychological Bulletin, 136*, 495-525. doi: 10.1037/a0019486
- Hofer, J., Busch, H., & Kärtner, J. (2011). Self-regulation and well-being: the influence of identity and motives. *European Journal of Personality, 25*, 211-224. doi: 10.1002/per.789
- Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences, 16*, 174-180. doi: 10.1016/j.tics.2012.01.006
- Kanning, M. K., Ebner-Priemer, U., & Schlicht, W. M. (2013). How to investigate within-subject associations between physical activity and momentary affective states in everyday life: a position statement based on a literature overview. *Frontiers in Psychology, 4*, 1-16. doi: 10.3389/fpsyg.2013.00187
- Kühnhausen, J., Leonhardt, A., Dirk, J., & Schmiedek, F. (2013). Physical activity and affect in elementary school children's daily lives. *Frontiers in Psychology, 4*, 1-8. doi: 10.3389/fpsyg.2013.00456
- Laufs, R. (2013). [Master thesis]. Unpublished raw data.



- Laurent, J., Catanzaro, S. J., Joiner, T. E. Jr., Rudolph, K. E., Potter, K. I., Lambert, S., ... Gathright, T. (1999). A measure of positive and negative affect for children: scale development and preliminary validation. *Psychological Assessment, 11*, 326-338. doi: 10.1037/1040-3590.11.3.326
- Liao, Y., Shonkoff, E. T., & Dunton, G. F. (2015). The acute relationships between affect, physical feeling states, and physical activity in daily life: a review of current evidence. *Frontiers in Psychology, 6*, 1-7. doi: 10.3389/fpsyg.2015.01975
- Luby, J. L., Belden, A., Sullivan, J., & Spitznagel, E. (2007). Preschoolers' contribution to their diagnosis of depression and anxiety: uses and limitations of young child self-report of symptoms. *Child Psychiatry and Human Development, 38*, 321-338. doi: 10.1007/s10578-007-0063-8
- Michie, S., Abraham, C., Whittington, C., McAteer, J., & Gupta, S. (2009). Effective techniques in healthy eating and physical activity interventions: a meta-regression. *Health Psychology, 28*, 690-701. doi: 10.1037/a0016136
- Montroy, J. J., Bowles, R. P., Skibbe, L. E., McClelland, M. M., & Morrison, F. J. (2016). The development of self-regulation across early childhood. *Developmental Psychology, 52*, 1744-1762. doi: 10.1037/dev/0000159
- Muthén, B. O., & Satorra, A. (1995). Complex sample data in structural equation modeling. *Sociological Methodology, 25*, 267-316. Retrieved from <http://www.jstor.org/stable/271070>
- Muthén, L. K., & Muthén, B. O. (1998-2012). *Mplus User's Guide, Seventh Edition*. Los Angeles, CA: Author.
- Nigg, J. T. (2017). Annual research review: On the relations among self-regulation, self-control, executive functioning, effortful control, cognitive control, impulsivity, risk-

- taking, and inhibition for developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *58*, 361-383. doi: 10.1111/jcpp.12675
- Paluska, S. A., & Schwenk, T. L. (2000). Physical activity and mental health: current concepts. *Sports Medicine*, *29*, 167-180.
- Preacher, K. J., & Selig, J. P. (2010, July). Monte Carlo method for assessing multilevel Mediation: An interactive tool for creating confidence intervals for indirect effects in 1-1-1 multilevel models [Computer software]. Available from <http://quantpsy.org/>
- Preacher, K. J., Zyphur, M. J., & Zhang, Z. (2010). A general multilevel SEM framework for assessing multilevel mediation. *Psychological Methods*, *15*, 209-233. doi: 10.1037/a0020141
- Ravagnani, F. C. P., Coelho-Ravagnani, C. F., Brazendale, K., Weaver, R. G., Bornstein, D. B., & Beets, M. W. (2017). Application of the Rosetta Stone to understand how much MVPA preschoolers accumulate: a systematic review. *Journal of Science and Medicine in Sport*. Advance online publication. doi: 10.1016/j.jsams.2017.02.003
- Ridgers, N. D., Stratton, G., & Fairclough, S. J. (2006). Physical activity levels of children during school playtime. *Sport Medicine*, *36*, 359-371.
- Schmutz, E. A., Leeger-Aschmann, C. S., Radtke, T., Muff, S., Kakebeeke, T. H., Zysset, A. E., ... Kriemler, S. (2017). Correlates of preschool children's objectively measured physical activity and sedentary behavior: a cross-sectional analysis of the SPLASHY study. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 1-13. doi: 10.1186/s12966-016-0456-9
- Sirois, F. M. (2015). A self-regulation resource model of self-compassion and health behavior intentions in emerging adults. *Preventive Medicine Reports*, *2*, 218-222. doi: 10.1016/j.pmedr.2015.03.006
- Statistical Office of the Federal State xxxx (2016). xxxxx [xxxx]. Retrieved from xxxxxxx

Telama, R., Yang, X., Leskinen, E., Kankaanpää, A., Hirvensalo, M., Tammelin, T., ...

Raitakari, O. T. (2014). Tracking of physical activity from early childhood through youth into adulthood. *Medicine & Science in Sports & Exercise*, *46*, 955-962. doi: 10.1249/MSS.0000000000000181

Thiel, C., Gabrys, L., & Vogt, L. (2016). Registrierung körperlicher Aktivität mit tragbaren Akzelerometern [Measuring physical activity with wearable accelerometers]. *Deutsche Zeitschrift für Sportmedizin*, *67*, 44-48. doi: 10.5960/dzsm.2016.220

Wang, L. P., & Maxwell, S. E. (2015). On disaggregating between-person and within-person effects with longitudinal data using multilevel models. *Psychological Methods*, *20*, 63-83. doi: 10.1037/met0000030

World Health Organization (2010). *Global recommendations on physical activity for health*.

Retrieved from

[http://apps.who.int/iris/bitstream/10665/44399/1/9789241599979\\_eng.pdf](http://apps.who.int/iris/bitstream/10665/44399/1/9789241599979_eng.pdf)

Zhao, X., Lynch, J. G. Jr., & Chen, Q. (2010). Reconsidering Baron and Kenny: myths and truths about mediation analysis. *Journal of Consumer Research*, *37*, 197-206. doi: 10.1086/651257

Table 1

*Descriptive Statistics and Correlations among Indicators at the Within- and Between-Person Levels*

	<i>Mean</i>	<i>SD</i>	<i>ICC</i>	1	2	3	4	5
1 MVPA [in minutes]	94.50	40.46	.40	1	.08*	-.05	-.06	-.05
2 Positive affect	3.92	0.76	.42	-.01	1	.29***	.37***	.44***
3 Behavioral SR	3.69	0.77	.35	-.12	.39***	1	.48***	.49***
4 Emotional SR	4.30	0.74	.30	-.09	.35***	.57***	1	.32***
5 Attentional SR	3.90	0.80	.40	-.08	.62***	.62***	.34**	1

*Notes.* Correlations below the diagonal are correlations at the between-person level (L2;  $N = 98$ ). Correlations above the diagonal are correlations at the daily within-person level (L1;  $N$ 's range from 638 to 676 due to occasional missing data). *SD* = standard deviation; *ICC* = intraclass correlation; MVPA = moderate-to-vigorous physical activity; SR = self-regulation. \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

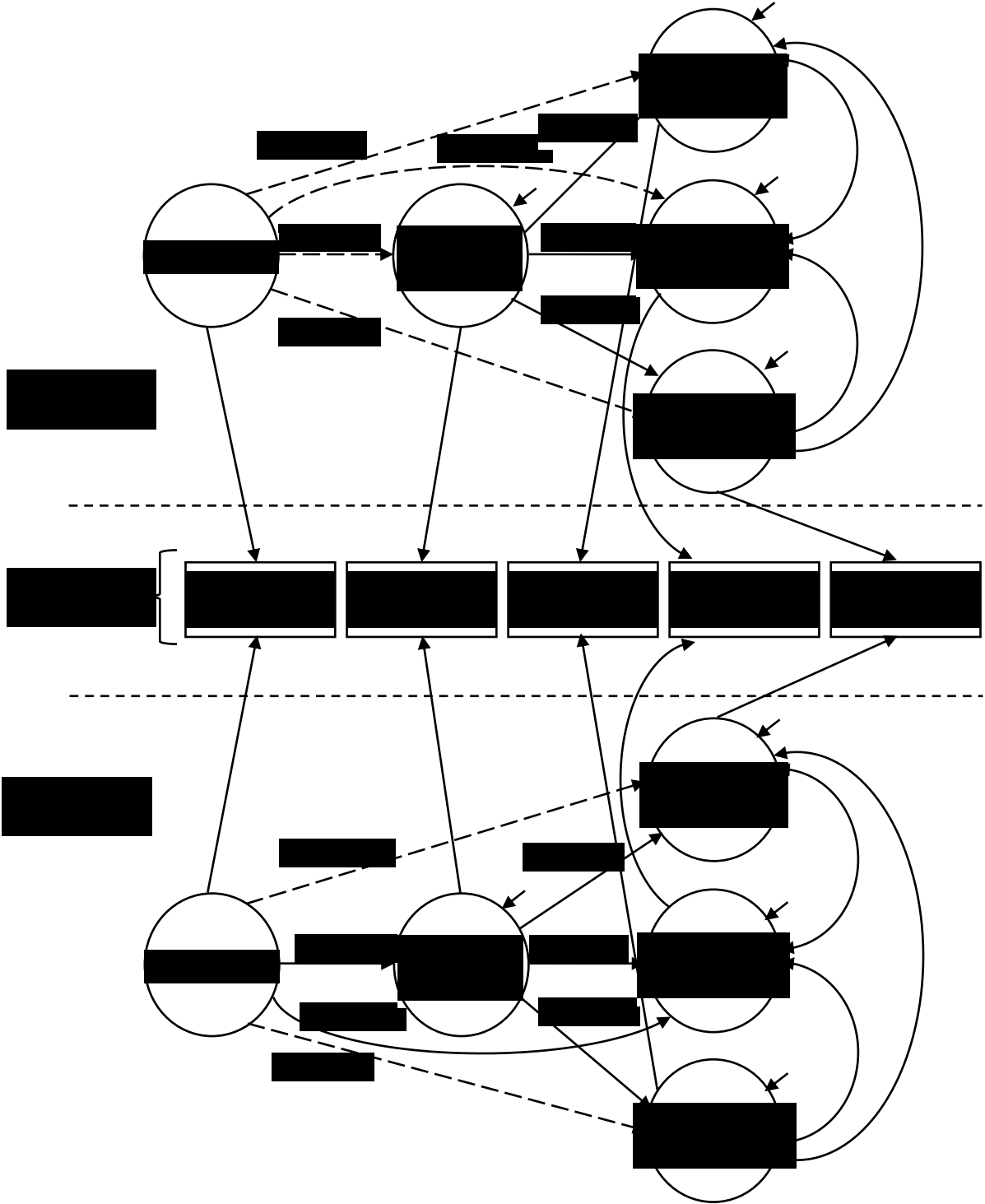


Figure 1. MSEM model with standardized estimates. Single headed arrows indicate direct and fixed effects; dashed arrows indicate non-significant effects ( $p > .05$ ). Short arrows indicate residual variances. MVPA = moderate-to-vigorous physical activity; SR = self-regulation.

## Appendix C – Publication 3

Ludwig, K., & Rauch, W. A. (2017). *Preschoolers' multi-faceted self-regulation: Relations to the home context and parenting behaviors*. Manuscript submitted for publication.

Preschoolers' Multi-Faceted Self-Regulation: Relations to the Home Context and Parenting  
Behaviors

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This research was part of the Kiga-BeR project at the Junior Research Group: Development of Self-Regulation, and was partially funded by Field of Focus 4, University of Heidelberg. We thank our student research assistants for their highly committed work as well as the parents and children for their interest and participation in our research.

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### Abstract

The purpose of this study was to investigate the relations of household chaos, SES, and diverse parenting dimensions to preschool-aged children's distinct emotional, behavioral, and cognitive self-regulation skills. The sample included 176 children aged four to six years with their parents and preschool teachers. Household chaos, SES, and parenting were assessed via questionnaires by parents. Preschoolers' self-regulation skills were assessed using multiple informants: Parents and preschool teachers rated children's self-regulation skills, and children participated in performance-based self-regulation tests. Structural equation modeling revealed distinct relationships according to self-regulation facets: Household chaos was negatively related to preschoolers' emotional and behavioral self-regulation, and family SES was positively related to cognitive self-regulation. Child-centered communication was positively related to children's cognitive and behavioral self-regulation, while harsh discipline was negatively related to emotional and cognitive self-regulation facets. Parental warmth and inconsistent discipline were, however, unrelated to children's self-regulation when all variables were simultaneously taken into account. These findings emphasize the importance of conceptualizing self-regulation as a multi-faceted construct with distinct relations to children's rearing context and to parenting dimensions.

*Keywords:* parenting, household chaos, SES, self-regulation, preschool



## Preschoolers' Multi-Faceted Self-Regulation: Relations to the Home Context and Parenting Behaviors

Early self-regulation skills of preschool-aged children are predictive of multiple important outcomes, such as academic achievement (Dindo et al., 2017) and psychological adjustment (Brody, Murry, Kim, & Brown, 2002). Self-regulation involves the modulation of one's emotions, cognitions, and behaviors by oneself, thus enabling adaptive responses to internal and environmental demands (Nigg, 2017). In different contexts, children face different environmental demands that require successful self-regulation. Parents and preschool teachers, for example, observe children in different contexts and situations (e.g., interactions with other children within groups in preschools vs. playing alone or with siblings at home) during their everyday lives, and the same is true for researchers who assess children's maximal (vs. typical) self-regulation performances under laboratory conditions (De Los Reyes, Thomas, Goodman, & Kundey, 2013; Toplak, West, & Stanovich, 2013). This context dependency needs to be taken into account when studying self-regulation. Focusing on young samples is particularly important because of neuropsychological improvements, marking early childhood as a sensitive developmental stage (Montroy, Bowles, Skibbe, McClelland, & Morrison, 2016). Thus, the investigation of early influencing factors on children's self-regulation is essential to prevent negative developmental trajectories associated with self-regulatory deficits (Brody et al., 2002; Hardaway, Wilson, Shaw, & Dishion, 2012). Primary influencing factors on children's self-regulation development are the home context and interactions within the family (Bridgett, Burt, Edwards, & Deater-Deckard, 2015). Accordingly, the primary goal of the present study was to examine the relations of diverse family-level factors (i.e., household chaos, family socioeconomic status, and parenting behaviors) to preschool-aged children's multi-informant-assessed emotional, cognitive, and behavioral self-regulation skills.

Familial influences on children's development are conceptualized from a theoretical perspective in Bronfenbrenner's bioecological model (Bronfenbrenner & Morris, 2006). The model emphasizes the importance of taking into account the influences of individuals' development and their environment in understanding human development. That is, the immediate settings in which children live and the characteristics of these settings shape children's development and their interactions with persons living in the same settings (Bronfenbrenner & Morris, 2006; Wachs & Evans, 2010). In line with this, empirical research indicates that the family's socioeconomic status (SES), the amount of household chaos (i.e., the setting's characteristics), and parenting behaviors (i.e., interactions) influence children's self-regulation (Bridgett et al., 2015). Self-determination theory (SDT; Deci & Ryan, 2008) provides a theoretical explanation of why the characteristics of families' settings and parenting influence children's self-regulation development. According to SDT, self-regulation development is facilitated when children's needs for a sense of autonomy, competence, and relatedness are fulfilled, that is, by clear parental guidelines, expectations and rules as well as by interactions marked by warmth and responsiveness (Grolnick & Farkas, 2002). Highly chaotic homes, however, describe family environments that are hectic, noisy, and lacking in structures and routines (Matheny, Wachs, Ludwig, & Phillips, 1995). A chaotic setting undermines children's feelings of autonomy or competence and, consequently, their cognitive and behavioral self-regulation (e.g., Bridgett et al., 2015; Evans, 2006). In contrast, family routines and meaningful rituals positively influence children's mental health by providing a secure and stable hotbed of childhood development (Spagnola & Fiese, 2007). Thus, there is strong evidence that the unpredictable, overstimulating, and distracting nature of chaotic homes seems to interfere with the acquisition of self-regulation skills (Wachs & Evans, 2010). The family's SES (i.e., income, educational background) is also relevant to children's self-regulation development, especially during early childhood (Lengua, 2006). Research suggests

that children from low-income families suffer from higher levels of psychological distress and psychophysiological stress compared to middle-income children (Evans & English, 2002; Evans & Kim, 2013). Additionally, household chaos seems to be more present for children from low-income families (Evans & English, 2002; Vernon-Feagans, Willoughby, Garrett-Peters, & The Family Life Project Key Investigators, 2016). Also, research suggests that poor educational and financial resources undermine neurocognitive performances, such as less-advanced executive functioning (Hackman & Farah, 2009; Raver, Blair, Willoughby, & The Family Life Project Key Investigators, 2013). These adverse conditions seem to hinder the development of children's self-regulation, as indicated by studies showing that growing up in families with lower income seems to be associated with lower, particularly cognitive, self-regulation levels in children (Evans & Kim, 2013; Raver et al., 2013).

Parenting behaviors additionally act as a social interactional mechanism in the transmission of self-regulation during children's everyday lives (Bridgett et al., 2015; Kopp, 1982). According to SDT, parents who give clear guidelines and support rather than control their children's initiatives and encourage their actions (e.g., child-centered communication) will fulfill their children's need for autonomy and competence, thus facilitating their internalization of external rules and behaviors (i.e., self-regulation; Grolnick & Farkas, 2002). Self-regulation will be further facilitated when parents provide a sense of relatedness by warm, secure and caring parenting (Deci & Ryan, 2008; Grolnick & Farkas, 2002). In contrast, harsh parenting and power-assertive control are supposed to undermine children's emerging self-regulation. As outlined by Eisenberg and colleagues (2005), harsh punitive parenting behaviors may also produce negative arousals in children, thus limiting their cognitive resources (e.g., executive functions), which are essential to successful self-regulation (Hofmann, Schmeichel, & Baddeley, 2012). Moreover, punitive parents, in contrast to sensitive parents, may act as a negative role model regarding the modulation of emotions or

emotional responses to stress (Eisenberg et al., 2005; Morris, Silk, Steinberg, Myers, & Robinson, 2007) and may reduce both the motivation and opportunity to encourage self-regulation (Grolnick & Farkas, 2002). So far, empirical evidence is mixed regarding the effects of different parenting behaviors on children's self-regulation. There consistently seem to be adverse effects of negative parenting, such as harsh discipline, on early forms of children's self-regulation (Karreman, van Tuijl, van Aken, & Deković, 2006), while parental warmth is either found to be positively related to children's self-regulation facets (e.g., Eisenberg et al., 2005) or unrelated (Karreman et al., 2006). In regard to autonomy and competence promoting parenting behaviors, such as child-centered communication or consistent discipline, studies are rare and inconclusive (Lengua & Kovacs, 2005; Karreman et al., 2006; Moilanen, Rasmussen, and Padilla-Walker, 2014). Since children's self-regulation is a multi-faceted construct with distinct emotional, cognitive, and behavioral facets (Jahromi & Stifter, 2008; Ludwig, Haindl, Laufs, & Rauch, 2016), it is so far unclear whether divergent findings can be explained by the possibility that different parenting behaviors are differently related to children's distinct emotional, behavioral, and cognitive self-regulation facets. Hence, a differentiated consideration of the relations between parenting behaviors and children's multi-faceted self-regulation is required.

Overall, household chaos, SES, and parenting each individually seem to be important for children's self-regulation development, raising the question of their relations to self-regulation while controlling for each other's influences. A recent study by Vernon-Feagans and colleagues (2016) investigated the effects of instable and disorganized homes and responsive parenting on children's regulatory behaviors in a structural equation model, including the family's SES as a covariate. The authors showed that a disorganized home context was indirectly related to children's ADHD symptoms (i.e., self-regulation failure) through parental responsiveness and acceptance. The present study adds to this and other

previous research by investigating the relations between factors of the home context (i.e., household chaos, SES) and diverse parenting behaviors (i.e., parental warmth, child-centered communication, harsh discipline, inconsistent discipline) in regard to three distinct (i.e., emotional, behavioral, cognitive) self-regulatory facets assessed by multiple informants in a sample of preschool-aged children. Specifically, we expect household chaos, harsh discipline, and inconsistent discipline to be negatively related to preschoolers' self-regulation (e.g., Grolnick, & Farkas, 2002; Hardaway et al., 2012; Karreman et al., 2006), and we expect SES, parental warmth, and child-centered communication to be positively related to preschoolers' self-regulation (e.g., Eisenberg et al., 2005; Moilanen et al., 2014; Raver et al., 2013).

According to the above-mentioned explanations, we expect the strongest associations between household chaos and behavioral and cognitive self-regulation facets as well as between SES and children's cognitive self-regulation. Harsh discipline and parental warmth were expected to be most strongly related to emotional self-regulation, while child-centered communication and inconsistent discipline were expected to be particularly related to behavioral and cognitive self-regulation facets.

## **Method**

### **Participants**

The present study was part of a larger research project ("XXX") that focused on different influencing factors on children's physical and mental health at the individual, family, and preschool levels. Participants were recruited between October 2016 and March 2017 in the state of XXXX in Germany. Families were invited to participate by leaflets and information letters distributed in 14 preschools. To be included in the sample, children had to be aged four to six years. Parents interested in participation gave written informed consent in accordance with the ethical standards in research and publication of the American Psychological Association (APA, 2010). In total, 191 parents initially agreed to participate.

Of these, seven dropped out of the study because their child did not visit the preschool during the data collection period. Additionally, in eight cases, there were missing values on all predictor variables that could not be handled by the full maximum likelihood procedure (FIML). Thus, the final sample consisted of 176 parents (77.3% mothers) with their children aged four to six years ( $M_{\text{age}} = 4.67$ ,  $SD_{\text{age}} = 0.66$ ; 41.5 % girls). Little's test (1988) was conducted to ensure data were missing completely at random (MCAR). According to Little (1998), data are MCAR when the missing values are independent of all observed variables in the data set (i.e., the null hypothesis). Little's MCAR test revealed a non-significant result ( $\chi^2(256) = 265.78$ ;  $p = .324$ ), suggesting the dropout in the present study was completely (observed) at random.

On average, participants' SES was in the middle to upper range, as indicated by education and income: The highest maternal school qualifications were 64.7% for university entrance, 22.8% for middle school, 8.1% for lower secondary school, and 0.7% without any school qualifications (3.7% missing values). The average net family income per month was distributed as follows: 35.2% above €4,000, 26.7% between €3,000 and €4,000, 15.4% between €2,000 and €3,000, 7.3% between €1,000 and €2,000, and 4.5% below €1000 (10.9 % missing values). In total, 62.5% of the sample spoke German as their mother tongue at home, 15.9% spoke German at home most of the time, 16.5% spoke German at home at least part of the time, and 5.1% spoke a foreign language at home most of the time.

## **Procedure**

Parents completed the questionnaires at home; preschool teachers could do so at home or during their working hours. Completed questionnaires were stored in anonymous sealed envelopes in the preschool to be collected by members of the research team. For the performance-based assessments, trained members of our research group (undergraduate and graduate students) visited the preschools. In each preschool, direct assessments of the

children's self-regulation were administered during one-on-one sessions with two research assistants that lasted approximately 10 minutes. One research assistant interacted with the child, while the second research assistant took notes. The assessments took place in a quiet, separate room provided by the preschool. The children were compensated with stickers and a small toy for their participation in the study. The preschool teachers' efforts in the complete study increased with an increasing number of participating children; thus, the preschools (but not the teachers directly) received €10 for each participating child. The study was approved by the local ethics committee of the Faculty of XXX at the University of XXX.

### Measures

**Household chaos.** The Confusion, Hubbub and Order Scale (CHAOS; Matheny et al., 1995; translated into German by Wirth et al., 2017) was used to assess the degree of chaos in the home environment. The scale consists of 15 items (e.g., 'no matter what our family plans, it usually doesn't seem to work out'). Parents answered the items using a 5-point Likert scale ranging from 1 'this is not true' to 5 'this is true'. The responses were aggregated into a chaos score ranging from 1 to 36, with higher values reflecting higher levels of household chaos ( $\alpha = .83$ ).

**Parenting.** Parenting was assessed by 16 items (Walper & Grgic, 2013), which were aggregated into four scales describing four different parenting behaviors: four items measured parental warmth (e.g., 'I praise my child',  $\alpha = .67$ ), four items measured child-centered communication (e.g., 'I converse with my child about the things that bother her/him',  $\alpha = .77$ ), four items measured harsh discipline (e.g., 'I severely punish my child, even in small matters',  $\alpha = .63$ ), and four items measured inconsistent discipline (e.g., 'I find it difficult to be consistent in my parenting',  $\alpha = .70$ ). Parents rated the incidence of each item using a 4-point scale ranging from 1 'never' to 4 'always'.

**SES.** Family SES was assessed by monthly net household income, maternal educational background and life partner's educational background. Net income was defined as the sum of all earnings minus taxes and social security contributions and was rated using a 9-point scale ranging from 1 'under €500' to 9 'more than €4,000'. Educational background was rated on a 5-point scale ranging from 0 'no school qualifications' to 4 'qualified for university entrance'.

**Self-regulation.** Children's self-regulation skills were assessed by three structurally different methods: parent reports, preschool teacher reports, and direct assessments.

**Parent report.** Parents rated their child's self-regulation using a questionnaire consisting of 15 items developed within our research group. Confirmatory factor analyses of a previous 10-item version of this questionnaire showed the best fit for three distinct but correlated self-regulation factors (i.e., emotional, cognitive, behavioral) in a sample of preschool-aged children (XXXX et al., XXXX). However, only two items assessed cognitive self-regulation; therefore, we included more items in this subsequent study. An exploratory factor analysis also confirmed the differentiated three-factor structure of self-regulation in the current sample. Parents answered the items using a 5-point Likert scale ranging from 1 'this is not true' to 5 'this is very true'. The item stem was the same for each item ('during the last three weeks, my child...'). Four items captured emotional self-regulation (e.g., '... was frustrated when things did not work out as well as expected'), four items captured behavioral self-regulation (e.g., '... easily waited until his/her turn'), and six items captured cognitive self-regulation (e.g., '... concentrated easily'). One item had to be excluded because the scale reliability increased after exclusion. The internal reliabilities were  $\alpha = .71$  for emotional self-regulation,  $\alpha = .75$  for behavioral self-regulation, and  $\alpha = .84$  for cognitive self-regulation.

**Preschool teacher report.** Preschool teachers answered the same 15-item questionnaire as parents to rate children's self-regulation but with a slightly different item



stem ('during the last three weeks, the child...'). The same item (cf. parent report) was excluded from further analyses because the scale reliability also increased after exclusion. The internal reliabilities were  $\alpha = .82$  for emotional self-regulation,  $\alpha = .83$  for behavioral self-regulation, and  $\alpha = .86$  for cognitive self-regulation.

***Self-regulation tests.*** Children performed two cognitive self-regulation tests measuring working memory and inhibitory control. Children's working memory performance was assessed by the number recall subtest of the Kaufman Assessment Battery for Children, second edition (K-ABC II; Kaufman, Kaufman, Melchers, & Preuß, 2007). The number recall subtest is a forward digit span test. That is, an examiner reads aloud several numerical series to be remembered and correctly repeated by the child. One practice trial was performed in which corrective feedback was given when needed. Performance was measured by the resulting digit span, indicating children's working memory capacity.

To assess inhibitory control, an adapted version of the Boy-Girl Stroop-like task (cf. Berlin & Bohlin, 2002; Diamond, Kirkham, & Amso, 2002) was used. In 16 trials, children were presented cards (21 cm × 14.5 cm) by the experimenter that either depicted a cartoon boy or a cartoon girl. Children were instructed to say 'boy' as fast as they could when the picture of a girl was shown and to say 'girl' when the picture of a boy was shown. The children's responses were coded 0 when the answer was wrong, 1 when the child very quickly corrected himself or herself, and 2 when the answer was initially correct. Two practice trials were performed in which corrective feedback was given when needed.

### **Data Analysis**

The hypotheses were tested within a structural equation model (SEM). The measurement model was built as a multiple-indicator correlated trait-correlated method minus one (CT-C(M-1); Eid, Lischetzke, Nussbeck, & Trierweiler, 2003) model. A CT-C(M-1) model contains one method factor less (i.e., the reference method) than the methods applied.

The CT-C(M-1) model approach is adequate for assessing the same construct by non-interchangeable, structurally different methods (e.g., because of multiple informants), as was the case in the present study (Nussbeck, Eid, Geiser, Courvoisier, & Lischetzke, 2009). Three different methods (i.e., parent ratings, preschool teacher ratings, and direct performance-based assessments) were included assessing three traits (i.e., children's emotional, cognitive, and behavioral self-regulation). Parent ratings were chosen as a reference method. To evaluate model fit, several fit indices were used according to the criteria proposed by Schermelleh-Engel, Moosbrugger, and Müller (2003): the root mean square error of approximation (RMSEA: good fit:  $\leq .05$ , acceptable fit:  $\leq .08$ ), the comparative fit index (CFI: good fit:  $\geq .97$ , acceptable fit:  $\geq .95$ ), and the standardized root mean square residual (SRMR: good fit:  $\leq .05$ , acceptable fit:  $\leq .10$ ). The model was estimated using Mplus version 7 (Muthén & Muthén, 1998-2012) with a maximum likelihood estimator (ML). A full information maximum likelihood approach (FIML) was used in Mplus by default to handle missing data in the outcome variables.

## Results

### Descriptive Statistics

Descriptive statistics for all indicators are depicted in Table 1. According to the 5-point Likert scale, the parents' and preschool teachers' self-regulation ratings were generally in the higher range in this sample (range  $M_{\text{parent-rated}} = 3.29$  to  $3.83$ ; range  $M_{\text{teacher-rated}} = 3.67$  to  $3.69$ ). The preschool teachers tended to rate the children's emotional and behavioral (but not cognitive) self-regulation higher than did the parents. Likewise, the children's performance-based inhibitory control ( $M = 23.02$ , [0; 30]) was rather highly developed. The children's mean correct responses in the digit span task (i.e., working memory performance) was 6.05 ( $SD = 2.32$ ), which corresponds to a mean digit span of three digits (digit span range = 0 to 6 digits). Bivariate correlations among indicators can be found in the appendix.

INSERT TABLE 1 HERE.

### Structural Equation Model

The standardized parameter estimates of the SEM are depicted in Figure 1. Fit indices suggest that the hypothesized model fit well with the data ( $\chi^2 = 76.50$ ,  $df = 72$ ,  $p = .33$ ;  $CFI = 0.99$ ;  $TLI = 0.99$ ;  $RMSEA = 0.02$ ;  $SRMR = 0.06$ ). When interpreting the results, it should be kept in mind that all estimates are partial regression weights, controlling for all other variables. Household chaos was negatively related to preschoolers' emotional ( $\beta = -.26$ ,  $p < .05$ ) and behavioral self-regulation ( $\beta = -.33$ ,  $p < .01$ ), but not with cognitive self-regulation ( $\beta = -.13$ ,  $p = .16$ ). Parental warmth was not associated with any facet of preschoolers' self-regulation (emotional:  $\beta = .16$ ,  $p = .15$ ; behavioral:  $\beta = -.08$ ,  $p = .34$ ; cognitive:  $\beta = .09$ ,  $p = .32$ ), while child-centered communication was positively related to preschoolers' cognitive ( $\beta = .20$ ,  $p < .05$ ) and behavioral self-regulation ( $\beta = .22$ ,  $p < .01$ ). Inconsistent discipline was not associated with any facet of preschoolers' self-regulation skills (emotional:  $\beta = -.03$ ,  $p = .78$ ; behavioral:  $\beta = -.10$ ,  $p = .20$ ; cognitive:  $\beta = .08$ ,  $p = .35$ ), while harsh discipline was negatively related to emotional ( $\beta = -.31$ ,  $p < .01$ ) and cognitive ( $\beta = -.20$ ,  $p < .05$ ) self-regulation facets. SES was positively related to children's cognitive self-regulation ( $\beta = .26$ ,  $p < .05$ ), but there were no associations with emotional ( $\beta = .09$ ,  $p = .43$ ) or behavioral ( $\beta = .05$ ,  $p = .58$ ) self-regulation facets. Overall, the predictors explained 36% of the variance in emotional self-regulation, 25% in behavioral self-regulation, and 23% in cognitive self-regulation.

INSERT FIGURE 1 HERE.

### Discussion

This study complements previous research by examining whether two factors of the home context (i.e., household chaos and family SES) as well as different dimensions of parenting (i.e., parental warmth, child-centered communication, harsh discipline, and

inconsistent discipline) are related to preschoolers' distinct emotional, behavioral, and cognitive self-regulation levels. Previous studies have focused on only one or two parenting aspects and single facets of children's self-regulation, resulting in inconsistent findings (e.g., Eiden, Colder, Edwards, & Leonard, 2009; Lengua, Honorado, & Bush, 2007). In this study, preschool-aged children's self-regulation was assessed by multiple informants to take into account that self-regulation levels may vary according to the different contexts children inhabit. Overall, the study's findings indicate that the amount of household chaos, family SES, and distinct parenting behaviors were over and above each other's influences differently related to preschoolers' distinct self-regulation skills. The results will be discussed in more detail in the following.

Household chaos and family SES were examined as two indicators of children's rearing context relevant to their self-regulation development (Bridgett et al., 2015). Household chaos was expected to be negatively related to self-regulation, with the strongest relations to behavioral and cognitive self-regulation facets, while family SES was thought to be positively related to preschoolers' cognitive self-regulation. The results suggest that higher levels of household chaos were related to lower emotional and behavioral but not cognitive self-regulation levels, which were positively associated with family SES. The negative relations between household chaos and preschoolers' emotional and behavioral self-regulation facets are in line with research linking home chaos to children's poor socioemotional functioning and behavioral inhibition (Evans, Gonnella, Marcynyszyn, Gentile, & Salpekar, 2005; Fiese, Foley, & Spagnola, 2006). For example, Evans and colleagues (2005) reported higher levels of psychological distress and learned helplessness in children from chaotic homes. An unstructured, chaotic home environment is lacking in routines such as regular mealtimes, which provide meaningful opportunities to talk about emotions or conflicts in children's everyday life (Fiese et al., 2006). Because of this, children's opportunities to

internalize rules or appropriate strategies facilitating the development of their emotional and behavioral self-regulation are limited. Accordingly, Martin, Razza, and Brooks-Gunn (2012) recently showed that a lack of routine in preschoolers' home environment was longitudinally associated with lower delayed gratification scores, which assess aspects of children's emotional and behavioral self-regulation. Moreover, children who live in unpredictable circumstances miss clear expectations and contingencies to guide their behavior, reducing their feelings of competence and autonomy and thus undermining internalization processes (Grolnick & Farkas, 2002). The current finding that household chaos was unrelated to children's cognitive self-regulation facet was unexpected, given the evidence that chaotic home environments jeopardize children's cognitive functioning (Evans, 2006). However, as outlined by Ackerman and Brown (2010), the direct effects of a chaotic home on children's cognitive development seem to apply particularly to noise exposures as one aspect of chaotic homes, while disorganization, unpredictability, and crowding seem to indirectly influence children's cognitive resources through poor or inadequate parent-child interactions. Valiente, Lemery-Chalfant, and Reiser (2007) provide evidence for this assumption; the authors also used the CHAOS scale (Matheny et al., 1995) and showed strong negative effects of chaos on positive parenting that in turn influenced children's attention shifting, activation control, and inhibitory control. In addition, family SES was particularly relevant to children's cognitive self-regulation in the current study, which is consistent with theoretical arguments and prior evidence (Evans & Kim, 2013). This finding is most likely because of a more stimulating rearing context facilitated by enhanced parental educational and financial resources, improving neurocognitive performances (Hackman & Farah, 2009) that are expressed in higher abilities to modulate one's attention. Thus, while household chaos seems to be more relevant to emotional and behavioral self-regulatory processes, SES seems to be particularly relevant to children's cognitive self-regulation.

In regard to parenting behaviors, this study's results indicated a negative relationship between harsh discipline and preschoolers' cognitive and emotional self-regulation, while child-centered communication was positively related to preschoolers' cognitive and behavioral self-regulation. The beneficial relations between child-centered communication and preschoolers' behavioral and cognitive self-regulatory processes correspond to theoretical assumptions and empirical evidence. Specifically, the beneficial relation of child-centered communication to preschoolers' cognitive self-regulation facets is in line with prior research that also showed beneficial effects of communicative, child-centered, and autonomy supportive behaviors on cognitive self-regulation facets (Bernier, Carlson, & Whipple, 2010; Lengua et al., 2007; Valiente et al., 2007). A clear but warm child-centered communication seems to foster a sense of relatedness, autonomy, and competence, facilitating the internalizations of rules and appropriate behaviors needed for successful prospective self-regulation (Grolnick & Farkas, 2002). Also, regarding the above-mentioned findings of household chaos, this finding further supports the idea that opportunities to talk are especially important regarding children's self-regulation skills and can be facilitated by daily routines such as regular mealtimes (see also Martin et al., 2012).

Consistent with prior research, harsh discipline was negatively related to preschoolers' cognitive and emotional self-regulation (Bridgett et al., 2015; Valiente et al., 2007). This supports the idea that punitive parents may act as negative role models regarding the regulation of emotions or emotional responses to conflicts or distress (Morris et al., 2007). Moreover, punitive behaviors seem to cause negative affect or distress in children, limiting their cognitive resources (Eisenberg et al., 2005; Fredrickson, 2001). In addition, the relation of both harsh discipline and child-centered communication to preschoolers' cognitive self-regulation may provide further support for the above-mentioned idea that there are indirect relations between household chaos and self-regulation through parenting behaviors (Valiente

et al., 2007; Wachs & Evans, 2010). Also, by showing incremental relations of household chaos, family SES, harsh discipline, and child-centered communication, the present study underlines the importance of both settings' characteristics (i.e., household chaos) and interactions (i.e., parenting) for children's development, as outlined in Bronfenbrenner's bioecological model (Bronfenbrenner & Morris, 2006).

Contrary to our expectations, parental warmth and inconsistent discipline were unrelated to any self-regulation facet. Lengua and Kovacs (2005) also did not find effects of maternal acceptance and inconsistent discipline on children's self-regulation, concluding that socialization processes such as parenting might not be relevant to children's self-regulation. However, the findings of the present study suggest another conclusion, namely, that parenting is indeed important to children's self-regulation over and above the impacts of family SES and household chaos, but it depends on the discrete parenting behavior and self-regulation facet. Parental warmth and inconsistent discipline showed significant zero-order correlations with preschoolers' (yet only parent-reported) self-regulation, but these relations vanished when harsh discipline and child-centered communication were simultaneously taken into account. The diverse consideration of parenting behaviors in this study therefore indicates that dimensions of parenting behaviors (i.e., child-centered communication and harsh discipline) other than parental warmth and inconsistent discipline seem to be relevant to preschool-aged children's self-regulation, in addition to family SES and household chaos. Lengua and colleagues (2007) also did not find effects of parental warmth on children's self-regulation when limit setting and scaffolding behaviors were taken into account. However, it has to be noted that in the present study, parental warmth was limited in its variance because of ceiling effects, which may be an alternative explanation for the non-significant relations.

### **Implications**

The knowledge that household chaos, family SES, harsh discipline, and child-centered communication each seem to be important for young children's distinct self-regulation skills is crucial given the multiple outcomes predicted by preschool-aged children's self-regulation skills over several contexts throughout the life span – from school readiness in childhood (e.g., Blair & Raver, 2015) and academic achievement in adolescence (e.g., Dindo et al., 2017) to later health and wealth in adulthood (e.g., Fergusson, Boden, & Horwood, 2013). The present study underlines the importance of setting characteristics and parenting behaviors for children's distinct self-regulation facets. Fostering adequate parenting behaviors, particularly high levels of child-centered communication and low levels of harsh discipline, thus seems to be promising to prevent negative trajectories. Additionally, adverse effects of household chaos may be compensated by the implementation of routines in children's everyday lives (Martin et al., 2012; Spagnola & Fiese, 2007). Prior research also indicates parental self-regulation skills as important for child self-regulation skills (Bridgett et al., 2015). Parenting programs such as the Triple P program (Sanders & Mazzucchelli, 2013) are promising for fostering parental self-regulation as well as parenting behaviors that in turn facilitate children's self-regulation development. However, low parental self-regulation skills, inadequate parenting practices, household chaos, and low SES are typically interrelated (Bridgett et al., 2015; Evans & Kim, 2013). Therefore, at-risk families (i.e., low parental self-regulation skills, low-income families) may be less likely to participate in parenting programs because of a range of stressors (e.g., lack of child care, transportation) (Zachary, Jones, McKee, Baucom, & Forehand, 2017), and therefore, single parenting programs or interventions may be ineffective. In light of Bronfenbrenner's bioecological model (Bronfenbrenner & Morris, 2006), this underlines the importance of a more holistic approach, such as socio-pedagogical family assistants (e.g., social workers) who perform capacity



building, specifically in poor families within their home context by (among other tasks) structuring daily routines and providing educational support.

### **Limitations**

Several limitations of this study should be noted. First, the sample is not representative of the population at large, as it was self-selected with a middle-to-high socio-economic background. Also, the children's mean cognitive, emotional, and behavioral self-regulation scores were high. Nevertheless, there was still substantial variation in family SES and preschoolers' self-regulation, yet a more heterogeneous sample might enhance individual variation and improve the generalizability of the findings. Also, consistent with prior research (e.g., Moilanen & Rambo-Hernandez, 2017), most questionnaires were answered by mothers, and paternal impacts on children's self-regulation skills are still only poorly investigated. Second, a causal direction cannot be derived from this study's results because of the cross-sectional design. Reverse effects are likewise possible, that is, preschoolers' self-regulation levels might also shape parents' behaviors or contribute to a more chaotic home environment. For example, children with lower self-regulation may evoke distress in parents, fostering harsh discipline behaviors. Also, higher levels of child self-regulation may limit negative affect experiences in parents, broadening their resources (Fredrickson, 2001) and thus their child-centered communication behaviors. Likewise, self-regulation deficits in children may contribute to a chaotic home environment. Empirical evidence regarding these assumptions so far is inconsistent; longitudinal studies that investigated bidirectional relations in older samples showed both reverse effects of self-regulation aspects on parenting behaviors (e.g., Lengua, 2006) and no reverse effects (e.g., Brody & Ge, 2001; Eisenberg et al., 2005; Moilanen et al., 2014). Thus, further research is needed, particularly regarding self-regulation as a predictor of household chaos. Furthermore, previous studies called for using multiple informants when studying self-regulation (e.g., Lengua & Kovacs, 2005). A strength of the

current study is that efforts were made to reduce informant bias by combining performance-based measures with parents' and preschool teachers' ratings to adequately capture preschoolers' self-regulation facets. However, all independent variables were measured using questionnaires answered by parents, and the internal consistencies of parental warmth and harsh discipline measures were somewhat low. Observational ratings such as the HOME instrument (Bradley, Caldwell, Rock, Hamrick, & Harris, 1988) should be included in future studies, as this may increase reliability for allowing the inclusion of latent parenting variables. Finally, although the finding of this study that contextual and interactional factors of preschoolers' family environment are related to their self-regulation skills, in line with the theoretical assumptions outlined above, the concrete mechanisms explaining why they are related were not explicitly tested. The present study draws on SDT (Deci & Ryan, 2008) to explain why the home environment and parenting behaviors are linked to children's self-regulation skills (Grolnick & Farkas, 2002). However, measures of feelings of autonomy, competence, and relatedness should be included in future studies to support these assumptions.

## **Conclusion**

The findings of this study demonstrate that children's multi-informant-assessed cognitive, behavioral, and emotional self-regulation facets are differently related to the amount of household chaos, family SES, and distinct dimensions of parenting. Preschoolers' cognitive self-regulation was particularly related to family SES, child-centered communication, and harsh discipline. Preschoolers' behavioral self-regulation was associated with household chaos as well as child-centered communication, while their emotional self-regulation was related to household chaos and harsh discipline. Parental warmth and inconsistent discipline yielded no additional contributions to children's self-regulation skills beyond child-centered communication and harsh discipline. Parents should be educated or

supported by family assistants regarding the interrelations of their home environment, everyday parenting behaviors, and their child's self-regulation skills, which have important implications for life success. Future studies should also include a differentiated assessment of preschoolers' cognitive, behavioral, and emotional self-regulation facets to examine distinct mechanisms explaining these divergent relations.

**Declaration of Interests and Funding**

The author(s) declare no potential conflicts of interest concerning the research, authorship, and/or publication of this article. The present study was supported by Field of Focus 4, University of Heidelberg, Germany, funded by the German Excellence Initiative.

## References

- Ackerman, B. P., & Brown, E. D. (2010). Physical and psychosocial turmoil in the home and cognitive development. In G. W. Evans & T. D. Wachs (Eds.), *Chaos and its influence on children's development: an ecological perspective* (pp. 35-47). Washington: American Psychological Association.
- American Psychological Association (2010). *Ethical principles of psychologists and code of conduct*. Retrieved from <http://www.apa.org/ethics/code/>
- Berlin, L., & Bohlin, G. (2002). Response inhibition, hyperactivity, and conduct problems among preschool children. *Journal of Clinical Child Psychology, 31*, 242-251.
- Bernier, A., Carlson, S. M., & Whipple, N. (2010). From external regulation to self-regulation: early parenting precursors of young children's executive functioning. *Child Development, 81*, 326-339.
- Blair, C., & Raver, C. C. (2015). School readiness and self-regulation: a developmental psychobiological approach. *Annual Review of Psychology, 66*, 711-731. doi: 10.1146/annurev-psych-010814-015221
- Bradley, R. H., Caldwell, B. M., Rock, S. L., Hamrick, H. M., & Harris, P. (1988). Home observation for measurement of the environment: development of a home inventory for use with families having children 6 to 10 years old. *Contemporary Educational Psychology, 13*, 58-71.
- Bridgett, D. J., Burt, N. M., Edwards, E. S., & Deater-Deckard, K. (2015). Intergenerational transmission of self-regulation: a multidisciplinary review and integrated conceptual framework. *Psychological Bulletin, 141*, 602-654. doi: 10.1037/a0038662
- Brody, G. H., & Ge, X. (2001). Linking parenting processes and self-regulation to psychological functioning and alcohol use during early adolescence. *Journal of Family Psychology, 15*, 82-94. doi: 10.1037//0893-3200.15.1.82

- Brody, G. H., Murry, V. M., Kim, S., & Brown, A. C. (2002). Longitudinal pathways to competence and psychological adjustment among African American children living in rural single-parent households. *Child Development, 73*, 1505-1516.
- Bronfenbrenner, U., & Morris, P. A. (2006). The bioecological model of human development. In W. Damon & R. M. Lerner (Eds.), *Handbook of child psychology, volume 1: theoretical models of human development* (pp. 793-828). New Jersey: John Wiley & Sons.
- De Los Reyes, A., Thomas, S. A., Goodman, K. L., & Kundey, S. M. A. (2013). Principles underlying the use of multiple informants' reports. *Annual Review of Clinical Psychology, 9*, 123- 149. doi: 10.1146/annurev-clinpsy-050212-185617
- Deci, E. L., & Ryan, R. M. (2008). Facilitating optimal motivation and psychological well-being across life's domains. *Canadian Psychology, 49*(1), 14-23. doi: 10.1037/0708-5591.49.1.14
- Diamond, A., Kirkham, N., & Amso, D. (2002). Conditions under which young children can hold two rules in mind and inhibit a prepotent response. *Developmental Psychology, 38*, 352-362. doi: 10.1037//0012-1649.38.3.352
- Dindo, L., Brock, R. L., Aksan, N., Gamez, W., Kochanska, G., & Clark, L. A. (2017). Attachment and effortful control in toddlerhood predict academic achievement over a decade later. *Psychological Science*. Advance online publication. doi: 10.1177/0956797617721271
- Eid, M., Lischetzke, T., Nussbeck, F. W., & Trierweiler, L. I. (2003). Separating trait effects from trait-specific method effects in multitrait-multimethod models: a multiple-indicator CT-C(M-1) model. *Psychological Methods, 8*, 38-60. doi: 10.1037/1082-989X.8.1.38

- Eiden, R. D., Colder, C., Edwards, E. P., & Leonard, K. E. (2009). A longitudinal study of social competence among children of alcoholic and nonalcoholic parents: role of parental psychopathology, parental warmth, and self-regulation. *Psychology of Addictive Behaviors, 23*, 36-46. doi: 10.1037/a0014839
- Eisenberg, N., Zhou, Q., Spinrad, T. L., Valiente, C., Fabes, R. A., & Liew, J. (2005). Relations among positive parenting, children's effortful control, and externalizing problems: a three-wave longitudinal study. *Child Development, 76*, 1055-1071. doi: 10.1111/j.1467-8624.2005.00897.x
- Evans, G. W. (2006). Child development and the physical environment. *Annual Review of Psychology, 57*, 423-451. doi: 10.1146/annurev.psych.57.102904.190057
- Evans, G. W., & English, K. (2002). The environment of poverty: multiple stressor exposure, psychophysiological stress, and socioemotional adjustment. *Child Development, 73*, 1238-1248.
- Evans, G. W., Gonnella, C., Marcynyszyn, L. A., Gentile, L., & Salpekar, N. (2005). The role of chaos in poverty and children's socioemotional adjustment. *Psychological Science, 16*, 560-565. doi: 10.1111/j.0956-7976.2005.01575.x
- Evans, G. W., & Kim, P. (2013). Childhood poverty, chronic stress, self-regulation, and coping. *Child Development Perspectives, 7*, 43-48. doi: 10.1111/cdep.12013
- Fiese, B. H., Foley, K. P., & Spagnola, M. (2006). Routine and ritual elements in family mealtimes: a context for child well-being and family identity. *New Directions for Child and Adolescent Development, 111*, 67-89. doi: 10.1002/cd.156
- Fergusson, D. M., Boden, J. M., & Horwood, L. J. (2013). Childhood self-control and adult outcomes: results from a 30-year longitudinal study. *Journal of the American Academy of Child & Adolescent Psychiatry, 52*, 709-717. doi: 10.1016/j.jaac.2013.04.008

- Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: the broaden-and-build theory of positive emotions. *American Psychologist*, *56*, 218-226. doi: 10.1037/0003-066X.56.3.218
- Grolnick, W. S., & Farkas, M. (2002). Parenting and the development of children's self-regulation. In M. H. Bornstein (Ed.), *Handbook of parenting, Vol. 5. Practical issues in parenting* (2nd ed., pp. 89-110). Mahwah, NJ: Erlbaum.
- Hackman, D. A., & Farah, M. J. (2009). Socioeconomic status and the developing brain. *Trends in Cognitive Sciences*, *13*, 65-73. doi:10.1016/j.tics.2008.11.003
- Hardaway, C. R., Wilson, M. N., Shaw, D. S., & Dishion, T. J. (2012). Family functioning and externalizing behaviour among low-income children: self-regulation as moderator. *Infant and Child Development*, *21*, 67-84. doi:10.1002/icd.765
- Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. *Trends in Cognitive Sciences*, *16*, 174-180. doi: 10.1016/j.tics.2012.01.006
- Jahromi, L. B., Stifter, C. A. (2008). Individual differences in preschoolers' self-regulation and theory of mind. *Merrill-Palmer Quarterly*, *54*, 125-150. doi: 10.1353/mpq.2008.0007
- Karreman, A., van Tuijl, C., van Aken, M. A. G., & Deković, M. (2006). Parenting and self-regulation in preschoolers: a meta-analysis. *Infant and Child Development*, *15*, 561-579. doi: 10.1002/icd.478
- Kaufman, A. S., Kaufman, N. L., Melchers, P. & Preuß, U. (2007). *Kaufman Assessment Battery for Children – German Version*. Leiden: PITS.
- Kopp, C. B. (1982). Antecedents of self-regulation: a developmental perspective. *Developmental Psychology*, *18*, 199-214.

- Lengua, L. J. (2006). Growth in temperament and parenting as predictors of adjustment during children's transition to adolescence. *Developmental Psychology, 42*, 819-832. doi: 10.1037/0012-1649.42.5.819
- Lengua, L. J., Honorado, E., & Bush, N. R. (2007). Contextual risk and parenting as predictors of effortful control and social competence in preschool children. *Journal of Applied Developmental Psychology, 28*, 40-55. doi:10.1016/j.appdev.2006.10.001
- Lengua, L. J., & Kovacs, E. A. (2005). Bidirectional associations between temperament and parenting and the prediction of adjustment problems in middle childhood. *Applied Developmental Psychology, 26*, 21-38. doi:10.1016/j.appdev.2004.10.001
- Little, R. J. A. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association, 83*, 1198-1202.
- Ludwig, K., Haindl, A., Laufs, R., & Rauch, W. A. (2016). Self-regulation in preschool children's everyday life: exploring day-to-day variability and the within- and between-person structure. *Journal of Self-Regulation and Regulation, 2*, 98-117. doi: 10.11588/josar.2016.2.34357
- Martin, A., Razza, R., & Brooks-Gunn, J. (2012). Specifying the links between household chaos and preschool children's development. *Early Child Development and Care, 182*, 1247-1263. doi:10.1080/03004430.2011.605522
- Matheny, Jr., A. P., Wachs, T. D., Ludwig, J. L., & Phillips, K. (1995). Bringing order out of chaos: psychometric characteristics of the confusion, hubbub, and order scale. *Journal of Applied Developmental Psychology, 16*, 429-444. doi: 10.1016/0193-3973(95)90028-4
- Moilanen, K. L., & Rambo-Hernandez, K. E. (2017). Effects of maternal parenting and mother-child relationship quality on short-term longitudinal change in self-regulation



- in early adolescence. *Journal of Early Adolescence*, *37*, 618-641. doi: 10.1177/0272431615617293
- Moilanen, K. L., Rasmussen, K. E., & Padilla-Walker, L. M. (2014). Bidirectional associations between self-regulation and parenting styles in early adolescence. *Journal of Research on Adolescence*, *25*, 246-262. doi: 10.1111/jora.12125
- Montroy, J. J., Bowles, R. P., Skibbe, L. E., McClelland, M. M., & Morrison, F. J. (2016). The development of self-regulation across early childhood. *Developmental Psychology*, *52*, 1744-1762. doi: 10.1037/dev0000159
- Morris, A. S., Silk, J. S., Steinberg, L., Myers, S. S., & Robinson, L. R. (2007). The role of the family context in the development of emotion regulation. *Social Development*, *16*, 361-388. doi: 10.1111/j.1467-9507.2007.00389.x
- Muthén, L. K., & Muthén, B. O. (1998-2012). *Mplus User's Guide, Seventh Edition*. Los Angeles, CA: Muthén & Muthén.
- Nigg, J. T. (2017). Annual research review: On the relations among self-regulation, self-control, executive functioning, effortful control, cognitive control, impulsivity, risk-taking, and inhibition for developmental psychopathology. *Journal of Child Psychology and Psychiatry*, *58*, 361-383. doi: 10.1111/jcpp.12675
- Nussbeck, F. W., Eid, M., Geiser, C., Courvoisier, D. S., & Lischetzke, T. (2009). A CTC(M-1) model for different types of raters. *Methodology*, *5*, 88-98. doi: 10.1027/1614-2241.5.3.88
- Raver, C. C., Blair, C., Willoughby, M., & The Family Life Project Key Investigators (2013). Poverty as predictor of 4-year-olds' executive function: new perspectives on models of differential susceptibility. *Developmental Psychology*, *49*, 292-304. doi: 10.1037/a0028343

- Sanders, M. R., & Mazzucchelli, T. G. (2013). The promotion of self-regulation through parenting interventions. *Clinical Child and Family Psychology Review, 16*, 1-17.
- Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online, 8*, 23-74.
- Spagnola, M., & Fiese, B. H. (2007). Family routines and rituals: a context for development in the lives of young children. *Infants & Young Children, 20*, 284-299. doi: 10.1097/01.IYC.0000290352.32170.5a
- Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, 54*, 131-143. doi:10.1111/jcpp.12001
- Valiente, C., Lemery-Chalfant, K., & Reiser, M. (2007). Pathways to problem behaviors: chaotic homes, parent and child effortful control, and parenting. *Social Development, 16*, 249-267. doi: 10.1111/j.1467-9507.2007.00383.x
- Vernon-Feagans, L., Willoughby, M., Garrett-Peters, P., & The Family Life Project Key Investigators (2016). Predictors of behavioral regulation in kindergarten: household chaos, parenting, and early executive functioning. *Developmental Psychology, 52*, 430-441. doi: 10.1037/dev0000087
- Wachs, T. D., & Evans, G. W. (2010). Chaos in context. In G. W. Evans & T. D. Wachs (Eds.), *Chaos and its influence on children's development: an ecological perspective* (pp. 3-13). Washington: American Psychological Association.
- Walper, S., & Grgic, M. (2013). Verhaltens- und Kompetenzentwicklung im Kontext der Familie. Zur relativen Bedeutung von sozialer Herkunft, elterlicher Erziehung und Aktivitäten in der Familie. [Behavior and competence development in the family

context: the relative importance of social origin, parental education, and activities in the family]. *Zeitschrift für Erziehungswissenschaft*, 16, 503-531.

Wirth, A., Reinelt, T., Gawrilow, C., Schwenck, C., Freitag, C. M., & Rauch, W. A. (2017).

Examining the relationship between children's ADHD symptomatology and inadequate parenting: the role of household chaos. *Journal of Attention Disorders*.

Advance online publication. doi: 10.1177/1087054717692881

Zachary, C., Jones, D. J., McKee, L. G., Baucom, D. H., & Forehand, R. L. (2017). The role

of emotion regulation and socialization in behavioral parent training: a proof-of-concept study. *Behavior Modification*. Advance online publication. doi:

10.1177/0145445517735492

Table 1

*Descriptive Statistics for all Indicators (Final Sample Size: N = 176).*

	<i>M (SD)</i>	Min	Max	Skewness	Kurtosis	missing data
emotional self-regulation <sup>p</sup>	3.29 (0.87)	1.25	5.00	-0.05	-0.72	0%
cognitive self-regulation <sup>p</sup>	3.83 (0.73)	1.67	5.00	-0.45	-0.32	0%
behavioral self-regulation <sup>p</sup>	3.49 (0.84)	1.00	5.00	-0.48	-0.10	0%
emotional self-regulation <sup>t</sup>	3.69 (1.00)	1.00	5.00	-0.64	-0.29	1.7%
cognitive self-regulation <sup>t</sup>	3.68 (0.93)	1.00	5.00	-0.71	-0.17	1.7%
behavioral self-regulation <sup>t</sup>	3.67 (1.01)	1.00	5.00	-0.48	-0.62	1.7%
inhibitory control	23.02 (7.48)	0	30	-1.51	1.80	0.6%
working memory	6.07 (2.32)	0	13	-0.22	0.41	0.6%
household chaos	15.20 (7.57)	1	36	0.45	-0.26	0%
parental warmth	3.64 (0.34)	2.00	4.00	-1.22	2.44	0%
harsh discipline	1.73 (0.40)	1.00	3.00	0.41	0.02	0%
child-centered communication	3.24 (0.47)	1.50	4.00	-0.76	0.95	0%
inconsistent discipline	2.15 (0.46)	1.00	3.00	0	-0.36	0%
family income	7.11 (2.16)	1.00	9.00	-1.15	0.60	10.80%
educational background <sup>m</sup>	3.19 (1.12)	0	4	-0.72	-0.66	3.70%
educational background <sup>l</sup>	3.25 (1.12)	1	4	-0.67	-0.71	12.5%

*Notes.* *N*'s range from 126 to 176 due to occasional missing data. *M* = mean, *SD* = standard deviation. <sup>p</sup> parent report, <sup>t</sup> preschool teacher report (scales ranging from 1-5). Inhibitory control assessed by stroop test; working memory assessed by number recall test. <sup>m</sup>maternal, <sup>l</sup>life partner (scales ranging from 0'no school qualifications' to 4'qualified for university entrance').

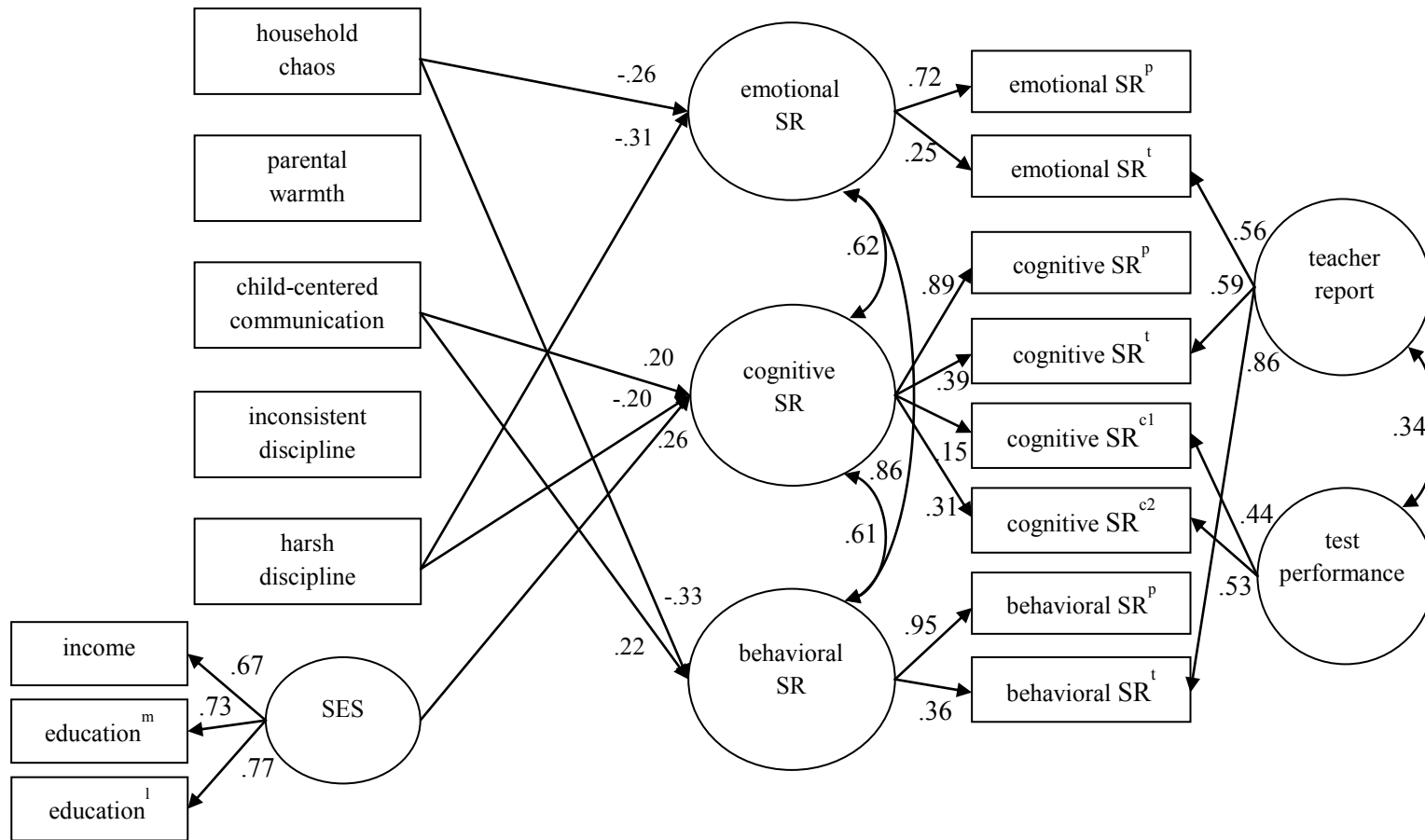


Figure 1. SEM with CTCM-1 model. Covariances among indicators, residual arrows, and non-significant paths are not depicted for clarity; all shown coefficients are standardized and significant with at least  $p < .05$ . SR = self-regulation; SES = socioeconomic status; <sup>m</sup>maternal education; <sup>l</sup>lifepartner's education; <sup>p</sup>parent report; <sup>t</sup>teacher report; <sup>c1</sup>child stroop test; <sup>c2</sup>child number recall test.  $N = 176$ ;  $\chi^2_{ML} = 76.50$ ,  $p = .34$ ;  $CFI = .99$ ,  $RMSEA = .02$ .

## Appendix

*Bivariate Correlations among Indicators*

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 emotional self-regulation <sup>p</sup>	.44	.57	.22	.22	.29	.05	.09	-.34	.28	-.35	.20	-.20	.15	.11	-.02
2 cognitive self-regulation <sup>p</sup>	1	.54	.19*	.39	.27	.15	.28	-.22	.26	-.26	.30	-.06	.26	.18	.15
3 behavioral self-regulation <sup>p</sup>		1	.22	.24	.35	.08	.17	-.43	.14	-.21	.28	-.26	.14	.13	.04
4 emotional self-regulation <sup>t</sup>			1	.38	.57	.13	.22	-.00	.13	-.11	.06	-.05	.06	.09	.10
5 cognitive self-regulation <sup>t</sup>				1	.62	.18	.29	-.14	.12	-.05	.07	-.09	.29	.23	.26
6 behavioral self-regulation <sup>t</sup>					1	.16	.22	-.06	.14	-.14	.10	-.09	.18	.11	.11
7 inhibitory control						1	.28	-.05	.03	-.10	.04	-.09	.13	.05	.08
8 working memory							1	.03	-.00	-.11	.10	.02	.14	.15	.21
9 household chaos								1	-.29	.31	-.27	.46	-.08	-.09	-.13
10 parental warmth									1	-.37	.41	-.15	.01	.03	.01
11 harsh discipline										1	-.15	.30	-.03	-.02	-.02
12 child-centered communication											1	-.01	.10	.12	.07
13 inconsistent discipline												1	-.06	-.02	-.19

14 family income	1	.51	.47
15 educational background <sup>m</sup>		1	.54
16 educational background <sup>l</sup>			1

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*Notes.* *N*'s range from 145 to 176 due to occasional missing data. <sup>p</sup> parent report, <sup>t</sup> preschool teacher report (scales ranging from 1-5). Inhibitory control assessed by stroop test; working memory assessed by number recall test. <sup>m</sup>maternal, <sup>l</sup>life partner (scales ranging from 0 'no school qualifications' to 4 'qualified for university entrance'). All correlations above .15 are significant with at least  $p < .05$ .

## Appendix D – Declarations in Accordance to Doctoral Degree Regulation

### **Promotionsausschuss der Fakultät für Verhaltens- und Empirische**

### **Kulturwissenschaften**

### **der Ruprecht-Karls-Universität Heidelberg**

### **Doctoral Committee of the Faculty of Behavioural and Cultural Studies, of Heidelberg**

### **University**

### **Erklärung gemäß § 8 (1) c) der Promotionsordnung der Universität Heidelberg**

### **für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften**

### **Declaration in accordance to § 8 (1) c) of the doctoral degree regulation of Heidelberg**

### **University, Faculty of Behavioural and Cultural Studies**

Ich erkläre, dass ich die vorgelegte Dissertation selbstständig angefertigt, nur die angegebenen Hilfsmittel benutzt und die Zitate gekennzeichnet habe.

I declare that I have made the submitted dissertation independently, using only the specified tools and have correctly marked all quotations.

### **Erklärung gemäß § 8 (1) d) der Promotionsordnung der Universität Heidelberg**

### **für die Fakultät für Verhaltens- und Empirische Kulturwissenschaften**

### **Declaration in accordance to § 8 (1) d) of the doctoral degree regulation of Heidelberg**

### **University, Faculty of Behavioural and Cultural Studies**

Ich erkläre, dass ich die vorgelegte Dissertation in dieser oder einer anderen Form nicht anderweitig als Prüfungsarbeit verwendet oder einer anderen Fakultät als Dissertation vorgelegt habe.

I declare that I did not use the submitted dissertation in this or any other form as an examination paper until now and that I did not submit it in another faculty.

Vorname Nachname

First name Family name \_\_\_\_\_

Datum, Unterschrift

Date, Signature \_\_\_\_\_