

Natural Spaces, Affect, and ADHD Symptoms

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Within-Person Associations in Children's Daily Life

Dissertation

der Mathematisch-Naturwissenschaftlichen Fakultät

der Eberhard Karls Universität Tübingen

zur Erlangung des Grades eines

Doktors der Naturwissenschaften

(Dr. rer. nat.)

vorgelegt von

Dipl. Psych. Merle Katharina Margarete Reuter

aus Stühlingen am Hochrhein

Tübingen

2020

Gedruckt mit Genehmigung der Mathematisch-Naturwissenschaftlichen Fakultät der
Eberhard Karls Universität Tübingen.

Tag der mündlichen Qualifikation:

22.07.2020

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Danksagung

Mein herzlicher Dank gilt allen, die mich bei dieser Dissertation unterstützt haben.

Bedanken möchte ich mich insbesondere bei *Prof. Dr. Caterina Gawrilow* für die Förderung meiner wissenschaftlichen Interessen, die ausgezeichnete Betreuung sowie die Finanzierung während der gesamten Arbeitszeit. Zudem danke ich *Prof. Dr. med. Tobias Renner* für seine fachlichen Beiträge und die flexible Betreuung dieser Forschungsarbeit.

Außerdem gilt mein besonderer Dank *Dr. Jan Kühnhausen*, dessen methodische Expertise und fachliche Beratung maßgeblich zum Gelingen dieser Dissertation beitrugen und der in zahlreichen Gesprächen über Wissenschaft meinen Arbeitsalltag bereicherte. Zudem möchte ich mich bei meinen Freundinnen und Kolleginnen *Dr. Petra Haas*, *Dr. Leona Hellwig* und *Dr. Parvin Nemati* für ihre tatkräftige Unterstützung beim Korrekturlesen, den fachlichen Austausch sowie die motivierenden Gespräche vor dem Hexenhaus bedanken.

Den KollegInnen und FreundInnen aus der Doktorandeninitiative *sustainAbility* der Universität Tübingen danke ich für aufschlussreiche Gespräche über die Themen Nachhaltigkeit und Umweltschutz. Außerdem möchte ich mich bei der *Graduiertenschule & Forschungsnetzwerk LEAD* der Universität Tübingen sowie dem *IDEA Zentrum* der Universität Frankfurt für die ideelle und finanzielle Förderung des bildungsbezogenen wissenschaftlichen Austauschs bedanken.

Allen Kindern, Eltern und Lehrkräften danke ich für die Teilnahme am Forschungsprojekt AttentionGO. Ebenso danken möchte ich den MitarbeiterInnen und Hilfskräften des Arbeitsbereichs Schulpsychologie sowie dem IT-Team des Fachbereichs Psychologie für ihre engagierte Unterstützung bei der Datenerhebung und bei technischen Schwierigkeiten.

Besonders bedanken möchte ich mich auch bei meinen Eltern, meinen Brüdern und all meinen FreundInnen für ihr inhaltliches Interesse an meiner Arbeit. Mein herzlicher Dank gilt meinem Freund *Max*, der mit seiner Empathie und musikalischen Gabe während der gesamten Promotionszeit, insbesondere in den letzten Wochen, für gelassene und freudige Momente sorgte.

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List of Abbreviations

AA	ambulatory assessment
ADHD	attention deficit hyperactivity disorder
APA	American Psychological Association
ART	attention restoration theory
DGPs	German Psychological Society (German: Deutsche Gesellschaft für Psychologie)
DFG	German Research Foundation (German: Deutsche Forschungsgemeinschaft)
DSM-5	Diagnostic and Statistical Manual of Mental Disorders, 5th edition
EA	environmental attitude
EMA	ecological momentary assessment
ESM	experience sampling method
EU	European Union
GPS	Global Positioning System
MDBF	Multidimensional Mood Questionnaire German: Mehrdimensionaler Befindlichkeitsfragebogen
MISD	mean intra-individual standard deviation
NDVI	normalized difference vegetation index
UN	United Nations
WHO	World Health Organization

Abstract

Spending time in nature can have a positive impact on physical and mental health. With regard to the latter, restorative experiences in nature can for example consist of the enhancement of positive affect, as one aspect of emotional well-being, and the reduction of inattention, as one symptom of attention deficit hyperactivity disorder (ADHD). ADHD symptoms (inattention, hyperactivity, and impulsivity) are dimensionally spread between children and might fluctuate within each child. Importantly, while between-person comparisons suggest that ADHD symptoms are related to the experience of negative affect as well as to increased affect fluctuations, there is not much research investigating the co-variation of ADHD symptoms and affect occurring within a child and in the context of daily life. Assessing daily-life experiences can be implemented by using the methodological approach of ambulatory assessment. This approach enables a researcher to gain insights into the fluctuations of a child's emotions and cognitions, such as affect and inattention, over a certain period of time and in the context of his or her daily life, such as natural spaces. Since more than half of the world's population lives in cities, the association between the context of nature in children's daily life and children's affect or the ADHD symptom inattention seems to be of great relevance for daily-life research. Overall, the present dissertation focuses on two main research goals which are investigated in three empirical research foci.

The first research goal is the investigation of fluctuations of affect and ADHD symptoms and how they are related over time in children's daily life (*Research Focus 1*). Second, the restorative effect of children's daily experiences of natural spaces on affect and on inattention, as an ADHD symptom, is examined (*Research Focus 2*). As an extension, this second overarching research goal is also reflected in the third empirical research focus. This empirical research focus is on the question of whether restorative experiences of natural spaces are moderated by a child's overall association with nature (*Research Focus 3*). Thereby, the association with nature is operationalized as a child's environmental attitude. Applying an ambulatory assessment design to these overarching research goals, the present dissertation extends former research in two ways. In the first place, the focus of the present research is on fluctuations of affect and ADHD symptoms that occur within individuals over short time periods in addition to the already well-investigated between-person differences. Also, an understanding of restorative experiences from natural spaces as they occur in children's daily life enriches past research due to its focus on the context in real life instead of examining the effect of nature with experimental research designs.

All *Research Foci* refer to the same study sample. Children ($N = 55$) of a community sample were asked about their affect and ADHD symptoms (inattention, hyperactivity, and impulsivity) three times a day (morning, afternoon, and evening) over the course of 18 consecutive study days. Moreover, the amount of time spent in natural spaces on a given day was assessed each evening. Background questionnaires from parents and children provided information about a child's association with nature.

Research Focus 1 aimed at the investigation of the within-person relationship – in addition to the already assumed between-person relationship – between negative affect (e.g., depressive) and ADHD symptoms. Focusing on the within-person relationship, it was hypothesized that on occasions when children experience a higher level of ADHD symptoms they also experience enhanced negative affect. In addition, the study examined whether children with increased ADHD symptoms report higher affect fluctuations, which can be regarded as an indicator for emotional impulsivity. The results from a multilevel model confirmed previous findings on the positive relationship between ADHD symptoms and negative affect on a between-person level. However, on a within-person level, negative affect and ADHD symptoms were not related. These findings indicate that children who in general experience more ADHD symptoms also show enhanced negative affect. However, on occasions when children reported a higher level of ADHD symptoms than usual, they did not report an increased negative affect. Moreover, the hypothesis that children with a higher trait level of ADHD symptoms experience more affect fluctuations could not be confirmed. Results are discussed with their implications for future research on intra-individual fluctuations and for practical work with children.

Research Focus 2 is concerned with the restorative effect of the amount of time spent in natural spaces on affect and inattention as an ADHD symptom, thereby also focusing on within-person effects in addition to between-person effects. Multilevel models revealed a statistically significant between-person effect for affect, but not for inattention, which indicates that children who in general spent more time in natural spaces over the entire study period also reported enhanced positive affect, but not less inattention. Within-person effects for both outcome variables were not significant. However, significant random effects for both outcome variables indicate that children differ in their particular within-person relationship. Therefore, it was concluded that some children seemed to benefit from their time spent in natural spaces regarding their experience of affect and inattention whereas other children did not seem to benefit.

The last research result led to the hypothesis that the assumed recovery after time spent in natural spaces could be moderated by a factor due to differences between the children that is described and analysed in *Research Focus 3*. The perceived association with nature (operationalized by the child's environmental attitude) was assumed to moderate the within-person relationship between time spent in nature and positive effects for affective well-being and inattention in children. Correlational analyses revealed no significant results, indicating that children with a stronger environmental attitude do not benefit more from spending time in natural spaces than children with a weaker environmental attitude. Further individual characteristics that could account for the differential associations between time spent in nature and both affective well-being and inattention are discussed.

Overall, the present dissertation shows that between-person effects do not necessarily transfer to within-person effects. This is important, particularly with regard to the history of psychological science, in which the focus often laid on differences that occur between people. Moreover, although most within-person effects were not statistically significant, the present dissertation enriches previous research by providing first insights into the within-person fluctuations of affect and ADHD symptoms (in particular, inattention) by using a comprehensive ambulatory assessment study with children. These results can inform further ambulatory assessment studies in children on feasibility, implementation, and sensitivity of assessments.

1 Introduction

Children and adults are recommended to spend time in nature because of the ascribed positive effect on both physical and mental health (World Health Organization [WHO], 2016). Considering mental health, restorative effects are attributed to nature (Kaplan & Kaplan, 1989; Ulrich, 1983). The restorative experiences are mainly recognized as an enhancement of emotional well-being or cognitive functioning. For example, an individual's affect can be enhanced after exposure to natural environments (e.g., Ulrich et al., 1991). Moreover, children's ADHD symptoms can be reduced when they spend time in natural environments (e.g., Faber Taylor & Kuo, 2009). These restorative experiences seem to be important since Western societies are associated with a hectic and stressful daily life, which can affect mental health, such as affect and symptoms of ADHD (e.g., inattention, hyperactivity, and impulsivity). However, little is known about the restorative experiences of nature from a daily-life perspective.

Daily-life experiences can be studied well by investigating an individual on several occasions within their daily lives, which is also called ambulatory assessment (e.g., Bolger & Laurenceau, 2013). With an ambulatory assessment design, study participants are asked for their experiences or behaviour on multiple occasions in their daily life (e.g., Ebner-Priemer, Kubiak, & Pawlik, 2009). These days, it is not at all unusual for people to measure any – especially physical – activity in everyday life, for example with fitness trackers or smartphones. However, the use of such ambulatory assessment methods in psychological science is not yet very widespread, especially when the subjects are children. This is surprising, since this research approach allows for fluctuations of certain phenomena to be tracked *within a person* over time. Taking ADHD symptoms as an example, the investigation of fluctuations occurring within an individual is highly relevant in practice, since some individuals might show higher levels of a certain symptom in certain situations and lower levels in others. Information about the situation in which the symptom level increases or decreases enables, for example, a practitioner to conceive interventions that are individually addressed to a child's needs.

Moreover, an additional benefit of daily-life research consists in studying effects in the *context* of a person's real life and thus with a high ecological validity (e.g., Reis, 2012). Since nature has a restorative potential, it is of great interest to investigate the context of how nature occurs in daily life. A positive impact of daily experienced natural spaces on affect and ADHD could be beneficial for children's mental health. In the meantime, an overall positive association with nature seems to strengthen the beneficial effects for different aspects of mental health

(Korpela, Ylén, Tyrväinen, & Silvennoinen, 2008). However, nowadays, children are assumed to spend less time in natural environments than before (Kellert, 2002). The lack of contact with nature could possibly affect a child's association with nature (i.e., environmental attitude). Thus, it is of further interest to investigate the role of a child's environmental attitude in the potential restorative experience of nature.

Overall, the present dissertation provides relevant insights into the feasibility of ambulatory assessment as a research approach with children in psychological science. Thereby, on the content level, it focuses on the within-person relationship of negative affect and ADHD symptoms in daily life as two relevant aspects of children's mental health. Moreover, the research of the present dissertation sheds light on the daily-life experiences of affect and the ADHD symptom inattention in the specific context of *natural spaces*. Finally, the influence of the environmental attitude on a child's relationship between natural spaces and aspects of mental health is examined. All this is summarized in the illustration of the research topics of the present dissertation presented in Figure 1.

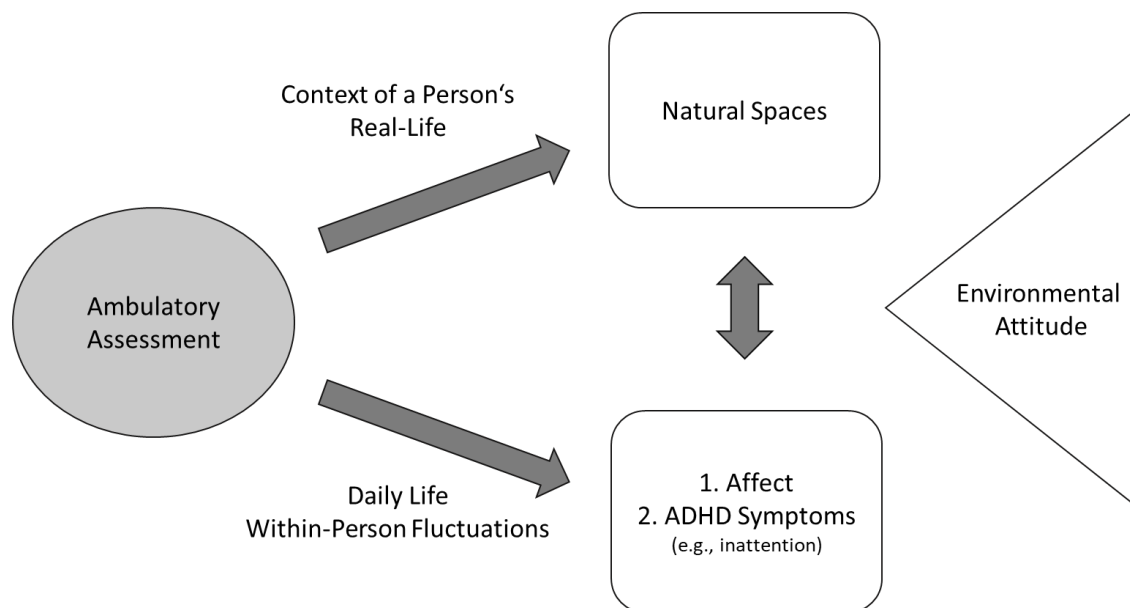


Figure 1. Schematic illustration of the contents (white boxes) examined in the present dissertation using ambulatory assessment as a research approach (grey ellipse).

2 Theoretical and Empirical Background

The overarching goals of the present dissertation are twofold. First, the positive impact of nature on affect and the ADHD symptom inattention and possible determinants for that impact are investigated in children's daily lives. Second, the dissertation aims at investigating the relationship between negative affect and ADHD symptoms in a child's daily life.

In accordance with the overarching research goals, the background of the present dissertation is divided into three main sections. The first (Sect. 2.1) explains how the context of natural spaces is understood in the present dissertation and how it is related to emotional well-being, such as affect, as well as cognitive functioning, such as inattention. In addition, the role of an individual's environmental attitude in restorative experiences of natural spaces is described in the final part of that section. In the second section (Sect. 2.2) the research approach of ambulatory assessment is described in detail, since this methodological approach lies at the core of all three empirical studies (see also Figure 1). The final section (Sect. 2.3) contains the definition of the present outcome variables: affect and ADHD symptoms, such as inattention.

2.1 Natural spaces

Nature can have a positive impact on children's mental health (for a review see Vanaken & Danckaerts, 2018). For example, nature can enhance emotional well-being, such as affect, and cognitive functioning, such as attentional capacities. Two meta-analyses of correlational and (quasi-)experimental studies have revealed positive associations between nature and various measures of emotional and cognitive functioning in schoolchildren (Weeland et al., 2019).

However, since the industrial revolution, cities have been growing and, viewed globally, currently more people live in cities than in rural areas (Ritchie & Roser, 2019). Consequently, this also applies to children. Approximately 70% of children worldwide will live in urbanized areas in the near future (Unicef, 2016). In Germany, already three quarters of individuals below the age of 18 years live in cities (Unicef, 2016). These facts are accompanied by the assumption that children spend less time in nature than before (Kellert, 2002). Particularly for children, spending less time in nature is thought to have negative consequences for their mental health (Vanaken & Danckaerts, 2018; WHO, 2016). Consequently, it is interesting to investigate whether nature as it occurs in the surroundings of children's daily lives can have a positive effect on children's mental health.

Several terms are used in research to examine the positive effects of nature on mental health, such as nature, natural environments, naturalness, and green and blue space. With a focus on nature as it occurs in children's daily lives, the present research uses the term natural spaces. *Natural spaces* can be described as environments that contain vegetation and/or natural waters (Ulrich, 1983). Those environments may also occur in urbanized areas (McAllister, Lewis, & Murphy, 2012), and thus may include small buildings such as in a park or on a playground. In empirical research, natural spaces are mostly referred to as either green (vegetation) or blue (natural water) spaces (Dzhambov et al., 2018). Combining green and blue spaces as they potentially occur in an individual's daily life, the present research refers to both of them as *natural spaces*.

The following section describes two theories, on which the present research is based, which ascribe a restorative potential to nature (Sect. 2.1.1). Subsequently, an overview of the empirical evidence for the positive effect of natural spaces in children's daily lives is provided and a gap in the literature is pointed out (Sect. 2.1.2). Finally, this section ends with a description of a possible determinant for the restorative potential of natural spaces: a child's environmental attitude (Sect. 2.1.3).

2.1.1 Theoretical background

The positive effect of natural spaces is often framed as a restorative effect. This mental restoration is based on the assumption that psychological resources, such as emotional and cognitive functioning, can be 'depleted' by urban environments, which are considered to be busy and hectic in character (Kaplan & Berman, 2010). The majority of research builds on one of two theories that describe the restorative potential of natural spaces on emotional well-being as well as cognitive functioning: The *stress recovery theory* and the *attention restoration theory* (ART; Kaplan & Kaplan, 1989; Ulrich, 1983).

The *stress recovery theory* (Ulrich, 1983) describes a restorative potential of nature on an individual's emotional well-being, such as affect. The author claims a psychophysiological stress recovery after viewing natural scenes (Ulrich et al., 1991). Stress reduction and enhancement of emotional well-being occurs when the *immediate affective* reaction towards a certain environment is evaluated as positive (Ulrich, 1983). According to this theory, a positive affective reaction of an individual occurs when the surrounding environment provides safety, clearance, and recognition value. This is applied when the specific environment shows a moderate or high level of complexity, structural aspects that capture an individual's focus of

perception, a distinct amount of depth, as well as a rather even ground but a curved line of site (Ulrich, 1983). Empirical evidence for the effect of nature on enhancing positive affect stems from a study with university students (Ulrich et al., 1991). These participants watched a 10 min, stress-inducing movie about the prevention of work accidents. Afterwards they were presented with either a nature movie, containing green vegetation or water, or a control condition video, containing an urban environment. Physiological measurements as well as self-reported affect indicated a faster stress recovery in students randomly assigned to the nature video compared to those who watched the urban video (Ulrich et al., 1991).

In addition to this restorative effect of nature on emotional well-being, a restorative effect of nature on cognitive functioning is described in the *ART* (Kaplan & Kaplan, 1989). According to this theory, the potential of nature lies in the restoration of directed attention. Directed attention is described as a kind of mental activity during which distraction is always possible (Kaplan, 1995). An individual's directed attention is usually depleted after it was required. By working on directed-attention tasks, individuals will progress into a state of directed-attention fatigue (Kaplan & Kaplan, 1989). Thus, in order to concentrate on tasks again, there is a need for restoration of directed attention. Therefore, it seems important to find a way to restore an individual's capacity for directed attention. ART claims that nature can restore an individual's directed attention, therefore possibly reducing the state of directed attention fatigue, by providing the following situational characteristics: 'fascination', the individual's attention is held by the environment effortlessly; 'extent', the individual's attention is restored by their potential of immersing in a familiar and comfortable place; 'being away', an individual can escape their everyday life for a moment; and 'compatibility', characteristics of natural environments that let the individual experience their own intrinsic motivations or preferences (Kaplan, 1995).

In brief, nature is assumed to have a restorative potential on emotional and cognitive functioning. However, in both theories the criteria for an environment's potential to be restorative are more abstract than concrete. Hence, in the following section (Sect. 2.1.2), empirical evidence for positive emotional and cognitive outcomes of nature as it occurs in a child's daily life is outlined.

2.1.2 Empirical evidence for positive effects of natural spaces on children

Empirical evidence for the positive effect of nature as it occurs in a child's daily life can either be derived from studies investigating a distinct natural space in which a child is assumed

to spend a lot of time in everyday life or from studies that provide geographical data on the amount of greenness in a child's residential or school surrounding. Experimental and correlational studies have investigated whether areas where a child is assumed to spend a lot of time in his or her daily life, such as school yards, have a positive effect on children when they contain natural spaces. Correlational studies, for example, revealed that children showed less inattention the greater their access to areas with trees and bushes in their pre-school environment (Martensson et al., 2009). Moreover, girls performed better in attention tasks the greener their view from their apartment (Faber Taylor, Kuo, & Sullivan, 2002). For emotional well-being, correlational studies observed that children can handle stressful life events better when their homes and schools are surrounded by natural spaces (Corraliza, Collado, & Bethelmy, 2012). Experimental research showed that after schools greened their schoolyards, children benefitted more from their recess time with regard to aspects of emotional well-being as well as cognitive functioning compared to children whose schools did not change their school yards into a greener place (van Dijk-Wesselius, Maas, Hovinga, van Vugt, & van den Berg, 2018). In addition, a study with a within-subject design showed that children showed more directed attention after playing in school yards with natural spaces during their school breaks compared to playing on rather built-up school yards (Amicone et al., 2018).

However, those studies failed to investigate the different kinds of natural spaces a child actually experiences in his or her daily life. This lack of information can be provided by studies that are based on geographical data about the amount of greenness in a child's daily-life surroundings. Among the various indicators for greenness, a commonly used index is the normalized difference vegetation index (NDVI). This index is based on land surface reflectance of red and infrared light. Vegetation reflects near-infrared and green light more strongly than other wavelengths of the colour spectrum (GIS Geography, 2020). The NDVI ranges from -1 to $+1$, with higher values indicating more vegetation, and thus more green space (e.g., Dadvand et al., 2015).

From a longitudinal perspective, a higher NDVI in children's everyday life was associated with better working memory capacity and reduced inattention in a large sample of school children from Barcelona after a 12-month period (Dadvand et al., 2015). Furthermore, another study reported that the higher the NDVI of a child's residential surroundings, the lower the average ADHD symptom level of a child reported by his/her teacher (Amoly et al., 2014). In addition, another large-scale study observed that a separate indicator for greenness (the objectively assessed amount of trees and shrubs) was related to students' test performance,

while the NDVI in the school surroundings was not (Tallis, Bratman, Samhouri, & Fargione, 2018).

What these large-scale studies do not take into account, is how much time on a given day a child actually spends in the natural spaces that are close to their everyday lives and how this exposure is then related to psychological outcomes. This missing information can only be provided by research with an ambulatory assessment design (AA; see Sect. 2.2). So far, to the best of my knowledge, there is only one AA study that has investigated this association between natural spaces and emotional well-being and cognitive functioning. Over a period of seven days, schoolchildren were equipped with a Global Positioning System (GPS) receiver (Ward, Duncan, Jarden, & Stewart, 2016). Emotional well-being and cognitive functioning was assessed via different measurements once before the AA period. Exposure to natural spaces was linked to emotional well-being but not to cognitive functioning (Ward et al., 2016). Due to their high objectivity, research with data obtained from satellites is very popular. Nevertheless, they do not provide a child's subjective perception of his or her time spent in natural spaces, which may also include other natural environments, such as natural waters, in addition to environments with vegetation. For example, the GPS data from the study conducted by Ward and colleagues (2016) only provides information about exposure to public natural spaces, not other kinds of natural spaces, such as backyards or vacant land.

Moreover, in all of those studies, the amount of time spent in a natural space was not directly associated with a child's emotional or cognitive experiences. Thus, the research in the present dissertation investigates within-person relationships between the self-reported subjective amount of time spent in natural spaces and affect, as an emotional outcome, and inattention, as a cognitive outcome, on a daily basis (*Research Focus 2*; for a further description of affect and inattention see Sect. 2.3).

2.1.3 Environmental attitude and mental restoration

An individual's environmental attitude (EA) has often been investigated in relation to pro-environmental behaviour in psychological science. Individuals with a stronger EA show more pro-environmental behaviours than individuals with a weaker EA (e.g., Kaiser, 1996). The role of a person's EA for restorative experiences from nature has only rarely been the focus of empirical research. Since restorative experiences from nature are considered to be relevant for a person's mental health, it seems to be important to investigate possible determinants that can influence these restorative experiences. In addition to other determinants (e.g., type of

natural environment; e.g., Wyles et al., 2019), an individual's general relationship with nature is considered to be a determinant for mental restoration through natural experiences (Korpela et al., 2008). This relationship with nature can be conceptualized by the term EA, which is defined as "a collection of beliefs, affect, and behavioural intentions a person holds regarding environmentally related activities or issues" (Schultz, Shriver, Tabanico, & Khazian, 2004, p. 31). An attitude in general is regarded as a personal *trait*, thus, reflecting a rather stable personal characteristic (Ajzen, 2005). Restorative experiences of affect and inattention are a momentary condition and therefore are referred to as *states* (see Sect. 2.3). Linking an individual's EA to the daily-life restorative experiences of natural spaces provides information about the role of an individual's trait of EA in those experiences (*Research Focus 3*).

In summary, restorative experiences are important for children's mental health (Sect. 2.1). Nature is thought to provide this kind of restoration, although this might only be true under certain circumstances (Sect. 2.1.1), and an individual's general association with nature may be linked to that individual's likelihood of restoration from exposure to nature. Therefore, the present research investigates this link by assuming an individual's *trait* EA to be a moderator for the within-person relationship of the daily time spent in nature and *state* affect as well as *state* inattention. Thereby, the present research focuses on the investigation of nature as it occurs in children's daily life. For studying experiences in daily life, research applying with ambulatory assessment is needed.

2.2 Ambulatory assessment (AA)

Ambulatory assessment (AA) is a method with the potential to investigate an individual's experiences in daily life by several repeated measurements (e.g., Shiffman, Stone, & Hufford, 2008). By using an AA design, different methods are combined to assess 'people in their natural environment, including momentary self-report, observational, and physiological methods' (Trull & Ebner-Priemer, 2014, p. 466). The investigation of daily-life experiences is of special importance because in the last century psychological research mostly focused on experimental or longitudinal study designs with long-term assessment intervals (Reis, 2012). Compared to experimental or longitudinal research, the assessment of people's daily life provides three main advantages (e.g., Bolger & Laurenceau, 2013; Mehl & Conner, 2012). These are assessing behaviour, emotion, and/or cognition (1) at the exact time when they occur (e.g., Schwarz, 2012); (2) in the *context of an individual's real life* and thus, where they usually occur (e.g.,

Reis, 2012); and (3) on several occasions within short intervals *within persons* (e.g., Hamaker, 2012).

Owing to the relevance of these advantages for the present research, they are further generally described in the following (Sects. 2.2.1–2.2.3). References and examples for the research content of the present dissertation are mentioned at the end of each section. After the description of the advantages, further designations (Sect. 2.2.4), practical guidelines for the implementation of an AA design (Sect. 2.2.5), and challenges for this research approach (Sect. 2.2.6) are discussed.

2.2.1 Real-time assessment

Research with AA designs usually focuses on an individual's current experience instead of retrospective self-report, in contrast to many laboratory settings (Schwarz, 2012a). This is of special importance due to the relevance of the well-known *recall bias*, a phenomenon describing memory distortions due to several mechanisms (e.g., Piasecki, Hufford, Solhan, & Trull, 2007). In psychological research it is quite common to ask a study participant about his or her feelings, experiences, or behaviour in the past. This recall has to rely on the participant's memory. However, the answer does not have to reflect the reality because the process of retrieval can be distorted (Piasecki et al., 2007). For example, an individual's true score of requested facts might be biased by using retrospection because an individual's memory might deviate from the exact fact (e.g., Bradburn, Rips, & Shevell, 1987). For instance, one study showed that study participants often overestimate the frequency of an occurred behaviour (e.g., Homma et al., 2002). These distortions do not appear randomly but rather systematically (Shiffman et al., 2008). Several mechanisms exist on which the recall bias can be based. As an example, the retrieval of discrete events can be biased by rounding effects (Piasecki et al., 2007). For the current dissertation, it is especially noteworthy that, the retrieval of variables that constantly vary over time can be especially difficult (Piasecki et al., 2007). The various experiences may not be present in detail in the participant's memory, tempting him to use heuristic methods to get to an answer that fits the particular research question (Piasecki et al., 2007).

These are just a few examples showing that answers relying on different aspects of an individual's memory can be distorted and therefore do not necessarily correspond to the exact truth (Piasecki et al., 2007). By using an AA design, an individual's experience or behaviour can be assessed at that very moment, thus providing the opportunity to reduce the above-

mentioned possible disadvantages of data from recalled self-report (Schwarz, 2012a). In the present dissertation, affect is assessed at the very moment it occurs, thus circumventing the problem of memory biases due to recall biases (for a further description of affect see Sect. 2.3).

2.2.2 Context of real life

Using AA study designs, researchers practice field research. Thus, the assessment of daily-life experiences provides the possibility of investigating an individual's emotion, cognition, and behaviour in the *context and environment* where it usually occurs (Reis, 2012). Taking the natural context of the target phenomenon into account is of great relevance for psychological research as it promises a high *ecological validity* compared to laboratory research (for an overview see Reis, 2012). Nevertheless, so far, researchers have mostly used experimental designs in laboratory conditions to investigate psychological phenomena. Thus, most of our understanding of these phenomena relies on reports generated in artificial settings, thereby missing the change of experiences or behaviour in the real world (Shiffman et al., 2008). Experimental designs implemented in a laboratory have the potential to investigate the target phenomenon under controlled conditions, thereby enhancing the internal validity (e.g., Fahrenberg, Myrtek, Pawlik, & Perrez, 2007). Thus, experts in the field of AA suggest regarding the two research approaches as complementary, instead of opposed, to investigate the context of psychological phenomena (e.g., Hamaker, 2012).

Taking context into account can either be relevant as a control, if a researcher is interested in a special behaviour or experience, or it can be the focus of daily-life research (Reis, 2012). Referring to the latter, within the present research the focus was placed in the context of natural spaces (Sect. 2.3). Experimental research on experiences of natural spaces has already been conducted repeatedly. However, daily-life experiences of this special context have rarely been the focus of psychological research, which enhances the relevance of the research in the present dissertation.

2.2.3 Within-person effects

The third main advantage of research using an AA design lies in the possibility of collecting data from each individual on several occasions. Therefore, using an AA design provides a closer look at effects occurring within a person over time. The investigation of within-person fluctuations (also often called intra-individual variability) of an individual's

experiences or behaviours is an important complementation to the traditional investigation of between-person comparisons. By investigating within-person fluctuations, research addresses the notion that an individual is characterized not only by his or her stable *traits*, but also by personal, possibly fluctuating *states* (e.g., Hamaker, 2012). Traits are considered to be features that do not change over time, whereas states are regarded as momentary experiences, allowing for variability within a person. However, although the investigation of an individual's (fluctuating) state experiences via AA designs has increased in the past decade, so far, most researchers have focused on the investigation of between-person differences, and processes occurring on a within-person level have been rather neglected in psychological research (Bolger & Laurenceau, 2013; Hamaker, 2012). Importantly, comparing different individuals with each other disregards the possible influence of states on the particular characteristic of interest, which is often the case in large-sample research. Since between-person comparisons are often based on a one-time assessment, the results rely on a random state experience.

In addition to the inclusion of states, the assessment of within-person processes is advantageous from another point of view. In general, research in psychology that is trying to find general laws for each individual (also called *nomothetic research*) was prescribed to be research focusing on between-person differences by using large sample sizes in a cross-sectional design (Allport, 1942 as cited in Hamaker, 2012). In contrast, *idiographic* research, which focuses on particular individuals, used to be ignored in nomothetic science (Hamaker, 2012). The following example provides an illustration of a possible false conclusion when within-person processes are ignored (*Figure 2*; adapted from Hamaker, 2012, p. 44). From a cross-sectional, between-person perspective, there is assumably a strong negative correlation between the number of mistakes and typing speed (left graph), as people who are good at typing will generally show less mistakes as well as faster typing than people who are bad at it. However, the within-person relationship between typing speed and mistakes assumably shows the opposite, that is positive, direction (right graph), as a person will make more mistakes, the faster he or she writes.

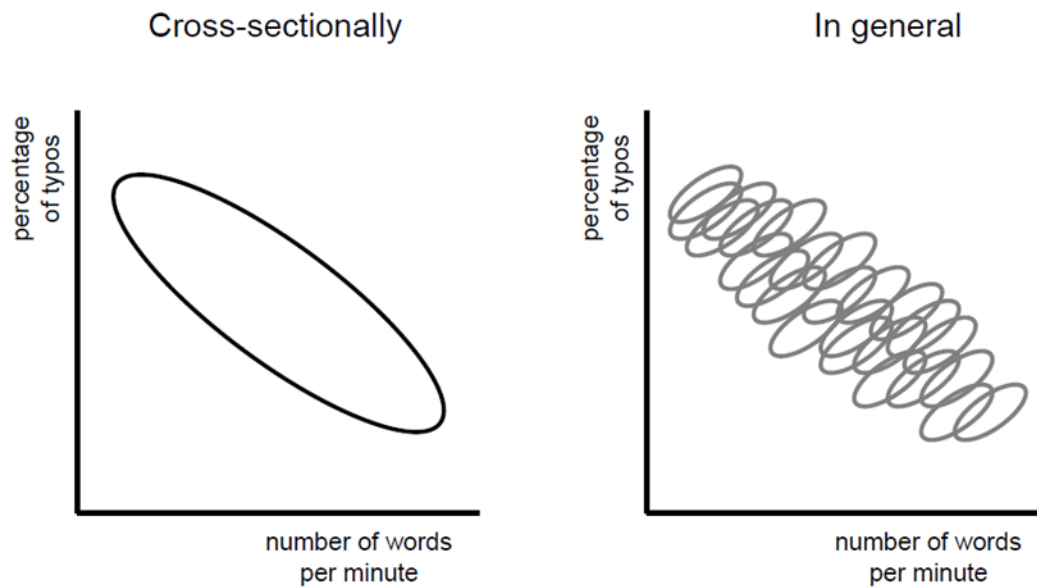


Figure 2. Correlational relationship between typing speed and mistakes of secretaries from a between-person (left graph) and within-person perspective (right graph; Hamaker, 2012, p. 44).

This example depicts that findings from correlational results obtained from a between-person comparison do not necessarily apply for each individual (e.g., Molenaar & Campbell, 2009). Theoretically, the correlation between two characteristics on a between-person level can even point in the opposite direction compared to the within-person relationship (Hamaker, 2012; Schmitz, 2006). A transfer of the effects that were found between individuals by using large-sample designs to effects occurring within individuals is only possible if certain statistical parameters are consistent at both levels, which refers to the notion of *ergodicity* (for a further description of ergodicity see Molenaar & Campbell, 2009). However, experiences or behaviour are anything but ergodic (Hamaker, 2012). Thus, research focusing solely on the cross-sectional between-person effects and thereby ignoring the within-person effects might lead to completely different results than research considering both levels. In short, no generally valid conclusions that must apply to each individual should be drawn solely from the between-person level.

At this point, it is important to note that research focusing on between-person differences is important. Yet, a combination of between- and within-person effects of the characteristics of interest might be helpful in order to generate rules that apply to each individual (Hamaker, 2012). An AA design provides a way to study effects on both a within-person and a between-person level. Moreover, by using an AA design, researchers can shed light on between-person differences in within-person relationships. Additionally, because of the assessment of daily life, the application of AA makes it possible to record within-person

relationships in real life and real time, thus within relatively short intervals (Bolger & Laurenceau, 2013; Mehl & Conner, 2012). This is of special interest for characteristics that show natural microtemporal fluctuations.

These fluctuations, which occur within a person during relatively short intervals, are addressed in the research presented in this thesis. Therefore, Section 2.3 is dedicated to within-person fluctuations of the characteristics of interest in the present dissertation: ADHD symptoms and affect. But before that, in order to describe AA in more detail, the next sections provide information about further designations that are commonly used to describe AA processes as well as practical guidelines and challenges for AA study designs.

2.2.4 Further common designations for AA

In addition to AA, further terms exist that describe the process of data collection via measurements at several times in a person's daily life (Bolger & Laurenceau, 2013). For example, the term *diary* (i.e. daily or electronic) is used when data is requested only once a day (Reis, 2012). The term *ecological momentary assessment* (EMA) is mostly used when the data-collecting process provides data from self-report obtained by electronic diaries at the actual moment, and the term *experience sampling method* (ESM) describes the assessment of the particular characteristic of interest using paper and pencil formats, usually (Trull & Ebner-Priemer, 2014). The term *intensive longitudinal* also refers to data collection using several shortly distanced times of measurement per person (Bolger & Laurenceau, 2013), however, this term has not been commonly used in the literature so far. The terms AA, EMA, and ESM are often used interchangeably (Trull & Ebner-Priemer, 2014). However, whereas the terms EMA and ESM usually focus on data based on self-report, the term AA also includes objectively assessed data, for example, physical activity (Reis, 2012). Thus, AA studies combine different research methods providing information about many different characteristics in a person's daily life (Trull & Ebner-Priemer, 2014). Nevertheless, some researchers also use the term EMA for this combination of research methods (Shiffman et al., 2008). Therefore, no clear delineation between AA and EMA can be made.

The study on which this research is based examines physical activity as well as working memory in an objective manner in addition to self-reports of different variables. Thus, within the present dissertation, the term AA is used to describe the study design employed. Nevertheless, in the following, research using the terms EMA, ESM or electronic diary – and

therefore usually focusing on data based on self-report – will be mentioned as well, since the present study is primarily concerned with data from self-reports.

2.2.5 Practical guidelines for AA

For the implementation of AA studies, experts in the field of AA research provide practical guidelines (e.g., Bolger, Davis, & Rafaeli, 2003; Bolger & Laurenceau, 2013; Dunton, 2018; Shiffman et al., 2008). Two main guidelines that should be considered before conducting an AA study are important for the present research: (1) the type of research questions that can be answered with AA (e.g., Dunton, 2018) and (2) the necessity of carefully thinking through the type of study design according to the particular research questions (e.g., Shiffman et al., 2008).

Regarding the first guideline, by using AA designs, data from several individuals at several points in time can be collected (Bolger et al., 2003). This provides the researcher with a data set that includes, for the variable of interest, variations of the mean and the variance structure both between and within different people (Bolger & Laurenceau, 2013). Regarding the mentioned data structure, it is obvious that research can investigate effects on a between-person as well as within-person level (Sect. 2.2.3). Focusing on within-person effects allows one to analyse fluctuations of a variable, such as affect, over time within a person. Moreover, researchers can also investigate whether several characteristics vary together over time within a person, also referred to as a within-person relationship or co-variation. In addition, it can be interesting to look at between-person differences in within-person relationships.

Concerning the second guideline, after deciding to use an AA study for the research objective of interest, researchers should think about the exact design structure (e.g., Bolger & Laurenceau, 2013). Within an AA study design it is generally possible to discriminate between *event-based* and *time-based* sampling (e.g., Bolger & Laurenceau, 2013; Shiffman et al., 2008). Data collection in *event-based* designs is coupled to the event, meaning that directly when the target event occurs, the study participant is asked to respond to questions or do a required task, as in intervention studies, for example. This target event could be, for example, the appearance of a symptom or health behaviour. By using *time-based* designs, data is collected at certain times of measurement. Thereby, at the appropriate time, the participants are usually informed by means of a signal, such as a ring tone, about the questions to be answered. Time-based designs can be further distinguished according to whether they contain fixed time intervals (e.g., every 4 hours; also called ‘interval-contingent designs’; Bolger & Laurenceau, 2013) or certain

times of measurements (e.g., always at 3 and 5 pm; also called ‘signal-contingent designs’; Bolger & Laurenceau, 2013). Signal-contingent designs can further be differentiated according to their sampling strategy. They can use either fixed times of assessment or randomly assigned moments within certain periods of time (‘random sampling’; Shiffman et al., 2008).

The present research conducted a study with a time-based, signal-contingent design and a fixed sampling strategy, in which study participants were prompted at three distinct measurement times (i.e., occasions) per day. This decision is based on the following reasons. Time-based assessments are suggested for phenomena that usually fluctuate rather frequently (i.e., affect). This is mainly due to the fact that the assessment of frequent fluctuations cannot be achieved via event-based designs, because participants would have to carefully monitor themselves during the whole day and decide whether an event happened or not (Bolger & Laurenceau, 2013). The variables of interest (affect and ADHD symptoms) are of continuous character, meaning that they fluctuate continuously over time, thus a time-based design is preferred in the present research (cf. Bolger & Laurenceau, 2013).

In order to decide on a sampling strategy, the expected frequency of the fluctuations should be considered when planning an AA design. The number of measurements within a day and within the whole assessment period depends on the theoretical assumption of the fluctuations of the target phenomenon in question (Collins, 2006). Psychological variables can change, for example, from moment-to-moment, several times within a day or across days (Shiffman et al., 2008). Since affect is expected to show natural fluctuations over rather short periods of time (Ekkekakis, 2013), but little is known about ADHD-symptom fluctuations (see also Sect. 2.3), this raises the question of how and when exactly a study participant should be prompted for the assessment (cf. Bolger & Laurenceau, 2013).

The present research decided to choose a fixed sampling, in consideration of the burden for the participants, which is argued to be an important decision criterion for the choice of study design (e.g., Bolger & Laurenceau, 2013). Compared to traditional study designs, the burden for participants in all AA studies is rather high (see also Sect. 2.2.6). In order to reduce the burden for the participants, fixed times of measurement provide the advantage of a larger structure for the participant, which often facilitates the survey in everyday life. Since the study participants can prepare themselves, the burden can be reduced, and thus compliance can be increased.

2.2.6 Challenges of AA studies

Studies using an AA design are rather complex compared to traditional research designs, because they usually generate more data per person and typically the assessment period lasts longer. Along with this complex study design, three main challenges emerge: (a) participant compliance, (b) financial resources, and (c) ethical issues.

In an AA study, a participant's compliance is challenged through the relatively long period of data collection. This can lead to more missing data compared to traditional research designs, because participants become bored after some time or forget to participate. In addition, participants may regularly skip over certain questions that do not apply to their ordinary experiences, leading to missing responses even at measurement times when the experience in question is actually happening (Bolger et al., 2003). Thus, in order to keep the compliance high, it is imperative to keep the time taken to respond on each occasion short (Bolger et al., 2003). Thereby it is important to consider that a decrease in time of a measurement instrument can be accompanied by a reduction in reliability of that instrument (Bolger et al., 2003).

A further challenge can be seen in the anticipated large amount of financial resources usually required for AA studies. Since study participants are often equipped with technical devices in their daily lives and experts in the field of technology are needed, sufficient financial resources are a necessary precondition for AA studies.

Finally, AA faces ethical challenges. Assessing various phenomena within the individuals' daily lives can have an intrusive character (Bolger & Laurenceau, 2013). Participants might not be able to imagine what the dedicated assessment period is going to be like before the assessment begins (Fahrenberg et al., 2007). Therefore, unpleasant situations might arise during participation in the study, for example due to the fact that the person's participation in a study is often obvious for other people in the daily environment of the participant. Thus, the signed consent might not reflect the participant's true consent (Fahrenberg et al., 2007). Furthermore, the total amount of data assessed over many days of many participants in each of their daily lives can already be regarded as big data, which brings on the challenge of data storage, especially with regard to the content of the data (e.g., a person's location measured via GPS).

Although researchers are faced with these challenges, the advantages of AA are very promising for research in psychology (Sects. 2.2.1–2.2.3). Regarding the advantages of the investigation of *within-person fluctuations* in the context of *real life*, the following section refers to these aspects for the two target phenomena, that is, ADHD symptoms and affect (Sect. 2.3).

2.3 ADHD symptoms and affect in daily life

Daily-life assessment allows the investigation of effects from both a between- and a within-person perspective¹. From a *within-person* perspective, the present dissertation investigates (1) within-person fluctuations of ADHD symptoms over time, (2) the relationship of ADHD-symptom fluctuations with negative affect over time (i.e., co-variation), and (3) the context dependency of symptom occurrence in a daily-life setting (i.e., natural spaces). From a *between-person* perspective, differences between children in the within-person fluctuations, within-person co-variations, and context dependency are investigated.

With regard to those research interests, ADHD symptoms and affect are described in more detail in Sections 2.3.1 and 2.3.3, respectively. Moreover, empirical research that has been conducted on within-person fluctuations of both constructs is outlined (Sects. 2.3.2 and 2.3.4).

2.3.1 ADHD symptoms: Definition and dimensional approach

The core symptoms of attention deficit hyperactivity disorder (ADHD) are inattention, hyperactivity, and impulsivity (American Psychological Association [APA], 2013). The core symptoms are described via 18 behaviour manners or experiences. Examples for each core symptom can be taken from Table 1. The present dissertation investigates the daily-life experiences of ADHD symptoms by a community sample of children. This approach provides insights into the varying *state level* of ADHD symptom occurrence in children with different *trait levels* of ADHD symptoms². The latter refers to a *dimensional* perspective of the disorder.

¹ Investigations from a within-person perspective are also referred to as within-person effects and investigations comparing different individuals are referred to as between-person effects. An overview of the general description of between- and within-person effects is given in Section 2.2.3.

² For a general explanation of the differentiation between states and traits in psychological research see Section 2.2.3.

Table 1

Examples of ADHD core symptoms from the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; APA, 2013).

<i>Symptom</i>	<i>Example behaviour/experience</i>
Inattention	Often fails to give close attention to details or makes careless mistakes in schoolwork, at work, or during other activities (e.g., overlooks or misses details, work is inaccurate).
Hyperactivity	Often leaves seat in situations when remaining seated is expected (e.g., leaves his or her place in the classroom, in the office or other workplace, or in other situations that require remaining in place).
Impulsivity	Often has difficulty waiting his or her turn (e.g., while waiting in line).

Importantly, it can be discussed whether ADHD should be regarded as a categorical or dimensional disorder (e.g., Coghill & Sonuga-Barke, 2012). By applying a *categorical* approach, a child either has the disorder or it does not. In contrast, a *dimensional* approach suggests that each child shows ADHD symptoms, although to a different extent or level. Currently, ADHD is diagnosed according to a categorical diagnostic system. However, in science the consideration of ADHD as a dimension has become a common approach (Coghill & Sonuga-Barke, 2012). One reason can be seen in the fact that ADHD is considered to be a highly heterogeneous disorder (Willcutt, 2015). Affected children differ from each other in the extent of the level of symptoms or key features. For instance, children with ADHD differ between each other regarding their executive functioning (e.g., Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005)³.

Moreover, empirical research has shown that children with subthreshold ADHD also show certain deficits that meaningfully impair normal functioning (for a review see Balázs & Keresztény, 2014). This indicates that children without an ADHD diagnosis also experience symptoms of ADHD. Finally, by looking at the examples (Table 1) it is noticeable that the description of the symptoms (APA, 2013) suggests that they can be experienced by any child. Only the adverb ‘often’ suggests that the experience or behaviour has to happen more frequently than in mentally ‘healthy’ children. The exact amount of ‘often’ is not specified. Hence the frequency of the occurring symptoms is possibly described with respect to different estimates for the frequency by different diagnosticians.

³ Deficits in executive functioning are regarded as a relevant feature of ADHD (e.g., Barkley, 2015). Executive functioning comprises the cognitive aspects working memory, shifting, and inhibition (Miyake et al., 2000).

In summary, these three aspects call for a dimensional perspective of the ADHD disorder. Hence, by applying a dimensional approach to ADHD, the present dissertation considers that a child's trait level of ADHD symptom expression can be higher or lower than the trait of another child.

2.3.2 ADHD symptoms: Within-person fluctuations and context dependency

From a within-person perspective, the *state* level of ADHD symptoms can be regarded as variable over time (temporal variability) and also as variable between different situations (situational or contextual variability; e.g., Wheeler, Pumfrey, & Wakefield, 2009). Empirical evidence from different study designs (case study, experimental research, and AA) suggests that the state ADHD symptom level fluctuates within a child over different temporal intervals. For example, a case study observed symptom variability over time in a child with ADHD (Wheeler et al., 2009). A meta-analysis revealed that children with ADHD exhibit moment-to-moment fluctuations of response time (Kofler et al., 2013). Since in general within-person fluctuations over time can be studied well by using ambulatory assessment (AA; Sect. 2.2.3), research has already started to investigate within-person fluctuations of ADHD symptoms with AA. Findings from an adult sample indicate that the state level of ADHD symptoms fluctuate within a person over a period of seven days (Knouse et al., 2008). In addition, first findings indicate that ADHD symptoms can fluctuate within adolescents from day to day (Schmid, Stadler, Dirk, Fiege, & Gawrilow, 2016). In accordance with those empirical findings, the research in the present dissertation assumes that the state level of ADHD symptoms fluctuates over time.

In addition to the variability of symptoms over time, *context dependency* states that symptoms vary depending on context within a given setting (APA, 2013). Thus it refers to the fact that a child might show symptoms in a specific context whereas in a different context the symptoms are not displayed (e.g., Hellwig, 2017; Rommelse et al., 2015). Contextual variability dependency of ADHD symptoms has already been proposed in the early 1990s (DuPaul & Barkley, 1992).

According to the common psychiatric nosology, some symptom descriptions highlight that the ADHD experience or behaviour only occurs in a specific context. For instance, the hyperactivity symptom 'Often runs about or climbs in situations where it is inappropriate' says that a certain behaviour is only inappropriate in a certain situation (APA, 2013). That means in

another situation the behaviour, in this case running and climbing, would not be inappropriate and therefore not a symptom of the disorder.

Empirical evidence for the difference of symptom occurrence between different situations can be derived from studies investigating different kinds of contexts. For example, using an experimental study design, researchers observed that children with ADHD show more behavioural symptoms of ADHD in idle than in structured classroom situations (Imeraj et al., 2016), and that they performed better while working on computerized instead of paper-and-pencil tasks (Shaw & Lewis, 2005).

Moreover, differences between two contexts can be derived from studies using the estimation of multiple informants. A meta-analysis showed that the overall correspondence for externalizing disorders between informants was low to medium (De Los Reyes et al., 2015). Findings specific to ADHD symptoms indicate that there is only a moderate concordance between parents and teachers, indicating symptom differences between the home and school context (Kennerley et al., 2018; Mitsis, McKay, Schulz, Newcorn, & Halperin, 2000). Although differences between informants across situations are sometimes explained by measurement error, experts suggest that those discrepancies provide information about a child's symptom variation due to changes in context (De Reyes & Kazdin, 2005; Rommelse et al., 2015). This assumption can be corroborated by the fact that estimations from informants who experience a child's ADHD symptoms within the same context match more than estimations from informants observing different contexts (Burns, Servera, del Mar Bernad, Carrillo, & Geiser, 2014).

That symptom behaviour fluctuates within a child and depends on the situation can be underpinned by the *state regulation model* (van der Meere, 2005). In contrast to previous models (Willcutt, 2015)⁴, this model includes the possibility of behavioural variability in its theoretical conception. According to this model, ADHD symptoms occur when a person experiences a mismatch between the level of activation a given task requires and a person's actual state of activation. Since the state of activation depends on the current context, a person's ADHD symptoms vary across situations (van der Meere, 2005). Van der Meere (2002) further criticizes that ADHD symptoms have mostly been investigated in the laboratory, which fails to take the context in a person's daily life into account. Thus, daily-life research of ADHD symptoms is highly relevant.

⁴ Other common theoretical models of ADHD are the *executive dysregulation model* (Barkley, 2015; Barkley, 1997) and the *dual pathway model* (Sonuga-Barke, 2002; Sonuga-Barke, 2003). Since neither model includes symptom variability in its theoretical framework, which is also criticized by other experts (e.g., Willcutt, 2015), they are not considered to be relevant for the present research.

To summarize, it can be assumed that all children experience ADHD symptoms, albeit to a different extent and in different situations. Therefore, applying a dimensional perspective of ADHD is a more suitable approach for the disorder. Moreover, studying different levels of ADHD symptoms within children over time enables one to obtain more information about the extent of ADHD symptom fluctuations within children with varying trait levels of ADHD. Finally, studying ADHD symptoms in children's daily life provides further indications about the context in which the symptoms might be higher or lower.

Therefore, the present dissertation analyses ADHD-symptom fluctuations within a child over time in daily life. Moreover, the contextual relationship of ADHD-symptom fluctuations over time within a *child* in daily life is the focus of the present research, since this has not been investigated so far with an AA design. Thereby, the ADHD symptom inattention is examined in the distinct context of *natural spaces* (Sect. 2.1). Moreover, since there is a growing amount of research interested in the *emotional context* of ADHD symptoms (e.g., Graziano & Garcia, 2016), the co-variation with negative affect is a further research goal of the present dissertation (*Research Focus 1*).

2.3.3 Affect: Definition and theory

Affect can be defined as a “neurophysiological state consciously accessible as a simple primitive nonreflective feeling most evident in mood and emotion but always available to consciousness” (Russel & Feldman Barrett, 2009, p. 104). The valence of affect can be positive or negative (Watson, Clark, & Tellegen, 1988). High positive affect is associated with, for example, pleasure and happiness, whereas negative affect is associated with being upset or sad (Russell, 2003). Affect varies over time in intensity and kind (Ekkekakis, 2013). Affect is regarded as an aspect of *emotion* (Mulligan & Scherer, 2012). Importantly, these terms are sometimes used interchangeably (Ekkekakis, 2012). However, there are major differences and thus it is important to disentangle these and other terms that circulate in emotion research: Affect, emotions, moods, and feelings (for an overview see Table 2). According to Ekkekakis (2013), the mentioned constructs can be distinguished based on their intensity, frequency, duration, and whether they are related to an external or internal stimulus or object.

Table 2

Tentative distinctions between the constructs of affect, emotion, and mood (adapted from Ekkekakis, 2013, p.47f.).

<i>Criterion</i>	<i>Affect</i>	<i>Emotion (Feeling)</i>	<i>Mood</i>
Intensity	Variable	High	Lower than emotion (in clinical cases sometimes high)
Frequency	Always	Rarely	Constant
Duration	Constant	Short	Long (hours or days)
Temporal relation to stimulus	direct	Immediate or close	May be distant
Direction to an object	No	Yes	Not necessarily
Examples	Pleasure, displeasure	Love, pride, guilt	Euphoria, grumpiness

Emotions are considered to have a beginning and an end (Mulligan & Scherer, 2012). Emotions are expected to have a high intensity and are linked to an object intentionally (Mulligan & Scherer, 2012, p. 346). Emotions can be described as of a discrete, episodic nature (Ekman, 1992). *Feelings* are mostly regarded as a synonym of emotions in psychology (Scherer, 2009). In science, instead of feelings, the term emotion is preferred.

In contrast to emotions and affect, *moods* usually last over a longer period of time (Ekkekakis, 2012). Moreover, moods do not change rapidly and are not necessarily aimed at a certain object (Frijda, 2009). The intensity of moods is lower than that of emotions, although some moods can reach a high intensity as well (e.g., depression; Frijda, 2009).

Daily-life research on emotional aspects mostly refers to the construct of affect. This is mainly due to the nature of affect. In contrast to emotions, it is constantly present and therefore can be assessed at any time. Moreover, it constantly varies within individuals (Ekkekakis, 2013). For those reasons, the present research focuses on the construct of affect to study fluctuations of emotional feeling states.

Different *theoretical models* of the construct of affect exist (Ekkekakis, 2013). The present research refers to the circumplex model of affect, which is based on a dimensional instead of a categorical approach (Russell 2003). According to the author, the construct of affect is subdivided into two different dimensions, one for the valence and one for the arousal (Figure 3). The two dimensions can be regarded as independent (Russell, 2003). By applying the circumplex model of affect, both dimensions are regarded as bipolar instead of unipolar.

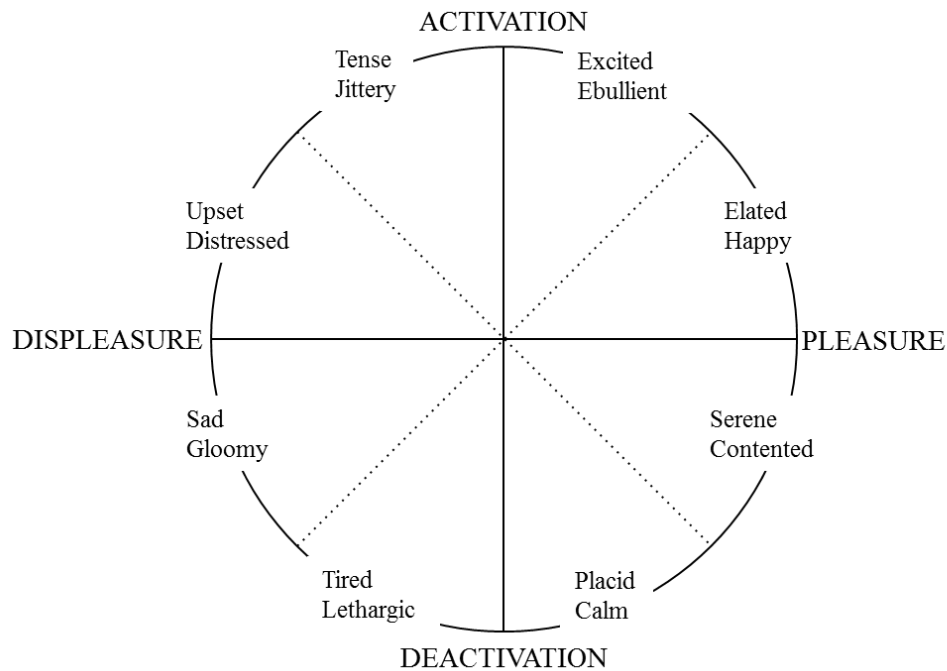


Figure 3. Circumplex model of affect (Russell, 2003; p. 148).

In contrast to that model, the two-dimensional model of Watson, Clark, and Tellegen (1988) regards positive and negative affect as unipolar, and thus two independent dimensions. However, in line with prior research on the factor structure and dimensionality of affect measures at the within-person level in children (e.g., Leonhardt, Könen, Dirk, & Schmiedek, 2016), in the present research affect is assessed with a bipolar measure. Moreover, the present dissertation focuses on the valence dimension of affect (positive–negative or pleasure–displeasure), since the interest lies in the investigation of negative affect as related to ADHD symptoms.

2.3.4 Affect: Within-person fluctuations

A person's overall affective experience can be regarded as a *trait* (Brose, Voelke, Lövdén, Lindenberger, & Schmiedek, 2015). However, the state of affect *fluctuates* in both short- and long-term periods within a person (for a review see Röcke & Brose, 2013). Empirical research with AA observed that positive and negative affect fluctuates during a day and between days in non-clinical adults (Brose, Scheibe, & Schmiedek, 2013; Rush & Hofer, 2014). Children and adolescents also show fluctuations of affect (Fulgini & Hardway, 2006; Leonhardt et al., 2016; Neumann, Van Lier, Frijns, Meeus, & Koot, 2011). For example, one AA study showed that the affective experience of children also fluctuates naturally over the course of

several days (Leonhardt et al., 2016). However, research on affect fluctuations in children is still rare.

With this in mind, the relevance of studying affect as a state in addition to a trait becomes apparent. However, a person's experience of affect is still often assessed only once in order to provide information about a person's trait affect, thereby ignoring the influence of an affective state. Especially in children, there is very little empirical research on affect fluctuations over time and in relation to other time-varying constructs, such as ADHD symptoms. Thus, in order to provide more information about a child's affective experience over time, the research in the present dissertation focuses on the investigation of affect fluctuations and its association with fluctuating ADHD symptoms in daily life.

Empirical evidence for a within-person relationship over time in daily life of negative affect and ADHD symptoms can only be derived from studies using AA. For example, in adults, ADHD symptoms were related on a within-person level to negative affect (Knouse et al., 2008). However, a study with adolescents did not find a corresponding within-person relationship in children with ADHD, although in the same study a sub-sample of adolescents without ADHD showed a within-person relationship between the ADHD symptom inattention and negative affect (Schmid, 2014).

Research on the within-person relationship of ADHD symptoms and negative affect with *children* does not exist so far. Thus, the research of this dissertation provides relevant insights into the within-person relationship of the state level of ADHD symptoms and negative affect in children's daily lives (*Research Focus 1*).

3 Research Aims

The present dissertation has two overarching research goals. First, the research interest lies in the restorative potential of natural spaces for affect and the ADHD symptom inattention in a child's daily life. Second, the research aims at investigating the relationship of affect and ADHD symptoms within children over time, and thus whether both constructs potentially covary within children in their daily lives. By applying these research goals, the present dissertation contributes to a better understanding of the restorative potential of nature as it occurs in children's *daily lives*, which is very valuable due to high ecological validity compared to studies using experimental study designs (Sect. 2.2.2). Moreover, the investigation of ADHD symptoms and negative affect within a child over time provides first findings for the *within-person* relationship of both constructs in *children*. This is highly relevant because within-person effects do not necessarily have to be the same as between-person effects, which already indicate a connection between the respective constructs.

Experiences in daily life and within a person over time can be investigated well by using an AA design (Sect. 2.2). Thus, the present research used an AA design to investigate these two general research goals, which are represented in three single research foci. The empirical results of all three research foci stem from one and the same AA study. Children in Grade 5 (age in years: $M = 10.7$, $SD = 0.5$) of German comprehensive and middle schools were asked to report their affect and ADHD symptoms three times a day over 18 consecutive days. Moreover, time spent in natural spaces on each day was assessed once in the evening. The children were provided with smartphones, so that they could respond to the questions via a specifically designed smartphone application. Thus, it was also possible to remind the children at individually scheduled times to respond to the questions. Before this AA period, the children were asked to answer a background questionnaire containing items to assess personality traits, such as a child's environmental attitude. Although all research foci refer to the same study sample, they shed light on different research questions.

Research Focus 1 investigates whether there is a within-person relationship between negative affect and ADHD symptoms in children's daily lives. Moreover, the possible link between a child's high trait level of ADHD symptoms and increased fluctuations of affect is explored. *Research Focus 2* sheds light on experiences of nature in children's daily lives and how those experiences are related to a child's affect and the ADHD symptom inattention. The goal of *Research Focus 3* is to elucidate the role of a child's trait relationship with nature in the restorative potential of daily experiences in natural spaces.

4 Empirical Research Foci

4.1 *Research Focus 1: Experiencing children's daily life: Do ADHD symptoms and negative affect co-vary within individuals?*⁵

Abstract

Background: Children with ADHD symptoms show enhanced experiencing of negative affect as well as greater affect fluctuations than children without ADHD symptoms. Until recently, research focused on the retrospective, one-time assessment of affective traits from a between-person perspective. The current research investigates whether in addition to a between-person relationship between ADHD symptoms and negative affect a within-person relationship of ADHD symptoms and negative affect as an emotional state exists. Thereby assuming that ADHD symptoms co-vary with negative affect in children's daily lives of a community sample. Moreover, affect fluctuations are specifically investigated.

Methods: Children (N = 55; M = 10.7y) rated their affect state and the level of ADHD symptoms three times a day for 18 consecutive days in an ambulatory assessment study. For data collection, children were provided with smartphones that prompted the children to respond to the questions based on a previously arranged schedule.

Results: Children with a higher level of ADHD symptoms reported an enhanced negative affect than children with a lower level of ADHD symptoms. However, within-person associations were not significant. This indicates that, on occasions when children experience a higher level of ADHD symptoms compared to their personal average of ADHD symptoms, they did not report an enhanced negative affect. Overall, affect fluctuations were not significantly higher in children experiencing a higher level of ADHD symptoms.

Conclusion: We replicated the relationship of ADHD symptoms and negative affect on a between-person level, but we could not find the same relationship on a within-person level. However, due to methodological limitations, further research is needed to provide more information about the co-variation of ADHD symptoms and negative affect as well as affect fluctuations in children.

Keywords: ADHD symptoms, affect, within-person relation, ambulatory assessment

⁵ Reuter, M., Kühnhausen, J., Haas, P., & Gawrilow, C. (2020). Experiencing children's daily life: Do ADHD symptoms and negative affect co-vary within individuals?. *Manuscript in preparation.*

Introduction

Children and adolescents with attention-deficit/ hyperactivity disorder (ADHD) experience symptoms of inattention, impulsivity, and hyperactivity (APA, 2013). The psychiatric disorder presents with a worldwide prevalence rate of 5-7% and is frequently diagnosed in childhood and adolescence (Polanczyk, Willcutt, Salum, Kieling, & Rohde, 2014). Deficits in cognitive functioning, such as executive functions (EF; e.g., Barkley, 2015), were widely researched and documented; however, emotional difficulties in children with ADHD symptoms were often neglected. A more recent stance is that the core symptoms of ADHD can be accompanied by emotional disturbances as well (APA, 2013). For example, affected children can display an increased negative emotionality (Martel, 2009). In concordance with this finding, children with ADHD often show high comorbidity rates with oppositional-defiant disorder (ODD; e.g., Reale et al., 2017), major depressive disorder (MDD), or anxiety disorder (e.g., Blackman, Ostrander, & Herman, 2005; Chronis-Tuscano et al., 2010; Jarrett & Ollendick, 2008). Diagnostic criteria for these disorders involve different types of negative affect, such as anger or aggression (in ODD), sadness (in MDD), or fear (in anxiety disorders; APA, 2013). Apart from negative emotionality, another emotional impairment of individuals with ADHD can be seen in increased fluctuations of intense emotional states (e.g., Bunford, Evans, & Wymbs, 2015; Graziano & Garcia, 2016; Skirrow & McLoughlin, 2009).

To date research has often focused on emotional impairments in children with an ADHD diagnosis in comparison to children without an ADHD diagnosis. Since ADHD symptoms are dimensionally spread in the population (e.g., Marcus & Barry, 2011) and children without an ADHD diagnosis can also show increased emotional impairments (for a review see Balázs & Keresztény, 2014), ADHD can be regarded as a dimensional disorder (e.g., Coghill & Sonuga-Barke, 2012; Haslam et al., 2006; Larsson, Anckarsater, Råstam, Chang, & Lichtenstein, 2012). Therefore, the present research focuses on emotional impairments in children with varying degrees of ADHD symptom levels in a community sample.

Importantly, past research often investigated emotional impairments in children with ADHD symptoms using retrospective self-report methods thereby often focusing on differences that occurred between groups of children. Since the experience of emotions strongly depends on the context (Ekkekakis, 2012), and retrospective reports are prone to recall bias (e.g., Schwarz, 2012), there is an urgent need to study individual's emotional experiences in daily life in the exact moment when they occur.

Affect and ADHD symptoms: a between-person perspective

To assess emotional experiences in daily life, research mostly refers to the construct of *affect*. Affect can be regarded as one part of the complete emotional experience (Mulligan & Scherer, 2012). Affect usually refers to the “neurophysiological state consciously accessible as a simple primitive non-reflective feeling most evident in mood and emotion but always available to consciousness” (Russel & Feldman Barrett, 2009, p.104). The valence of affect can be positive or negative and refers to a bipolar dimension, whereby positive affect (PA) can be described by attributes such as happy or contented and negative affect (NA) usually can be referred to as sadness or distress (Russell, 2003). Although affect is usually regarded as a state (Russell, 2003) that may vary in intensity and valence within a person over time (Ekkekakis, 2013), a person’s overall affective experience can be regarded as a trait (Brose et al., 2013). Previous research that investigated the relationship of ADHD symptoms and affect most commonly considered affect as a trait rather than a state. In the following, the perspective of previous research that combined ADHD symptoms and a person’s general experience of affect will be mentioned.

On the one hand, the affective trait in children with ADHD symptoms is considered to be rather negative (Martel, 2009). Enhanced negative affect was found in children as well as in adults with ADHD symptoms (Anastopoulos et al., 2011; De Pauw & Mervielde, 2011; Lugo-Candelas, Flegenheimer, McDermott, & Harvey, 2017; Nigg et al., 2002). Moreover, negative affective reactivity is enhanced in children with ADHD symptoms compared to controls (Foley, McClowry, & Castellanos, 2008). Furthermore, increased experiences of negative affect were found in boys with ADHD symptoms compared to non-affected boys (Braaten & Rosén, 2000). In this study, the children showed more anger, sadness and guilt according to parental reports. Furthermore, more negative affect has been found in children showing impulsivity when compared to control children (Shea & Fisher, 1996). A commonly discussed reason for enhanced negative affective experiences in children with ADHD symptoms is that affected children constantly experience frustration in various contexts (e.g., Daviss, 2008). For example, despite good cognitive abilities, children with ADHD symptoms often perform worse than their peers in school (Frazier, Youngstrom, & Naugle, 2007). Highly frequent events of frustration are regarded as possible indicators for the development of internalizing disorders such as depression (e.g., Blackman et al., 2005; Daviss, 2008). Depression in turn, constitutes an enhanced experience of negative affect, such as sadness. Since there is a rather long-term association between ADHD symptoms and negative affect, it can be assumed that they are also related in a more immediate context.

In addition to the enhanced experience of negative affect, children with ADHD symptoms experience quick and volatile fluctuations of affect (for a review see Skirrow & McLoughlin, 2009), which is often referred to as mood instability (APA, 2013) emotional impulsivity (e.g., Rosen & Factor, 2015), or emotional lability (e.g., Sobanski et al., 2010). For example, emotional lability was tested as stronger in children with more severe ADHD symptoms (Sobanski et al., 2010). Furthermore, when comparing children with ADHD symptoms to their healthy siblings, the affected children showed more positive and more negative affect (Anastopoulos et al., 2011). This indicates that children with ADHD symptoms suffer from increased fluctuations in affect, when compared to children without ADHD symptoms (e.g., Anastopoulos et al., 2011; Brocki, Forslund, Frick, & Bohlin, 2019).

In summary, evidence showing a relationship between ADHD symptoms and negative affect as well as between ADHD symptoms and affect fluctuations exists. However, past research studied ADHD symptoms, negative affect as well as affect fluctuations from a one-time, retrospective and/or between-person perspective, thereby referring to affect as a *trait*. Since affect varies within individuals in short time periods (e.g., Kuppens, Oravecz, & Tuerlinckx, 2010), affect should also be regarded as a *state* and thus be assessed in the moment it is experienced as well as at several occasions for each person. Hence, the fluctuations of affect that occur within a person from one occasion to the other can be assessed. In order to provide data from several occasions in a child's daily life, an *ambulatory assessment* study design is recommended (Mehl & Conner, 2012).

Affect and ADHD symptoms: a within-person perspective

Ambulatory assessment (AA) is a research method that assesses data during multiple occasions in the participants' daily lives by using research methods, such as self-report or objective tasks via smartphones (e.g., Reis, 2012). Compared to a one-time assessment, the repeated measurement during an individual's daily life has three general advantages that can also be applied to the assessment of affect. First, recall biases are prevented, because people are asked about their affect in the current moment of experience as opposed to their affect within the last week or month (e.g., Schwarz, 2012). Secondly, the ecological validity is high because in contrast to laboratory experiments, data collection takes place in the context where affect is experienced (e.g., Reis, 2012). Thirdly, effects that occur within persons can be assessed, because repeated measurements provide multiple data entries per person over time. This is important since conclusions about the effects within persons over time cannot be drawn from between-person effects, as they do not have to be the same (e.g., Hamaker, 2012; Molenaar & Campbell, 2009).

Although these general advantages of assessments in individuals' daily lives are evident, studies using AA designs and assessing affect or affect fluctuations in children with ADHD symptoms are rather rare. One of the AA studies (Whalen et al., 2006) analysed the valence of affect experienced by children with ADHD symptoms as compared to children without ADHD symptoms. Whalen and colleagues (2006) asked children about their affective experiences every 30 min for seven consecutive days outside of school hours. Results showed that children with ADHD symptoms ($n = 27$) reported less positive affect over time but not more negative affect during the seven-day reporting time when compared to healthy children ($n = 25$). Importantly, all children with ADHD symptoms were taking stimulant medication during the data collection which is known as an influencing factor for emotional experiences (for a review see Manos et al., 2011). In another study with a community sample, adolescents with a higher level of ADHD displayed more negative affect than adolescents with a lower level of ADHD over two collection waves, each of them lasting for four days (Whalen, Jamner, Henker, Delfino, & Lozano, 2002). Another study investigated the intensity of *affect fluctuations* in children with ADHD symptoms. Over a period of 28 days, 27 children (and one of their respective parents) were asked to rate the child's affect three times a day (Rosen & Factor, 2015). The authors found that the children who experienced greater emotional impairments in general also demonstrated more affect fluctuations over the 28-day period (Rosen & Factor, 2015). Rather recently, a pilot trial investigated the intensity as well as general fluctuations of negative affect in girls with ADHD symptoms. Over the course of seven days, 13 girls (between the age of 12 and 16) and their mothers rated the adolescent's negative affect twice a day (or four times on weekends; Babinski & Welkie, 2019). The results showed that girls with a comorbid depression ($n = 5$) showed increased negative affect as well as increased fluctuations in negative affect (Babinski & Welkie, 2019).

These findings give first insights into the within-person experience of affect valence as well as affect fluctuations in children with ADHD symptoms. However, research assessing affect of children with ADHD symptoms in daily life is still in its infancy and thus further studies are needed. Moreover, previous studies did not investigate whether there is a within-person relationship between ADHD symptoms and negative affect. However, with regard to the strong evidence for the relationship between ADHD symptoms and negative affect on a between-person level, meaning that children with ADHD symptoms show increased negative affect when compared to children without ADHD, and since effects between-persons need not apply to effects within-persons, it is important to study the respective within-person relationship of these variables. Thus, the present study will focus on the within-person relationship between

ADHD symptoms and negative affect in such a way that investigates whether the experience of enhanced ADHD symptoms co-varies with an enhanced experience of negative affect.

To the best of our knowledge, the within-person relationship of ADHD symptoms and negative affect in the daily life of non-adult samples was only investigated in one previous studies. In a sample of 75 male adolescents ($M_{\text{age}} = 13.15\text{y}$; $SD = 1.93$), affective experiences and ADHD symptoms were assessed every evening over eight days (thus, referring to 600 occasions; Schmid, 2014). On a between-person level, ADHD symptoms and negative affect were significantly related, indicating that males who in general experience more ADHD symptoms also experience more negative affect. However, on a within-person level associations between ADHD symptoms and negative affect were not significantly related. This indicates that on days when ADHD symptoms were higher than usual male adolescents did not experience more negative affect (Schmid, 2014). Nevertheless, this study has limitations that the present research addresses. First, compared to boys with ADHD symptoms girls have a higher risk for developing depression (e.g., Chronis-Tuscano et al., 2010), and yet they were not included in that study sample. Second, the data collection in the Schmid study (2014) took place via telephone calls once every evening over 8 days. Current research can investigate the within-person relationship of ADHD symptoms and negative affect in boys and girls by collecting data on more occasions and by using personal assessment tools, such as smartphones.

The present research and hypotheses

Previous research suggests that children with ADHD symptoms experience enhanced negative affect and enhanced fluctuations of affect. However, most research investigated the relationship between ADHD symptoms and negative affect or affect fluctuations from a between-person perspective and by using one-time retrospective research methods. Thus, the present research focusses on the daily, live assessment of within-person associations in addition to the already assumed between-person relation of ADHD symptoms and negative affect. Since affect fluctuates within-persons during short time periods, the present study investigates whether the experience of negative affect co-varies with the level of ADHD symptoms from occasion to occasion in children. Moreover, the present study investigates affect fluctuations and how they vary between children.

We will test three hypotheses: (1) Between-person perspective: Children with a higher level of ADHD symptoms report more negative affect than children with a lower level of ADHD symptoms. (2) Within-person perspective: On occasions when children experience a higher level of ADHD symptoms compared to their personal average of ADHD symptoms, they also experience an enhanced negative affect. (3) Between-person perspective: children with a

higher level of ADHD symptoms (operationalized by the mean of ADHD symptoms over the period of 18 days) show more affect fluctuations compared to children with less ADHD symptoms.

Methods

The present study is part of the larger research project AttentionGo (e.g., Reuter, Kühnhausen, Haas, & Gawrilow, in press), focussing on fluctuations in ADHD symptoms, affect and self-control in school children's daily life. The study used a measurement burst design (Sliwinski, 2008), including three waves of data collection. Each wave consisted of a period of 18 consecutive days and had three assessments per day. For data collection, the participating children were provided with smartphones. Importantly, the present article only refers to data from the first wave, taking place during November and December in 2017 in Southern Germany.

Study sample

Recruitment of $N = 59$ children took place in October 2017. One participant dropped out after the beginning of the ambulatory assessment period and another child had to be excluded from data analyses because of the exclusion criteria of a Trisomy 21. Moreover, the code names of two children were mixed up and thus, their data had to be excluded from data analyses as well. Therefore, the final sample consisted of 55 children. The mean age was 10 years and 9 months ($SD = 6$ months; $n = 54$; birth date for one child was not provided). Males ($n = 25$; 45.45%) and females ($n = 30$; 54.55%) were relatively evenly split. All children were enrolled in Grade 5 of either a middle ($n = 48$; 87.3%) or general school ($n = 7$; 12.7%). The socioeconomic status (operationalized by monthly net salary) of a family was provided by the parents via self-report. The monthly net salary, was divided into categories, with most families either disposing over an amount of €3000 to €4000 ($n = 18$; 32.73%) or $> €5000$ ($n = 14$; 25.45%), whereby no answer was provided from six parents (10.91%). A voucher for a joint family trip (e.g., fun pool or leisure park) endowed with an amount of 40 Euro was provided for each family as a reimbursement. In addition, a training for the teaching staff covering self-regulation interventions for school children was offered to the school principals.

Procedure

The research project was run from October 2017 to November 2018, including three waves of data assessment, each of them lasting 18 consecutive days. Within each wave, parents and children were asked to participate in both a one-time survey and an ambulatory assessment period. The one-time survey was meant to gain rather general information in addition to the

momentary assessment of the ambulatory assessment period. However, only the parental one-time assessment delivers data for the present study.

Recruitment and one-time assessment. Recruitment of schools took place from July to October 2017. After a school principal gave us his/her and the Grade 5 classroom teachers' signed informed consent forms, the project was presented to all children enrolled in Grade 5 at that referring school in October 2017. After receiving a parental informed consent form, a structured telephone interview was conducted with one parent, lasting about 45 minutes. Each interview contained questions about demographic aspects and other variables that are not relevant in this study (for further details, see for example Reuter et al., in press).

Ambulatory assessment. For the ambulatory assessment, the children were provided with smartphones including a specially programmed application that denied access to the internet or any other functioning of the phone (Dalir & Rölke, 2012). The ambulatory assessment period consisted of eighteen consecutive days and children were asked to respond to the items three times a day. Thus, for every child 54 occasions were assessed (18 days * 3 times daily). The study used a time-contingent sampling method, thus smartphones prompted the children via a ringtone to respond to the items in the morning, afternoon (excluding school time), and evening before the children went to bed. However, due to the children's different daily life schedules, the timings of the smartphone prompts were individually designed and thus, they differed slightly between the children. At the parents' request, the time of the alarm for the morning and evening time slot could vary on weekends. All time ranges and the respective frequencies are depicted in Table 6 (Appendix Research Focus 2). The smartphone always rang for ten seconds. If the child did not respond to the first prompt, the alarm rang again after ten minutes. This ringing procedure was repeated for half an hour, after which the children could no longer respond. All items presented to the children during the ambulatory assessment period were explained to the children in advance (i.e., ADHD symptoms and affect, see section about measurements). Answering the questions took about three minutes in the morning (19 items) and afternoon (17 items) and – due to a larger amount of items – up to five minutes in the evening (28 items).

Measurements

ADHD symptoms. To assess ADHD symptoms at every time of measurement children answered four items referring to the three core symptoms, inattention, hyperactivity, and impulsivity. All items are depicted in Table 5 (Appendix Research Focus 1). We adopted four items from the original version of the Conners3 Rating Scale (Lidzba, Christiansen, & Drechsler, 2013). In comparison to the original version of the questionnaire, we changed the

temporal reference in order to match daily assessment (Bolger & Laurenceau, 2013). Moreover, in order to enable the children to respond in a more differentiated way, we changed the response scale of the items, using a six-point instead of four-point Likert scale (Piasecki et al., 2007), with higher values indicating a higher symptom level. To gain a mean value for an ADHD symptom score for each child, we calculated the mean value of all four items at each time of measurement, and finally averaged these scores. Thus, without any missing values, the mean value for each child is based on 54 scores (the compliance is reported in the result section). The items for assessing the ADHD symptoms were always presented to the children after the assessment of affect. For the between-person reliability, *Cronbach's alpha* was calculated for every measurement time separately. The results were then averaged over all measurement times ($M = 0.74$; $CI_{95} = 0.71, 0.76$). The within-person reliability showed relatively good scores (*McDonalds Omega*: $\omega = 0.69$).

Valence of affect. Children rated their present affective experience on an adopted version of the Multidimensional Mood Questionnaire (German: Mehrdimensionaler Befindlichkeitsfragebogen; MDBF; Steyer, Schwenkmezger, Notz, & Eid, 1997). With this questionnaire, the valence of affect can be assessed as an independent dimension (Russell, 2003). We adopted the original version by changing the temporal reference as well as the response format thus following recommendations for capturing fluctuations in an ambulatory assessment study (Piasecki et al., 2007; Trull & Ebner-Priemer, 2014). Compared to the original version, children rated their momentary *affect* instead of their *mood* in the last two weeks and they responded on a six-point instead of five-point Likert scale. Furthermore, we changed the unipolar to a bipolar response format (ranging from 1 “negative affect” to 6 “positive affect”) in order to reduce the burden for the participants (Piasecki et al., 2007). The mean value over all four items was calculated for each child and every measurement. Lower scores indicate higher negative affect states. All affect items are depicted in Table 5 (Appendix Research Focus 1). For the between-person reliability we calculated Cronbach's alpha for every measurement time separately and averaged the results ($M=.90$; $CI_{95} = 0.89, 0.91$). An estimation of the scale's within-person reliability was done via calculating the *McDonalds Omega* ($\omega = 0.87$).

Statistical Analyses

For the first and second hypothesis, we used multilevel modeling with a hierarchical structure (e.g., Singer & Willet, 2003). Within the two-level structure, measurement occasions (Level 1) were nested within-persons (Level 2). We constructed a random slope model to test our hypotheses and added the occasion as a predictor for the time trend to the model, thus we could control for an effect of time trends on the relationship of the variables (Bolger &

Laurenceau, 2013). The predictor variable *ADHD symptoms* was centered at the person mean as well as the grand mean (Wang & Maxwell, 2015). Thus, effects on the within-person level refer to children's individual deviation from their own average of ADHD symptoms. After the model comparison, we tested whether the data follows the assumed linear structure by visual inspection of the residuals plotted against the true score of the outcome. We further tested whether the residuals between the children are normally distributed because the normal distribution is an assumption for multilevel modeling (Bolger & Laurenceau, 2013). We tested for normality distribution by visual inspection of the respective QQ plot as well as by using the Shapiro Wilk normality test (Rahman & Govindarajulu, 1997). Because affect was not normally distributed, we transformed the outcome variable by using either logarithmic functions or the mean square root (Snijders & Boskers, 2012). None of the transformations changed the results significantly, thus, for the interpretation we will use the effects of the original, non-transformed model. The conducted random slope model is represented by the following equations.

$$\text{Level 1: } \text{affect}_{ti} = \beta_{0i} + \beta_{1i}\text{time}_{ti} + \beta_{2i}\text{ADHDsymptoms}_{si} + \beta_{3i}\text{ADHDsymptoms}_{si} + \varepsilon_{ti}$$

$$\text{Level 2: } \beta_{0i} = \gamma_{00} + \sigma_{0i}$$

$$\beta_{1i} = \gamma_{10}$$

$$\beta_{2i} = \gamma_{20}$$

$$\beta_{3i} = \gamma_{30} + \sigma_{3i}$$

The outcome variable *affect* at a certain measurement occasion (subscript t) for a distinct person (subscript i) was predicted by fixed as well as random effects. The Level 1 equation represents the within-person effects by assuming the following effects: (a) an intercept β_{0i} ; (b) an effect of a linear time trend, modeling a possible trend over time in affect changes, β_{1i} ; (c) the effect of each child's average of ADHD symptom level, β_{2i} ; (d) the effect of each child's daily deviation from their personal average of ADHD symptom level, β_{3i} ; and (e) an error term, ε_{ti} . Equations on Level 2 represent the between-person effects and were specified as follows: (a) a fixed intercept of the population, γ_{00} , and a person specific deviation from the average intercept, σ_{0i} [random effect]; (b) a fixed effect of time, γ_{10} ; (c) a fixed effect of the average ADHD symptom level, γ_{20} , and (d) a fixed effect for the effect of ADHD symptom level on affect, γ_{30} , as well as, (e) person specific deviations from the average effect of ADHD symptom level on affect, σ_{3i} [random effect].

In the first step, we fitted an empty model (Model 1 in Table 4) to the data and in a second step added the fixed effect of time as a predictor for within-person changes in affect (Model 2 in Table 4). In a third step, we inserted the fixed effects of ADHD symptom level in the model (Model 3 in Table 4). Finally in a last step, random effects were added to the model

(Model 4 in Table 4). The parameters of the model were estimated by using a maximum likelihood estimation (Singer & Willet, 2003). In all models we controlled for a continuous auto-correlation of Level 1 residuals (e.g., Bolger & Laurenceau, 2013).

To test our third hypothesis, whether children with a higher ADHD symptom level show an enhanced experience of affect fluctuations than children with lower ADHD symptom levels, we calculated a Kendall's rank correlation, because the required assumptions of a Pearson correlation were not fulfilled (Field, Miles, & Field, 2012). Before testing the hypothesis, we calculated the *Person Mean* of each child's ADHD symptoms and the *Mean Square Successive Difference (MSSD)* of affect for each child over all 54 occasions. The *MSSD* refers to a measure of within-person fluctuations that takes both the amplitude of the fluctuations as well as the temporal dependency into account (e.g., Wang, Hamaker, & Bergeman, 2012). Importantly, missing values were removed in advance, thus the difference between two affect scores was only taken into account when both of the respective measurements were completed.

For all analyses, we used an $\alpha = .05$ for the level of significance and the statistic program R (version 3.6.0; R Core Team, 2018). Exceptionally the within-person reliability of ADHD symptoms and affect was calculated with the program MPlus (Muthén & Muthén, 1998-2010).

Results

Descriptive statistics

The frequencies of the respective time ranges of the smartphone prompts are depicted in Table 6 (Appendix Research Focus 1). The compliance rate is 79.25% for ADHD symptoms and 81.48% for the valence of affect. Descriptive statistics of ADHD symptoms and affect are presented in Table 3. In reference to the response range, the mean value of the ADHD symptom scale is rather low, indicating that the children did not experience a high level of ADHD symptoms overall. In contrast, the mean value of affect is very high, indicating a positive affective experience across children and occasions. However, the course of ADHD symptoms and affect scores over time varies between the children (Figure 4: Appendix Research Focus 1). For example, one child showed a *MSSD* of 0.0 and a total of five children had a *MSSD* < 0.2 on the affect scale.

Table 3

Descriptive Statistics across all 54 measurement occasions for ADHD symptoms and valence of affect.

Scale	<i>M</i> (<i>SD</i>)	<i>n</i>	<i>MISD</i> (<i>SD</i>)	<i>MSSD</i> (<i>SD</i>)	<i>ICC</i>	Empirical Range
ADHD Symptoms	1.74 (1.02)	2387	0.74 (0.41)	0.85 (0.47)	0.38	1-6
Affect	5.25 (1.13)	2437	0.80 (0.49)	0.91 (0.61)	0.32	1-6

Note. *M* = mean value; *SD* = standard deviation; *n* = number of occasions, taken into account for the calculations; *MISD* = mean intra-individual standard deviation; *MSSD* = mean square successive difference; *ICC* = intra-class correlation coefficient.

Hypotheses

In reference to our first hypothesis, whether children with a higher ADHD symptom level show an enhanced experience of negative affect, the multilevel models showed significant between-person effects for ADHD symptoms and negative affect (all model results are depicted in Table 4).

Table 4

Parameter estimates for the multilevel models.

	(1)	(2)	(3)	(4)
	Empty model	Time Trend Fixed Effects	ADHD symptoms Fixed Effect only	ADHD symptoms Fixed and Random Effects
Affect				
<i>Fixed effects</i>				
Intercept, γ_{00}	5.271*	5.139*	5.134*	5.143*
Effect of time, γ_{10} Averaged		0.005*	0.005*	0.005*
ADHD symptoms per child, γ_{20}			-0.381*	-0.307*
ADHD symptoms, γ_{30}			-0.015	-0.012
<i>Random effects</i>				
Intercept	0.379	0.380	0.327	0.330
Variance of daily ADHD symptoms				0.028*
Residual, ϵ_{ti}	0.869	0.863	0.864	0.843
log-Likelihood	-3230.6	-3230.1	-3229.7	-3218.1

Note. * $p < .05$. Model numbers (1) - (4) refer to the respective models in the text.

The results indicate that children with a higher level of ADHD symptoms experience more negative affect than children with a lower ADHD symptom level (Model 3; γ_{20}). Thus, the first hypothesis can be confirmed. However, during occasions when children experienced a

higher symptom level of ADHD than usual, they did not experience an enhanced negative affect (Model 3&4: γ_{30}). Therefore, the second hypothesis could not be confirmed. Nevertheless, the random effects were significant (Model 4), indicating that the children differed significantly in their respective within-person relation between ADHD symptoms and negative affect.

In order to test the third hypothesis whether children with more ADHD symptoms show enhanced affect fluctuations than children with less ADHD symptoms, a non-parametric correlation was calculated because neither the $MSSD_{affect}$ ($W = 0.93, p < .05$) nor the *Person Mean* of ADHD symptoms ($W = 0.89, p < .05$) were normally distributed. No significant effects were found for the third hypothesis ($\tau MSSD_{affect} = 0.22, p = .991$). This result indicates that the overall level of ADHD symptoms was not related to affect fluctuations.

Discussion

The present findings support the widespread assumption that children with a higher self-reported level of ADHD symptoms also experience increased negative affect in general. However, on occasions when ADHD symptoms are rather high compared to a child's personal mean of ADHD symptoms, the experience of negative affect is not increased. Thus, we could not confirm the second hypothesis. Furthermore, we also could not confirm hypothesis three. Hence, children with a higher level of ADHD symptoms did not experience higher fluctuations of affect than children with less ADHD symptoms.

The findings that children with a higher level of ADHD symptoms showed an enhanced experience of negative affect corroborate the proposition that children with ADHD symptoms suffer from an increased negative emotional trait (e.g., Bunford et al., 2015; Martel, 2009). The present study findings, are innovative in that both ADHD symptoms and negative affect were assessed in real time and not only once but at 54 occasions in children's daily lives. Moreover, contrary to former research that investigated children with an ADHD diagnosis, the present research considered ADHD as a dimensional disorder. Thus, children with varying levels of ADHD were included, which therefore also allows a dimensional perspective on the between-person relationship of ADHD symptom level and negative affect.

The non-significant effects of the second hypothesis indicate that on occasions when the level of ADHD symptoms in a child was higher than usual the negative affect was not increased. This finding contradicts the assumption that ADHD symptoms are linked to the experience of negative affect on a within-person level (e.g., Daviss, 2008). However, since the random effects were significant, it can be assumed that some children experienced enhanced negative affect during occasions when they experienced a higher level of ADHD symptoms; whereas, other

children did not show this relationship. Overall, a number of explanations can be considered for the non-significant within-person relationship between ADHD symptoms and negative affect, as well as possible explanations for the significant difference that was found between children for the respective within-person relationship (random effects).

The first explanation can be seen in accordance with the theory that, ADHD symptoms are linked to an enhanced experience of frustration which in turn is linked to enhanced experiences of negative affect (e.g., Daviss, 2008). On average, the experience of ADHD symptoms was rather low in the present study sample with regard to the possible range. Thus, it can be assumed that children did not experience much frustration and therefore not much negative affect. However, since the respective within-person relationship was found for some children, the relationship might be especially true for those children who experienced a higher level of ADHD symptoms and thus possibly more frustration.

The second explanation, can be seen from a between-person perspective which theoretically assumes that only the ADHD symptoms of hyperactivity and impulsivity (and not inattention) are linked to an enhanced experience of negative affect (Barkley, 1997). However, one AA study discovered that adolescents displaying rather few ADHD symptoms, showed a significant within-person relationship between inattention and negative affect (Schmid, 2014). Moreover, in a community sample of healthy children, working memory performance which requires attention, was negatively associated with negative affect on a within-person level (Neubauer, Dirk, & Schmiedek, 2018). These findings for the different ADHD symptoms and their relationship to negative affect indicate that a within-person effect in the present study findings might have been obscured by the general perspective on ADHD symptoms. However, since the findings concerning the between- and the within-person level differ from each other, they corroborate the importance of studying within-person effects in addition to between-person effects, which could be especially different in short-term measurements in daily lives.

The third explanation for the non-significant within-person relationship could be seen in the assumption that in addition to enhanced negative affect children with ADHD symptoms experience enhanced positive affect when compared to non-affected kids (Anastopoulos et al., 2011) or compared to children with another psychiatric disorder (Okado, Mueller, & Nakamura, 2016). However, these between-person findings rely on retrospective one-time assessments. The present findings indicate that the children differed significantly in their respective within-person association between ADHD symptom level and negative affect (significant random effects), meaning that for some children we found the assumed within-person relationship whereas for other children we did not. Thus, it can be hypothesized that a sample with children

showing a higher level of ADHD symptoms could provide further information about the daily life within-person relationship between the level of ADHD symptoms and negative affect.

A fourth consideration should address that the within-person fluctuations on both scales are rather small for some children (see Figure 4 in Appendix Research Focus 1). Even though so far there is only one study that investigated within-person fluctuations of ADHD symptoms (Schmid et al., 2016), within-person fluctuations of affect are part of its definition (e.g., Ekkekakis, 2013). If there are no fluctuations, that is no variation within individuals, there can be no co-variation either. Thus, we analyzed the hierarchical linear model after excluding those children that showed no or very little within-person fluctuation of affect over time ($MSSD_{affect} < 0.2$; $n=5$). However, the fixed effect of the assumed within-person association between ADHD symptom level and negative affect was not significant either.

Additionally, minor affect fluctuations are an important explanation for the non-significant between-person relationship of ADHD symptoms and fluctuations of affect, which we assumed in our third hypothesis. Because we assumed that children with a higher level of ADHD symptoms also show enhanced fluctuations of affect, it is obvious that if there are only few or even no within-person fluctuations of affect, it cannot be predicted by anything. The lack of within-person fluctuations is therefore further discussed with regard to methodological limitations in the following section.

Limitations and future research

The lack of within-person fluctuations is an essential limitation of the present study. Several methodological aspects can be taken into account to explain this problem and should be addressed in further research. For the lack of within-person fluctuations of *ADHD symptoms* it can be noted that we only used four items to assess an overall ADHD symptom score. Although those items display four typical ADHD symptoms (Lidzba et al., 2013; see Table 5 in Appendix Research Focus 1), ADHD is considered to be a highly heterogeneous disorder. Thus, the participating children possibly did not identify with exactly those behaviours or experiences at all. Therefore, more items should be included in order to assess general ADHD symptom experience at each measurement occasion. However, the reduction of the burden for the participants is important, especially when it concerns children, and thus items should be kept to a minimum (Bolger & Laurenceau, 2013). In order to strengthen the possibility of fluctuations in ADHD symptoms in further research, item selection should be further discussed with regard to the possible moment-to-moment fluctuation of the respective symptom.

Moreover, although we addressed children with attention-deficit problems and their parents in our recruitment, ADHD symptoms were not an overall inclusion criterion. This might

be a possible reason that the average ADHD symptom score in the present study sample is rather low, which possibly also effects the lack of within-person fluctuations. In addition to the small fluctuations of ADHD symptoms, fluctuations in affect are also rather small when compared to a study on affect fluctuations in healthy children (Leonhardt et al., 2016). For future research we recommend including the arousal dimension of affect in addition to the affect valence (Russell, 2003) in order to differentiate between negative affect with a high arousal (which can be referred to anger or aggression) and negative affect with a low arousal (which can be referred to sadness). Moreover, according to the theoretical model of affect (Russel & Feldman Barrett, 1999; Russell, 2003), the present study assessed the valence of affect on a bipolar dimension. Since children with ADHD symptoms might experience more positive affect in addition to more negative affect, further research should consider using a unipolar two-dimensional model (one dimension for negative and one for positive affect; e.g., Watson, Clark, & Tellegen, 1988) to assess the valence of affect in children with ADHD symptoms.

In addition to the lack of within-person fluctuations of ADHD symptoms and affect, a further limitation that possibly affects the within-person relationship of ADHD symptoms and negative affect is the difference in the temporal reference (see Table 5 in Appendix Research Focus 1). Whereas ADHD symptoms were assessed in regard to the time span since the previous point of assessment, negative affect was assessed in regard to the present moment. Thus, ADHD symptoms were assessed from a remotely retrospective perspective and could therefore be biased (e.g., Schwarz, 2012). Moreover, the different temporal references could affect the within-person relationship of both constructs. Thus, further research should apply the same temporal reference across all variables. A third limitation of the present study can be seen in the sampling character of the study design. Because we assessed ADHD symptoms and negative affect outside school hours and at fixed time points, children were possibly prompted when they did not experience ADHD symptoms or negative affect. By applying a school assessment as well as an interval-contingent design including a random sampling structure (e.g., Bolger & Laurenceau, 2013), children would be prompted to respond rather spontaneously, thereby enhancing the possibility of assessing the appearance of the variables of interest rather frequently. Finally, the small sample size of children limits the power of the between-person findings and thus, conclusions should only be interpreted with caution. Further research should investigate a greater sample size of children in order to increase the power for the between-person findings.

Practical implications

The present study shows that children reporting a higher level of ADHD symptoms over the period of 18 study days also report higher levels of negative affect than children with a lower level of ADHD symptoms, the findings corroborate the relationship between ADHD symptoms and negative affect. Thus a practical implication for the future would be that trainings made for children with ADHD symptoms include methods that reduce negative affect in addition to the reduction of ADHD symptoms. Moreover, although ADHD symptoms and negative affect were not related on a within-person level, the present study findings indicate that children differ individually in their within-person relationship of ADHD symptoms and negative affect. Thus, in practical interventions it could be helpful to observe whether a child's ADHD symptoms might be related to their negative affect. However, since this finding only provides data from a community sample with a low average of ADHD symptoms it limits practical implications.

Conclusion

The present ambulatory assessment (AA) study confirms the assumption that ADHD symptoms and negative affect are related on a between-person level. It extends prior research by creating trait ADHD and affect variables based on within-person, repeatedly assessed ADHD symptoms and affect across 18 consecutive days. However, no significant effect was found for the respective within-person relationship of these variables. This indicates that on occasions when children experience more ADHD symptoms than usual, they do not necessarily experience enhanced negative affect. However, significant random effects indicate that some children experienced enhanced negative affect when their level of ADHD symptoms was higher than usual, whereas other children did not experience this variable relationship. In addition, the present study investigated whether children who experience more ADHD symptoms also show increased fluctuations in their affect. Although there is some evidence for affect fluctuations in children with ADHD symptoms, the present research could not confirm this assumption. Nevertheless, by using an AA design with 54 measurement occasions for each child, the present research highlights the importance of studying emotional states, such as affect, within persons. Moreover, the present study provides first impressions of a within-person co-variation of ADHD symptoms and negative affect in children's daily lives.

Acknowledgements

We especially thank the research assistant Ulrike Schwarz for her effort in the research project AttentionGO. Furthermore, we thank all children and their parents as well as the school principals and teachers for participating in this research project. We also thank all research and

student assistants for their enthusiastic support during data collection. Moreover, we owe special thanks to Judith Dirk and Florian Schmiedek for providing the application from the Assessment of Cognitive Performance Fluctuations in the School Context (FLUX) project and sharing their experiences concerning experience sampling with children. The research project was supported by the *Ministry of Culture, Youth and Sport, Baden-Württemberg*, was funded by the *German Research Association* (DFG) and was approved by the ethics committee of the *German Psychological Society* (DGPs). This research was supported as part of the LEAD Graduate School & Research Network [GSC1028], which was funded within the framework of the Excellence Initiative of the German federal and state governments.

Appendix Research Focus 1

Table 5

List of items used to assess the children’s experience of ADHD symptoms and affect at every occasion.

Item	Response Scale	Item (German)	Response Scale (German)
<i>ADHD symptoms</i>			
1. Since the last assessment I talked too much.	(1) not true at all to (6) absolutely correct	Seit dem letzten Ausfüllen habe ich zu viel geredet.	(1) trifft gar nicht zu (6) trifft ganz genau zu
2. Since the last assessment I lost track of what I was supposed to do.		Seit dem letzten Ausfüllen habe ich zwischendurch vergessen, was ich eigentlich tun sollte.	
3. Since the last assessment I had too much energy to stay still.		Seit dem letzten Ausfüllen habe ich zu viel Energie gehabt, um still zu sitzen.	
4. Since the last assessment I had trouble keeping my mind on what I was doing		Seit dem letzten Ausfüllen habe ich mich schlecht konzentrieren können.	
<i>Affect</i>			
Right now, I feel...	1. (1) unhappy to (6) happy 2. (1) unsatisfied to (6) satisfied 3. (1) uncomfortable to (6) comfortable 4. (1) bad to (6) good	Im Moment fühle ich mich...	(1) unglücklich bis (6) glücklich (1) unzufrieden bis (6) zufrieden (1) unwohl bis (6) wohl (1) schlecht bis (6) gut

Note. All ADHD items had the same ‘response scale’; all affect items had the same ‘item’.

Table 6

Frequencies of time ranges for the smartphone prompts in the mornings, afternoons and evenings.

Time	<i>N</i>	<i>N</i>	Time	<i>N</i>	Time	<i>N</i>	<i>N</i>
Morning	(Mo-Fr)	(Sa & Su)	Afternoon		Evening	(Su - Thu)	(Fr & Sa)
06:00 – 06:59	40	1	13:30 – 13:59	1	19:00 – 19:59	2	2
07:00 – 07:59	15	4	14:00 – 14:59	0	20:00 – 20:59	40	17
08:00 – 08:59	0	21	15:00 – 15:59	13	21:00 – 21:59	13	20
09:00 – 09:59	0	22	16:00 – 16:59	36	22:00 – 22:59	0	14
10:00 – 10:59	0	6	17:00 – 17:59	5	23:00 – 23:59	0	2
11:00 – 11:59	0	1					

Note. *N* = number of children whose smartphone prompt took place in the respective period; Mo-Fr or Su-Thu refers to Mondays to Fridays or Sundays to Thursdays, respectively; Sa & Su or Fr & Sa refers to Saturdays and Sundays or Fridays and Saturdays, respectively.

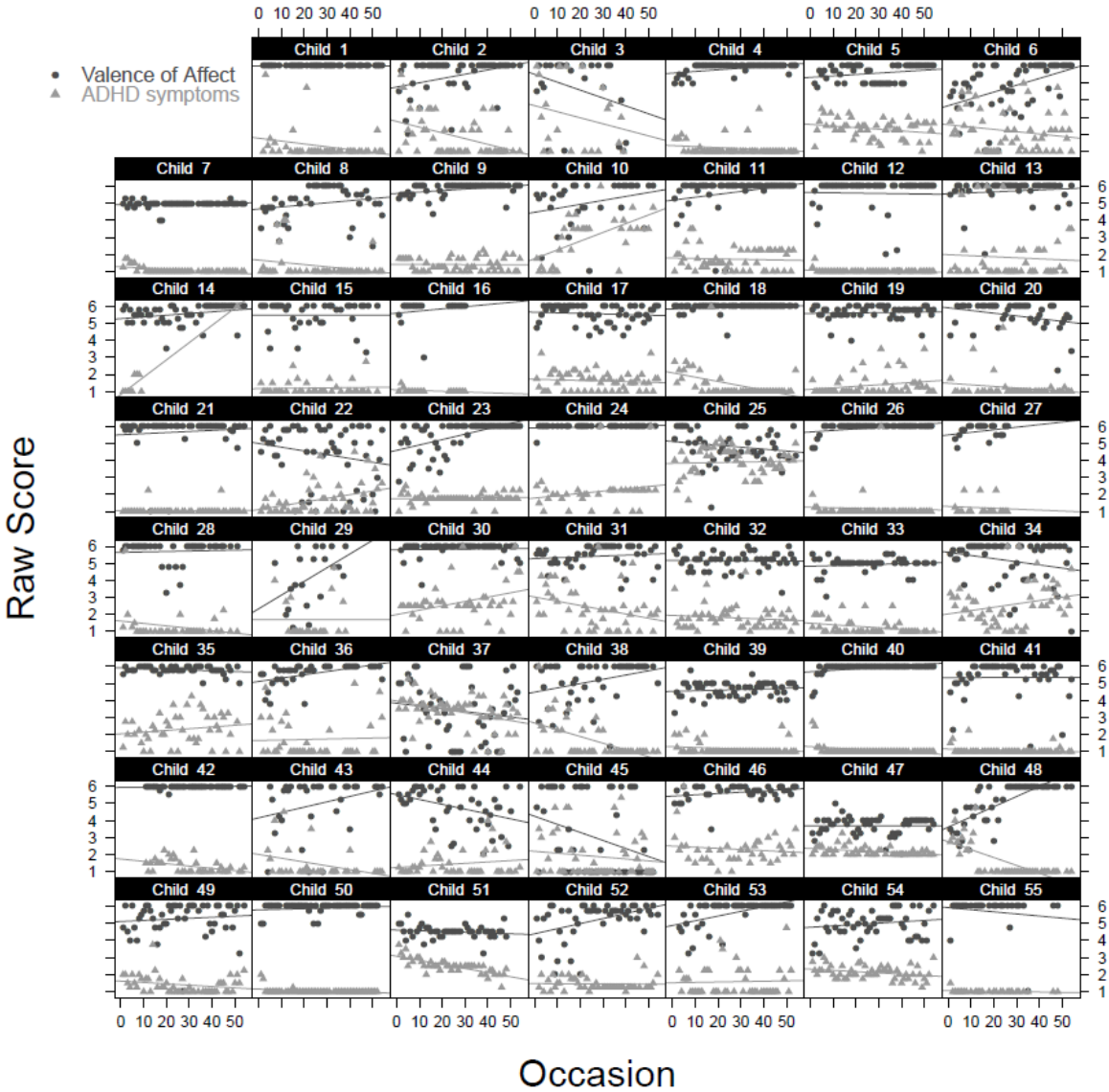


Figure 4. Raw Scores of ADHD symptoms and valence of affect over 54 occasions for each child. The raw score refers to the mean value of all items for the respective scale.

4.2 *Research Focus 2: Within-person relationship between daily time spent in natural spaces and affect as well as inattention in children's daily life.*⁶

Abstract

Background: Exposure to nature can be beneficial for children in regards to a restorative experience pertaining to affect and inattention. Whether natural spaces can enhance positive affect and reduce inattention in children's daily life has only been investigated with traditional research designs (i.e., cross-sectional study designs). In addition to the already tested between-person relationship this study focuses on the daily within-person relationship of time spent in natural spaces and affect and inattention in children's daily life.

Methods: In an ambulatory assessment design, students from German middle schools (N = 55; age in years: M = 10.7, SD = 0.5) were asked to rate their time spent in natural spaces, affect, and inattention each day in the course of 18 consecutive days.

Results: Mixed model analyses revealed a significant between-person effect of time spent in natural spaces and affect, but not for time spent in natural spaces and inattention. For the within-person relationship of the daily time spent in natural spaces as related to affect or inattention no significant fixed effects were found. However, significant random effects indicated that children differ in their within-person relationship between time spent in natural spaces and affect or inattention.

Conclusions: The results indicate that children who consistently spend more time in natural spaces show greater positive affect than children that spend less time in natural spaces. Moreover, some children seem to benefit from the daily time spent in natural spaces by showing enhanced positive affect and/or less inattention, while others do not.

Keywords: natural spaces, restoration, ambulatory assessment, within-person relationship

⁶ Reuter, M., Kühnhausen, J., Haas, P., & Gawrilow, C. (in press). Within-person relationship between daily time spent in natural spaces and affect as well as inattention in children's daily life. *Umweltpsychologie*

Introduction

Spending time in *natural spaces* has a positive impact on adult's mental health, which has found repeated mention in public media (e.g., Abrams, 2017; Otto, 2018), but also in science (e.g., Lai, Flies, Weinstein, & Woodward, 2019). Moreover, children benefit from spending time in natural spaces regarding their mental health as well (for reviews see: Amoly et al., 2014; McCormick, 2017). Natural spaces are environments that include vegetation and/or natural water (e.g., Ulrich, 1983) and thus are also referred to as green, and/or blue spaces (e.g., Dzhambov et al., 2018). In contrast, spending little time in natural spaces is supposed to have detrimental consequences for mental health (e.g., World Health Organization, [WHO], 2016). To prevent these negative effects, all member states in the WHO European Region are committed that by 2020 every child should have access to green spaces in which they can play and be physically active (WHO, 2010). This resolution was adopted due to the presumption that nature has a positive impact on mental health, which can be described as a restorative effect that is explained by two theories.

According to the *stress recovery theory* (SRT), nature reduces stress and enhances emotional well-being, such as affect, in individuals (Ulrich, 1983; Ulrich et al., 1991). *Affect* is defined as a state of feeling which can always be consciously perceived (Russell, 2003). The valence of affect can be negative or positive (Russell, 2003) and it varies within a person over time (Ekkekakis, 2013). Natural spaces can elicit immediate positive affective responses when they are perceived of as attractive and pleasant, hold interest and block or reduce stressful thoughts (Ulrich, 1983). The *attention restoration theory* (ART; Kaplan & Kaplan, 1989) postulates that nature can recover our ability of directed attention, a state that refers to the effortful implementation of mental activity while distraction is always possible (Kaplan, 1995). Since tasks requiring directed attention supposedly lead to a state of attention fatigue (Schutte, Torquati, & Beattie, 2017) in which the individual is no longer able to effectively concentrate on tasks (Kaplan, 2001), attention fatigue is comparable to the state of inattention (APA, 2013).

These restorative effects of natural spaces have been investigated and found in healthy *adults* (e.g., Hartig, Evans, Jamner, Davis, & Gärling, 2003), patients with psychiatric disorders, such as exhaustion disorder (e.g., Sonntag-Öström et al., 2014), or depression (e.g., Korpela, Stengård, & Jussila, 2016), and in healthy *children* (e.g., Martensson et al., 2009; Schutte et al., 2017) as well as children with psychiatric disorders, such as attention deficit-/hyperactivity disorder (ADHD; e.g., Faber Taylor & Kuo, 2009, 2011). The restorative effect was for example assessed by measuring the enhancement of emotional well-being, such as

positive affect (Hartig et al., 2003), and/or directed attention or the reduction of inattention, respectively (Faber Taylor & Kuo, 2009; Martensson et al., 2009). Thus, since emotional well-being, such as positive affect (Mulligan & Scherer, 2012), is enhanced as well as inattention is reduced after the exposure to natural spaces, previous research confirms the two mentioned theories.

However in the future, more than three quarters of the German population will be living in cities by 2025 (Statistisches Bundesamt, 2019) and therefore, it can be assumed that opportunities to experience natural spaces will be increasingly scarce in individual's daily lives. Therefore, it is necessary to investigate, whether the environment in which people spend their everyday life, already has a restorative potential when it is characterized by some kind of *natural space*.

Importantly, since the WHO resolution's focus is on the restorative effect of natural spaces in *children*, this places relevance of the assumed underlying restorative effect in particular to childhood, so in the following a focus will be placed on the investigation of the restorative effect of *natural spaces* in *children*.

Natural spaces and restoration in children's daily life: traditional research designs

In reference to the restorative effects of natural spaces, research has shown that children who live in (Wells & Evans, 2003), or are surrounded by natural spaces at school and at home can buffer stressful life events better (Corraliza et al., 2012). For the restorative effect of natural spaces on *attention*, correlational analyses found that girls perform better in attention tasks the greener their view is from their apartment (Faber Taylor et al., 2002). Moreover, children showed less inattention the greater their access to areas with trees and bushes was in their pre-school environment (Martensson et al., 2009).

In addition to these studies, researchers also investigated the restorative effects of natural spaces in children's everyday lives with longitudinal study designs. One study indicated that children who had moved with their parents to a greener place, showed less inattention after the move (Wells, 2000). Another longitudinal study showed that green spaces have an impact on inattention in school children between the ages of seven and ten. A greater reduction in inattentiveness at a 12-months follow-up was found in children when their homes, schools, and their ways to school were surrounded by more green spaces (Dadvand et al., 2015).

Moreover, experimental study designs were conducted in order to find out, whether the experiences of natural spaces in children's daily life can have restorative effects. For example, two studies showed that children benefitted from schoolyards that included natural spaces when compared to built environments in regards to their directed attention as well as other

recreational aspects either directly after playing outside, during school breaks (Amicone et al., 2018) or after the schoolyard was changed from a built to a greener environment (van Dijk-Wesselius et al., 2018).

In summary, there is already evidence for the restorative effect of natural spaces in the surrounding of children's everyday lives on their emotional well-being, such as affect, and directed attention or inattention, respectively. However, current research has not investigated whether the restorative effect of natural spaces also exists on a daily basis within children in their daily lives. This is important, since, compared to traditional research designs, the assessment in daily life provides the advantages of (1) a high ecological validity due to assessment in the context of real-life (e.g., Reis, 2012) and (2) a reduction of recall biases due to immediate assessment (e.g., Schwarz, 2012).

Natural spaces and restoration in daily life: ambulatory assessment

To assess experiences in daily life, a research design that assesses data at multiple occasions per person with different research methods, such as self-report or physiological assessment instruments can be applied (*ambulatory assessment*, AA; e.g., Trull & Ebner-Priemer, 2013). Multiple measurement points per person over a certain time frame are used to assess an individual's momentary condition, usually by providing the participating person with technical equipment (i.e., smartphones, e.g., Bugl, Schmid, & Gawrilow, 2015). Due to the provision of several data points per person, fluctuations that occur within-persons can be assessed. These within-person fluctuations can occur over different time periods depending on the nature of the characteristic studied (e.g., Reis, 2012). Moreover, by investigating the fluctuations of two constructs, information about the co-variation of the referring fluctuations within an individual over a certain period of time can be provided. This co-variation of two constructs over time is also called a within-person relationship.

Since within-person effects are not necessarily the same as between-person effects (e.g., Hamaker, 2012; Molenaar & Campbell, 2009), the investigation of within-person effects for the relationship between natural spaces and emotional well-being and inattention is also necessary. Thus, the present study investigates whether within-person fluctuations of emotional well-being and inattention might occur simultaneously with the variation of outdoor experiences in natural spaces (within-person effect). To the best of our knowledge, there is only little research looking at the daily life within-person relationship between experiences in natural spaces and emotional well-being or inattention so far. For example, evidence for the positive within-person effect of natural environments on well-being comes from a study with an *adult* sample (MacKerron & Mourato, 2013). More than 20.000 individuals from the UK participated

in an AA study. Via satellite positioning (GPS) of the participants' smartphone the participant's location was tracked and momentary affect was assessed at random time points on each study day, with participants choosing the frequency of prompts and duration of the time interval in which prompts were allowed. The authors found that individuals were happier when they were surrounded by natural environments compared to urban environments (MacKerron & Mourato, 2013).

Nevertheless, it is still not clear whether the daily time spent in natural spaces is linked to emotional well-being on a daily basis in children. Additionally, research focusing on daily couplings of natural spaces and inattention is needed. Thus, studies with AA designs are necessary to investigate this daily within-person relationship between natural spaces and emotional well-being, such as affect, as well as inattention in children.

The present research and hypotheses

The present research investigates between-person as well as within-person effects of time spent in natural spaces and affect as a momentary state of emotional well-being, as well as inattention, with a particular focus on within-person effects. The within-person effect refers to the relationship between the day-to-day fluctuations of time spent in natural spaces and day-to-day fluctuations of affect or inattention within persons. Thus, this study investigates whether on days where children are exposed to natural spaces to a greater extent than usual, their positive affect is enhanced and inattention decreased, when compared to days where they spent less time in natural spaces than usual.

In the present research, we focused on two hypotheses. First, we were interested in whether there were between-person effects in such a way that children who spent more time in natural spaces over a period of 18 days, showed greater positive affect and lower inattention than children who spent less time in natural spaces over a period of 18 days (Hypothesis 1). Second, we were interested in the daily within-person relationship between natural spaces and affect, as well as between natural spaces and inattention in children. We hypothesized that on days when children spent more time in natural spaces than usual (thus, as compared to their personal mean time spent in natural spaces), they would show enhanced positive affect and less inattention in the evening of that day, when compared to days where they spent less time in natural spaces (Hypothesis 2).

Methods

The present ambulatory assessment study is part of the research project *AttentionGO*. Within this project, three phases of ambulatory assessment took place in a measurement burst

design over the course of 13 months. Each phase included 18 days of assessment in which school children rated their affect and inattention three times a day via smartphones amongst other psychological characteristics. Parents as well as teachers were also asked to rate their child's affect and inattention, besides other variables. The focus of this research project lies in the investigation of within-person fluctuations of affect and ADHD symptoms, such as inattention, in children as well as possible context factors co-varying with those fluctuations. As part of this research, the present article only focuses on the context factor time spent in natural spaces. In addition, this article only presents data gathered from children in the first ambulatory assessment phase, which had been conducted in the first months after the children's transition from primary to secondary school. Thus, the study was conducted during winter time. The research project has been approved by the ethics committee of the German Society for Psychology (DGPs) and was funded by the German Research Foundation (DFG).

Study Sample

The recruitment of the participating 59 children took place across six schools in the South of Germany after authorization from the Ministry of Education and the Arts of Baden-Wuerttemberg. One participant dropped out after eight days without stating any reasons. Two participants had to be excluded from data analyses because their identities were mixed up before data collection and one because of the exclusion criteria of a Trisomy 21. Thus, the final sample consists of 55 children with the mean age of 10 years and 9 months ($SD = 6$ months; $n = 54$). All children were enrolled in the fifth grade of either a middle ($n = 48$; 87.3%) or a general school ($n = 7$; 12.7%). The study sample was relatively evenly split between males ($n = 25$; 45.45%) and females ($n = 30$; 54.55%). As reimbursement, the children and their parents got a voucher for a joint family trip to a local extracurricular activity (e.g., fun pool or leisure park) endowed with the amount of 40€. The participating school principals were offered further training for their teaching staff.

Procedure

Recruitment and background information. The study's recruitment of children took place in October 2017. After receiving a signed informed consent form from their school principal and respective classroom teachers, two investigators introduced the research project to all children enrolled in Grade 5 at that referring school. After the introduction, all children were provided with envelopes for their parents, containing an informed consent form. As soon as a signed consent form from a parent was provided, investigators called the respective parent to clarify study details (i.e., time for the smartphone alarm).

Data collection took place from November to December 2017. In this time period, parents were asked for one structured telephone interview, lasting 45 min and comprised of questions about demographic aspects as well as the child's trait affect and trait self-regulation skills that will not be analyzed in this study. Children were also asked to fill in a background questionnaire (i.e., questions about trait affect, trait self-regulation, and additionally their environmental attitude) one or two days before the start of the ambulatory assessment period. Data analyses from the background questionnaires of parents and children will not be reported in this article. Children were provided with the individually programmed smartphones at school handed out by the experimenters. The investigators also explained the questions which the children should be answering on a regular basis during the ambulatory assessment period.

Ambulatory assessment. For all children, the ambulatory assessment period consisted of eighteen consecutive days in November and December 2017. Due to practical reasons, the participating children started in different sequential assessment weeks. However, for all participating children, the starting day was always a Wednesday, thus the ambulatory assessment period ended always on a Saturday. During that time period, children were asked to rate their affect and inattention on a smartphone three times a day, using a time-contingent sampling method. Thus, for every child 54 occasions (18 days * 3 times daily) were estimated. The smartphone alarm rang at specific times that were coordinated with the children's parents. Smartphones rang in the morning after the children had awoken (time range: 6:00-7:45 a.m.), in the afternoon, but not during school time (time range: 3:00-5:30 p.m.; for one child the prompt was scheduled at 1:30 p.m.), and in the evening before the children went to bed (time range: 7:30 – 9:30 p.m.). At the parents' request, the time of the alarm for the morning and evening time slot could vary on weekends (time range morning: 6:00-11:00 a.m.; time range evening: 7:30-11:00 p.m.). The smartphone always rang for ten sec, and, if the child missed the alarm, again after ten min. If necessary, this was repeated for half an hour, after which the children could not respond any more. Answering the questions took about three min in the morning and afternoon and up to five min in the evening. Within every time slot, children were asked about their present affective state as well as their inattention since the last beep. In addition, the evening session contained items concerning the child's time spent in natural spaces for that day. Because time spent in natural spaces was only assessed in the evening time slot, for this article only data from the evening occasions were included in the current analyses.

Measurements

Smartphones. All children received a Moto G4 smartphone with Android 6.0 operating system. The software used IMS Question & Test Interoperability Specification (IMS, 2011, as

cited in Dalir & Rölke, 2012). The application used in this study was provided by colleagues from the DIPF | Leibniz Institute for Research and Information in Education (e.g., Kühnhausen, Leonhardt, Dirk, & Schmiedek, 2013). We changed the content and response format of the questions in the application to fit our research interests (see below). The application deactivates the usage of wireless networks or any other applications, thus the children were not able to use anything other than the *AttentionGO*-application on the phone.

The assessment of natural spaces. In order to assess a child's self-reported time spent in *natural spaces*, we used the following criteria: the place has to be outside, it must include any kind of vegetation or waters, but it can include small buildings (e.g., park-like buildings or the landscaped area on a playground). The daily time spent in natural spaces was assessed using a single item. Every evening, the children responded whether "Today I spent time in nature" (a detailed description of the item and the response format can be found in Table 9 (Appendix Research Focus 2)). Higher values indicate that the child spent more time in natural spaces. For descriptive data analyses, the response format was changed as follows: from every value 1 point was subtracted. Hence, the value 0 indicates that the child did not spend any time in natural spaces on that specific day.

In addition, the kind of activity during the children's exposure to natural spaces was assessed every evening with the item "When I was in nature, I did the following things:" (for a further description of the item response see Table 9 in Appendix Research Focus 2).

For a further description of locality during the exposure to natural spaces, the kind of location during the children's exposure to natural spaces was assessed every evening with the item "When I was in nature, I was in this place:" (for a further description of the item response see Table 9 in Appendix Research Focus 2). The children always answered the items for assessing the natural space after answering the items referring to affect and inattention (see Sections 2.3.3 and 2.3.4).

Children's self-reported affect. Children rated their affect on an adopted version of the Multidimensional Mood Questionnaire (German: Mehrdimensionaler Befindlichkeitsfragebogen; MDBF; Steyer, Schwenkmezger, Notz, & Eid, 1997). Thus, children were asked to rate their affect on the basis of the statement: "At the moment I feel..." (for a further description of the items see Table 10 in Appendix Research Focus 2). Compared to the original measurement, which used a five-point Likert scale, we used a bipolar item format and a six-point Likert scale (ranging from 1 "bad affect" to 6 "good affect"), thus following recommendations for capturing fluctuations in an ambulatory assessment study (Piasecki et al., 2007). The items were always presented in the same order and were assessed at every

measurement time. Mean values over all four items were calculated for every occasion. Higher values indicate greater positive affect. An estimation of the scale's within-person reliability was done via calculating the McDonalds Omega ($\omega = 0.87$). This indicates that the within-person reliability is very good (Bolger & Laurenceau, 2013). For the between-person reliability we calculated Cronbach's alpha for every occasion separately and averaged the results ($M=.90$; $CI_{95} = 0.89, 0.91$).

Children's self-reported inattention. To assess inattention, children answered two items, for example "Since the last assessment I had trouble keeping my mind on what I was doing" at every occasion on a six-point Likert scale (for a further description of the items see Table 10 in Appendix Research Focus 2). We adopted these items from the original version of the Conners3 Rating Scale (Lidzba et al., 2013), a scale for measuring ADHD symptoms. In comparison to the original items, we changed the temporal reference, as well as, the response scale of the items in order to match daily assessment. For descriptive and model analyses, mean values of both items for each occasion were calculated.

Statistical analysis

In order to test whether there is within-person variance on the variables of affect, inattention and time spent in natural spaces, we calculated the intra class correlation (*ICC*). The *ICC* depicts the percentage of variance that is between persons in relation to the total variance. Thus, one minus *ICC* illustrates the variance that lies within persons plus an error variance.

To analyze our hypotheses, we used Multilevel Modeling also called Hierarchical Linear Modeling (HLM, Singer & Willet, 2003) with a two-level structure. Occasions (level 1) are nested within persons (level 2). Thus, we are able to assess both the *between-person* relationship between the time spent in natural spaces and affect or inattention (Hypothesis 1), and the *within-person* relationship of time spent in natural spaces and affect or inattention (Hypothesis 2) in one model for affect and one model for inattention. In order to disentangle within-person and between-person effects, we centered the predictor variable *time spent in natural spaces* at the person-mean as well as the grand-mean (Wang & Maxwell, 2015), resulting in two predictor variables, one for the between-person and one for the within-person effect. Thus, effects on the between-person level refer to children's deviation from the sample mean of time spent in natural spaces, whereas effects on the within-person level refer to children's deviation from their individual average of time spent in natural spaces. Furthermore, we added time as a predictor to the model, thus we could control for an effect of time trends on the relationships (Bolger & Laurenceau, 2013). When the fixed effect of time was not significant, we excluded the predictor time from the model specification. We constructed a

mixed effect model to test our hypotheses for each outcome variable with the following equations:

$$\text{Level 1:} \quad \text{affect}_{ti} = \beta_{0i} + \beta_{1i}\text{time}_{ti} + \beta_{2i}\text{naturalspace}_{ti} + \beta_{3i}\text{naturalspace}_{ti} + \varepsilon_{ti}$$

$$\text{Level 2:} \quad \beta_{0i} = \gamma_{00} + \sigma_{0i}$$

$$\beta_{1i} = \gamma_{10} + \sigma_{1i}$$

$$\beta_{2i} = \gamma_{20}$$

$$\beta_{3i} = \gamma_{30} + \sigma_{3i}$$

The outcome variable evening affect at a certain occasion (subscript t) for a distinct person (subscript i) is predicted by fixed as well as random effects. The Level 1 equation represents the within-person effects of a typical person by assuming the following effects: (a) an intercept β_{0i} ; (b) an effect of a linear time trend, modeling a possible trend over time in affect changes, β_{1i} ; (c) the effect of each child's average time spent in natural spaces, β_{2i} ; (d) the effect of each child's daily deviation from their average time spent in natural spaces, β_{3i} ; and (e) an error term, ε_{ti} . Equations on Level 2 represent the between-person effects and were specified as follows: (a) a fixed intercept of the population, γ_{00} , and person specific deviations from the average intercept, σ_{0i} [random effect]; (b) a fixed effect of time, γ_{10} , and person specific deviations from the average slope of time, σ_{1i} [random effect]; (c) a fixed effect of the average time spent in natural spaces per person, γ_{20} , and (d) a fixed effect for the effect of natural spaces on affect, γ_{30} , as well as, (e) person specific deviations from the average effect of natural spaces on affect, σ_{3i} [random effect].

For both the outcome variable affect and for the outcome variable inattention the same stepwise procedure was applied [M1: the following step numbers (1) - (4) refer to the respective model numbers in Table 8]. In the first step, we fitted an empty model (1) to the data and added time as a predictor for within-person changes in affect or inattention (2) in a second step. Third, the fixed effects of time spent in natural spaces were inserted in the model (3), before finally, random effects as well as the correlation of intercept and slope were added to the model in a last step (4). The parameters of the model were estimated by using restricted maximum likelihood estimation (REML). REML was replaced by maximum likelihood estimation in model comparison whenever the fixed effects between the two models were not the same (Boedeker, 2017). Models were compared by the log Likelihood coefficient (Singer & Willet, 2003). After the model comparison we tested whether the residuals of each random slope model were normally distributed by using the Shapiro Wilk normality test (Rahman & Govindarajulu, 1997), because the normal distribution is an assumption for Multilevel Modeling. For all analyses we used an $\alpha = .05$ for the level of significance. We conducted all analyses in R

(version 3.6.0; R Core Team, 2018) except the within-person reliability which was calculated by using MPlus (Muthén & Muthén, 1998-2010).

Results

Compliance

The study was designed with an ambulatory assessment phase of 18 days and children were asked to rate their affect and inattention levels three times a day. The time spent in natural spaces was only assessed in the evening. Therefore, only data from the evening occasions were included in the current analyses. Thus, the total sum of occasions would be $n = 990$ (55 children * 18 days = 990). The number of occasions without any missing data for inattention, affect and time spent in natural spaces is $n = 819$ (82.72%).

Descriptives

On most days, children reported being in natural spaces for up to one hour and only in 5.6% of the cases they claimed that they spent more than four hours in natural spaces (Figure 5).

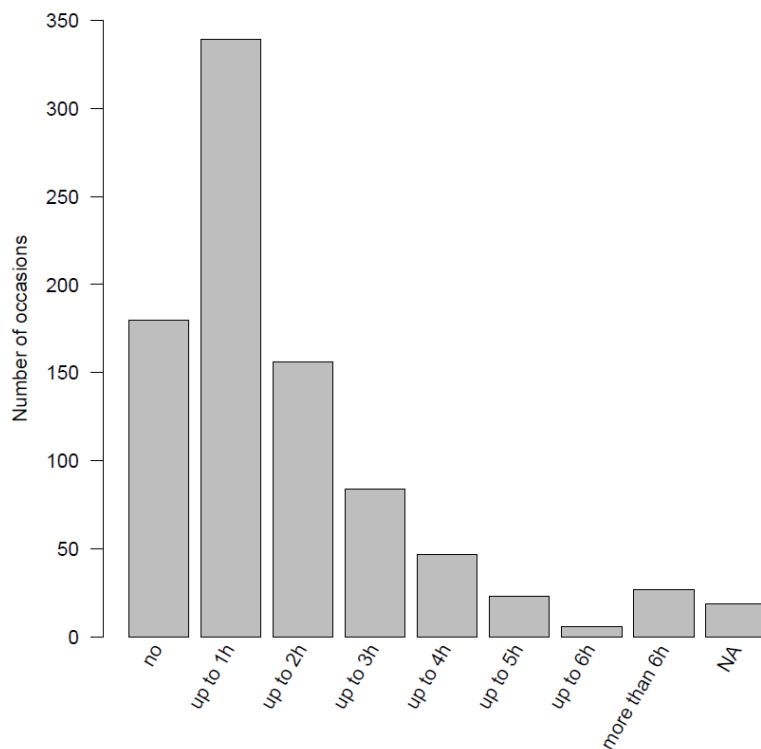


Figure 5. Number of occasions for the time spent in natural spaces summarized across children and study days.
 $n(\text{occasions}) = 881$, NA= includes only those occasions, when children responded to the prompt, but did not report their time in natural spaces.

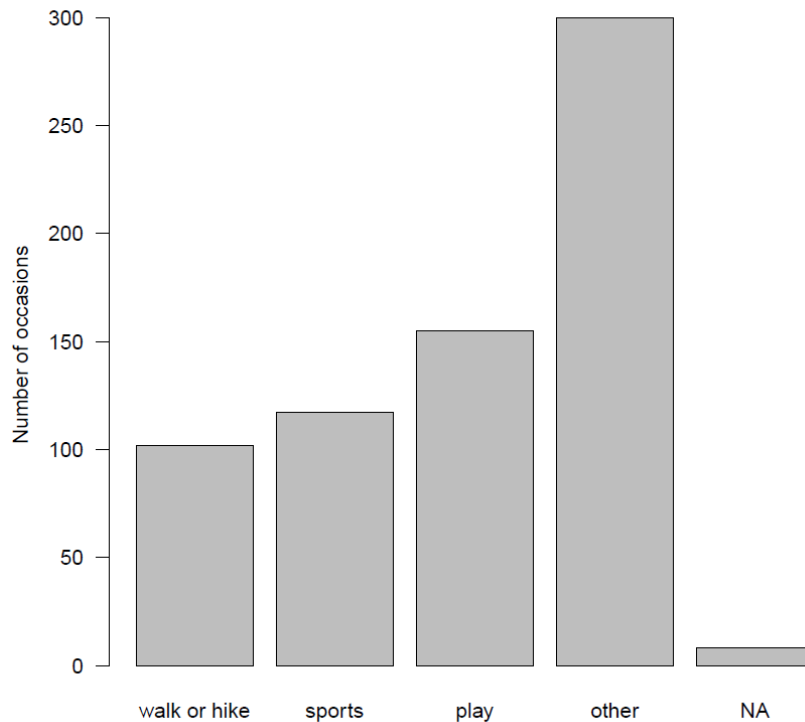


Figure 6. Frequencies of the kind of activities children did while they spent their time in natural spaces.
 $n(\text{occasions}) = 682$, NA = includes only those occasions, when children rated their time in natural spaces, but not their kind of activity.

In most cases, children did not use the given categories to describe their kind of activity during their time spent in natural spaces (Figure 6). Instead they used the given category ‘other’ most of the time. With respect to the location of their time spent in natural spaces, the children also used the category ‘other’ most commonly (Figure 7). Compared to that category, children rated the content based categories (e.g., in the forest) very rarely. The average time spent in natural spaces per day (Figure 8) differs only slightly between children. During the period of eighteen days, most of the participating children reported that they spent between one or two hours in a natural space on a daily basis. Only three children showed a daily mean of above three hours of time spent in natural spaces. Descriptives of relevant variables are depicted in Table 7. The mean value of *time spent in natural spaces* indicates that on average children spent around one hour in natural spaces. Overall, children rated their evening affect as being relatively positive and they reported little inattention. An indicator for within-person fluctuations of the dependent variables is seen in the mean intra-individual standard deviation (*MISD*) and is also depicted in Table 7. The *MISD* values of time spent in natural spaces, affect and inattention indicate that there is some within-person fluctuation. The mean square successive difference (*MSSD*), indicates that the *MISD* values of time spent in natural spaces, affect and inattention are not only due to mean changes in the dependent variable over time. According to the *ICC*

for the dependent and independent variables, there is variance that lays not only between persons, thus multilevel analysis is the appropriate method to use with this data.

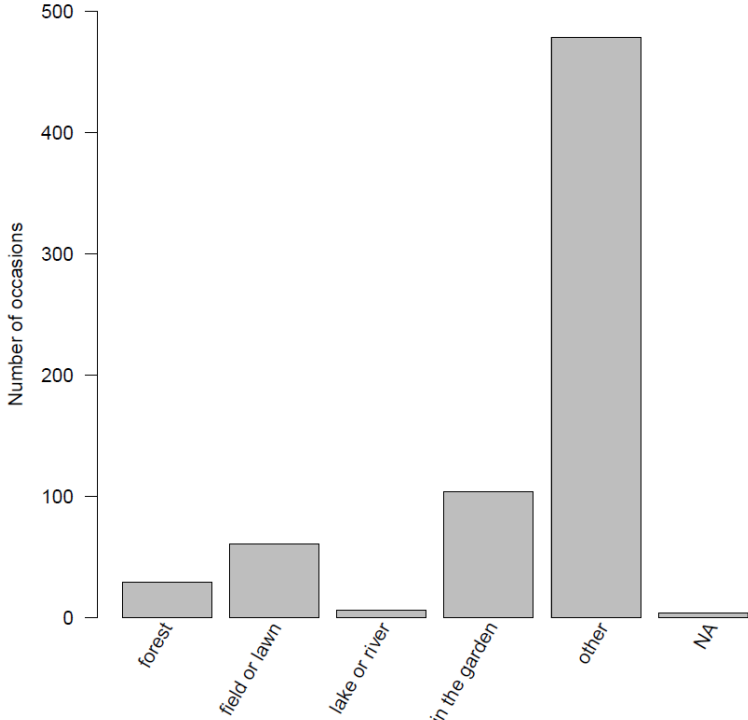


Figure 7. Frequencies of locations where children spent their time in natural spaces. N(occasions) = 682, NA = includes only those occasions, when children rated their time in natural spaces, but not their location.

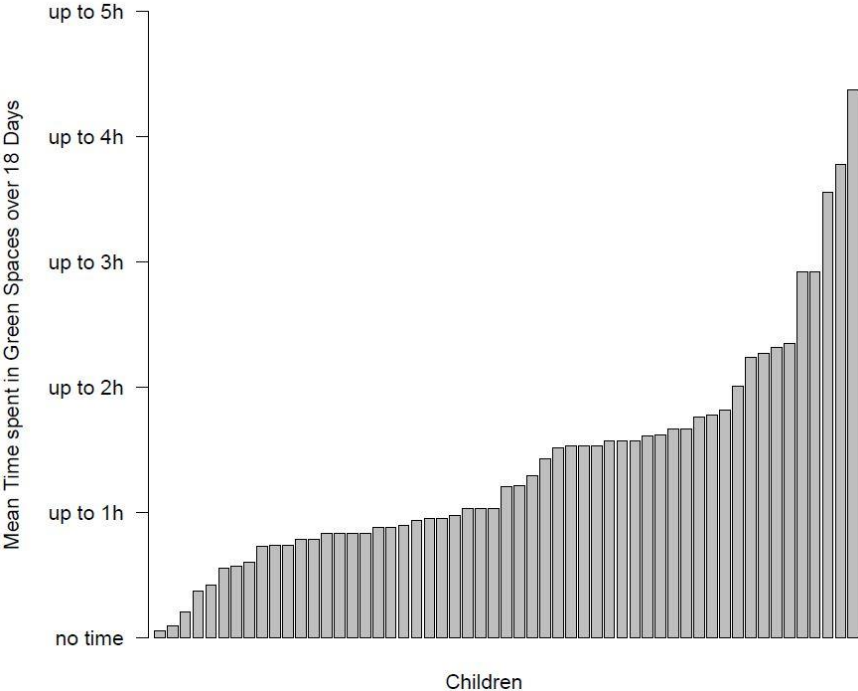


Figure 8. Average daily time spent in natural spaces per child over eighteen days. One column represents one child (N = 55).

Table 7

Descriptive statistics across all evening time points of measurement for the main variables.

Item name	<i>M</i> (<i>SD</i>)	<i>n</i>	<i>MISD</i> (<i>SD</i>)	<i>MSSD</i> (<i>SD</i>)	<i>ICC</i>	Possible range
Time spent in natural spaces	1.66 (1.60)	862	1.04 (0.65)	1.14 (0.7)	0.41	0-7
Affect	5.33 (1.07)	869	0.76 (0.56)	0.94 (0.70)	0.29	1-6
Inattention	1.56 (1.00)	850	0.65 (0.57)	0.73 (0.64)	0.30	1-6

Note. *M* = mean; *SD* = standard deviation; *n* = number of occasions, taken into account for the calculations; *MISD* = Mean Intra-individual Standard Deviation; *MSSD* = Mean Square Successive Difference; *ICC* = Intra-class Correlation Coefficient.

Multilevel Models

All model results are depicted in Table 8.

Affect Model: The fixed between-person effect of the average time spent in natural spaces on affect were significant (γ_{20} for the affect model), indicating that children who on average spent more time in natural spaces over the entire study period, showed greater positive affect than children who on average spent less time in natural spaces over the entire study period (in line with Hypothesis 1). The fixed within-person effects of the predictor *time spent in natural spaces* were not significant (γ_{30} for the affect model), indicating that, on average, children did not show enhanced positive affect on days when children spent more time in natural spaces than usual (contrary to Hypothesis 2). Since the fixed effects of the time trend for *affect* were not significant, the time trend was excluded from the model specifications. Thus, only the grand-mean centered person-mean, as well as the individual deviations from person-means of daily time spent in natural spaces were used as predictors for the affect model.

Inattention Model: The fixed *between-person* effects of the average time spent in natural spaces per child on inattention were not significant (γ_{20} for the inattention model), indicating that children who on average spent more time in natural spaces over the entire study period than others did not experience less inattention (contrary to Hypothesis 1). Moreover, the fixed *within-person* effects for the inattention model were not significant as well (γ_{30} for the inattention model; contrary to Hypothesis 2).

Random Effects: Although the fixed effect for the within-person relationship in both models were not significant, the random effects were significant in both models. This indicates that the children vary from each other in the respective within-person relationship between time spent in natural spaces and affect or inattention (Figure 9 and 10). Although this effect was not included in our hypotheses, the inclusion of random effects improves a multilevel model in

most cases (Bell, Fairbrother, & Jones, 2019). The distribution of the random slopes of the models for both outcome variables can be taken from Figure 11 and 12, respectively (Appendix Research Focus 2). The Shapiro Wilk test was significant for both random effect models ($W_{\text{affect}} = 0.80, p < .05$; $W_{\text{inattention}} = 0.79, p < .05$), indicating that the residuals were not normally distributed.

Table 8

Parameter estimates of the multilevel models.

	(1)	(2)	(3)	(4)
	Empty model	Trend only Fixed and random effects	Time spent in natural spaces Fixed effect only	Time spent in natural spaces Fixed and random effects
Affect				
Fixed effects				
Intercept, γ_{00}	5.319*	5.234*	5.314*	5.310*
Effect of time, γ_{10}		0.009		
Averaged time spent in natural spaces per child, γ_{20}			0.095*	0.085*
Time spent in natural spaces, γ_{30}			0.045	0.056
Random effects				
intercept	0.341	0.347	0.347	0.359
Variance of time		0.002*		
Variance of daily time spent in natural spaces				0.032*
Residual, ε_{ii}	0.821	0.765	0.816	0.780
log-Likelihood	-1201.8	-1190.8	-1188.2	-1178.4
Inattention				
Fixed effects				
Intercept, γ_{00}	1.548*	1.662*	1.663*	1.673*
Effect of time, γ_{10}		-0.012*	-0.013	-0.014
Averaged time per child spent in natural spaces, γ_{20}			0.004	0.014
Time spent in natural spaces, γ_{30}			0.020	0.026
Random effects				
Random intercept	0.303	0.578*	0.555	0.591
Variance of time		0.002*	0.002	0.002
Variance of daily time spent in natural spaces				0.038*
Residual, ε_{ii}	0.699	0.647	0.649	0.613
log-Likelihood	-1065.8	-1096.5	-1088.9	-1084.8

Note. * $p < .05$. Model numbers (1)-(4) refer to the respective models described in the Method section.

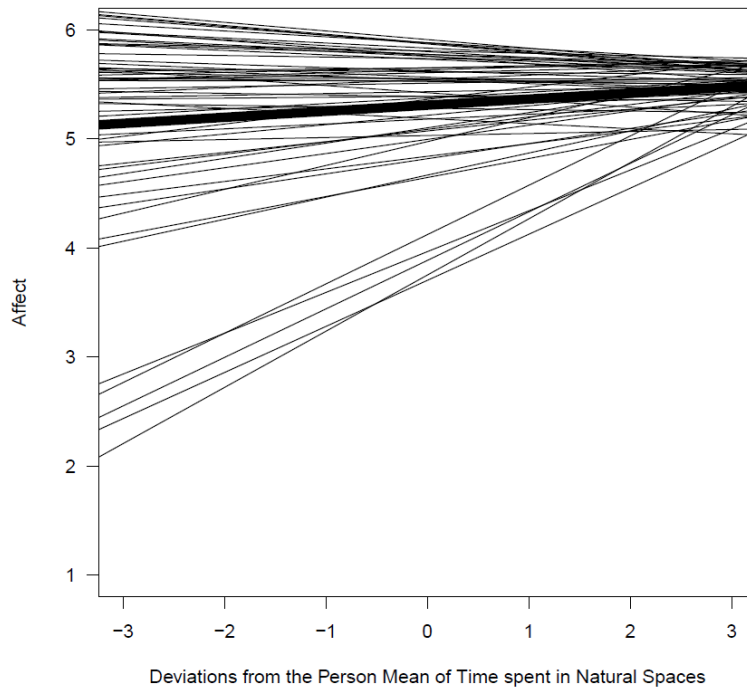


Figure 9. Individual within-person relationships between time spent in natural spaces and valence of affect. Each line represents a single child. The bold line represents the averaged within-person relationship between time spent in natural spaces and valence of affect over all children.

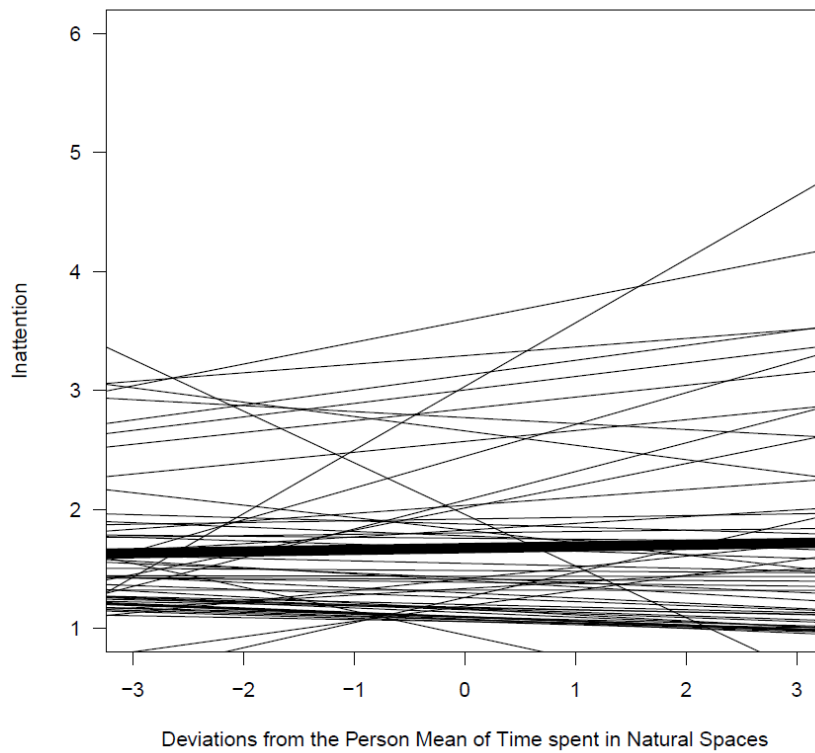


Figure 10. Individual within-person relationships between time spent in natural spaces and inattention. Each line represents a single child. The bold line represents the averaged within-person relationship between time spent in natural spaces and inattention over all children.

Discussion

The main aim of the present study was to investigate how the time spent in natural spaces relates to children's affect and inattention in their daily lives. Importantly, we looked at this relationship both on the within- and the between-person level. We tested two hypotheses: (1) the between-person relationship between the time spent in natural spaces and affect or inattention, and (2) the daily within-person relationships between the time spent in natural spaces and affect or inattention.

Before testing our hypotheses, we described how often children around the age of ten years spent time in natural spaces, where they went most often, when they were in natural spaces, and what they usually did at that time. The descriptive statistics showed that children did not differ a lot from one another regarding their mean time spent in natural spaces over an 18-day time period. Furthermore, the within-person fluctuations of the time a child spent in natural spaces were rather low in the whole sample. Additionally, the results showed that children often did not use the provided categories for the kind of activity or their specific location while spending time in natural spaces.

Focusing on Hypothesis 1, we investigated whether children who on average spent more time in natural spaces over the entire study period, showed greater positive affect and lower inattention than children who on average spent less time in natural spaces over the entire study period. Concerning the relationship between natural spaces and affect the multilevel model revealed significant between-person effects. In line with our Hypothesis 1 and with the proposed theory as well as the mentioned evidence for between-person effects regarding the restorative effect of natural spaces on affect in children (for a review see McCormick, 2017), this result indicates that children who, on average, spend more time in natural spaces feel better than children who spend less time in natural spaces. For inattention, the model results did not show a significant between-person effect, indicating that children who, on average, spend more time in natural spaces did not experience less inattention than children who spend less time in natural spaces. One reason for the non-significant between-person effect might be the children's overall low inattention scores and, thus, that children did not differ much from each other regarding their average inattention (see Table 1).

Focusing on Hypothesis 2, the aim of the study was to assess the daily within-person relationship between natural spaces and affect, as well as, between natural spaces and inattention. We hypothesized that on days when children spend more time in natural spaces than usual (referring to their person mean of time spent in natural spaces), they would show

enhanced positive affect and less inattention in the evening of that day, when compared to days where they spent less time in natural spaces (referring to their person mean of time spent in natural spaces). No significant within-person effects for the relationship between natural spaces and affect were found in this study, indicating that on days when children spent more time in natural spaces than usual they did not report enhanced positive affect. But the significance of the random effects showed that the children varied in their within-person relationship of time spent in natural spaces and affect. These results indicate that for some children there is a positive relationship between the time spent in natural spaces and their affect; whereas some children showed a negative relationship. Moreover, no significant within-person effect for the relationship between natural spaces and inattention was found, indicating that on days when children spent more time in natural spaces than usual, they did not show less inattention. Nevertheless, the random effects were also significant, indicating that some children showed the expected negative relationship between time spent in natural spaces and inattention; whereas a few children showed a positive relationship. Thus, our hypotheses can only partly be confirmed.

Several possible reasons can explain the non-significant findings of both investigated within-person relationships. First, it can be questioned whether the natural spaces the children spent their time in, could provide restoration, since our study was conducted in the months of November and December in Germany (months with an increase in coldness; Deutscher Wetterdienst, 2019). Coldness in summer time can affect mental health (Hartig, Catalano, & Ong, 2007). Apart from coldness, natural spaces also contain less vegetation during winter than during spring or summer months, which possibly affects the restorative potential of nature (Hartig, 2004). Moreover, according to the ART, nature needs to fulfill four criteria (1. fascination, 2. extent, 3. being away, 4. compatibility) in order to have a restorative effect (Kaplan, 1995). It was not the purpose of the current study to prove the effects of the criteria, but certainly it might be possible that the current children did not experience the restorative effect of nature because the main criteria were possibly not present for the natural space they spent their time in. For example, it might be possible that the children had been at a certain place that contained vegetation but also too many buildings to be able to perceive the restorative effect (Kaplan, 1995). As the descriptive statistics show, there is hardly any information about the specific kind of place the children were located in when they spent time in natural spaces. Thus, the quality of the natural space cannot be analyzed. For those reasons, it is possible that current children did not have a restorative experience while they spent their time in natural spaces.

A different explanation for the missing within-person relationship of time spent in natural spaces and affect as well as inattention could be the very little within-person fluctuations of these variables; even though ambulatory assessment seems to be a promising method for analyzing the daily fluctuations of affect and inattention in school children (for an overview, see Bugl et al., 2015). Affect, on average, was rated very positively. Current research has shown that even younger children are already able to differentiate their affective experiences (Leonhardt et al., 2016), thus the general very positive affect cannot be explained by a lack of differentiation ability. Inattention, on average, was rated very low, thus children experienced very little inattention, even though working memory (requiring directed attention) is supposed to fluctuate both from day to day and within a day in school children (Dirk & Schmiedek, 2015). As within-person fluctuations are rather low, associations among the constructs over time can hardly be depicted. At this point, the relatively good compliance rate in this research project is particularly noteworthy. Compared to other ambulatory assessment studies with adults (Courvoisier, Eid, & Lischetzke, 2012) and children (Dunton et al., 2014), the compliance is rather high, thus the little within-person fluctuations cannot be explained by too many missing values.

However, the small within-person fluctuations of *time spent in natural spaces* could be explained by the fact that nowadays people usually spend more time indoors than outside (WHO, 2013). Thus, it can be assumed that children tend to spend more time indoors as well. Moreover, since the study was conducted in November and beginning of December, it was only bright until 4:27 – 5:03 p.m. (Time and Date AS, 2019). At that time in the afternoon, some children are first coming home from school. For these two reasons, there might not be much time left on a usual day to spend outside in natural spaces. This is also represented by the fact that the average time spent in natural spaces was reported to be between one and two hours for a usual day.

However, since the between-person relationship of two constructs is not necessarily the same as the within-person relationship (e.g., Hamaker, 2012; Molenaar & Campbell, 2009) it might also be possible that the findings for the between-person relationship of experience of natural spaces and affect or inattention does not have to apply to all children on a within-person level. The current study findings indicate that, the children varied from each other in the respective within-person relationship. This indicates that contrary to our assumption, for a few children there might be a negative instead of a positive relationship between their experiences of natural spaces and affect. Moreover, for some children findings revealed a positive relationship between time spent in natural spaces and inattention, instead of the assumed

negative relationship. First, it might be possible that those differences between the children relate to their personal attitude towards nature. For example, children living in work-related rural areas (areas, where work instead of free-time is associated more often with nature, e.g. because children have to work on their parents' farms) more often associate work with nature than children living in urban areas or children living in non- work-related rural areas (Collado, Corraliza, Staats, & Ruiz, 2015). Since some children in the present study live in rural areas, it is possible that they do not have a positive association with natural spaces since these could be connected to work (field work, garden work) and therefore the children could not experience positive affect while spending time in natural spaces. As the children provided information about their environmental attitude in the background information of this study, further analyses of the data can contribute to the clarification of this question.

Furthermore, research has shown that children can profit from physical activity regarding affect (e.g., Wichers et al., 2012) and inattention (Hoza et al., 2015). Thus, physical activity could moderate the relationship between the exposure to natural spaces and affect or inattention for some children. For example, children who spend their time in natural spaces with physical activity could profit more from natural spaces than children who did not move a lot while they spend their time in natural spaces. Further analyses of the dataset from the complete research project *AttentionGO* can provide information about objectively assessed physical activity for most of the children.

However, the overall within-person relationship between time spent in natural spaces and affect or inattention was not significant and due to methodological limitations of the present study, which are discussed in the following section, the differences between the children in the respective within-person relationships (significant random effects) should be interpreted with caution.

Limitations, strengths, and implications for further research

First of all, due to the feasibility of conducting an ambulatory assessment study in school children, the results of all within-person fluctuations are based on 18 measurement points. Other ambulatory assessment studies usually use more occasions to assess the within-person variability of adults (Brose et al., 2013; Lischetzke, Pfeifer, Crayen, & Eid, 2012) and children (e.g., Kühnhausen et al., 2013). Furthermore, only a limited number of items could be used in order to keep the duration of response time in an acceptable range at each occasion (Bolger et al., 2003). For instance, the state of inattention was only assessed via two items. Including more items for assessing the experience of inattention at each occasion would be beneficial in order to be able to calculate the within- and the between-person reliability of the construct. In order

to detect within-person fluctuations more precisely, further research should therefore include a longer period of AA including more occasions per child and more items for every construct to strengthen reliability. However, it is always important to keep the burden for the participants as low as possible in order to keep the motivation on a high level throughout the entire assessment phase (Bolger & Laurenceau, 2013).

Moreover, the overall assessment of natural spaces shows some deficiencies. First, although it provides interesting information to look at a child's time spent in natural spaces during winter time, the assessment during that time of year limits the experience of natural, especially green spaces. Thus, the exposure to natural spaces should be assessed in a season in which there is more vegetation and when it is still bright in the late afternoon or evening in order to have more time left in a day that can be spent outside in natural spaces. Second, the kind of activity as well as the location during the children's exposure to natural spaces was assessed via given categories. Those categories were used rather rarely. Since children were not able to respond to a broad range of categories in the present study (for example park or playground was not offered), further research should therefore apply more categories, in order to provide information about the possible influence of the kind of activity or location on the effect of time spent in natural spaces on affect or inattention. Third, the children were asked to give information about the time they have spent in natural spaces on the basis of a given time response rating scheme. This response format is easily and validly answerable for the age group in the present study (e.g., Manz et al., 2014). Nevertheless, this response format leads to a loss of information because the exact amount of minutes spent in natural spaces during a day cannot be depicted. To analyze the relationship between experiences of natural spaces and different outcome variables (i.e., affect), it would be helpful to have more information about the exact duration of time spent in natural spaces. However, using minutes as units in the response format would mean that self-report would not work because children are not able to estimate time duration exactly (Block, Zakay, & Hancock, 1999). Further research could counter this limitation by including shorter time intervals as categorical response format (e.g., 15 min instead of one hour).

A further limitation can be seen in the general disadvantages of *self-report*. Even though self-report is a common method for assessing an individual's experience (e.g., Schwarz, 2012), validity of time spent in nature, affect, and inattention is questionable, because self-reports can be biased by different factors, such as self-serving bias or social desirability (Klein, Gould, & Corey, 1969; Mezulis, Abramson, Hyde, & Hankin, 2004). To counter these aspects, children in the present study were instructed that there were no wrong answers and their parents as well

as their teachers would not be able to see their individual responses. However, it is also possible that children couldn't fully assess their level of inattention at the point of assessment because the attention capacity was not actively required in the evening. Thus, future studies should try to implement objective assessments of inattention to provide further proof of the restorative effects of natural spaces. Moreover, objective measurements or parental report could be used for the assessment of time spent in natural spaces in future studies. For example, via Global Positioning Systems (GPS) on smartphones, an individual's location and thus also time spent in natural spaces could be tracked (e.g., Almanza, Jerrett, Dunton, Seto, & Pentz, 2012; Lachowycz, Jones, Page, Wheeler, & Cooper, 2012). At the same time, this would raise data security challenges with regard to the anonymity to be guaranteed, thereby respecting a participant's privacy (e.g., Fahrenberg, Myrtek, Pawlik, & Perrez, 2007). Importantly, since according to the *General Data Protection Regulation* (EU, 2016), each study participant has the right to access to their stored data and since we required parental signed consent, parents would always have the right to know the location of their children, and this limits the child's privacy (Fahlquist, 2015). In addition, when children play in natural spaces (i.e., forests) they may not take their smartphone with them, thus the time and location in natural spaces could not even be determined. For those reasons, the present study used children's self-report of their time spent in natural spaces.

Furthermore, another possible bias of the data which can be generated by self-report, lies in the distortion of memory due to false recollection (Kahneman & Riis, 2005). One of the largest advantages of ambulatory assessment is the usage of momentary assessment and therefore the renunciation of retrospection (Schwarz, 2012b). For practical reasons, this study used a time-based ambulatory design (for an overview see Bolger & Laurenceau, 2013), which means that children always answered the questions at a predetermined time. But the experience of natural spaces had probably taken place earlier in the day, thus the answer was retrospective and thus maybe biased. Future research on the within-person relationship between natural spaces and affect or inattention could avoid the problem of retrospection by using an event-based instead of a time-based design, which enables the children to rate their affect or inattention whenever they are in contact with natural spaces.

In addition, there is one limitation regarding the data analysis, which revealed that the residuals in both models were not normally distributed according to the Shapiro Wilk test. Therefore, although visual inspection of the histograms hinted towards a normal distribution, further research should try to replicate the present findings. Thereby the inclusion of possible moderators, such as environmental attitude or physical activity is recommended, since those

person specific factors could moderate the within-person relationship of time spent in natural spaces and affect or inattention.

Practical implications

Although the findings in this study should be interpreted with caution due to several methodological limitations, the results provide some information for practice. The results indicate that on average children did not show the assumed within-person relationship between time spent in natural spaces and affect or inattention. However, the effect might be different for each child. Although some children seem to benefit from their time spent in natural spaces, as defined in this study, regarding their affect and inattention, other children did not show this relationship. Thus, educators could carefully observe a child while it spends time in natural spaces with regard to the child's experience of affect and inattention to conclude whether it benefits from natural spaces.

Conclusions

In the present study, we investigated day-to-day within-person fluctuations of self-reported experiences of natural spaces in children. While the results demonstrate that children who, on average, spent more time in natural spaces reported greater positive affect, they do not report lower inattention than children who spent less time in natural spaces. In addition, the study provides first indications for the day-to-day within-person relationship of time spent in natural spaces and affect as well as inattention in children's daily life. Some children showed enhanced positive affect and less inattention on days when they spent more time in natural spaces than usual, while other children did not benefit on days when they spent more time in natural spaces. Thus, the within-person relationship differed from one child to the other. Therefore, the findings support the notion that it is important to look at both the between-person as well as the within-person relationship. Importantly, further research is needed to identify factors that can explain the between-person differences in within-person relationships between time spent in natural spaces and affect or inattention. Thereby, experiences in natural spaces could be more individually tailored to a child's needs, making the experience of natural spaces more valuable for every child.

Acknowledgements

We thank Heiko Rölke and the Technology Based Assessment Group at the DIPF | Leibniz Institute for Research and Information in Education for developing and providing the software to assess children's experiences via smartphones. We owe special thanks to Judith Dirk and Florian Schmiedek for providing the application from the Assessment of Cognitive

Performance Fluctuations in the School Context (FLUX) project and sharing their experiences concerning experience sampling with children. Moreover, we thank all parents and children for their participation in the research project AttentionGO. Finally, we also give thanks to all research assistants, especially Ulrike Schwarz, and student candidates for their enthusiastic and effective work as well as the German Research Foundation for financing this project. This research was supported as part of the LEAD Graduate School & Research Network [GSC1028], which was funded within the framework of the Excellence Initiative of the German federal and state governments.

Appendix Research Focus 2

Table 9

List of items used to assess the children's daily experiences in natural spaces every evening.

Item	Response Scale	Item (German)	Response Scale (German)
Today I spent time in nature	(1) No; (2) Yes, up to 1 hour; (3) Yes, more than 1 hour, up to 2 hours; (4) Yes, more than 2 hours, up to 3 hours; (5) Yes, more than 3 hours, up to 4 hours; (6) Yes, more than 4 hours, up to 5 hours; (7) Yes, more than 5 hours, up to 6 hours; or (8) Yes, more than 6 hours	Heute bin ich in der Natur gewesen	(1) Nein; (2) Ja, bis zu einer Stunde; (3) Ja, mehr als 1, bis zu 2 Stunden; (4) Ja, mehr als 2, bis zu 3 Stunden; (5) Ja, mehr als 3, bis zu 4 Stunden; (6) Ja, mehr als 4, bis zu 5 Stunden; (7) Ja, mehr als 5, bis zu 6 Stunden; (8) Ja, mehr als 6 Stunden
¹ When I was in nature, I did the following things:	(1) walking, hiking; (2) sports, e.g. soccer, horse riding; (3) playing; (4) other	Als ich in der Natur war, habe ich folgende Dinge gemacht: Als ich in der Natur war, habe ich mich an folgendem Ort aufgehalten:	(1) Spazieren, wandern; (2) Sport, z.B. Fußball, Reiten; (3) Spielen; (4) Sonstiges
² When I was in nature, I was in this place:	(1) in the forest; (2) on a meadow or a field; (3) at a lake or river; (4) in the garden; (5) other		(1) Im Wald; (2) Auf einer Wiese oder einem Feld; (3) An einem See oder Fluss; (4) Im Garten; (5) Sonstiges

Note. ¹the response scale of the corresponding item consisted of a multiple choice format; ² the response scale of the corresponding item consisted of a single choice format.

Table 10

List of items used to assess the children’s daily experience of affect and inattention every evening.

Item	Response Scale	Item (German)	Response Scale (German)
<i>Affect</i>			
Right now, I feel...	1. (1) unhappy to (6) happy 2. (1) unsatisfied to (6) satisfied 3. (1) uncomfortable to (6) comfortable 4. (1) bad to (6) good	Im Moment fühle ich mich...	(1) unglücklich bis (6) glücklich (1) unzufrieden bis (6) zufrieden (1) unwohl bis (6) wohl (1) schlecht bis (6) gut
<i>Inattention</i>			
Since the last assessment I lost track of what I was supposed to do.	(1) not true at all to (6) absolutely correct	Seit dem letzten Ausfüllen habe ich zwischendurch vergessen, was ich eigentlich tun sollte.	(1) trifft gar nicht zu (6) trifft ganz genau zu
Since the last assessment I had trouble keeping my mind on what I was doing.		Seit dem letzten Ausfüllen habe ich mich schlecht konzentrieren können.	

Note. All affect items had the same ‘item’. All inattention items had the same ‘response scale’.

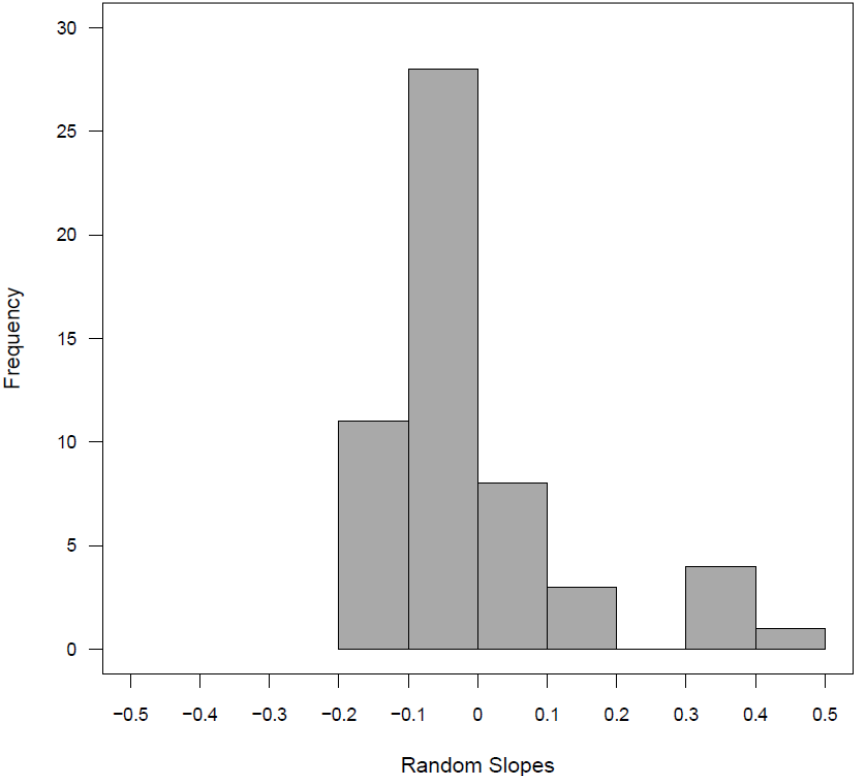


Figure 11. Histogram of the distribution of the random slopes, referring to the multilevel model of the relationship between natural spaces and affect.

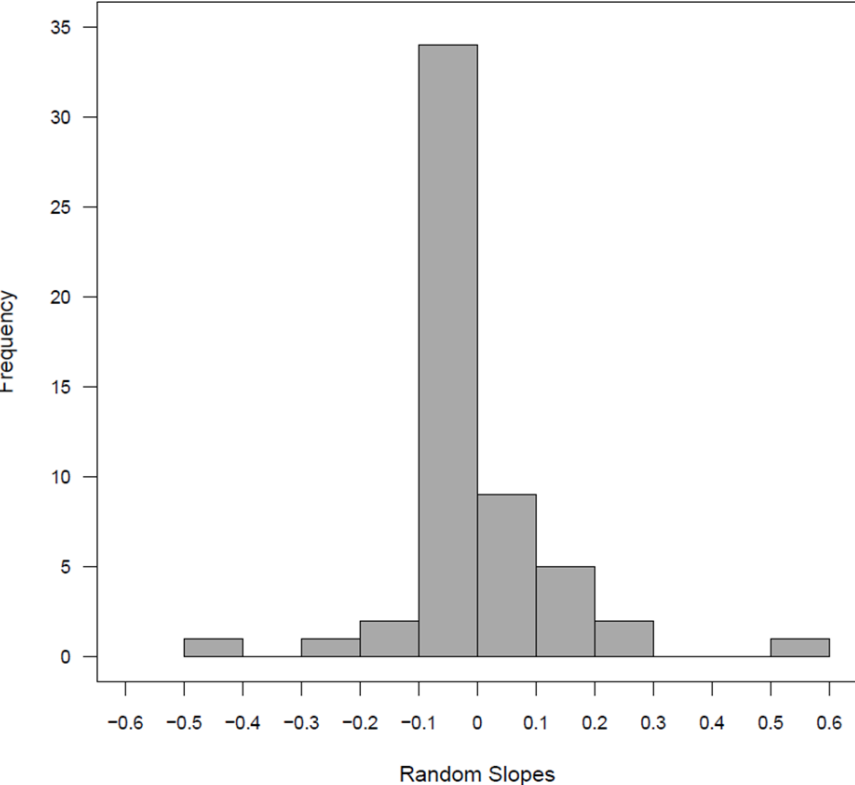


Figure 12. Histogram of the distribution of the random slopes, referring to the multilevel model of the relationship between natural spaces and inattention.

4.3 *Research Focus 3: The role of environmental attitude in association with exposure to natural spaces and mental restoration in children's daily life.*⁷

Abstract

Background: The exposure to nature can lead to mental restoration in adults and children. However, the role that a positive environmental attitude plays for this restoration effect remains unclear. Thus, this research investigates whether a stronger environmental attitude is related to a higher restoration of affect and cognitive processes (i.e., inattention) in children after time spent in natural spaces.

Methods: Children ($N = 55$; $M = 10.7y$) filled out a questionnaire about their environmental attitude at the beginning of the study. Affect, inattention, and time spent in natural spaces were recorded ambulatory over 18 consecutive days once each evening. The children were provided with smartphones for data collection that prompted them to respond to the question items each evening.

Results: Correlational analyses revealed that environmental attitude was not associated with children's restorative experiences of affect or inattention after exposure to natural spaces over the entire study period. Even though multilevel analyses indicated that some children benefit more than others from their daily exposure to natural spaces, the present findings suggest that environmental attitude does not moderate this within-person relationship.

Conclusion: More research is needed to investigate possible factors moderating within-person associations of natural spaces and children's mental restoration of affect and inattention. Limitations and methods to further develop the assessment of environmental attitude are discussed.

Keywords: environmental attitude, mental restoration, within-person relation, ambulatory assessment

⁷ Reuter, M., Kleinhansl, M., Kühnhausen, J., & Gawrilow, C. (2020). The role of environmental attitude for the association of exposure to natural spaces and mental restoration in children's daily life. *Manuscript in preparation.*

Introduction

Exposure to *natural spaces* can be beneficial for children with regard to their emotional, as well as cognitive functioning (e.g., Amoly et al., 2014; Dadvand et al., 2015). Natural spaces refer to environments that contain vegetation and/or natural waters (Ulrich, 1983). Exposure to natural spaces can lead to restorative experiences of recharging or enhancing previously depleted abilities (Kaplan & Berman, 2010). According to two separate theories, the restorative effect of nature can be comprised of either the enhancement of emotional well-being such as positive affect, or the enhancement of directed attention, thus the reduction of inattention (Kaplan, 1995; Ulrich, 1983; Ulrich et al., 1991). *Affect* can be defined as a state of feeling that a person can always be aware of (Russel & Feldman Barrett, 2009). Moreover, affect is dynamically variable due to changing contexts (Cranford et al., 2006). *Inattention* is described as an individual's difficulties with sustained, focused attention (APA, 2013)

A positive effect of natural spaces on overall affect and attention or inattention has repeatedly been investigated and found in adults (for a meta-analysis see: McMahan & Estes, 2015), and children (for a meta-analysis see: Weeland et al., 2019). In addition, the restorative effect caused by natural spaces was found in several studies that compared different settings of environments with each other. For instance, contrasting outdoor urban spaces with natural environments showed large positive effects in favour of natural environments (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009).

Overall, a research consensus exists arguing that natural spaces can have a restorative effect for adults and children. Yet, it can be assumed that an individual's restoration likelihood caused by natural spaces depends on several determinants which can be allocated to three categories (Korpela et al., 2008): (1) situational determinants (e.g., type and fit of natural spaces; e.g., Wyles et al., 2019); (2) demographic determinants (e.g., such as participant's gender; Hartig, Lindblom, & Ovefelt, 1998); or (3) person specific determinants (e.g., a person's dispositional associations with nature; e.g., Mayer et al., 2009). Although the general restorative effect of natural spaces on human beings is well documented, there is not much research on the determinants shaping individuals' daily lives (Korpela et al., 2008). However, the investigation of the factors influencing the restorative experience is important, since this can contribute to the understanding of mechanisms underlying the restorative effect of natural spaces for various aspects of human health (Korpela et al., 2008).

The present research focuses on individual traits association with nature. According to the *psychosocial stress recovery theory* (Ulrich, 1983; Ulrich et al., 1991), an individual's

experience of restoration depends on an individual's affective association towards the environment that they are currently perceiving (Ulrich, 1983). The affective association can be either positive (e.g., appreciation of the natural environment) or negative (e.g., fear or disdain of the natural environment). Importantly, restoration effects can only be experienced if the immediate affective reaction towards the perceived environment is positively valenced (Ulrich, 1983). Therefore, since the experience of restoration depends on the positive evaluation of the specific environment (Ulrich, 1983), an individual's restoration likelihood from natural spaces might also depend on the person's *environmental attitude (EA)*.

Environmental Attitude (EA)

Generally, an attitude can be described as a person's evaluative reaction towards a person, issue, object, behavior, or entity (Oskamp, 1977 as cited in Staats, 2003). In addition, attitudes are often built on a theoretical tripartite model including a cognitive, affective, and behavioral component (e.g., Breckler, 1984; Milfont & Duckitt, 2010; Schultz, Shriver, Tabanico, & Khazian, 2004). Following this general definition, the construct of EA is described as "the collection of beliefs, affects, and behavioral intentions a person holds regarding environmentally related activities or issues" (Schultz, Shriver, Tabanico, & Khazian, 2004, p.31). A person's EA can be directed to different components such as nature itself, a certain aspect of the natural environment (e.g., water quality), or a specific conservation behavior (e.g., energy consumption (Brügger, Kaiser, & Roczen, 2011).

Due to this broad scope of components, different measurement instruments have been developed, in particular in the fields of environmental education, environmental psychology, and conservation psychology (for overviews see for example Brügger et al., 2011; Milfont & Duckitt, 2010). Despite the different topics and themes covered by a measurement instrument, the instruments can be further distinguished by the way they measure EA (i.e. explicit, indirect, implicit; Brügger et al., 2011). For example, explicit instruments are the *Environmental Identity* (Clayton, 2003), *Connectedness-to-Nature Scale* (Mayer & McPherson Frantz, 2004), and *Inclusion of Nature in Self* (Schultz, 2001; Schultz, 2002). While examples of indirect and implicit measures are the *Disposition to Connect with Nature Scale* (Beckers, 2005) and the *Implicit Association with Nature* (Schultz et al., 2004) scale. Furthermore, instruments regarding environmental concern also exist such as the *New Ecological Paradigm* (NEP; Dunlap, Van Liere, Mertig, & Jones, 2000; Manoli, Johnson, & Dunlap, 2007). Finally, there are instruments focusing on the underlying values that individuals can see in nature such as the *Two-Major Environmental Value Model* (2-MEV with the two values being *utilization* and *preservation*; Bogner, 2018; Wiseman & Bogner, 2003) and instruments focusing on

individual's *Ecological Behavior* (e.g., Kaiser, Oerke, & Bogner, 2007; Kaiser & Wilson, 2004).

The instruments can be categorized based on the environmental issues they question (e.g., energy consumption, waste, population growth) and the type of personal expression towards the environmental issues (e.g., beliefs, values, concerns, attitudes, behavior intentions, and behaviors; categorization as mentioned in Dunlap & Jones, 2002). This classification leads to a four-fold typology composed of the number of topics (single vs. multiple topics) and the type of expression (single vs. multi-expression; Milfont & Duckitt, 2010) being measured. The themes included in most of the instruments can be assigned to two higher order factors, namely preservation and utilization (F. G. Kaiser et al., 2007; Milfont & Duckitt, 2004, 2010; Wiseman & Bogner, 2003). Thereby, the factor preservation is described as the “biocentric dimension that reflects conservation and protection of the environment” that indicates altruistic or biospheric values, whereas utilization is the “anthropocentric dimension that reflects the utilization of natural resources” and indicates more self-interest, egoistical and utilitarian values (Wiseman & Bogner, 2003, p. 787; Kaiser et al., 2007). Despite the large number of instruments and regardless of the theoretical differences, empirical research suggests that there is a substantial overlap among most of the currently available instruments (Brügger et al., 2011).

Importantly, since an individual's EA usually develops during childhood and seems to be enhanced until the age of 10, then consolidates before decreasing again between the age of 14 and 18 (S. Otto, Evans, Moon, & Kaiser, 2019), the assessment of *children's* EA seems worth considering. As pointed out by Brügger, Kaiser, and Roczen (2011) a measurement that sets the focus on specific behavior seems to be better suited for research with children as it reduces the level of self-reflection and self-exploration necessary to answer the measurement. Hence, asking a child about specific behavior is assumed to be easier for them to answer, when compared to rather abstract questions concerning the child's association with nature (e.g., Evans et al., 2007; Otto et al., 2019). Therefore, the present study builds on the assumption that a child's EA can be indirectly derived from self-reported behavior. Drawing from Campbell's paradigm (1963), behavior mannerisms are indicators for a person's latent attitude. Campbell's paradigm thus implies that a person's EA is expressed behaviorally and that a person's attitude can be measured by what a person reports about their behavior (Kaiser, Byrka, & Hartig, 2010). According to the research conducted by Kaiser and colleagues, specific behaviors indicating an EA can be grouped into six domains: energy conservation, mobility and transportation, waste avoidance, recycling, consumerism, and vicarious behaviors toward conservation (F. G. Kaiser et al., 2007; F. G. Kaiser & Wilson, 2004).

Regardless of the ongoing debate about how EA can best be measured, it is an underlying assumption that EA and mental restoration are connected (Korpela et al., 2008). The association could be such that the restorative effect of time spent in natural spaces is *moderated* by EA. We therefore examined to what extent the time spent in natural spaces and mental restoration is *moderated* by EA by using ecological behavior as an indicator for EA. In other words, if a person reports a stronger EA (i.e. perceives the environment as worth protecting and conserving) that person might benefit more from time spent in nature and experience higher restoration effects.

Environmental attitude and mental restoration from exposure to natural spaces

Although the relationship between EA and mental restoration from exposure to natural spaces might seem theoretically plausible, there is hardly any empirical research that investigates whether EA has the potential to moderate a restorative effect. Moreover, research examining the personal determinants of the restorative effect of natural spaces, refers to terms other than EA to describe an individual's general association with natural spaces (e.g., connectedness to nature).

For instance, one study reported that generally more nature oriented individuals reported higher assumed restoration due to exposure to natural spaces than did more city-oriented individuals (Korpela et al., 2008). Moreover, another study investigated whether university students' ($N = 722$) perceived restoration likelihood as modified by *connectedness to nature* (van den Bogerd, Coosje Dijkstra, Seidell, & Maas, 2018). Students who in general feel more connected to nature estimated that a university with greener outdoor spaces would be more restorative for them than built environments would be when compared to students with a weaker connectedness to nature (van den Bogerd et al., 2018).

Those studies refer to *adult* samples. To the best of our knowledge, there is only one study that examines the role of a person's association with natural spaces for the anticipated restorative potential of a certain place in both *children* and adults. In that study, both adults ($n = 239$) and children ($n = 178$) were asked about their favorite places when they consider themselves in a rather negative affective state (Regan & Horn, 2005). The authors found that children and adults who reported preferences for natural spaces during their leisure time and holidays also reported higher anticipated restoration effects of natural spaces (Regan & Horn, 2005).

All these previous studies only investigated an individual's anticipated restoration effect of natural environments. In contrast the present research investigates whether EA has the potential to moderate the relationship between a *child's* self-reported amount of time spent in

natural spaces and their experience of positive influences on affect and inattention. It is assumed that the stronger a child's EA towards nature the more they will benefit from time spent in natural spaces.

The present research and hypotheses

Regarding the restorative effect of natural spaces on affect and inattention, in a previous study the authors already investigated within-person associations between the daily time spent in natural spaces and affect and inattention in *children* in an *ambulatory assessment* design (Reuter, Kühnhausen, Haas, & Gawrilow, in press). *Some* children showed enhanced positive affect and/or reduced inattention after they spent more time in natural spaces than they usually do. However, for other children the time spent in natural spaces did not yield any positive effects. One reason could be a moderator variable explaining the differences between the participating children in the respective within-person relationship of time spent in natural spaces and mental restoration. Thus, in the present study we now assume that against the background of the theoretical aspects of EA described above, there is a correlation between a child's EA and their restorative experiences of time spent in natural spaces. Thus, the EA can be considered as a suitable moderator for the within-person relationship between time spent in natural spaces and affect or inattention.

In this article we therefore hypothesize that (1) the stronger a child's EA the more they benefit from the daily time spent in natural spaces in regards to their affective state, and (2) the stronger a child's EA the more they benefit from the daily amount of time spent in natural spaces regarding their state of inattention.

Methods

The data presented in this article was collected within a larger ambulatory assessment research project⁸ (Reuter, Kühnhausen, Haas, & Gawrilow, in press). Over the course of eighteen days, school children rated some of their daily experiences (e.g., affect and inattention) three times a day via smartphones. In addition, the children were asked to rate other daily experiences, such as their time spent in natural spaces every evening. Because this information is relevant for the research question, the analyses for this article only refers to data from the evening measurement times. The research project was funded by the German Research Association (DFG); and was approved by the ethics committee of the German Psychological Society (DGPs) and the Ministry of Culture, Youth and Sport, Baden-Württemberg.

⁸ The entire research project funded by the DFG (GA 1277/9-1) is titled '*Adaptive Dynamics of Cognitive and Behavioral Variability in Children with Attention Deficit Hyperactivity Disorder: Long-Term Effects, Neural Bases, and Susceptibility to Intervention*'.

Study Sample

The present sample consists of 55 children with a mean age of 10 years and 9 months ($SD = 6$ months; $n = 54$). For one child no exact age data was provided. The study sample was relatively evenly split between gender ($n = 25$ male; 45.45%). A family's socioeconomic status (income level) was disclosed by the parents via self-report. Income level, defined as monthly net salary, was divided into 7 categories: <€1250 ($n = 3$; 5.45%), €1250 to €1750 ($n = 0$), €1750 to €2250 ($n = 2$; 3.64%), €2250 to €3000 ($n = 6$; 10.91%), €3000 to €4000 ($n = 18$; 32.73%), €4000 to €5000 ($n = 6$; 10.91%), and >€5000 ($n = 14$; 25.45%). Six parents choose not to answer questions concerning their income level (10.91%). From each participating child, one parent was asked whether the child likes to be outside in natural spaces and how often the child spends time in natural spaces during a normal week. The descriptive results are depicted in Table 11.

Table 11

Children's connection to and contact with nature according to their parents.

<i>Item</i>	<i>Missings</i>	<i>M</i>	<i>SD</i>	<i>n_a</i>	<i>n_b</i>	<i>n_c</i>	<i>n_d</i>	
Likes being in natural spaces	0	1.58	0.76	32	14	9	0	-
Frequency of contact with natural spaces	0	3.56	1.32	2	14	10	9	20

Note. n depicts the frequencies of the parents' answers for the referring type of answer: n_a = very gladly; n_b = rather gladly; n_c = rather reluctantly; n_d = very reluctantly; n_e = no time; n_f = two times per week; n_g = three times per week; n_h = four times per week; n_i = almost every day.

Procedure

Data collection took place from November to December 2017 in Southern Germany. Children were asked to complete a background questionnaire (containing items that assessed, for example, individual trait affect and *environmental attitude*) one or two days before the start of the ambulatory assessment period. This background questionnaire was completed during a school lesson. After the children had answered the background questionnaire, they were provided with smartphones that were individually scheduled. The software used IMS Question & Test Interoperability Specification (IMS, 2011, as cited in Mahtab & Rölke, 2012) and the children were unable to use typical functions like wireless network or any other application on the smartphone during the 18 days of the data collection.

During the ambulatory assessment period of 18 days, the children were asked to rate their affect and inattention apart from other behaviors and experiences on a smartphone three times a day, using a time-contingent sampling method. Furthermore, the children provided some additional information each evening, such as time spent in natural spaces on the referring

day. An overview of the measurement times at which each construct that is relevant for the present article was assessed are depicted in Table 12.

Table 12

Overview of the measurement times of the constructs relevant for the present research focus assessed within the entire ambulatory assessment research project.

	Time of measurement			
	Pre ambulatory assessment one measurement	Daily recurring assessment over 18 days		
		morning	afternoon	evening
Environmental attitude	X	-	-	-
Daily experience of natural spaces	-	-	-	X
Affect	X _a	X _a	X _a	X
Inattention	X _a	X _a	X _a	X

Note. X = variable was assessed at the referring time of measurement and was used for the analyses; X_a = variable was assessed at the referring time of measurement but was NOT used for the analyses of this article.

Measurements

Environmental attitude (EA). The original questionnaire was designed for adolescents (F. G. Kaiser et al., 2007) and was adopted for children in this study (for a detailed description of all items see Table 15 in Appendix Research Focus 3). Compared to the original version we changed the item number since according to experts from the field of pedagogical research, some behaviors were considered not in the decision-making power of children (i.e., 'I contribute financially to environmental organizations'). Moreover, we added four items that should be able to differentiate in the peripheral areas of EA (i.e., 'I eat meat') or assess behavior which concerns the everyday life of schoolchildren (i.e., 'I prefer to paint with felt pens rather than with wooden crayons.'). Thus, the final questionnaire consisted of 19 items (five were slightly changed in their wording in comparison to the original questionnaire) which can be assigned to the six different subscales of the original questionnaire (for sample items of each subscale see Table 12): (1) energy conservation, (2) mobility and transportation, (3) waste avoidance, (4) recycling, (5) consumerism, and (6) vicarious behaviors toward conservation. The theoretically conceived subscales were not specifically indicated to the participating children on the questionnaire. As a response format we used a five-point Likert scale ranging from zero ('not true at all') to four ('absolutely true'). All items could be answered with the option 'not specified', which was treated as a missing value within the calculation of the EA index. Moreover, to determine an EA index for each child (for further calculation details see the statistical analyses section), seven items had to be recoded. Compared to the original version of the questionnaire with a 'separation reliability' of $r = .80$ and an internal consistency of $\alpha = .78$

(F. G. Kaiser et al., 2007), the reliability of the questionnaire in this study is rather low ('separation reliability' $r = .60$ and Cronbach's $\alpha = .69$, $CI_{95} = .57, .81$).

Children's daily experiences. The daily amount of *time spent in natural spaces* was assessed every evening via the single self-constructed item 'Today I spent time in nature' (for a detailed item description see Table 14 in Appendix Research Focus 3). The children responded to the item via given time intervals. Higher values indicate that the child spent more time in natural spaces on the referring day. Children's *affect* was assessed via four items of an adopted version of the Multidimensional Mood Questionnaire (German: 'Mehrdimensionaler Befindlichkeits-fragebogen'; MDBF; Steyer, Schwenkmezger, Notz, & Eid, 1997). Higher values indicate higher positive affect. *Inattention* was measured via two items that were adopted from the original version of the Conners3 Rating Scale (Lidzba et al., 2013). Higher values indicate less inattention. Affect and inattention items (for a detailed item description see Table 14 in Appendix Research Focus 3) were always presented in the same order and were assessed three times a day, thus at every data collection occasion. However, since affect and inattention are associated with the daily experience of nature, which is measured only once a day, only the evening occasions of affect and inattention are taken into account in the present calculations. Mean values for the current affect state as well as inattention were calculated for every child on every occasion (Reuter et al., in press).

Statistical analyses

Before testing the hypotheses, we determined each child's EA via calculating a Rasch model (Rasch, 1960). The Rasch model allows for the determination of a person's EA on the basis of the difficulty of each item (F. G. Kaiser & Wilson, 2004). Thus, difficult items are pro-environmental behaviors which are rather unlikely to be implemented by children. The model can be depicted as in the following equation (F. G. Kaiser & Wilson, 2004):

$$p(x = 1|\theta, \delta) = \frac{\exp(\theta - \delta)}{1 + \exp(\theta - \delta)}$$

The probability p of the implementation of a pro-environmental behavior $x = 1$ is determined by two parameters: a person's entire performance level θ as well as the difficulty of the respective environmental behavior δ . Thus, the pro-environmental behavior index of each child is a result of the discrimination of item difficulty (cf. Kaiser, 1998).

In accordance with our hypotheses 'The stronger a child's EA the more they benefit from the daily amount of time spent in natural spaces with regard to their affective (hypothesis 1) and their attentional (hypothesis 2) state', in a first step, we used the results of the previous study (Reuter, et al., in press). In that study, we used hierarchical linear modeling (Singer &

Willet, 2003) to analyze whether there are between-person differences in the within-person relationship of time spent in natural spaces and affect or inattention. The results showed significant random effects, indicating that there are between-person differences in the investigated within-person relationships.

In a second step, we used these random effects of the already calculated models, to check whether each child's slope correlates with their individual EA. Since the required assumptions of a Pearson correlation were not fulfilled, a non-parametric correlation was calculated (Field et al., 2012).

In addition to our pre-registered analyses, we wanted to explore whether there are differences between girls and boys regarding EA. To analyze these differences we used an independent t-test (Field et al., 2012). The calculation of the Rasch model was done by using the Quest software (Adams, & Koo, 1996), all further analyses were done by using R (R Core Team, 2018) and a significance level of $\alpha = .05$.

Results

Descriptive Statistics

All descriptive statistics of the environmental attitude (EA) index and its subscales as well as the frequencies of missing data are depicted in Table 13. For one child an EA could not be calculated since the child did not fill out the background questionnaire. Thus, further analyses will be done with $n = 54$ children. Furthermore, we analyzed descriptively whether children with a stronger EA spent more time in natural spaces over the whole ambulatory assessment period than children with a weaker EA. The results of a Spearman- rank correlation were not statistically significant ($\rho = .16$; $p = .257$). Thus, the results suggest that children with a stronger EA did not spend more time in natural spaces on average than children with a weaker EA.

Table 13
Descriptive statistics of the environmental attitude index.

<i>Scale</i>	<i>M</i>	<i>SD</i>	<i>n</i>	<i>Item example</i>
Environmental attitude index	0.25	0.98	19	
<i>Subscales</i>				
energy conservation	2.83	0.92	3	e.g., 'As the last person to leave a room, I switch off the lights'
mobility and transportation	3.35	1.31	1	e.g., 'I ride a bicycle, take public transportation or walk to school'
waste avoiding	2.75	0.69	6	e.g., 'I refrain from battery-operated appliances'
recycling	2.36	1.16	2	e.g., 'I separate my waste'
consumerism	1.85	0.83	3	e.g., 'I eat at McDonald's or Burger King'
vicarious behaviors toward conservation	1.92	0.86	4	e.g., 'After a picnic, I leave the place as clean as it was before'

Note. *M* = arithmetic mean value; *SD* = standard deviation; *n* = number of items, taken into account. *M* and *SD* of the first row are based on the EA index after calculating the Rasch model. *M* and *SD* of the subscales are based on the raw data.

The children had the possibility to answer 'not specified', this answer was considered as a missing for further analysis. For the descriptive representation of the questionnaire, all item characteristics are shown in Table 16 (Appendix Research Focus 3).

Hypotheses

To test the pre-registered hypotheses, we first checked whether the prerequisites for the planned analyses were fulfilled. Therefore, we tested whether the data of the children's EA and the random slopes of the multilevel models calculated in the previous study were normally distributed. The results of the Shapiro-Wilk tests showed that the EA was normally distributed ($W = 0.98, p = .376$), whereas the random slopes were not ($W_{affect} = 0.77, p < .05$; $W_{inattention} = 0.81, p < .05$).

Because the prerequisites of a Pearson correlation are not given, two Kendall rank correlations were calculated in order to test our two main hypotheses. We first assumed that there is a positive correlation between a child's individual EA and their affective benefit from the daily amount of time spent in natural spaces. This correlation revealed no statistically significant results ($\tau_{affect} = -0.03, p = .386$), indicating that a stronger EA is not accompanied by a higher benefit from time spent in natural spaces with regard to affect. Our second hypothesis assumed a positive relation between a child's EA and the child's attentional benefit from the daily amount of time spent in natural spaces. Due to the scaling of the dependent variable inattention, we expected a negative correlation for the assumed attentional benefit. The

correlation did not show statistical significance either ($\tau_{inattention} = -0.10, p = .146$). This indicates that the strength of the association between time spent in natural spaces and inattention is not related to EA. Thus, both hypotheses have to be rejected.

In addition to our pre-registered hypotheses, we explored whether there are differences between girls and boys regarding their EA. The data of the EA was normally distributed within boys ($W = 0.96, p = 0.457$) and girls ($W = 0.96, p = 0.246$), thus the prerequisites for a t-test are given. The results of the t-test were not significant ($t_{52} = -0.35; p = .730$). This indicates that boys do not differ from girls regarding their EA.

Discussion

None of our hypotheses could be confirmed. Thus, a child's environmental attitude (EA) does not moderate the relationship between time spent in natural spaces and affect or inattention. In addition, the descriptive statistics revealed that there were no differences between girls and boys regarding their EA.

There are several possible reasons that could explain the non-significant findings. First of all, it might be possible that the children did not experience much restoration of affect or inattention overall. Since the study was conducted during months with cold weather and rather little vegetation (November and December), the natural spaces might not provide much restoration (e.g., Hartig, 2004; Ulrich, 1983). Moreover, the enhancement of positive affect is only one aspect of an individual's perceived restoration after exposure to natural spaces (Ulrich et al., 1991). It is also possible that children benefit from natural spaces regarding other aspects of well-being, such as the reduction of stress (Ulrich et al., 1991) or the enhancement of calmness, as an additional dimension of the construct of affect (e.g., Hartig, Lindblom, & Ovefelt, 1998). For those reasons, further research should try to investigate children's restoration during spring or summer with a broader range of possible outcome variables.

However, since the previously published results revealed significant random effects, the results indicate that some children benefit from their daily time spent in natural spaces regarding their affect and inattention, whereas other children do not (for further details see Reuter et al., in press). Therefore, it seems important to find out possible moderators for the within-person relationship between time spent in natural spaces and affect or inattention. The present findings indicate that EA does not moderate the respective within-person relationship. Thus, it can be assumed that there are other possible moderators that could either be assigned to demographic or other personal aspects (Korpela et al., 2008). For example, the company of another person while spending time in natural spaces might influence an individual's restorative experience,

since former research found that adults seem to benefit more from spending time alone in natural spaces (Staats & Hartig, 2004). Moreover, physical activity could moderate the within-person relationship between exposure to nature and affect and inattention, since physical activity has the potential to enhance affect (Wichers et al., 2012) and cognitive functions (Hoza et al., 2015) in children. Thus, future research should investigate additional variables possibly determining the restorative effect of natural spaces for children.

Another reason for the non-significant results of the moderation lies in the theoretical conception of a child's relationship with natural environments and how it was operationalized in the present research (a child's dispositional *EA*). Our hypotheses that children show more mental restoration after their time spent in *natural spaces* if they have a stronger *EA*, is based on the assumption that a positive cognitive as well as affective connection towards nature is a necessary precondition for the experience of restoration. Therefore, the feeling of positive affect, such as pleasantness, during an individual's experience of natural spaces depends on the kind of general relationship an individual has towards that environmental location (Ulrich, 1983). Since attitudes consist of a cognitive as well as an affective component, in addition to a behavioral component (Breckler, 1984), the assessment of the construct of *EA* might depict this kind of relationship with natural spaces. However, since we applied a model of *EA* that is based on the assessment of an individual's pro-environmental behavior (e.g., Kaiser & Wilson, 2004), the affective relationship with natural spaces was not directly assessed. Thus, no direct conclusion can be drawn in regard to a child's affective relationship towards natural spaces. For this reason, instead of focusing on *EA*, future research could assess a child's relationship to natural spaces via a different construct. For example, the 10-item *New Ecological Paradigm (NEP)* scale for children between the age of ten and twelve measures a child's ecological worldview (Manoli et al., 2007). This rather indirect measure of *EA* assesses the position of a child within a dimension from the two poles of anthropocentric and ecocentric (Manoli et al., 2007). Thus, this measurement focuses on a child's perception of the relationship between humans and nature. Moreover, the *Model of Ecological Values (2-MEV)*; Bogner & Wiseman, 1999) claims to measure the *EA* defined as 'a psychological tendency expressed by evaluating the natural environment with some degree of favor or disfavor' (Milfont & Duckitt, 2010, p. 80). Both the *NEP* and the *2-MEV* model distinguish between the two terms *preservation* and *utilization*. In contrast to the *NEP*, the *2-MEV* model allows assessment of high expressions of both characteristics (Manoli, Johnson, Buxner, & Bogner, 2019). Furthermore, Larson and colleagues (2011), use the *Children's Environmental Perception Scale* to investigate a child's eco-affinity and eco-awareness. Each scale contains eight statements like 'I would spend time

after school working to fix problems in nature' (eco-affinity) or 'People need plants to live' (eco-awareness), achieving high reliability coefficients for this measurement tool. However, it is not definitive how exactly the authors connect the subscales of their measurement instrument to the concept of EA. In reference to Manoli, Johnson, and Dunlap (2007), the authors assume that the aspects 'interest in nature, the importance of nature, endangered eco-systems and environmental stewardship' (Larson, Green, & Castleberry, 2011; p.75) all belong to the concept of EA. Thus, they hypothesize that their constructs of eco-affinity and eco-awareness assess different aspects of the overall construct of EA. Finally, future research could use the *Connectedness to nature scale* (Mayer & McPherson Frantz, 2004), which assesses an individual's affective connection to natural spaces. With items like 'I often feel a sense of oneness with the natural world around me' or 'I recognize and appreciate the intelligence of other living organisms', express an individual's connection and their affective attitude towards natural spaces. Although those measurements use different items and refer to different kinds of relationships between human beings and natural spaces, they show high correlations (e.g., Tam, 2013). Therefore, it can be assumed that the different scales somehow measure similar latent constructs.

However, apart from the rather content based discussion about the assessment of the relationship between human beings and natural spaces, another two points of criticism lie in the assessment of EA based only on behavior. First, a disadvantage of the attitude assessment due to behaviour is that it has to rely on realistic behaviour for the referring age group. The items selected for this study were based on an adolescent sample; thus, for use with children we deleted some items from the original questionnaire or changed the wording (see methods section). During analysis we could see in the descriptive statistics that the content of some items was probably still too difficult for the children to answer. For example, the item 'I am a member of an environmental group (e.g., Environmental group at school, Greenpeace, Nature and Biodiversity Conservation Union [NABU])' showed a negative correlation with the total scale, and the item 'In winter I turn down my heating when I leave my room for a longer period of time' was answered with 'not specified' by twelve children. Moreover, it might have been too difficult for the children to understand the reversed items (e.g., Weijters, Baumgartner, & Schillewaert, 2013). Since our index is based on seven items with a reversed response format, this could have had a negative effect on the EA index as well as the scale's separation reliability, which is rather low in the present study compared to other studies (e.g., Otto et al., 2019). Therefore, for further research we recommend using a scale which does not use reversed items (i.e., *Children's Environmental Perception Scale*; Larson et al., 2011).

Nevertheless, the behavioral conception of EA might still be beneficial for research with younger children, since behavioral manners are possibly easier to understand than rather abstract questions about the kind of relationship a child has with natural spaces (Brügger et al., 2011). It was due to this seeming advantage of a behavioural assessment of EA, that the present study focused on a behavioural assessment of children's EA.

Finally, a reason for the non-significant results can be seen in the rather small sample size of the present research ($N = 54$). Further research should test the hypotheses with a larger sample size. However, this research was aimed at investigating restorative experiences within a child over time. Thus, by assessing affect and inattention at several occasions, this research provides relevant insights into the restorative potential of children's experiences of natural spaces on a daily basis. Since natural spaces are assessed the way they occur in a child's daily life, the data in the present research shows a high ecological validity (Reis, 2012).

Conclusion

This study provides first findings for a relationship between a child's EA and mental restoration effects for affect and inattention after time spent in natural spaces. However, since the results were not statistically significant, our hypotheses were not conclusively confirmed. Our findings indicate that children with a stronger EA do not benefit to a greater extent from their time spent in natural spaces with regard to their experience of affect and inattention than children with a weaker EA. Although there are several limitations, especially regarding the kind of EA assessed in this study, the present research can be highlighted due to the innovative ambulatory assessment design that was used to assess a child's restoration due to natural spaces.

Acknowledgements

We especially thank the research assistant Ulrike Schwarz for her effort and enthusiasm in the research project AttentionGO. We would also like to thank all research and student assistants for their support during data collection. Furthermore, we thank all children and their parents as well as the school principals and teachers for participating in this research project. Moreover, we owe special thanks to Judith Dirk and Florian Schmiedek for providing the application from the Assessment of Cognitive Performance Fluctuations in the School Context (FLUX) project and sharing their experiences concerning experience sampling with children. This research was supported as part of the LEAD Graduate School & Research Network [GSC1028], which was funded within the framework of the Excellence Initiative of the German federal and state governments.

Appendix Research Focus 3

Table 14

List of items used to assess the children's experience of affect, inattention, and time spent in natural spaces at every occasion.

Item	Response Scale	Item (German)	Response Scale (German)
<i>Affect</i>			
Right now, I feel...	1. (1) unhappy to (6) happy 2. (1) unsatisfied to (6) satisfied 3. (1) uncomfortable to (6) comfortable 4. (1) bad to (6) good	Im Moment fühle ich mich...	(1) unglücklich bis (6) glücklich (1) unzufrieden bis (6) zufrieden (1) unwohl bis (6) wohl (1) schlecht bis (6) gut
<i>Inattention</i>			
1. Since the last assessment I lost track of what I was supposed to do.	(1) not true at all to (6) absolutely correct	Seit dem letzten Ausfüllen habe ich zwischendurch vergessen, was ich eigentlich tun sollte.	(1) trifft gar nicht zu (6) trifft ganz genau zu
2. Since the last assessment I had trouble keeping my mind on what I was doing.		Seit dem letzten Ausfüllen habe ich mich schlecht konzentrieren können.	
<i>Time spent in natural spaces</i>			
Today I spent time in nature.	(1) No; (2) Yes, up to 1 hour; (3) Yes, more than 1 hour, up to 2 hours; (4) Yes, more than 2 hours, up to 3 hours; (5) Yes, more than 3 hours, up to 4 hours; (6) Yes, more than 4 hours, up to 5 hours; (7) Yes, more than 5 hours, up to 6 hours; or (8) Yes, more than 6 hours	Heute bin ich in der Natur gewesen	(1) Nein; (2) Ja, bis zu einer Stunde; (3) Ja, mehr als 1, bis zu 2 Stunden; (4) Ja, mehr als 2, bis zu 3 Stunden; (5) Ja, mehr als 3, bis zu 4 Stunden; (6) Ja, mehr als 4, bis zu 5 Stunden; (7) Ja, mehr als 5, bis zu 6 Stunden; (8) Ja, mehr als 6 Stunden

Note. All affect items had the same 'item'. All inattention items had the same 'response scale'.

Table 15

List of items used to assess the children's environmental attitude (EA).

	Item	Item (German)
1.	I ride a bicycle, take public transportation or walk to school.	Für den Schulweg benutze ich das Fahrrad oder den Bus oder ich gehe zu Fuß.
2.	I drink beverages in cans.	Ich trinke Getränke aus Dosen.
3.	On excursions, I take along beverages in single-use packages (e.g., Capri-Sonne).	Auf Ausflüge nehme ich Getränke in Wegwerfverpackungen mit (z.B. Capri-Sonne).
4.	I separate waste.	Ich trenne meinen Müll.
5.	I eat in fast-food restaurants, such as McDonalds and Burger King.	Ich esse bei McDonald's oder Burger King.
6.	I am a member of an environmental organization (e.g., Environment working group, Greenpeace, Nature and Biodiversity Union)	Ich mache bei einer Umweltgruppe mit (z.B.: Umwelt-AG, Greenpeace, NABU).
7.	After a picnic, I leave the place exactly as I found it.	Ich verlasse nach einem Picknick den Platz genauso, wie ich ihn angetroffen habe.
8.	I inform myself about environmental issues in the media (e.g., in newspapers, magazines or TV).	Ich informiere mich in den Medien über Umweltthemen, zum Beispiel in Zeitungen und Zeitschriften oder im Fernsehen.
9.	I prefer to paint with felt pens rather than with wooden crayons.	Ich male lieber mit Filzstiften als mit Holzbuntstiften.
10.	I take paper that is already used on one side.	Ich benutze die Rückseite von bedrucktem Papier.
11.	I refrain from battery-operated appliances.	Ich versuche keine Geräte mit Batterien zu benutzen.
12.	In the winter, I turn down the heat when I leave my room for a longer period of time.	Im Winter drehe ich meine Heizung herunter, wenn ich mein Zimmer für längere Zeit verlasse.
13.	If I see trash (e.g., a plastic bag) somewhere, I take it to a garbage can.	Wenn ich irgendwo Abfall (z.B. eine Plastiktüte) sehe, bringe ich ihn zu einer Mülltonne.
14.	I have pointed out unecological behavior to someone (e.g., let water run unnecessarily for a long time).	Ich mache jemanden auf sein falsches Umweltverhalten aufmerksam (z.B. lange unnötig Wasser laufen lassen).
15.	If I'm out somewhere and can't find a garbage can, I throw the garbage on the floor sometimes.	Wenn ich irgendwo unterwegs bin und keinen Mülleimer finde, schmeiße ich den Müll auch mal auf den Boden.
16.	As the last person to leave a room, I switch off the lights.	Wenn ich als letzte Person einen Raum verlasse, schalte ich das Licht aus
17.	In the winter, it is warm enough in my room to only wear a T-shirt.	Im Winter ist die Heizung in meinem Zimmer so warm eingestellt, dass es reicht, wenn ich nur ein T-Shirt trage.
18.	At school I take drinks to school in such bottles, which can be refilled again and again.	In die Schule nehme ich Getränke in solchen Flaschen mit, die man immer wieder auffüllen kann.
19.	I eat meat.	Ich esse Fleisch.

Table 16
Descriptive statistics of all items measuring the EA.

Item number	'not specified'	<i>M</i>	<i>SD</i>	<i>median</i>	<i>r</i>	skew	kurtosis
1	0	3.35	1.31	4	.41	-1.76	1.52
2	0	3.13	1.17	4	.39	-1.19	0.26
3	0	3.45	1.07	4	.35	-1.76	1.76
4	2	2.92	1.47	4	.53	-1.02	-0.51
5	1	2.39	1.23	3	.51	-0.46	-1.07
6	4	0.25	0.69	0	-.15	2.53	5.27
7	2	3.40	1.17	4	.38	-2.00	2.90
8	1	2	1.50	2	.37	-0.07	-1.53
9	2	2.47	1.40	2	.34	-0.40	-1.09
10	0	1.89	1.66	2	.56	0.05	-1.71
11	7	1.17	1.10	1	.49	0.43	-0.85
12	12	1.91	1.48	2	.43	0.08	-1.38
13	5	1.80	1.40	2	.42	0.18	-1.26
14	5	2.06	1.58	2	.44	-0.13	-1.57
15	2	3.45	1.03	4	.36	-2.00	3.27
16	1	3.13	1.17	4	.55	-1.30	0.76
17	4	3.22	1.31	4	.22	-1.53	0.93
18	2	3.15	1.49	4	.45	-1.32	0.02
19	1	0.70	1.19	0	.18	1.62	1.41

Note. Missings = number of missing data per item; *M* = arithmetic mean value; *SD* = standard deviation; *r* = correlation of the referring item with the mean value of the total scale of the EA; arithmetic mean value refers to the raw data not to the latent estimated dimension of the EA.

5 General Discussion

Nature can provide positive effects for children's mental health (Weeland et al., 2019). In modern societies, more and more children live in urbanized areas (Unicef, 2016). Children in particular might suffer from the lack of nature in the surroundings of their daily lives (Vanaken & Danckaerts, 2018; WHO, 2016). Whether natural spaces as they occur in daily life can have a positive effect on children's affect and symptoms of ADHD can be studied well by using an ambulatory assessment (AA) design. When an AA design is used, children's experiences can be assessed in real time, in the context of their real life, and on several occasions for each individual (Sects. 2.2.1–2.2.3). Hence, fluctuations occurring within children over time can be assessed. Although these characteristics of AA are well known, there is still very little research using such designs which require great effort, especially in children and for ADHD symptoms. The present research therefore provides insights into fluctuations of affect and ADHD symptoms within children over time and in the specific context of natural spaces in a child's daily life.

Against the theoretical and empirical background, the present dissertation sheds light on the relationship of negative affect and ADHD symptoms within children over time (*Research Focus 1*). It further provides insights into the relationship between the time a child spends in natural spaces and his/her affect and the ADHD symptom inattention on between- and within-person levels (*Research Focus 2*). Finally, the role of a child's environmental attitude for the within-person relationship between natural spaces, on the one hand, and affect and the ADHD symptom inattention on the other, is elucidated (*Research Focus 3*).

This chapter summarizes and discusses the main results (Sect. 5.1), followed by an outline of limitations in connection with directions for future research (Sect. 5.2). Section 5.3 discusses strengths of the present dissertation and Section 5.4 summarizes practical implications. Finally, a general conclusion is presented (Sect. 5.5).

5.1 Summary and discussion of the main results

The present dissertation had the goal of investigating within-person relationships of ADHD symptoms, affect, and natural spaces over time in children's daily lives. The main results are as follows: (a) On average, ADHD symptoms and negative affect were not related over time within children (*Research Focus 1*). (b) On average, the amount of time spent in natural spaces was not related to positive affect or to the ADHD symptom inattention over time

within children; however, for some children, more time in natural spaces was related to more positive affect and reduced inattention on a daily basis (*Research Focus 2*). (c) A child's personal trait of environmental attitude did not moderate the within-person relationship between natural spaces and affect or inattention as an ADHD symptom (*Research Focus 3*). In the following, the study design and methodology is briefly described and the results of each research focus will be discussed in more detail.

All research results of the present dissertation are based on the same study sample. Over a period of 18 days, 55 children rated their affect and ADHD symptoms three times a day (morning, afternoon, and evening), as well as their time spent in natural spaces on a given day each evening. For data collection, the children were provided with smartphones that prompted the children to respond to the items on each occasion. Before this AA period, children filled out a background questionnaire during a school lesson that assessed a child's environmental attitude.

Data from several occasions per person allow insights into effects on both a within- and a between-person level. On a within-person level, (a) fluctuations of the experiences or behaviour within a person over time and (b) fluctuations in relation to another experience, behaviour, or context over time, which is referred to as a within-person relationship or a co-variation over time, can be explored. On a between-person level, it can be investigated whether (c) there are additional variables that moderate the within-person relationship and (d) whether the target phenomena are related on average between different persons.

The results of *Research Focus 1* showed that on average the within-person relationship between ADHD symptoms and negative affect was not statistically significant, which contradicts the assumption. This finding indicates that on occasions when children experienced more ADHD symptoms than usual, they did not experience higher negative affect. However, further results also reflected that the children differ from each other in their respective within-person relationship, indicating that some children showed the assumed relationship between ADHD symptoms and negative affect, whereas other children did not. Moreover, on a between-person level the relationship was significant, which indicates that children who experienced more ADHD symptoms over the entire AA period also experienced higher negative affect on average. This result is in line with previous research suggesting that negative emotionality is increased in children with ADHD (APA, 2013; Martel, 2009). One explanation for the non-significant within-person relationship could be seen in the assumption that from a between-person perspective children with ADHD also experience enhanced positive affect in addition to enhanced negative affect when compared to non-affected children (Anastopoulos et al., 2011)

or compared to children with another psychiatric disorder (Okado et al., 2016). However, these between-person findings rely on retrospective one-time assessments. The present findings indicate that the children differed significantly in their respective within-person association between ADHD symptom level and negative affect (significant random effects), meaning that for some children the assumed within-person relationship was observed, whereas for other children it was not. One possible explanation for this difference between the children in the within-person effect could be that some children showed only a few affect fluctuations compared to others, as indicated by the *intra-individual standard deviation (ISD)*. Without within-person fluctuations, that is, no variation within individuals, there can be no co-variation either. However, the inclusion of only those children with within-person fluctuations of affect did also not reveal a significant fixed effect of the assumed within-person association between ADHD symptom level and negative affect.

Within *Research Focus 2* it was expected that the amount of time spent in natural spaces on a given day would be related to affect and the ADHD symptom inattention within children. This means, that if a child spent more time in natural spaces on one day compared to the child's usual time spent in natural spaces, he/she would also experience higher positive affect or lower inattention on that day. Moreover, it was assumed that children who spent more time in natural spaces over the entire study period would show higher positive affect and lower inattention over the entire study period (between-person effect). The between-person effect was significant for affect, but not for inattention, indicating that children who spent more time in natural spaces over the entire study period experienced higher affect, but not lower inattention. The results for the within-person relationships were not significant, and thus the hypotheses could not be confirmed. However, the results indicate that children differ between each other in their respective within-person relationships (e.g., for the relationship with affect, see Figure 13). This means that some children show the expected relationship between time spent in natural spaces and affect or inattention whereas other children do not.

These results lead to the research questions of *Research Focus 3*, in which it was assumed that the within-person relationship between the amount of time spent in natural spaces and affect or inattention is moderated by a child's personal trait of environmental attitude. This means that the stronger a child's environmental attitude, the more he/she benefits from the time spent in natural spaces with regard to affect and inattention. However, correlational analyses revealed that environmental attitude did not moderate the within-person relationship between time spent in natural spaces and affect or inattention. The results of *Research Foci 2* and *3* contradict the assumptions, which are based on the two theories that ascribe a restorative effect

to nature. This restorative effect comprises the enhancement of emotional well-being and cognitive functioning (Kaplan & Kaplan, 1989; Ulrich, 1983). In both theories, the criteria for an environment’s potential to be restorative are more abstract than concrete (Sect. 2.1.1). However, it is possible that the criteria for nature as assessed in the present study were not sufficient for the environment to be restorative for two reasons.

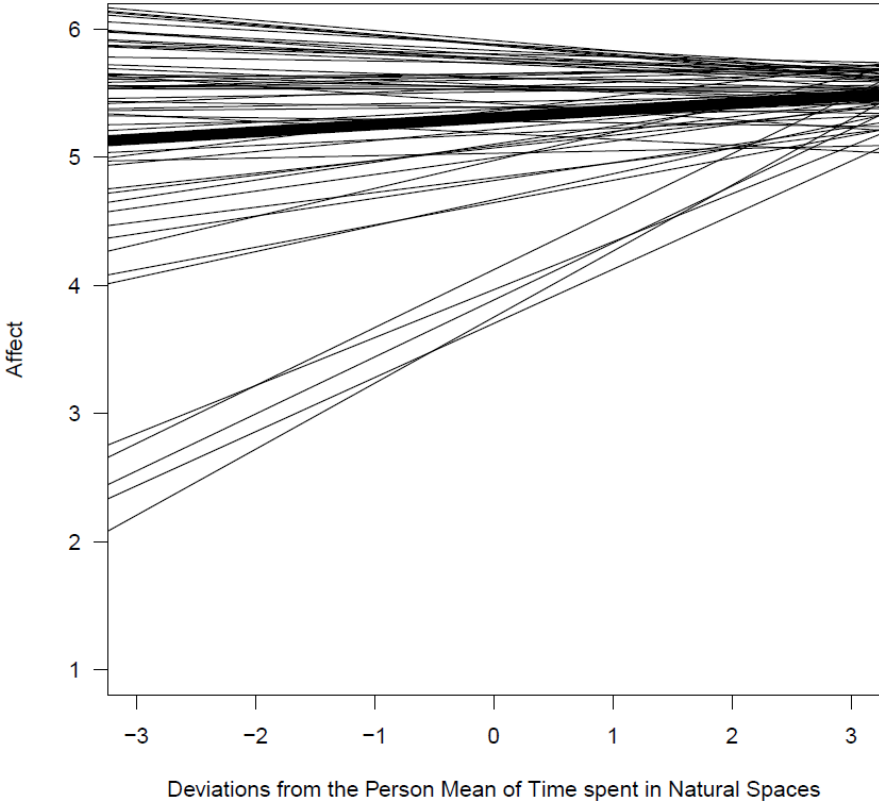


Figure 13. Individual within-person relationships between time spent in natural spaces and valence of affect. Each line represents a single child. The bold line represents the averaged within-person relationship between time spent in natural spaces and valence of affect over all children (Figure taken from *Research Focus 2*).

First, this research considered nature as it occurs in children's daily lives, and therefore used the term *natural spaces*. These natural spaces might not be that restorative for children, since for example the criterion 'being away' (i.e., an individual can escape from his/her everyday life) is not fulfilled, since the research focuses on exactly those spaces that occur in everyday life. However, previous AA research suggests that the amount of time spent in *natural spaces* over a course of a week is related to children's emotional well-being (Ward et al., 2016). Importantly, that study was conducted during *spring*, which leads to the second reason why the natural spaces in the present research were not related to affect or inattention on average on a within-person level. The present study is based on data that was collected during *winter*, a time of year in which it is rather cold outside and there is only little vegetation (Deutscher Wetterdienst, 2019). Since it may be that the greenery of plants is a necessary precondition for the restorative potential, it is possible that not all children benefitted from their time being outside in natural spaces with regard to their experience of affect and inattention. Nevertheless, the results of this study revealed that some children seem to benefit from their time spent in natural spaces (e.g., see Figure 5). These effects could not have been detected from data based on wave reflection of vegetation (NDVI; Sect. 2.2.2).

The present research could not confirm this restorative potential, although some children seem to benefit from spending time in natural spaces. Thus, more research is needed to explore the restorative potential of natural spaces for *children*, by addressing the limitations that are mentioned in the following section.

5.2 Limitations and implications for future research

The main limitations of the research in the present dissertation are fourfold: (a) small within-person fluctuations; (b) challenges in the state assessment of ADHD symptoms, affect, and time spent in natural spaces; (c) drawbacks in the choice of AA design; and (d) no causal interpretation.

In the first place, one limitation is the relatively small magnitude of within-person fluctuations of affect. This indicates that, on average, the children did not change that much in their reports of affect from one occasion to another. Since research using AA designs in children is not yet widespread, only a few comparisons with other studies assessing within-person fluctuations can be made. The fluctuations in affect are rather small when compared to a study on affect fluctuations in children (Leonhardt et al., 2016). However, within-person fluctuations of ADHD symptoms as indicated by the mean intra-individual standard deviation ($MISD = 0.74$,

$SD = 0.41$) were higher in the present research than in the study by Schmid and colleagues (2016; $MISD = 0.6$, $SD = 0.31$). Nevertheless, compared to fluctuations of affect ($MISD = 0.8$, $SD = 0.49$), the fluctuations of ADHD symptoms in the present study are still lower. Thus, future research should carefully consider assessment instruments that can capture possible within-person fluctuations in children, which is further addressed in the following limitation.

The present study also had to meet (b) challenges when assessing the fluctuating states of ADHD, affect, and time spent in nature. *ADHD symptoms* were only assessed via four items: Having difficulties with concentration and forgetfulness (inattention), talking too much (impulsivity), and having too much energy to sit still (hyperactivity). This amount seems to be appropriate against the background of keeping the daily burden for children in an acceptable range. However, although these items are widely used in the assessment for ADHD, it is possible that especially within a community sample, other behaviours or experiences specific to ADHD are also suited to reflecting daily impairments due to ADHD symptoms. Additionally, the items were adopted from a questionnaire that is conceived to differentiate between children with and without ADHD, thus from a categorical perspective (Lidzba et al., 2013). To address this, within the present research the response format for each item was changed from a four-point to a six-point Lickert scale.

Nevertheless, it is recommended that future AA research uses more items to assess a greater variety of symptom behaviours as well as an instrument that depicts ADHD symptoms from a dimensional perspective, such as the Strength and Weaknesses of ADHD-symptoms and Normal-behaviors rating scale (SWAN; Swanson et al., 2001). However, so far, no validated German version that can be used for AA studies is available.

Apart from the assessment of ADHD symptoms, the assessment of *natural spaces* could also be improved in future studies. The children rated their daily amount of time spent in natural spaces via given time intervals. Those time intervals were rather long (i.e., half an hour or an hour). Thus, in future research it would be better to use shorter time intervals (e.g., 15 minutes) in order to detect more variance within children and between children with regard to the daily time spent in natural spaces.

Furthermore, (c) the choice of the current study design also has some drawbacks (Sect. 2.2.5). This study used a time-based AA design with signal-contingent assessment, where the times for sampling were set at fixed times, which means that the children always answered the questions at a predetermined time (for an overview of types of AA designs see Bolger & Laurenceau, 2013). This is advantageous for running a study during children's daily life. For example, we chose time points for sampling such that school lessons were not interrupted. This

was a requirement made by the Ministry of Cultural Affairs, Youth and Sport to allow participant acquisition in schools. However, this type of study design cannot depict all affect or ADHD symptom fluctuations during the day as they naturally occur, since the valence of affect or level of ADHD symptom might also have changed before or after the three daily assessments.

Moreover, although it is already a great advantage to study the daily within-person relationship between time spent in natural spaces and affect or ADHD symptoms, this study design cannot be used to assess the relationship on a momentary basis. Since the experience of natural spaces might have happened earlier in the day but was assessed in the evening, it is not possible to draw conclusions for the momentary within-person relationship of natural spaces and affect or the ADHD symptom inattention. Thus, future research on the within-person relationship between ADHD symptoms, affect, and natural spaces over time could use a combination of an event-based and a time-based design with random sampling. Such a design combination enables the children to rate their affect or inattention whenever they are in contact with natural spaces (event-based) but also provides the researcher with information about the possible time ranges of ADHD-symptom and affect fluctuations (random sampling). However, a combination of both design types could be rather complicated, especially for children, and therefore should be carefully considered in advance.

Lastly, (d) the present results do not allow causal inferences to be drawn. The results are based on hierarchical linear modelling, which implies a correlational data structure (e.g., Singer & Willet, 2003). The investigated within-person relationships between ADHD symptoms and negative affect as well as between time spent in natural spaces and affect or inattention were observational in nature. Causal interpretations of the relationships were informed by the theoretical basis of the high comorbidity of ADHD with other psychiatric disorders that are ascribed with the experience of enhanced negative affect (e.g., major depression; Blackman, Ostrander, & Herman, 2005), as well as the restorative effect of nature (Kaplan & Kaplan, 1989; Ulrich, 1983). However, it could also be that higher states of negative affect lead to higher levels of ADHD symptoms or that higher positive affect and higher levels of inattention lead to spending more time in natural spaces. Research on interventions targeting the exposition to natural spaces or ADHD symptoms (e.g., Guderjahn, Gold, Stadler, & Gawrilow, 2013) could shed light on the directionality of the effects.

5.3 Strengths

The research in the present dissertation has several main strengths. First, one advantage is the assessment of ADHD symptoms, affect and time spent in natural spaces in daily life. Thus, the *ecological validity* is high compared to experimentally manipulated studies (Reis, 2012). This is especially important for the assessment of natural spaces. Investigating natural spaces in a person's real life can provide relevant insights into the recreational possibilities of such areas. This recreational potential becomes particularly evident against the background of increasing urbanization. Since urbanized areas consist mainly of streets and buildings, it is interesting to investigate whether people in such areas have access to natural spaces and, if so, whether these spaces can provide a restorative potential. Thus, this study delivers *ecologically valid* findings by addressing the kind of natural environment as it is *subjectively* perceived by a child in his or her *daily life*.

Second, the assessment of *state affect and ADHD symptoms* over time enables insights into within-person fluctuations as well as co-variation of the respective experiences. Unlike *traits*, states are considered to fluctuate over time. For affect, there is already quite some evidence that takes into account this intra-individual variability (Sect. 2.3.4). However, for ADHD symptoms, so far, only one study has investigated within-person fluctuations (Schmid et al., 2016). Nevertheless, this information is relevant, since it allows one to gain a deeper insight into the highs and lows of each person's state of ADHD symptom level as well as the association with negative affect over time. This can help to provide individually tailored training on the reduction of the state level of ADHD symptoms. Thus, by taking into account that ADHD symptoms and negative affect fluctuate over time, the present research delivers precious information about the fluctuations of the state component of ADHD symptoms in general as well as in relation to negative affect.

The third strength derives from the significant between-person effect for the relationship between ADHD symptoms and negative affect (Sect. 5.1). In comparison to previous research on this between-person relationship (for an overview see *Research Focus 1*), the present findings are based on multiple data points per person in their daily lives. Thus, previous research findings are enriched by the improvement of the *external validity* of the corresponding between-person effect (e.g., Trull & Ebner-Priemer, 2014).

The fourth and very important strength is that the research was conducted with *children*. Research using AA designs in children is still rather rare compared to AA research with adults. Research on within-person fluctuations in children is very important to be able to understand

their individual development, and thus to promote it in the best possible way. Therefore, the research in the present dissertation provides relevant information about the individual experiences of affect and ADHD symptoms in a child's daily life.

5.4 Practical Implications

The research of the present dissertation mainly assumed that ADHD symptoms and negative affect are related within children over time and that time spent in natural spaces is related to restorative experiences of affect and inattention, also within children. Our hypotheses were not confirmed. However, the descriptive statistics showed that ADHD symptoms and the valence of affect vary over time to some extent within children. Moreover, the results indicate that some children seem to benefit from time spent in natural spaces with regard to their affect and inattention. Thus, practitioners are recommended to carefully observe a child's experiences over time to recognize the moments or contexts, such as natural spaces, when ADHD symptoms and negative affect are higher or lower. These observations can then be used to diminish or enhance such moments or contextual settings for each child on an individually tailored basis.

5.5 General conclusion

To summarize, the present dissertation sheds light on children's experiences of ADHD symptoms, affect, and amount of time spent in natural spaces in their daily lives, whereby the focus is on within-person relationships in addition to the investigation of between-person relationships. Investigating within-person relationships in daily life is highly relevant due to the fact that relationships between two constructs within individuals over time do not necessarily have to be the same as between-person relationships (e.g., Hamaker, 2012). Moreover, the high ecological validity of daily-life research, in contrast to research conducted in the laboratory, is a great advantage of the present dissertation. This is especially relevant for the investigation of how natural spaces occur in a child's daily life. Whether those natural spaces can provide restorative experiences of affect and inattention for a child cannot be investigated in the laboratory but only by using AA as a research method.

German Summary

Naturerfahrungen können eine positive Wirkung auf die physische und psychische Gesundheit des Menschen haben. Im Hinblick auf die psychische Gesundheit kann ein Erholungseffekt der Natur zum Beispiel in der Stärkung des positiven Affekts (als einem Aspekt des emotionalen Wohlbefindens) sowie der Verringerung der Unaufmerksamkeit (als einem ADHS-Symptom) bestehen. ADHS-Symptome (Unaufmerksamkeit, Hyperaktivität und Impulsivität) sind dimensional zwischen Kindern verteilt und können innerhalb jedes Kindes schwanken. Während Vergleiche zwischen Personen darauf hindeuten, dass ADHS-Symptome sowohl mit einem höheren negativen Affekt als auch mit verstärkten Affektfluktuationen einhergehen, gibt es nicht viele Forschungsarbeiten, die die Ko-variation von ADHS-Symptomen und Affekt untersuchen, die innerhalb eines Kindes sowie im Kontext des täglichen Lebens auftreten. Die Erfassung von Alltagserfahrungen kann mit Hilfe des methodischen Ansatzes des ambulanten Assessment umgesetzt werden. Dieser Ansatz ermöglicht es einem Forscher, Einblicke in die Schwankungen der Emotionen und Kognitionen eines Kindes, wie Affekt und Unaufmerksamkeit, über einen bestimmten Zeitraum und im Kontext seines täglichen Lebens, z.B. in der Natur, zu gewinnen. Da mehr als die Hälfte der Weltbevölkerung in Städten lebt, ist der Zusammenhang zwischen dem Kontext der Natur im Alltag von Kindern und deren Affekt und Unaufmerksamkeit von großer Relevanz für die Forschung.

Der Fokus der vorliegenden Dissertation liegt auf zwei Kernforschungszielen, welche in drei empirischen Forschungsschwerpunkten untersucht werden. Das erste Forschungsziel besteht aus der Erforschung des Zusammenhangs von Schwankungen des Affekts und der ADHS-Symptome über die Zeit im Alltag von Kindern untersucht (Forschungsschwerpunkt 1). Das zweite Forschungsziel beinhaltet die Erforschung des Erholungseffekts von Erfahrungen in Naturräumen im Alltag von Kindern auf deren Affekt und deren Unaufmerksamkeit als ADHS-Symptom untersucht (Forschungsschwerpunkt 2). Als Erweiterung befasst sich auch der dritte Forschungsschwerpunkt mit diesem zweiten übergeordneten Forschungsziel. In diesem empirischen Forschungsschwerpunkt geht es um die Frage, ob Erholungseffekte von Naturräumen durch die allgemeine Assoziation, welche ein Kind gegenüber der Natur hat, moderiert werden (Forschungsschwerpunkt 3). Dabei wird die Assoziation gegenüber der Natur mit der Umwelteinstellung operationalisiert. Durch die Verwendung eines ambulanten Assessments auf diese übergeordneten Forschungsziele erweitert die vorliegende Dissertation die bisherige Forschung auf zwei Arten. In erster Linie werden, zusätzlich zu den bereits untersuchten inter-individuellen Effekten, Zusammenhänge zwischen ADHS-Symptomen und

Affekt auf der Ebene innerhalb von Personen über relativ kurze Zeiträume untersucht. Zudem werden im vorliegenden Forschungsvorhaben im Gegensatz zur manipulierten Naturerfahrung in experimentellen Forschungsdesigns, Naturräume des Alltags erfasst.

Alle Forschungsschwerpunkte beziehen sich auf dieselbe Stichprobe. Kinder (N = 55) aus der Allgemeinbevölkerung wurden dreimal täglich (morgens, nachmittags und abends) über 18 aufeinanderfolgende Studientage hinweg zu ihren Affekt- und ihren ADHS-Symptomen (Unaufmerksamkeit, Hyperaktivität und Impulsivität) befragt. Darüber hinaus wurde jeden Abend angegeben, wie viel Zeit das Kind an diesem Tag in der Natur verbracht hat. Hintergrundfragebögen, ausgefüllt von Eltern und Kindern, lieferten Informationen über die Beziehung eines Kindes zur Natur.

Forschungsschwerpunkt 1 zielte auf die Erforschung des Zusammenhangs von ADHS-Symptomen und negativem Affekt (z.B. depressiv) innerhalb sowie zwischen Kindern ab. Mit Blick auf den Zusammenhang innerhalb eines Kindes wurde die Hypothese aufgestellt, dass Kinder, wenn sie ein höheres Maß an ADHS-Symptomen erleben, auch einen verstärkten negativen Affekt erfahren. Zusätzlich wurde untersucht, ob Kinder mit erhöhten ADHS-Symptomen höhere Affektfluktuationen aufweisen, was als Indikator für emotionale Impulsivität angesehen werden kann. Die Ergebnisse aus einem Mehrebenenmodell bestätigten frühere Befunde über den positiven Zusammenhang von ADHS-Symptomen und negativem Affekt auf der Ebene zwischen Personen. Auf der Ebene innerhalb einer Person standen negativer Affekt und ADHS-Symptome jedoch in keinem Zusammenhang. Diese Ergebnisse deuten darauf hin, dass Kinder, die im Allgemeinen mehr ADHS-Symptome aufweisen, auch einen verstärkten negativen Affekt zeigen. Zu Zeitpunkten, in denen Kinder über ein höheres Maß an ADHS-Symptomen als gewöhnlich berichteten, berichteten sie jedoch nicht über einen erhöhten negativen Affekt. Darüber hinaus konnte die Hypothese, dass Kinder mit einem höheren trait-Level an ADHS-Symptomen mehr Affektfluktuationen erleben, nicht bestätigt werden. Die Ergebnisse werden mit ihren Implikationen für die zukünftige Forschung über intra-individuelle Fluktuationen und für die praktische Arbeit mit Kindern diskutiert.

Forschungsschwerpunkt 2 befasst sich mit dem Erholungseffekt von Naturräumen auf Affekt und Unaufmerksamkeit als einem ADHS-Symptom, wobei neben dem inter-individuellen Effekt der intra-individuelle Effekt im Mittelpunkt steht. Mehrebenenmodelle ergaben einen statistisch signifikanten inter-individuellen Effekt für den Affekt, nicht aber für die Unaufmerksamkeit, was darauf hindeutet, dass Kinder, die sich im Allgemeinen über den gesamten Studienzeitraum mehr in Naturräumen aufhielten, einen verstärkten positiven Affekt, nicht aber weniger Unaufmerksamkeit berichteten. Die Ergebnisse für die Effekte innerhalb

von Personen waren weder für Affekt noch für Unaufmerksamkeit signifikant. Signifikante Zufallseffekte für beide Ergebnisvariablen deuten jedoch darauf hin, dass sich die Kinder in ihrem jeweiligen intra-individuellen Zusammenhang unterscheiden. Daher kann man schlussfolgern, dass einige Kinder von der Zeit, die sie in Naturräumen verbrachten, hinsichtlich ihres Affekts und ihrer Unaufmerksamkeit zu profitieren schienen, während andere Kinder davon nicht zu profitieren schienen.

Dieses Forschungsergebnis führte zu der Hypothese, dass die angenommene Erholung nach in Naturräumen verbrachter Zeit auf einen Unterschied zwischen den Kindern zurückzuführen ist. Dieser wird in Forschungsschwerpunkt 3 beschrieben und analysiert. Es wurde angenommen, dass die allgemeine Assoziation gegenüber der Natur (operationalisiert durch die Umwelteinstellung) die intra-individuellen Zusammenhänge zwischen der in der Natur verbrachten Zeit und den positiven Auswirkungen auf das affektive Wohlbefinden und die Unaufmerksamkeit der Kinder moderiert. Korrelationsanalysen ergaben keine signifikanten Ergebnisse, was darauf hindeutet, dass Kinder mit einer positiveren Umwelteinstellung nicht mehr vom Aufenthalt in Naturräumen profitieren als Kinder mit einer negativeren Umwelteinstellung. Weitere individuelle Charakteristika, die für die unterschiedlichen Zusammenhänge zwischen der in Naturräumen verbrachten Zeit und sowohl affektivem Wohlbefinden als auch Unaufmerksamkeit verantwortlich sein könnten, werden diskutiert.

Insgesamt zeigt die vorliegende Dissertation, dass sich inter-individuelle Effekte nicht notwendigerweise auf intra-individuelle Effekte übertragen lassen. Dies ist wichtig, insbesondere im Hinblick auf die Geschichte der psychologischen Wissenschaft, in der sich die Wissenschaft oft auf Unterschiede konzentriert hat, die zwischen Menschen auftreten. Obwohl die meisten intra-individuellen Effekte statistisch nicht signifikant waren, bereichert die vorliegende Dissertation darüber hinaus die bisherige Forschung, da sie erste Einblicke in die intra-individuellen Schwankungen von Affekt und ADHS-Symptomen (insbesondere der Unaufmerksamkeit) anhand einer umfassenden ambulanten Assessment-Studie mit Kindern liefert. Diese Ergebnisse können als Grundlage für weitere Studien mit ambulantem Assessment bei Kindern dienen, indem über die Durchführbarkeit, Umsetzung und Sensitivität von Erhebungsmethoden berichtet wird.

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Appendix

A. Declaration on the Contribution of Co-authors

Research Focus 1: Experiencing children's daily life: Do ADHD symptoms and negative affect co-vary within individuals?

Author	Author position	Scientific ideas (%)	Data generation (%)	Analysis and Interpretation (%)	Paper writing (%)
Merle Reuter	first	30	45	75	85
Dr. Jan Kühnhausen	second	5	-	15	5
Dr. Petra Haas	third	5	-	10	5
Prof. Dr. Caterina Gawrilow	fourth	50	-	-	5
Status in publication process	Not published				

Research Focus 2: Within-person relationship between daily time spent in natural spaces and affect as well as inattention in children's daily life.

Author	Author position	Scientific ideas (%)	Data generation (%)	Analysis and Interpretation (%)	Paper writing (%)
Merle Reuter	first	75	45	55	75
Dr. Jan Kühnhausen	second	5	-	40	10
Dr. Petra Haas	third	5	-	5	10
Prof. Dr. Caterina Gawrilow	fourth	10	-	-	5
Status in publication process	Accepted: Reuter, M., Kühnhausen, J., Haas, P., & Gawrilow, C. (in press). Within-person relationship between daily time spent in natural spaces and affect as well as inattention in children's daily life. <i>Umweltpsychologie</i> .				

Research Focus 3: The role of environmental attitude for the association of exposure to natural spaces and mental restoration in children's daily life.

Author	Author position	Scientific ideas (%)	Data generation (%)	Analysis and Interpretation (%)	Paper writing (%)
Merle Reuter	first	60	45	60	65
Markus Kleinhansl	second	20	-	5	25
Dr. Jan Kühnhausen	third	5	-	15	5
Prof. Dr. Caterina Gawrilow	fourth	5	-	-	5
Status in publication process	Not published				

In addition to the named authors, contributions to the present dissertation stem from other scientists.

1. Basic scientific ideas stem from Prof. Dr. Florian Schmiedek (Goethe University Frankfurt) who was the main applicant of the research group application '*Dynamics of Adaptation – Short-Term Within-Person Processes as a Key to Individual Development Throughout the Lifespan*' (FOR 2081), on which the research project of the present dissertation is based.
2. Moreover, basic scientific ideas were contributed by Prof. Dr. Christian Fiebach (Goethe University Frankfurt), who applied together with Prof. Dr. Caterina Gawrilow for the research project '*Adaptive Dynamics of Cognitive and Behavioral Variability in Children with Attention Deficit Hyperactivity Disorder: Long-Term Effects, Neural Bases, and Susceptibility to Intervention*' (GA 1277/9-1), on which the present dissertation is based.
3. Ulrike Schwarz was involved in data generation in the same proportions as the doctoral candidate (i.e., 45%).
4. The process of data collection was supported by the student assistants Danica Algra, Marie Diekman, Anne Eppinger, Stephanie Natter, Caroline Schurz, and Jana Welkerling, as well as the student candidate Saskia Klein.
5. The scientist Dipl. Psych. Laura Henn (Otto von Guericke University Magdeburg) was involved in the process of data analysis of the third research focus with a contribution of 20%.

The conducted research project has been approved by the ethics committee of the German Society for Psychology (DGPs), was supported by the Ministry of Cultural Affairs, Youth and Sports Baden-Württemberg and funded by the German Research Foundation.