Coming to Terms with Risk-Factors for Obesity and Eating Disorders in Childhood and Early Adulthood

A Contribution to the Bio-Psycho-Social Etiology Model of Pathological Eating Behavior

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Erklärung der Selbstständigkeit

Ich erkläre ehrenwörtlich, dass ich meine Dissertation selbstständig und ohne unzulässige fremde Hilfe verfasst habe und sie noch keiner andern Fakultät vorgelegt habe.

Unterseen, 13. Februar 2016

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Wettstein, A., Bryjová, J., Faßnacht, G., & Jakob, M. (2011). Aggression in Umwelten frühadoleszenter Jungen und Mädchen. Vier Einzelfallstudien mit Kamerabrillen. Psychologie in Erziehung und Unterricht(4), 293-305.

Vorträge

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Bryjova, J., Munsch, S., Puder, J., Hoffmann, J. (2013). Die Reaktivität auf einen akuten Stressor und Emotionsregulationsmechanismen bei Kindern im Vorschulalter. 8 Workshopkongress für Klinische Psychologie und Psychotherapie, Trier.

Bryjova, J., Munsch, S., Schwarzkopf, K. (2012), Does GP's stress and momentary workload influence the treatment of Patients with frequent psychological disorders such as insomnia? 7th European Workshop on Clinical Reasoning and Decision Making, Fribourg.

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List of abbreviations

ADHD = Attention-Deficit/Hyperactivity Disorder

AN = Anorexia Nervosa

APA = American Psychiatric Association

BD = Body Dissatisfaction

BED = Binge-Eating Disorder

BMI = Body Mass Index

BN = Bulimia Nervosa

DECB = Disturbed Eating and Compensatory Behavior

DOG = Delay of Gratification

DSM = Diagnostic and Statistical Manual of Mental Disorders

ED(s) = Eating Disorder(s)

LH = Left Hand

LOC = Loss of Control Eating Disorder

PoT = Proportion of Time

RH = Right Hand

SD = Standard Deviation

TSF = Thought-Shape Fusion

VR = Virtual Reality

M = Mean

Abstract

This thesis incorporates three studies addressing different bio-psycho-social correlates of eating pathology. Each of the presented publications is reflecting a new development in the corresponding research field, as it employs novel methodological approaches and provides enhancements to the already existing etiological models. In the *Publication 1*, psychosocial factors such as familial role modeling and social network were investigated on the background of peer selection using an immersive virtual reality environment. School-aged children were confronted with normal weight and overweight avatars that were either eating or playing. As a main result, parental BMI was the strongest predictor for the children's minimal distance to the avatars. In the *Publication 2*, body dissatisfaction (BD), emotion dysregulation, and a specific type of food-related cognitive distortion (Thought-Shape Fusion, TSF) were integrated in a model of disturbed eating and compensatory behavior (DECB). Using cross-sectional data from an online-survey, the model was tested on a subpopulation of healthy young male university students. The results of this study indicated the susceptibility to body-related cognitive distortions (TSF) as a potential mediator in the relationship between BD and disturbed eating in men. In the study presented in the *Publication 3*, impulsivity impairments occurring within clinical symptoms of Attention-Deficit/Hyperactivity Disorder (ADHD) and Binge Eating Disorder (BED) as well as the two nonverbal self-control strategies, attentional deployment and self-touch movement were examined as psychological factors affecting the ability to delay food-related gratification (DOG). The findings suggest that besides attentional deployment, the left-handed self-touch constitutes an effective strategy that might enhance the ability to resist snacking during the DOG.

Introduction

Although a strict definition of eating disorders (EDs) only includes conditions such as anorexia nervosa (AN), bulimia nervosa (BN) and, more recently binge eating disorder (BED); terms such as weight-related disorders, eating disturbances and disordered eating have been commonly used to describe pathological eating behavior (APA, 2013; Nuemark-Sztainer, 2003). These conditions frequently involve disturbed body image coupled with problematic eating and/or weight loss behaviors, causing severe distress and impairment to quality of life (APA, 2013; Jenkins, Hoste, Meyer, & Blissett, 2011). Additionally, several studies have shown that problematic eating and/or weight loss behaviors such as e.g. dieting are also directly linked to obesity (Daee et al., 2002; Field et al., 2003; Patton, Selzer, Coffey, Carlin, & Wolfe, 1999). In the present thesis, the phenomena related to the eating disorder pathology as well as obesity are subsumed and referred to under an umbrella term *pathological eating behavior*.

While the prevalence rates for AN and BN in women are almost three times greater compared to those in men, women are also almost twice as likely to suffer from the BED than men (Hudson, Hiripi, Pope, & Kessler, 2007). A recent literature overview by Mitchison & Hay (2014) identified 149 articles dated from 1975 to 2008 reporting on socio-demographic, environmental and genetic correlates of ED epidemiology. Most importantly, the average proportion of female participants in the reported studies was 79% (Mitchison & Hay, 2014). The higher prevalence rates of EDs in women as well as the fact that most studies strictly focus on investigating etiological factors of EDs on samples of young women from urban areas might contribute to the stereotype of EDs as being a condition peculiar to wealthy, White, well educated women who live in major cities. On the other hand; despite the relatively low prevalence of eating disorders (EDs)

in men amounting up to 0.3% for AN, 0.9% for BN, and 2.0% for BED (Hudson et al., 2007); symptoms of pathological eating behavior on a subclinical level among men are quite frequent (Fiske, Fallon, Blissmer, & Redding, 2014). Thus, although full-blown EDs are rarely manifested, a significant proportion of male adolescents and young adults show symptoms of ED pathology on a subclinical level: based on representative samples, lifetime prevalence of repeated episodes of binge-eating without fulfilling the criteria of an ED in men range from 2.9 to 4% (Hudson et al., 2007; Schnyder et al., 2012). Moreover, further symptoms of pathological eating behavior, such as overeating, loss of control eating (LOC), body checking and extreme exercising in context of weight management are quite frequent among young men, with a prevalence ranging up to 26% (Dominé, Berchtold, Akré, Michaud, & Suris, 2009).

When it comes to the epidemiology of EDs in childhood and early adolescence, prevalence rates obtained for adolescents aged 13-18 years are comparable to those of young adults, with a lifetime prevalence estimates for AN, BN, and BED of 0.3%, 0.9%, and 1.6%, respectively (Swanson, Crow, Le Grange, Swendsen, & Merikangas, 2011). A recent meta-analysis including studies conducted between 2001 to 2004 with 3042 participants of 8 to 15 years of age from cross-sectional studies showed a 12-month prevalence for eating disorders of 0.1% (Merikangas et al., 2010). However, the prevalence of childhood overweight and obesity is much higher; with current estimations of approximately up to 6.7% (de Onis, Blössner, & Borghi, 2010). More importantly, the worldwide prevalence of childhood overweight and obesity increased from 4.7% to 6.7% between 1990 and 2010, and is expected to reach 9.1% by 2020 (de Onis et al., 2010). The ongoing trend can be traced down in almost all countries and is being referred to as a global epidemic of obesity (Wang & Lobstein, 2006). The increasing prevalence rates of obesity among children and youth as well as the strong correlations with body

dissatisfaction (BD), unhealthful dieting and disordered eating behaviors lead to the conclusion, that it is of the upmost significance to consider obesity when discussing weight-related problems in children and young adults.

In summary, eating disorders and especially obesity are rising in prevalence and represent problems of considerable public health significance. Obesity, disturbed eating, and eating disorders are in the present study subsumed under the broader term *pathological eating behavior*. Because of their potentially serious physical and psychosocial consequences (Mokdad et al., 2000; Neumark-Sztainer, Wall, Larson, Eisenberg, & Loth, 2011; Stice, Hayward, Cameron, Killen, & Taylor, 2000), it is crucial to understand risk factors as well as the underlying mechanisms of pathological eating behavior to develop effective prevention strategies.

Previous studies have identified several biological, psychological, and psychosocial factors that are important in the development and maintenance of pathological eating behavior in childhood (Lehrke & Laessle, 2003; Puder & Munsch, 2010) as well as in early adulthood (Jacobi, Hayward, de Zwaan, Kraemer, & Agras, 2004; Mitchison & Hay, 2014). As of the present time, the majority of studies addressing the risk factors for pathological eating behavior have been conducted on women (e.g. Mitchison & Hay, 2014; Stice, Marti, & Durant, 2011). Only a few studies have used mixed gender populations (e.g. Presnell, Bearman, & Stice, 2004) or exclusively male populations (e.g. Lavender & Anderson, 2010). Nevertheless, with the increasing incidence rates of pathological eating behavior in children and young adults as outlined above; it is important that the already existing models are extended and further etiological factors that are specific for these subpopulations are considered.

As a reflection of the contemporary mainstream in Western psychiatry (Ghaemi, 2006), the main goal of the present thesis was to address several correlates of pathological eating behavior that can be classified as predisposing, precipitating, maintaining, and protective factors within a bio-psycho-social etiology model of pathological eating behavior. Given the nature of the data collected and analyzed within the framework of this thesis, the status of each of the putative variables was established as a correlate or noncorrelate, in accordance to the risk factor approach outlined by Kraemer et al. (1997).

The present thesis has following structure: The first part is providing an overview of the most relevant biological and psychosocial variables commonly considered as factors playing an important role in the development and maintenance of pathological eating behavior. In the second part, three studies will be shortly outlined with regard to the corresponding methodical approach, followed by brief result summaries. Finally, in the third part a general discussion is provided with respect to the contribution of the presented studies to the enhancement of the bio-psychosocial model of pathological eating behavior; pointing out the strengths and limitations of the three studies and leading to the conclusions, clinical implications and future outlook in this area of research.

The *Publication 1* targets psychosocial factors that contribute to the development and maintenance of obesity in childhood, such as familial role modeling and social network. The role of child's self-perception and parental BMI with respect to their social approach/avoidance behavior was investigated using an immersive virtual reality environment. The study comprises a novel contribution to the research field with a unique methodological approach including implicit and explicit measures of child's peer selection.

In the *Publication 2*, a model of disturbed eating and weight-related compensatory behavior for men is being proposed. Psychosocial factors including body dissatisfaction (BD), dysfunctional emotion regulation, and food-related cognitive distortions (TSF) were investigated within a cross-sectional online-survey on a subsample of healthy young adult male university students. This study provides an important contribution to the state of the art etiological models of eating pathology, as it is testing the applicability of the common correlates of ED pathology for male populations.

The main goal of *Publication 3* was to investigate the nonverbal self-control strategies on a subpopulation of children with impulsivity impairments and healthy controls. Within the scope of an observational approach, attentional deployment and left-handed self-touch were addressed as protective factors influencing the child's ability to delay gratification in form of previously selected unhealthy but palatable snacks.

State of the Art: Risk Factors for Pathological Eating Behavior

Recent studies have identified more than 30 variables as putative correlates of pathological eating behavior that can be clustered into socioeconomic, environmental and genetic components (Jacobi et al., 2004; Mitchison & Hay, 2014). In the following sections, these variables are presented and integrated into the bio-psycho-social model of pathological eating behavior.

Biological Factors

Sex. One of the most consistent findings in the literature of eating disorders is the predisposition of the female sex for the development of eating disorders. This argument is also supported by the significantly higher prevalence rates for all eating disorders in women compared to men (APA, 2013; Hudson et al., 2007). The female to male ratio

from population-based studies is estimated to be in the range of 2.5:1 for BED (Hudson et al., 2007; Spitzer et al., 1992). Furthermore, female sex is also considered to be an independent predictor for developing obesity at 5 years with a relative risk of 1.4% (O'callaghan, Williams, Andersen, Bor, & Najman, 1997). Thus, female sex can be considered as a fixed marker for pathological eating behavior (Jacobi et al., 2004).

Age. Another consistent finding from both clinic- and population based samples is the peak in incidence of eating disorders during adolescence and early adulthood (Stice, Killen, Hayward, & Taylor, 1998; Wittchen, Nelson, & Lachner, 1998)[1]. When it comes to the incidence rates of obesity, a systematic analysis of 1,769 country-years of data and 19,244 country-year-age-sex data points from 183 countries published between 1980 and 2012 revealed that successive cohorts appear to be gaining weight at all ages, including childhood and adolescence, with more rapid gains between ages 20-40 years (Ng et al., 2014).

Body Mass Index (BMI). There seem to be a robust association between pathological eating behavior and higher BMI, or higher amount of body fat both in childhood and adulthood (e.g. Calam & Waller, 1998; Fairburn et al., 1998; Fairburn, Welch, Doll, Davies, & O'Connor, 1997; Killen et al., 1994; Vollrath, Koch, & Angst, 1992). Interestingly, up to 40% of the participants with an ED reported retrospectively childhood obesity as compared with only 13%-19% of the controls (Killen et al., 1994).

Parental Body Mass Index. Previous research revealed contradicting results regarding the role of parental BMI on development of children's overweight and obesity. Some studies report a strong influence of either mother's (Brion et al., 2010; Kral &

[1] However, the pubertal status itself cannot be considered as a risk factor because everyone goes through the puberty. It is also possible, that the association between ED symptoms and sexual maturation is a function of increasing body mass index (BMI) at puberty.

Rauh, 2010; Zimmermann, Gubeli, Puntener, & Molinari, 2004) or father's BMI (Freeman et al., 2012), comparable effects of father's and mother's BMI (Patel et al., 2011) or a sex specific influence with the mother's BMI being more important for girls and the father's BMI being more important for boys (Perez-Pastor et al., 2009). There is evidence that this same sex link is not genetic, but rather due to complex modeling mechanisms in the social environment (Perez-Pastor et al., 2009), based on findings showing a dominant influence of parents on children's eating behavior (Munsch, Hasenboehler, & Meyer, 2011).

Psychosocial Factors

Peer selection. In the late development, studies have been pointing out the crucial role of peers in spreading of dysfunctional eating behaviors (Christakis & Fowler, 2007; Koehly & Loscalzo, 2009). The social contagion of dysfunctional eating behavior starts at a relatively early age, as demonstrated in a study by Valente and colleagues investigating friendship networks among 617 adolescents aged 12-14 and finding that overweight adolescents are significantly more likely to have overweight friends (Valente, Fujimoto, Chou, & Spruijt-Metz, 2009). In terms of middle childhood up to the young teenage (7-13) years, family and peers are important determinants of behavior. Specifically, a child's social network depends on the social network of their parents, which is again influenced by bio-psycho- and sociological factors (Parke et al., 2002; Ragan, Osgood, & Feinberg, 2013). To sum it up along with Anderson (2009), individuals choose friends based on weight (peer selection); and at the same time they change their own behavior when friends change theirs (endogenous social effect). Thus, the peer selection process plays an important role as a maintaining factor for pathological eating behavior. Moreover, individuals adjust their behavior based on common influence e.g. presented in the media (contextual effects), which will be discussed in context of inducibility and transmission of

food-related cognitive distortions in the following section.

Dysfunctional cognitions. Body-related cognitive distortions are known to contribute to the development and maintenance of pathological eating behavior (Fairburn, Cooper, & Shafran, 2003). Cognitive distortions are characterized by skewed and non-veridical thoughts related to affective experiences and behavior that have been linked to psychological problems and mental disorders (Rachman & Shafran, 1999). Shafran and colleagues (1999) proposed a specific cognitive distortion mechanism regarding thoughts about food, weight and shape; the "Thought-Shape Fusion" (TSF). TSF was developed according to the "Thought-Action Fusion" (TAF) concept in obsessive-compulsive disorder (Shafran, Thordarson, & Rachman, 1996). Transmitted to the ED domain, TSF includes imagining of eating fattening, or "forbidden foods"; and/or of abstaining from compensatory behavior such as exercising or dieting. Not only can these thoughts trigger negative feelings about one's own body (Coelho et al., 2013), they are also directly related to dysfunctional behavior, such as the urge to engage in body checking or to restrict food intake (Shafran et al., 1999). Associations between TSF and the severity of ED symptoms as well as general psychopathology have been found in healthy women (Shafran et al., 1999) and women with EDs (Shafran & Robinson, 2004). When imagining specific fattening/forbidden food, TSF can be experimentally induced in healthy women (Coelho, Roefs, & Jansen, 2010), and is more pronounced in women with EDs (Coelho, Carter, McFarlane, & Polivy, 2008). In an Australian community sample of both sexes TSF significantly predicted ED pathology as well as BD (Dubois, Altieri, & Schembri, 2013). Their findings remain, however, preliminary, as the male sample was relatively small.

Self-perception and attitudes toward others. Negative self-concept has been examined in many cross-sectional studies using different constructs as well as methods of

operationalization; nevertheless these studies consistently relate low self-esteem and more negative self-concept to the symptoms of pathological eating behavior (Jacobi et al., 2004; Paxton, Eisenberg, & Neumark-Sztainer, 2006; Stice & Shaw, 2002). In terms of stigmatization, it has been demonstrated that overweight children have negative attitudes toward overweight people (Lerner & Korn, 1972). This has been demonstrated both via implicit measures; e.g. they placed a figure representing themselves farther away from an overweight child than from normal weight figures (Iwawaki, Lerner, & Chihara, 1977; Lerner, 1973) as well as when asked explicitly, they preferred to play with normal weight children and children with disabilities compared to overweight children (Brylinsky & Moore, 1994). What is more, the consumption of unhealthy food is perceived as negative by normal weight and overweight persons alike (Czyzewska & Graham, 2008).

Low self-esteem (as well as indicators of an impaired psychological well-being such as feelings of shame and depressive feelings) has also been associated with body dissatisfaction (Paxton et al., 2006; Stice & Shaw, 2002).

Body dissatisfaction. Body dissatisfaction (BD) as a negative attitude towards one's own body including thoughts and feelings about the size, shape, muscularity, and body weight has been linked to pathological eating behavior, both in men and women (Fiske et al., 2014; Ricciardelli & McCabe, 2001). BD is conceptualized as the perceived discrepancy between a person's evaluation of his or her own body and the individual concept of an ideal body (Cash, 2004). Thus, satisfaction with one's own body depends on the body weight of the reference group, rather than the absolute weight (Blanchflower, Landeghem, & Oswald, 2009).

The prevalence of BD among men varies widely (8–61%; Fiske et al., 2014). In a longitudinal study, Neumark-Sztainer and colleagues (2011) found that BD among US-

male adolescents predicted dysfunctional weight control strategies such as fasting, inappropriate use of food supplements, binge eating, and further correlates of an unhealthy lifestyle such as smoking and lack of physical activity. Similarly, in a longitudinal study, girls who reported high BD across ages 5 to 7, also reported higher dietary restraint, more maladaptive eating attitudes, and a greater likelihood of dieting at age 9, independent of their weight status (Davison, Markey, & Birch, 2003). Besides unhealthy dieting and other symptoms related to the pathological eating behavior, BD promotes a number of other health risk behaviors in men aiming at increasing muscularity and reducing body fat, such as steroid abuse and supplement intake (Blashill, 2014; Ricciardelli & McCabe, 2001). In contrast to women, whose primary goal is to achieve thinness, men's concerns regarding their body image seem more complex, as an increase in muscularity and/or weight loss/body fat reduction is desired. Accordingly, BD in men may either result in muscularity increasing behavior or in efforts to lose weight (Tylka, 2011).

Based on research in young women, Stice (2001) suggested the "Negative Affect Regulation Pathway", in which the BD is related to the negative affect and pathological eating behavior. Since appearance is an important evaluation component for individuals especially in Western societies, this pathway suggests that BD contributes to negative affect, which in turn increases the risk of developing pathological eating behavior in terms of restricting, dieting, binge eating and compensatory behaviors as an attempt to regulate the negative emotions (Stice, 2001). In this regard, deficits in emotion regulation pose yet another risk factor that needs to be considered within the etiological model of pathological eating behavior.

Emotion dysregulation. The notion of difficulties in emotion regulation leading to the development and maintenance of eating disorders has been discussed on the

background of a large body of research reporting comorbidity of pathological eating behavior with affective disorders, substance disorders, anxiety disorders, as well as some personality disorders (Jacobi et al., 2004). In a study by Gilboa-Schechtman and colleagues (2006), women with eating disorders exhibited lower emotional awareness and more deficient emotional regulation than healthy controls. A different study conducted on a sample of young college students, men who experienced negative mood related to their dissatisfaction with the own body (BD) were more likely to engage in pathological eating behaviors, such as binge eating, purging and excessive exercise, especially when they report not being able to accept or regulate those negative states (Lavender & Anderson, 2010).

Since the process of regulating one's negative affect requires self-control, during such self-control efforts, subsequent attempts at resisting temptations (for example in form of unhealthy but palatable and strongly desired food) are more likely to fail (Muraven & Baumeister, 2000). Thus, dispositional self-control is another important correlate (and possibly a fixed marker) that must be considered in context of pathological eating behavior.

Self-control. Self-control is a capacity that emerges in infancy (Kochanska, Coy, & Murray, 2001; Vaughn, Kopp, & Krakow, 1984) and continues to develop throughout early school years (Posner & Rothbart, 2000). Unlike state self-control, which varies as a function of factors such as mood (Fishbach & Labroo, 2007), working memory load (Hofmann, Gschwender, Friese, & Schmitt, 2007), and motivation (Muraven, 2008), dispositional self-control is relatively stable across situations and over time (Hay & Forrest, 2006) and has been equated with low trait impulsiveness (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012). In childhood, the self-control capacity can be assessed via the delay of gratification (DOG) paradigm. During the DOG, children

who are able to resist an immediately available, but less preferable gratification, achieve a more preferred but delayed outcome (Mischel, Shoda, & Rodriguez, 1989). Thus, delay of gratification occurs whenever a child chooses e.g. studying over a more tempting activity in short-term perspective such as e.g. playing with friends or watching TV. Indeed, a successful delay of gratification in preschool children predicted attentiveness, ability to concentrate and control over negative affect, as reported by parents when the children were adolescents (Mischel, 1983; Shoda, Mischel, & Peake, 1990). The ability to delay gratification in childhood is further associated with long-term outcomes in adulthood such as financial success, and physical and mental well-being (Moffitt et al., 2011). On the other hand, inability to successfully delay gratification in adolescence is associated with poor self-concept, poor academic performance and a greater use of substances such as nicotine, alcohol and marihuana (Wulfert, Block, Santa Ana, Rodriguez, & Colsman, 2002).

In clinical context, poor self-control is related to the Attention-Deficit/Hyperactivity Disorder (ADHD). School-aged children with ADHD are known to prefer smaller immediate rewards over a larger delayed reward compared to healthy controls, an effect that is even more pronounced when choosing the smaller reward reduces the duration of the trial (Marco et al., 2009; Schweitzer & Sulzer-Azaroff, 1995; Sonuga- Barke, Taylor, Sembi, & Smith, 1992). Poor inhibitory control, delay aversion, as well as deficits in executive functions in ADHD are frequently associated with pathological eating behavior, such as BED (Cortese, Dalla Bernardina, & Mouren, 2007; Davis, Levitan, Smith, Tweed, & Curtis, 2006; de Zwaan et al., 2011; Müller, Claes, Wilderjans, & de Zwaan, 2014). Indeed, the co-occurrence of BED symptoms in children and adolescents with ADHD is relatively frequent and amounts up to 61% (Biederman et al., 2007; Erhart et al., 2012; Neumark-Sztainer, Story, Resnick, Garwick, & Blum,

1995). This relationship can be explained by the heightened reward sensitivity and an impaired capability of controlling impulses, which is known to be associated with both BED and ADHD (Dawe & Loxton, 2004; Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006). One of the most prominent symptoms of BED is the experience of loss of control over eating (LOC), i.e. a feeling that one cannot stop eating, or control what or how much is one eating (APA, 2013). Several studies in adults have demonstrated impaired self-control and diminished ability to delay gratification in adults and young adolescents with BED (Davis, Patte, Curtis, & Reid, 2010; Müller, Brandl, et al., 2014; Nederkoorn, Jansen, Mulkens, & Jansen, 2007; Svaldi, Naumann, Trentowska, & Schmitz, 2014; Woznica, 1990), while a significant reduction of BED symptoms was associated with gaining flexible control over eating (Downe, Goldfein, & Devlin, 2009; Goodrick, Poston II, Kimball, Reeves, & Foreyt, 1998; Stice, Presnell, Groesz, & Shaw, 2005; Tangney, Baumeister, & Boone, 2004; Williamson et al., 2008).

To sum up, studies demonstrate diminished self-control including impaired ability to delay gratification in children and adolescents with clinical symptoms of BED and ADHD. Particularly binge eating is associated with experienced difficulties in DOG in form of loss of control over eating (LOC).

Besides impulsivity and psychiatric symptoms, failure in self-control can be related to an insufficient use of self-control strategies such as e.g. attentional deployment (Bourget & White, 1984; Rodriguez, Mischel, & Shoda, 1989) and self-touch (Barroso, Freedman, & Grand, 1980).

Self-control strategies. In school-aged children, effortful self-control has been shown to be fostered by employing attentional deployment (Duckworth, Gendler, & Gross, 2014; Mischel et al., 1989). Attentional deployment is an individually varying

ability to voluntarily sustain focus or shift the attention away from distracting elements (Fox & Calkins, 2003), that emerges early in infancy (Sethi, Mischel, Aber, Shoda, & Rodriguez, 2000) and can assume a more or less active form, ranging from gaze aversion (Fox, 1989) to engagement in alternative activities (Braungart & Stifter, 1991). Attentional deployment in form of distraction prolonged the DOG duration in preschoolers, even if the reward was present, whereas actively attending to reward significantly reduced the DOG time regardless of the nature of distraction (Peake, Hebl, & Mischel, 2002).

Despite some studies pointing out that healthy controls seem to generally adopt more adaptive self-control strategies compared to individuals with ADHD and BED (Schweitzer & Sulzer-Azaroff, 1995; Solanto et al., 2001; Tangney et al., 2004; Young, 2005), other studies show that children with adjustment and impulsivity-related problems can succeed in DOG once they assume the strategy of attentional deployment, and their success is proportional to the time spent distracting themselves from the tempting elements (Bourget & White, 1984; Rodriguez et al., 1989).

While there is some research on attentional deployment and other cognitive self-control strategies in school-age children (Duckworth et al., 2014), the influence of body-oriented self-control strategies is much less evaluated in children and adults. Self-touch, defined as any touching of the own body (Barroso et al., 1980; Kimura, 1973a, 1973b; Trevarthen, 1996) is considered a nonverbal regulatory strategy that contributes to stabilization of the state of emotion and arousal (Freedman & Bucci, 1981; Lausberg, 2013; Trevarthen, 1996).

Tactile self-stimulation in form of self-touch has been observed in several studies with infants whose age ranged from zero to twelve months, especially in situations of

tiredness and mild distress (Moszkowski & Stack, 2007; Toda & Fogel, 1993; Trevarthen, 1996), and thus can be seen as an attempt of the infant to regulate it's affective state. In school-aged children, observational studies show a peak of self-regulatory self-touch while performing cognitive tasks such as vocabulary task (Freedman, 1977), or the Stroop test (Barroso, Freedman, Grand, & Van Meel, 1978). Studies indicate that the self-directed movements in situations requiring self-control are predominantly performed with the left side of the body (Montirosso, Cozzi, Tronick, & Borgatti, 2012; Saucier & Elias, 2001; Trevarthen, 1996). Grounded in the empirical evidence on the spontaneous left-hand preference for self-touch indicating the hemispheric specialization of the right hemisphere in the generation of self-touch (Blonder, Burns, Bowers, Moore, & Heilman, 1995; Kimura & Harshman, 1984) as well as in the regulation of stress responses and emotional engagement (Henry, 1993; Schore, 2005); it has been suggested, that this in turn triggers the left-hand use (Lausberg, 2013; Trevarthen, 1996).

Based on the empirical research presented above, we argue that the left-handed self-touch, like attentional deployment, constitutes a strategy that extends the capacity of self-control in emotionally or cognitively challenging situations. While there is an ample empirical evidence demonstrating the effectiveness of attentional deployment as a self-control strategy in delay of gratification, we are not aware of any studies investigating the left-handed self-touch as a self-control strategy during the DOG experiment. Furthermore, the current body of evidence does not allow any conclusions whether individuals with BED and/or ADHD differ from healthy controls when it comes to the use of attentional deployment and self-touch as two self-control strategies during the DOG.

Integrating the Bio-Psycho-Social Correlates of Pathological Eating Behavior into an Extended Etiology Model

Based on the overview presented above, the bio-psycho-social correlates of pathological eating behavior can also be clustered into predisposing-, precipitating-, maintenance-, and protective factors of pathological eating behavior; as outlined in the Figure 1. In this model, female sex and high impulsivity as a dispositional trait associated with mental disorders such as ADHD and BED represent *personal* predisposing factors for pathological eating behavior. These two factors were examined with regard to their predictive value of premature snacking during a DOG paradigm in a study presented in the *Publication 3*, along with attentional deployment and the left-handed self-touch, which in turn represent protective factors in the model summarized in Figure 1. In this regard, the factors are characterized as *contextual*, because they can be acquired in the course of development and are not considered to be inherent, such as the *personal* factors in the model. Similarly, the parental BMI constitutes a *contextual* predisposing factor for pathological eating behavior, since there is a mounting evidence that the association between the parental BMI and pathological eating behavior of the child is not purely genetic, but rather reflects complex modeling mechanisms in the social environment, as outlined in the literature review in the previous section. The influence of parental BMI on the peer selection processes was investigated in a study presented in *Publication 1*. Child's peer selection, operationalized as approaching/avoiding behavior in VR represents a *contextual* maintaining factor for obesity, based on empirical evidence showing that individuals chose their peers based on their actual weight and at the same time, they adjust their eating behavior according to those of their peers. Based on the literature, low self-esteem can be considered as a further psychological factor contributing to the maintenance of the pathological eating behavior. In *Publication 1*, the

influence of self-esteem on the pathological eating behavior was investigated indirectly, through the association with the child's approaching/avoiding behavior in VR. However, in the *Publication 2*, a related construct, the body dissatisfaction (BD) was included in a theoretical model as a factor precipitating[2] pathological eating behavior. Emotion dysregulation and weight-and shape related cognitive distrotions (Thought-Shape-Fusion; TSF), represent the two psychological variables previously demonstrated as factors contributing to the maintenance of pathological eating disorders (see Figure 1). They were addressed in the *Publication 2* as possible mediators of the relationship between BD and pathological eating behavior.

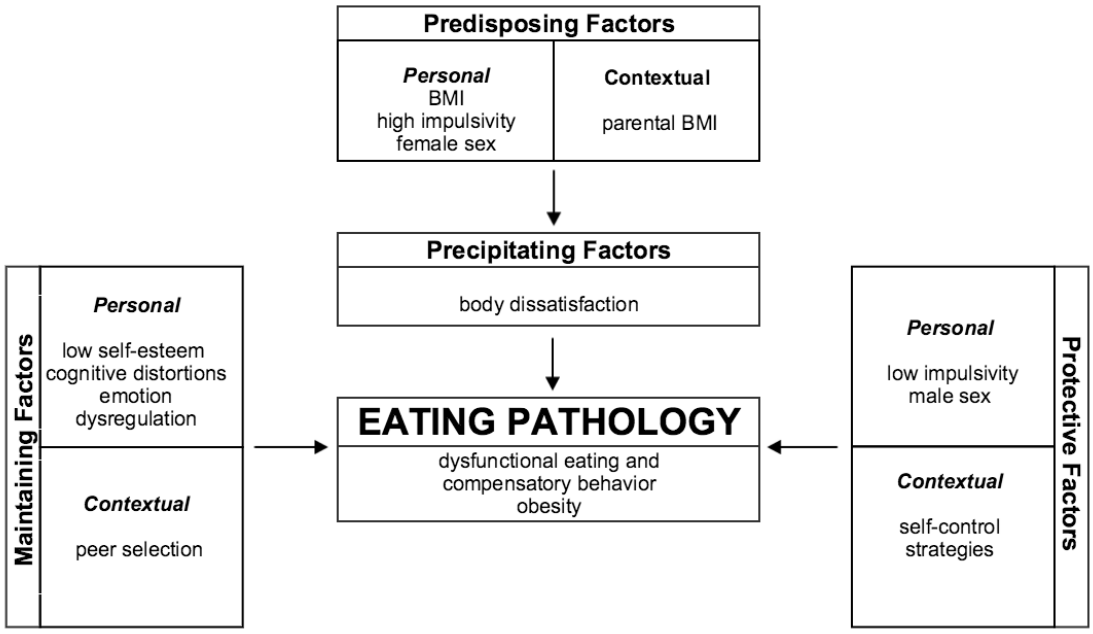

Figure 1: Extended Etiology Model of Pathological Eating Behavior.

Publication 1: The Influence of Parent's Body Mass Index on Peer Selection.

In *Publication 1*, several biological (sex, BMI), psychological (self-perception), and bio-psycho-social variables (parental BMI) of the above outlined etiology model were

[2] A *precipitating factor* is defined here as an element that causes or contributes to the occurrence of a disorder or a problem. Despite the causality assumption made in the theoretical model in the present thesis as well as in the *Publication 2*, the nature of the data used to test the model does not allow any conclusions in this regard. This will be addressed in the Discussion.

addressed in order to examine peer selection processes and familial role modeling in context of development and maintenance of childhood obesity.

Publication 1: Methods and main results. We assessed children's peer selection operationalized as approach/avoidance behavior in an immersive virtual schoolyard setting, applying both explicit and implicit measurements in order to overcome the bias of explicit preference ratings (Wilhelm Hofmann, Gawronski, Gschwendner, Le, & Schmitt, 2005). Accordingly, children's social behavior was assessed implicitly by measuring the interpersonal distance between the child and four avatar groups. In an explicit condition, children were asked to rank each of the four avatar groups as a function of their preference to play with during a school break. The characteristics of the virtual avatar groups were manipulated with regard to their body shape (normal weight vs. overweight) and activity (eating unhealthy food vs. playing). All participants were exposed to the four conditions, the order of which was counterbalanced.

Fifty-seven children aged 7 - 13 years took part in the study. Interpersonal distance to the avatars, child's BMI, self-perception, eating behavior and parental BMI were assessed. The mean BMI of the children was 19.06 (*SD* = 3.97). Social acceptance, physical appearance and global self-worth were assessed via Harter's self-perception scale for children (Asendorpf & Aken, 1993). Parental BMI was assessed through self-report of height and weight. In accordance with the bio-psycho-social model of obesity in childhood (Puder & Munsch, 2010), we entered first the biological information (age, sex and BMI of the child) in the statistical model. Then, we added the psychological information, i.e. self-perception and the three subscales of eating behavior of the child. Finally, BMIs of the child's father and mother were entered in the model. The dependent variables were the distances to the four avatar groups as an implicit measure of behavior. The four models (for each avatar group) explained between 25% and 47% of the variance.

Results showed that after statistically controlling for other variables, the mother's BMI still significantly contributed to the prediction of approach/avoidance behavior, with respect to the distance to the *normal weight eating avatars* (beta = 0.41***). When it comes to the distance to *normal weight playing avatars*, BMI of the child's father (beta = -0.32*), emotional (beta = -0.39*) and external eating behavior (beta = 0.43*) turned out to be significant predictors. Taking into account the distance to the *overweight eating avatars* as dependent variable showed a similar pattern, however none of the predictors yielded significant results (beta $_{\text{BMI of father}}$ = -0.29, p = 0.07). Finally, the distance to the *overweight playing avatars* was predicted by sex (beta = -0.33*) and external eating behavior (beta = 0.38*). BMI of the child's mother was close to statistical significance (beta = 0.30*, p = 0.06).

Due to the important relation between the distance measured in virtual reality (VR) and the BMI of the parents, we conducted a GLM analysis of variance, with two repeated factors and two between factors: weight of the avatars (normal vs. overweight) x activity of the avatars (eating vs. playing) x BMI of father (normal vs. overweight) x BMI of mother (normal vs. overweight). This approach allows considering the four distances to the avatars groups in the same model (two repeated factors). This analysis revealed that children with overweight mothers kept a larger distance to all the avatar groups compared to children with normal weight mothers. In contrast, the distance was smaller for children with overweight fathers compared to children with normal weight fathers. For detailed results, see *Publication 1* in Appendix A.

The explicit assessment of child's preference for the four avatar groups showed highly consistent responses with almost 77% of children explicitly choosing the *normal weight playing* avatar group (preferred group) over other avatar groups. To test whether the explicit choice (one out of the four avatar groups) interacted with the BMI of the

child, the BMI of the mother and the BMI of the father, three tests were computed and yielded non-significant results ($p > 0.203$), thus illustrating that the choice did neither depend on the BMI of the child nor of the mother's and the father's BMI.

Publication 1 is available in Appendix A.

Citation: Martarelli, C. S., Borter, N., Bryjova, J., Mast, F. W., & Munsch, S. (2015). The influence of parent's body mass index on peer selection: An experimental approach using virtual reality. Psychiatry research, 230 (1), 5-12.

Publication 2: A Model of Disturbed Eating Behavior in Men. In order to better understand the mechanisms underlying pathological eating behavior in men; in this study we proposed a comprehensive mediator model of disturbed eating and compensatory behavior (DECB) for men. This study's contribution to the body of research of pathological eating behavior is twofold: For the first time, the susceptibility to a specific body-related cognitive distortion (Thought-Shape-Fusion; TSF) has been taken into an account as a mediator explaining the relationship between body dissatisfaction (BD) and pathological eating behavior. Additionally, the model was designed for- and tested on an exclusively male sample.

Publication 2: Methods and main results. We obtained data from 123 men who participated in an online-survey carried out at the Department of Clinical Psychology at the University of Fribourg. The majority of the sample (68.3%) constituted young university students, with a mean age of 23.7 years (*SD*=3.2) and the mean BMI of 23.3 (*SD*=3.1). We assessed participant's BMI based on the self-reported body weight and height as assessed in the German version of the EDE-Q (Hilbert, Tuschen-Caffier, Karwautz, Niederhofer, & Munsch, 2007); depressive symptoms with the German version of the Beck's Depression Inventory (BDI-II, Beck, Steer, & Hautzinger, 1994); body

dissatisfaction (BD) with the German version of Body Shape Questionnaire (Fragebogen zum Figurbewusstsein, FFB; Pook, Tuschen-Caffier, & Stich, 2002); emotion dysregulation with the German version of The Difficulties with Emotion Regulation Scale (DERS; Ehring, Fischer, Schnülle, Bösterling, & Tuschen-Caffier, 2008); and cognitive distortions (TSF) via The Short Trait Thought Shape Fusion

Scale (Coelho et al., 2013). Finally, we created a new outcome variable named Disturbed Eating and Compensatory Behavior (DECB) assessing symptoms of pathological eating behavior such as restrained eating, binge-eating, self-induced vomiting, taking laxatives, and excessive exercising, while omitting items regarding shape and weight-concern. The new outcome variable was created in order to avoid a conceptual overlap between the variable BD and the scales weight- and shape concern from the Eating Disorder Examination Questionnaire (EDE-Q; Fairburn & Beglin, 1994). While only 2.4% of men in our study reported clinically relevant symptoms of EDs, a larger proportion of men (14.6%) reported symptoms of pathological eating behavior on a subclinical level.

To test the suggested mediator model DECB in men, we conducted a multiple mediation analysis with two mediators operating in parallel and being allowed to correlate with each other, similarly to the proposed Model 4 in Hayes' PROCESS Model (Hayes, 2012). In this model, the variable body dissatisfaction (BD) was the independent variable, dysfunctional eating and compensatory behavior (DECB) the dependent variable, and the variables cognitive distortions and emotion dysregulation the two mediators. Participants' age, BMI as well as depressive symptoms were included as covariates since they were previously shown to be associated with disturbed eating. For detailed information about the statistical procedure as well as further descriptive statistics of the assessed variables, see *Publication 2* in Appendix B.

In the following, a brief summary of the most significant results will be reported: Altogether, the mediator model explained 43% of the total variance in DECB. We found a significant effect of BD on DECB (b = 0.37, p <.001). Furthermore, BD was significantly associated with increased body-related cognitive distortions (TSF) (b = 1.49, p <.001), as well as with increased emotion dysregulation (b = 1.42, p <.001). Increased level of TSF was also significantly associated with increased DECB (b = 0.09, p <.001). However, the analysis did not reveal any significant association between emotion dysregulation and DECB (b =–0.03, p = 0.09). The direct effect of BD on DECB, controlling for TSF and emotion dysregulation, was smaller compared to the total effect, but remained significant (b = 0.29, p =.001). Therefore, we conclude that TSF partially mediated the relationship between BD and DECB.

Publication 2 is available in Appendix B.

Citation: Wyssen, A., Bryjova, J., Meyer, A. H. & Munsch, S. (submitted). A Model of Disturbed Eating Behavior in Men: The Role of Body Dissatisfaction, Emotion Dysregulation and Cognitive Distortions.

Publication 3: Self-Control Strategies during the Delay of Gratification.

In this study, attentional deployment and left-handed (LH) self-touch were examined as nonverbal strategies affecting the ability to delay gratification in form of chosen unhealthy, but palatable snacks in a population of children with impulsivity impairments and healthy controls. With regard to the etiology model of pathological eating behavior (see Figure 1), high impulsivity manifested within the Attention-Deficit/Hyperactivity Disorder (ADHD) and the Binge Eating Disorder (BED) has been associated with pathological eating behavior and can therefore be seen as a predisposing factor. Furthermore, we argue that acquired self-control strategies in context of food-related

delay of gratification (DOG) can operate as protective factors within the etiology model of pathological eating behavior. While attentional deployment has been previously demonstrated as an effective self-control strategy even among children with impulsivity impairments, the effect of the LH self-touch on the effort to resist snacking during the DOG was tested for the first time.

Publication 3: Methods and main results. The study was embedded in the Swiss University Study of Nutrition (SUN, Munsch & Hilbert, 2010), approved by the Ethics Committee of the Canton Fribourg, Switzerland, as well as the Department of Psychology of the University of Fribourg, Switzerland. Altogether, data from 69 children aged 8-13 years (57% female, 97% Caucasian) were analyzed; with a mean age of 11.04 (*SD*=1.31), and a mean BMI of 20.23 (*SD*=3.97). Children in the clinical group (N=47) fulfilled clinical diagnostic criteria of either BED, and/or ADHD. The healthy control group (N=22) was matched according to sex, age, and BMI. For details regarding the sampling process and clinical screening, please see *Publication 3* in Appendix C. The delay of gratification (DOG) task was embedded within the experimental session of the SUN study. During the DOG, the experimenter put a small sample of a snack that had been previously rated by the child as most desirable on a table in front of the child and indicated that she is going to get the rest of the packages from the other room, however, she must make an urgent phone call first. She said to the child: "You can either wait for me to return or start eating right away. However, if you begin to eat before I come back, you will only receive the rest of the sample snack that had already been opened; and not the whole package." After the instruction, the experimenter left the room for fifteen minutes. The entire waiting period was video recorded and child's behavior was coded subsequently with the NEUROGES-ELAN coding system (Lausberg & Sloetjes, 2009). The NEUROGES coding system is a tool for empirical research on movement behavior,

based on a kinetic and functional analysis of arm movements (Lausberg, 2013; Lausberg & Sloetjes, 2009). The NEUROGES-ELAN coding system has been validated in several studies, demonstrating good psychometric properties, with reported Cohen's Kappa values for the inter-rater reliability for the *on body* movement ranging from .79 to 1.0 (Lausberg, 2013b). Five annotators previously trained in the NEUROGES-ELAN coding system, supervised by the author of this thesis annotated each child's gazing- and hand movement behavior. For inter-rater reliability, the annotators composed ten rater-dyads, with each dyad coding 15% percent of the video footage independently. The method of establishing the raw agreement and the Cohen's Kappa values is described elsewhere (Holle & Rein, 2014). In the following, the dependent and independent variables will be briefly outlined. For a detailed variable description as well as the corresponding psychometric properties, please see the *Publication 3* in Appendix C.

Attentional deployment was determined by child's active aversion of his/her gaze away from the table on which the desired snack was placed (Metcalfe & Mischel, 1999). The variable attentional deployment reflects the period of time during which the participants turned their head or the whole body at least 45 degrees in any direction away from the table, or were covering their eyes with hands. The variable self-touch was coded as the *on body* movement focus category in the NEUROGES coding system (Lausberg, 2013). The *on body* movement can have a phasic, irregular or repetitive structure. In the present study, the mean raw inter-rater agreement across five rater dyads for the *on body* category was .90 (*SD*=.08) and the Cohen's Kappa was .57 (*SD*=.28). As for the further assessed variables, the BMI of the child was computed as child's weight in kg divided by height in m^2; and the trait impulsivity was assessed in the present study with the UPPS impulsive behavior scale (Lynam, Smith, Whiteside, & Cyders, 2006). In order to control for the extent of child's hunger, satiety and craving for the selected snack at the beginning

of the DOG experiment, we created a short self-report scale. As for the dependent variable, a successful delay of gratification occurred, when the child did not eat during the absence of the experimenter at the DOG. The delay was coded as unsuccessful, when the child was eating, licking or nibbling on the snack that was present on the tray in front of him/her. The variable *duration of delay* was established as time that passed from the start of DOG, after experimenter's leave until the onset of eating in case the child ate; or until the return of the experimenter, in case the child did not eat. In order to determine comparable values for the durations of self-touch and attentional deployment for children that either did/or did not eat, the parameter proportion of time (PoT) was established, as seconds of the value per video minute (Lausberg, 2013).

We tested the Cox proportional hazard (PH) model for time-to-event-data in order to assess the absolute risk of snacking for of the left-handed (LH) self-touch and the attentional deployment. The event was defined as eating or snacking during the DOG; and the survival time was defined as milliseconds until onset of snacking or the end of experiment (*duration of delay*). Both linear and curvilinear fits of the LH self-touch were examined using orthogonal polynomial transforms, in order to assess the independent effects of these two types of trends. Child's age, sex, BMI, impulsivity, craving and the right-handed (RH) self-touch were added to the model as covariates (sequentially, first to last). For the purpose of testing the Cox PH model, we created a dummy variable named *clinical content* that indicated the presence of clinical symptoms of the child such as BED, and/or ADHD. All other variables were z-standardized. To avoid effects of over-fitting, the predicted risks were calculated using the LASSO penalized regression technique, with the lambda for quadratic penalty parameter referring to Ridge regression set to zero (Simon, Friedman, Hastie, & Tibshirani, 2011).

Results from the Cox PH analysis indicated that the LH self-touch significantly predicted the risk of snacking with a negative linear trend (β=-8.27, p<.01), suggesting that the risk of snacking during the DOG significantly decreased with increased PoT of the LH self-touch. As indicated by the survival curve depicted in the Figure 2; the probability of snacking in children with high levels of the LH self-touch (>75th percentile, corresponding to the PoT of 31% and higher) was significantly lower compared to children with low levels of the LH self-touch (<25th percentile, corresponding to the PoT of 8% and less; $\chi^2(10,69)=41.62$; p<.001). Similarly, the risk of snacking decreased significantly with increased attentional deployment (β=-0.66, p<.05). Additionally, the female sex significantly increased the risk of snacking during the DOG (hazard ratio=1.92, p<.05). The overall model had a good fit (Wald test (10) = 28.48; p<.001) and explained approximately 45% of the variance. Following variables were selected according to the LASSO penalization as a solution for the Cox PH model with nonzero parameter values and corresponding estimates: LH Self-Touch (quadratic term; 0.431), LH Self-Touch (linear term; -0.425), and Attentional Deployment (-0.003).

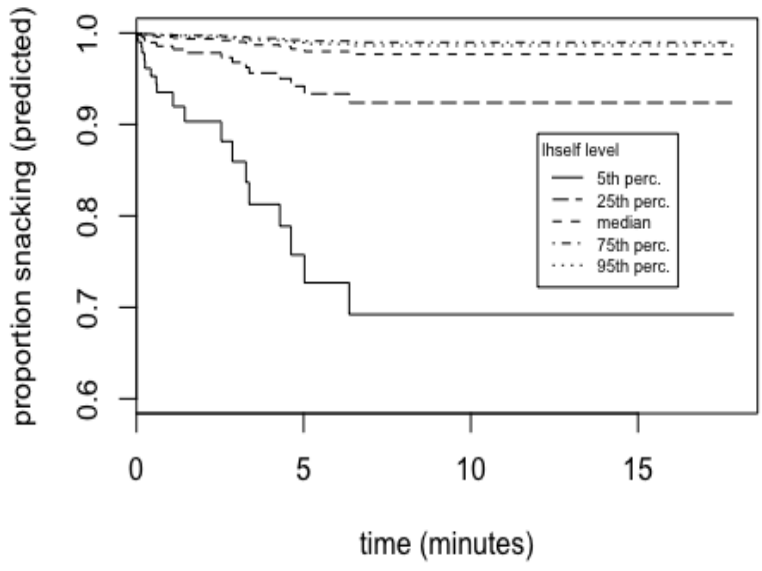

Figure 2 Survival Curve of the Cumulative Probability of Snacking during the Delay of Gratification Experiment according to the Level of the Left-Handed Self-Touch, Adjusted

for Child's Diagnosis, Sex, Age, BMI, Impulsivity, Craving, Attentional Deployment, and Right-Handed Self-Touch. Higher Levels of the Left-Handed Self-Touch are associated with Greater Probability of a Successful Delay.

Publication 3 is available in Appendix C.

Citation: Bryjova, J., Gross, J.J., Meyer, A.H., Kurz, S., Dremmel, D., Hilbert, A. & Munsch, S. (in preparation). Self-Control Strategies during the Delay of Gratification.

Summary: The Bio-Psycho-Social Correlates of Pathological Eating Behavior Integrated into the Extended Etiology Model

In the three publications presented within this thesis, some of the already established and some recently emergent bio-psychosocial factors were examined as correlates of pathological eating behavior on subsamples of children and young adult men.

When it comes to the *predisposing* factors, the female sex in the *Publication 3* significantly increased the hazard of snacking during the DOG. This finding is consistent with the conclusion that the female sex is a fixed marker for eating behavior pathology (Jacobi et al., 2004). On the other hand, high impulsivity as another predisposing factor for eating behavior pathology did not significantly increase the probability of snacking in the *Publication 3*. In *Publication 1*, the mother's and father's BMI predicted in a very differentiated manner child's preference for peers that were snacking unhealthy but palatable snacks. In line with the model of obesity spreading within a social network (Christakis & Fowler, 2007), we assume that the effect of parental BMI on the child's peer selection represents an important *contextual* predisposing factor in the etiology model of pathological eating behavior.

Regarding the *precipitating* factors in the etiology model of pathological eating behavior, body dissatisfaction was significantly associated with dysfunctional eating and compensatory behavior in *Publication 2*, even though the nature of the cross-sectional data does not allow any implication about the causality of these two variables (which will be further discussed in the following sections).

Several factors reviewed in the literature as possible *maintaining* factors of pathological eating behavior were addressed in the two studies presented in this thesis: In *Publication 1*, low self-esteem was significantly associated with an increased distance to the normal weight eating avatars. In *Publication 2*, the susceptibility to a specific food-related cognitive distortion, the Thought-Shape-Fusion (TSF) turned out to be an important factor mediating the relationship between the body dissatisfaction and disturbed eating and compensatory behavior in men. The results in *Publication 2* did not yield any significant association between emotion dysregulation and pathological eating behavior in men. Possible reasons for this result will be discussed in the following section.

As for the potential *protective* factors, the results presented in *Publication 3* identified the employment of the left-handed self-touch and attentional deployment as two self-control strategies associated with a higher probability of successful delay of gratification in form of a desired palatable snack in children with impulsivity impairments

Discussion

The Relevance of the Biological and Psychosocial Risk Factors Associated with Pathological Eating Behavior

In the following, the results of the three studies will be addressed separately with regard to their contribution to the already existing body of research of pathological eating behavior.

In the *Publication 1*, we examined peer selection processes on the background of familial role modeling and social network; using an immersive virtual reality (VR) environment. Based on the evidence that psychosocial factors play an important role in the spread of obesity in both adults and children (Christakis & Fowler, 2007; Valente et al., 2009) we investigated the process of child's peer selection as an important factor in developing social networks in 7- to 13-year-old children. Peer groups relate to activities such as eating behavior and nutrition intake and hence are linked to the development or maintenance of a healthy or unhealthy body weight (Anderson, 2009). The findings revealed that children with overweight mothers kept a larger distance to all the avatar groups compared to children with normal weight mothers. In contrast, the distance was smaller for children with overweight fathers compared to children with normal weight fathers. This finding is consistent with findings by Sikorski et al. (Sikorski et al., 2011) showing that overweight and obesity are less stigmatized in men. Therefore, fathers with a higher BMI may not be seen as overweight, but rather as muscular and physically strong. On the other hand, overweight is especially stigmatized in females (Hilbert, Ried, Zipfel, & de Zwaan, 2013). The avoiding behavior of children with overweight mothers could reflect the peer selection habits of their own mothers, possibly conveyed through mechanisms of stigmatization at the early age leading to the experience of exclusion of

peer groups (Grube et al., 2013). It is possible that children interpret the overweight of their father as a symbol of physical strength (Parke et al., 2002), hence as something that is rather positive and desirable. Another conceivable interpretation is that children with overweight fathers might perceive the social stigma of overweight more strongly than children with normal weight fathers. As a result of a coping strategy children with overweight fathers may have tried to approach normal weight rather than overweight avatars. When approaching normal weight eating avatars, we found an important impact of maternal BMI: the higher the mother's BMI the longer the distance to these avatars. With respect to the normal weight playing avatars higher BMI of the father significantly reduced distance. The BMI of the mother might relate to her specific social interaction experiences and style and thus to her approach/avoidance behavior in social situations. This could be transmitted via daily repeated modeling to the child (Munsch et al., 2011). Mothers with higher BMI who avoid social groups with lower BMI and are ashamed to eat in public, do not act as role models to engage in proactive social behavior on how to join (especially normal weight) peers. This might in turn inhibit engagement in playful activities during repetitive daily activities and contribute to the maintenance of disturbed eating behavior such as avoiding to eat in public (De Brún, McCarthy, McKenzie, & McGloin, 2013). With respect to overweight avatars, a higher BMI of the father was marginally linked to a smaller distance of the child to the overweight eating avatars. The distance to the overweight playing group was larger in children with higher maternal BMI. Again the results indicate, that in general, a higher BMI of the father does not seem to inhibit the approach behavior of the child to the avatar peers, whereas the opposite is true for the mother's BMI. A higher BMI of the mother seems to inhibit approach behavior toward playing avatars, which might in turn impede health-promoting activities (Ball et al., 2012). This could either be due to a lack of maternal model of such approach

behavior, to maternal sedentary behavior, or negative body image and low self-esteem. Although a comparable influence of mothers' and fathers' BMI on children's BMI has been reported in large survey studies (Lane, Bluestone, & Burke, 2013), the experimental approach in VR revealed specific approach measures indicative of maternal and paternal role modeling of social behavior. Furthermore, our findings might point to gender related differences in beauty ideal that are already established at this age. While thinness is important for women, a higher BMI in men might also be associated with physical strength and muscularity (e.g., Patel et al., 2011).

As expected, when asked explicitly, all children regardless of their own and their parents' BMI showed a clear preference for normal weight avatars engaged in a playful activity. No interaction between the child's BMI, maternal and paternal BMI was found in the explicit condition. These findings indicate the influence of various mechanisms of social desirability, such as impression management (Salvy, Jarrin, Paluch, Irfan, & Pliner, 2007) on the child's explicit behavior. In order to convey a good impression, all children chose a peer group of lower body weight that plays, thus avoiding the attribution to a group with several negative characteristics that are already highly stigmatized in young children.

In the study presented in *Publication 2*, a model of disturbed eating and compensatory behavior (DECB) was proposed and tested on a convenient sample of healthy young university students living in Switzerland. In accordance with the proposed theoretical model, we found a significant positive association between BD and DECB, which is consistent with previous findings describing BD as a risk factor for disturbed eating and unhealthy weight and shape regulation strategies in women and men (e.g., Neumark-Sztainer, Paxton, Hannan, Haines, & Story, 2006). Consistently with our hypothesis, we demonstrated for the first time the mediating effect of TSF on the

association between BD and DECB on a sample of young men. This emphasizes the importance of TSF in relation to pathological eating behavior in men. It has been demonstrated in studies with female populations that the experience of such body-related cognitive distortions can be induced by the exposure to food items or thin ideals (Coelho et al., 2008). Since exposure to fattening foods and body ideals occur repeatedly on a daily basis, future studies should address the role of cognitive processes such as TSF as maintenance factors of pathological eating behavior and especially focus on behavioral consequences such as the urge to diet or frequent body checking (e.g., Coelho et al., 2008).

Our analysis did not reveal any significant association between the correlates of an overall disturbed emotion regulation capacity and ED symptoms. These findings are in contrast to previous theories such as the escape-theory (e.g., Stice, 2001), where disinhibited eating in women is seen as an attempt to regulate negative affective states and thus represents a dysfunctional emotion regulation strategy. Previous literature showed that according to the DERS, women suffering from EDs more often report higher emotion intensity and lower acceptance of emotions, less emotional awareness and clarity and use less often functional but more often dysfunctional strategies than healthy controls (Heatherton & Baumeister, 1991). Also in men, Lavender and Anderson (2010) found that disordered eating and BD were both predicted by BMI, negative affect and the DERS global score. In our sample we could not confirm these findings, even though scorings of our sample were comparable to those of the slightly younger sample of male college students in the above-mentioned study.

To conclude, our model confirmed the role of TSF as a potential mediator in the relationship between BD and disturbed eating, but did not identify emotion dysregulation as a corresponding mediator. Overall, the model explained 43% of the variance in

disturbed eating and compensatory behavior of men. Even though the present findings have to be reassessed in larger samples and based on a longitudinal design, in the present sample of young and healthy male participants TSF seems to represent a cognitive vulnerability that needs to be taken into account when describing underlying mechanisms associated with BD and disordered eating behavior.

The main goal of the study presented in *Publication 3* was to investigate the ability to delay gratification in children with self-control impairments and the effectiveness of attentional deployment and the left-handed self-touch as self-control strategies.

We found that both attentional deployment and the left-handed self-touch significantly predicted the success in the DOG; even when accounting for child's clinical diagnosis and other factors that might influence the ability to delay, such as age, sex, BMI, impulsivity and craving for the selected snack. In line with results from other studies (Carper, Orlet Fisher, & Birch, 2000), we conclude that attentional deployment in form of diverting one's gaze away from the tempting snack demonstrates an effective strategy facilitating self-control in school-age children, as suggested in the process model of self-control (Mischel, Shoda, & Peake, 1988; Rodriguez et al., 1989). Besides the attentional deployment, our results demonstrate for the first time that the left-handed self-touch is an equally effective strategy to facilitate self-control during DOG. Among other variables that are assumed to have an effect on the ability to delay gratification and were included in the Cox PH model as covariates; only the female sex significantly increased the risk of an unsuccessful delay in the present study; somewhat inconsistently with results from a meta-analysis reported elsewhere (Silverman, 2003). In a post-hoc analysis, we did not find any significant differences between the two sexes with respect to the use of the self-control strategies. A possible reason for this finding could be that gratification

in the present study constituted a palatable snack. Since females perceive sweet snacks as more pleasurable; and at the same time they exhibit significantly more restraint towards snacking, when compared to men (Grogan, Bell, & Conner, 1997); we argue that the increased restrain towards a highly desirable snack might have resulted in a break-down of self-control in girls during the DOG (Muraven & Baumeister, 2000). Thus, despite the female gender being known as the one with more self-discipline (Duckworth & Seligman, 2006), it seems that girls experience increased difficulties especially when it comes to exhibiting self-control in context of calorie-intake.

Although we found that children in the clinical group had significantly higher impulsivity scores, we did not find any significant differences between the clinical group and the healthy group with regard to the mean *duration of delay* or their success in delay during the DOG. Similarly, the survival analysis indicated that child's clinical diagnosis of BED and/or ADHD did not significantly predict the success during the DOG, after accounting for child's age, sex, BMI, impulsivity, and the self-control strategies. A possible reason for the insignificant finding might be the fact that the clinical group consisted of children with two distinct clusters of psychiatric symptoms (BED and/or ADHD). In a post-hoc analysis, we found that the symptoms of ADHD, but not of BED were associated with a decreased probability of success during the DOG, which is comparable to previous findings on decreased ability to delay gratification in ADHD (Marco et al., 2009; Schweitzer & Sulzer-Azaroff, 1995; Sonuga-Barke, 2002). On the other hand, the BED symptoms were not associated with an impaired ability to delay of food-related gratification during the DOG. This could be because children with BED are "trained" at self-control in the presence of adults, as they often experience food-related restrictions in their home environments but cannot resist when being alone in daily life situations (Carper, 2000). A further possible reason for the comparable performance of

the clinical group compared to the healthy control group during the DOG could be that children in the clinical group compensated their high impulsivity with adopting effective self-control strategies, such as attentional deployment and left-handed self-touch.

Strengths, Limitations and Future Directions

In the following, the strengths, limitations and future directions of each publication will be outlined separately; but first, two general limitations concerning all of the presented publications will be addressed.

First, unlike the *Publication 3*, the *Publication 2*, as well as the *Publication 1* uses self-reported measures of the body mass index (BMI) of adult subjects. The validity of such measures is questionable, since participants tend to overestimate measured BMI values at the low end of the BMI scale (< 22) and underestimate BMI values at the high end, particularly at values > 28 (Stommel & Schoenborn, 2009). Although several studies have showed erroneous reporting on weight and height, recent research suggests that height rather than weight is incorrectly indicated (Keith, Fontaine, Pajewski, Mehta, & Allison, 2011; White, Masheb, & Grilo, 2010). Therefore, future studies should incorporate the assessment of height and weight in the study designs. Furthermore, larger and more balanced BMI samples are desirable.

Second, in the scientific literature, the terms used for potential risk factors are described as *vulnerability factors, predisposing factors*, *preceding factors,* or *etiology factors*. Thus, some authors argue that only if a variable can be demonstrated to precede the outcome (i.e. in this case, symptoms of pathological eating behavior), is the term *risk factor* justified (Jacobi et al., 2004). In this thesis, several bio-psycho-social correlates have been integrated into an etiology model of pathological eating behavior (see Figure 1). However, none of the presented publications is characterized by a study design

allowing any conclusion regarding the causality of these factors. Therefore, we suggest that these factors should be addressed in future studies by appropriate identification methods of risk factors including longitudinal studies or randomized clinical trials with preventive or therapeutic intervention studies (Jacobi et al., 2004).

Regarding the strenghts of the *Publication 1* presented in this thesis; the foremost quality of the study lies within the novelty of the VR approach in order to shed light on children's social interaction behavior, which might influence their eating behavior and energy intake. Furthermore, the findings from this study underline the advantage of a combined assessment of both implicit and explicit correlates of approach/avoidance behavior. While explicit measures can present a rich source of data, reflecting self-evaluation in the context of social norms, VR can offer a more accurate measure of social behavior. In contrast to the explicit measurement of preferences, the implicit assessment of distance regulation is less influenced by social desirability and might be more valid and reliable when it comes to approximate daily behavior of the children. Thirdly, our findings highlight the importance of parental BMI and might stimulate future research, detailing out the link between the parents' BMI and their role model behavior.

As for the limitations of the *Publication 1*, further research will need to be carried out in order to include a more systematic assessment of children's and parental psychosocial variables such as parents' self-esteem and social anxiety. This argument is further elaborated in the discussion section of *Publication 1* in Appendix A. In order to consider the child's peer selection behavior operationalized as approach/avoidance behavior in VR as a maintaining factor for pathological eating behavior e.g. in adolescence or early adulthood, future studies should implement a follow-up assessment of pathological eating behavior (e.g., via the EDE-Q; Fairburn & Beglin, 1994).

There are several strengths of the *Publication 2* to be highlighted. First of all, we proposed a theoretical model of pathological eating behavior that included a novel psychological construct of weight- and shape-related cognitive distortions, the Thought-Shape-Fusion (TSF). Secondly, since most of the already existing theoretical models of patholical eating behavior have been generated based on the data from female populations (e.g., Stice, 2001), our model was designed specifically for- and tested on a population sample of young men. The evidence that a relatively large proportion of the tested population (14.6%) displayed symptoms of pathological eating behavior on a subclinical level highlights the importance of investigating correlates of pathological eating behavior in male populations. Most importantly, our findings suggest that besides body dissatisfaction, the TSF is an important psychological factor that needs to be considered in the context of development and maintenance of pathological eating behavior in young men.

Nevertheless, several limitations need to be addressed in the *Publication 2*. First of all, the cross-sectional design of the study does not allow drawing any conclusions about the causality of the relationship among the involved variables. Accordingly, future studies should investigate the proposed model in a longitudinal setting to examine whether BD subsequently affects susceptibility to TSF and whether TSF in turn affects disturbed eating behavior. Secondly, the sexual orientation of men in our sample was not assessed. Evidence shows that homosexual compared to heterosexual male adolescents and young adults tend to be more dissatisfied with their appearance (e.g., Jankowski, Diedrichs, & Halliwell, 2014). In a subsequent study, it should therefore be investigated, whether the coefficients in our model differ depending on men's sexual orientation.

Sociocultural factors, such as exposure to mass media presenting unrealistic male body ideals and the associated degree of internalization of the ideal as well as the

perceived pressure to conform to this ideals may have further impact on the variables in our model and should therefore be included in future models (Barlett, Vowels, & Saucier, 2008). Another drawback of this study is the use of some questionnaires that haven been originally developed for women and then adapted for men (such as the BSQ), as they focus on the drive for thinness and possibly neglect specific male concerns about losing body fat and gaining muscles (e.g., McCreary, Sasse, Saucier, & Dorsch, 2004; Tylka, Bergeron, & Schwartz, 2005). Moreover, the present sample exhibited lower scores on the EDE-Q, when compared to those reported by Lavender et al. (2010). Nevertheless, the relatively low BD and DECB scores in our sample might partly be due to the fact that participants, who prematurely terminated the online survey, distinguished by higher levels of shape concern and general symptoms of disordered eating. Finally, the present sample does not represent the general Swiss population, as it predominantly consists of young students of Swiss and German nationality, which may explain the somewhat lower prevalence of BD in our male sample (11.4%) compared to representative previous studies (Fiske et al., 2014).

Since the susceptibility to TSF impacts self-related information processing and has emotional and behavioral consequences, men with high BD may be prone to experiencing fear of weight gain following a simple confrontation with e.g. food or the prospect of physical inactivity (such as described in the TSF concept). The resulting negative affect may increase the risk of dysfunctional weight and shape regulation behavior. While it has already been shown that in women food items and thin ideals may provoke such reactions, it remains to be investigated, whether similar processes are present in men as well. Since TSF emerged to be an important mediator in the relationship between BD and DECB, it should be investigated, which gender-specific triggers induce such cognitive processes and behavioral reactions in men (e.g. specific

food items or muscularity ideals). Additionally, future research should include not only samples of the general but also the clinical population.

In order to better understand the different aspects of emotion regulation and their relatedness with disordered eating behavior, future study should assess emotion regulation difficulties also on a behavioral level. Additionally, dysfunctional emotion regulation tendencies such as ruminating about one's own body shape may lead to further clarification. As thus, it has recently been shown that rumination induction increased pathological eating behavior in women suffering from EDs (Svaldi, Griepenstroh, Tuschen-Caffier, & Ehring, 2012). In the same line, it remains unclear, whether men's tendency to engage in automatic and non-conscious emotion regulation processes (Naumann, Tuschen-Caffier, Voderholzer, Caffier, & Svaldi, 2015), which are not addressed by the DERS might represent a more gender-specific emotion regulation attribute relating to ED symptoms. Therefore, future studies should adopt a multimethod approach including not only self-reported emotion regulation strategies, but also the manipulation of automatic emotion regulation processes (such as through priming or training) in order to investigate the influence of non-conscious emotion regulation processes on disturbed eating in young men.

As for the strengths of the final *Publication 3*, the consideration of attentional deployment, and most importantly, the left-handed self-touch behavior as regulatory strategies affecting the child's self-control in context of delaying snacking in *Publication 3* constitute the foremost strengths of this study. Furthermore, our results establish the relevance of the laterality of self-touch in context of self-control, as suggested in previous studies (e.g., Trevarthen, 1996). Additionally, the implementation of the video-based behavioral observation methodology within the experimental setting enhances the assessment's content validity.

With regard to the limitations in *Publication 3*, the strong correlation between the right- and left-handed self-touch (Pearson's r=0.40, $p<.001$) raises several questions regarding the specificity of the LH self-touch movement in self-control during the DOG. A possible reason for the high correlation between the two indices might be bilateral hand movement, i.e. symmetrical or asymmetrical hand-movement carried out by the two hands simultaneously. In further analyses, it is therefore necessary to choose a more differentiated approach as to whether a self-touch movement is performed by the left hand only, or at the same time, accompanied, or mirrored by the right hand (Lausberg, 2013). Another considerable methodical drawback of this study is, that because of the experimental setting of the DOG paradigm, subjects who delayed successfully provided significantly more observational data points for the attentional deployment as well as the LH self-touch, since the duration of movement observation was per definition longer in those subjects compared to the subjects who were unsuccessful in delay. This has a significant implication for the validity of the observed variables. As a possible resolution to this problem, future analyses should implement both factors as time-varying covariates in the survival analysis; reflecting the phenomenon that these two variables are not constant, but change throughout the DOG paradigm.

Another limitation of the study is the lack of the information regarding the child's hand dominance. Some of the analyzed video footage, however, captured the child filling out forms before or after the experiment, or wearing a watch. Based on this information, the hand dominance of the child was estimated. Out of the total 69 children, we were able to estimate the handedness in 54 children. After entering estimates of handedness into the Cox PH model as a covariate, the predictive value of the LH self-touch remained significant ($beta_{LT}$= -7.916; $p<.001$; $beta_{QT}$ =11.78; $p<.001$; R^2=0.46; Logrank test = 38.79 on 11 df; $p<.001$). Nevertheless, a consequent assessment of child's hand

preference, for example via the Edinburgh inventory (Oldfield, 1971) needs to be implemented in future studies. Future studies should also implement brain imaging methods and an experimental manipulation of the self-control strategies; such as e.g. in form of active inhibition of the use of the left hand in order to better comprehend the underlying mechanism of the LH self-touch as a self-control strategy.

Interestingly, we did not find any significant differences between the clinical group and the healthy control group with regard to employment of the two self-control strategies. In order to determine whether these non-significant results favor the null hypothesis of no difference between the groups, we calculated the Bayes factors and obtained values of 0.74 for the PoT of attentional deployment and 0.6 for the PoT of the left-handed self-touch, leading to the conclusion that there is no substantial support in our data for the assumption that children in the clinical group used attentional deployment and the left-handed self-touch equally to their healthy peers (Dienes, 2014). Subsequent studies with a greater sample size are needed in order to clarify this matter.

Furthermore, we decided to operationalize self-touch as seconds of the observed body-oriented movement per video minute (proportion of time, PoT). Generally, every movement category of the NEUROGES coding system can be also operationalized in terms of frequency, i.e. the relative number of units of the movement category per a time unit. Because of the continuous structure of body-focused movements that can last for several minutes, several authors suggest that considering PoT in analyses has a higher informative value than frequency (Freedman & Bucci, 1981; Lausberg, 2013). Contradictory to this argument, neurological findings suggest, that the brain response to unchanging stimuli diminishes over time due to neuronal adaptation, compared to the consistently changing proprioceptive input from dynamic movements that create a stronger effect (Shafir, Taylor, Atkinson, Langenecker, & Zubieta, 2013). Bearing this in

mind, we conducted a post-hoc analysis with the LH self-touch conceptualized as frequency (i.e. number of movement units per minute), and obtained comparable results. Thus, the probability of snacking in children with high frequency of the left handed self-touch (up to 2.52 left-handed self-touch units per minute; corresponding to the 90th percentile) was significantly lower compared to the children with low frequency of left-handed self-touch (i.e. frequency of <0.36 corresponding to the 25th percentile; $\chi^2(10,69)=41.32$; $p<.001$).

Clinical Implications

With regard to the specific knowledge about modifiable psychosocial characteristics that might help improving prevention strategies for pathological eating behavior in childhood and early adulthood, several suggestions can be made based on the findings presented in this thesis.

When it comes to pathological eating behavior in childhood, the results from the *Publication 1* suggest that parental behavior should be considered. Recent research has shown a relevant increase of efficacy when adding VR components to e.g. cognitive behavioral treatment of negative body image in adults, which is equally present in obese children and often a reason for a lack of engagement in playful activities with peers (Cesa et al., 2013).

Furthermore, based on the findings presented in *Publication 3*, we conclude that children with impaired self-control and a clinical diagnoses of BED and/or ADHD can succeed in tasks demanding self-control, needed when engaging in a healthy diet; as long as they employ efficient self-control strategies such as diverting their focus of attention away from the tempting but unhealthy snacks, and/or performing simple self-touch movements. The left-handed self-touch could be trained and applied in a similar way as

the cognitive strategies in the process model of self-control proposed by Duckworth and colleagues (2014). Development and implementation of short exercises involving self-touch movements in a therapy setting or during a class at school could constitute a valuable and cost-effective method facilitating self-control in child's everyday life.

On the other hand, intervention strategies targeting the pathological eating behavior in young men should incorporate concepts targeting body dissatisfaction as demonstrated in *Publication 2*, especially with regard to the specific features of the male body ideal. Furthermore, the weight- and shape-related cognitive distortions should be addressed as a factor contributing to the development and maintenance of pathological eating behavior in young men.

Final Conclusions

The present thesis incorporates three publications addressing specific bio-psychosocial risk factors for pathological eating behavior in childhood and early adulthood.

The results of the studies suggest that not only child's variables (such as self-perception), but also parental variables (such as parental BMI) need to be considered as risk-factors contributing to the development and maintenance of child's pathological eating behavior. Further correlates of pathological eating behavior that must be addressed are body dissatisfaction and vulnerability for food- and weight-related cognitive distortions. Thirdly, unspecific nonverbal strategies that have been demonstrated to improve the ability to resist snacking such as attentional deployment and LH self-touch constitute general resilience factors for pathological eating, and can be consequently utilized in context of clinical intervention.

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Appendix

A) Publication 1

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The influence of parent's body mass index on peer selection: An experimental approach using virtual reality

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The influence of parent's body mass index on peer selection:

An experimental approach using virtual reality

Abstract

Relatively little is known about the influence of psychosocial factors, such as familial role modelling and social network on the development and maintenance of childhood obesity. We investigated peer selection using an immersive virtual reality environment. In a virtual schoolyard, children were confronted with normal weight and overweight avatars either eating or playing. Fifty-seven children aged 7 to 13 participated. Interpersonal distance to the avatars, child's BMI, self-perception, eating behavior and parental BMI were assessed. Parental BMI was the strongest predictor for the children's minimal distance to the avatars. Specifically, a higher mothers' BMI was associated with greater interpersonal distance and children approached closer to overweight eating avatars. A higher father's BMI was associated with a lower interpersonal distance to the avatars. These children approached normal weight playing and overweight eating avatar peers closest. The importance of parental BMI for the child's social approach/avoidance behavior can be explained through social modelling mechanisms. Differential effects of paternal and maternal BMI might be due to gender specific beauty ideals. Interventions to promote social interaction with peer groups could foster weight stabilization or weight loss in children.

Key words: BMI; school-age children; peer selection; virtual reality; interpersonal distance

The influence of parent's body mass index on peer selection:

An experimental approach using virtual reality

1. Introduction

The worldwide prevalence of childhood overweight and obesity increased from 4.7% to 6.7% between 1990 and 2010, and is expected to reach 9.1% by 2020 (De Onis, et al., 2010). The ongoing trend can be traced down in almost all countries and is being referred to as a global epidemic of obesity (Wang and Lobstein, 2006). Biological, psychological, and psychosocial factors are important in the development and maintenance of childhood obesity (Lehrke and Laessle, 2003; Puder and Munsch, 2010). According to the current Cochrane review summarizing treatment efforts and outcome, there is a need for research on how psychological and psychosocial factors such as familial role modelling (Munsch et al., 2008) or the social network contribute to obesity. This could allow for improvements in the long-term efficacy of childhood obesity treatment (Luttikhuis et al., 2009). The role of peers in the spread of obesity is also of considerable interest (Christakis and Fowler, 2007; Hammond, 2010), and indeed, the social contagion of overweight starts at a relatively early age. Valente and colleagues investigated friendship networks and BMI among 617 adolescents aged 12 to 14 and found overweight adolescents to be more likely to have overweight friends (Valente et al., 2009). According to Blanchflower et al. (2009) satisfaction with one's own body depends on the body weight of the reference group, rather than on the absolute body weight. A similar relevance of social networks has been shown for children and adolescents (Koehly

and Loscalzo, 2009). Anderson (2009) suggested three psychosocial explanations that finally lead to similar weight within groups of friends. First, persons choose friends based on weight (peer selection). Second, persons adjust their behavior based on common influence (contextual effects) and third, persons change their own behavior when friends change theirs (endogenous social effect). Thus, obesity status may play an important role in social peer selection process and this in turn has an impact on further weight development of children and adolescents (Christakis and Fowler, 2007; Hammond, 2010). Interestingly, the phenomenon of peer selection and its determinants has not yet been thoroughly addressed in previous studies of childhood obesity. For example, it has been shown that adolescent girls tend to select peers in terms of similarity of body satisfaction and eating behavior type (Rayner et al., 2013).

In accordance with a bio-psycho-social approach to the development of childhood obesity (Lehrke and Laessle, 2003; Puder and Munsch, 2010), we addressed the role of biological (age, BMI and sex of the child), psychological (self-perception and eating behavior of the child) and bio-psycho-social factors (mothers' and fathers' BMI) on the process of constitution of social groups in 7- to 13-year-old children. At this age both family and peers are important determinants of behavior. We assessed the behavior of peer selection applying both explicit and implicit measurements in order to overcome the bias of explicit preference ratings (Hofmann et al., 2005). Accordingly, children's social behavior was assessed implicitly by measuring the interpersonal distance between the child and four avatar groups in an immersive virtual schoolyard setting. Interpersonal distance is typically indexed as the minimal distance between participant and avatar (i.e. the

avatar that was approached closest) in different situations (Bailenson et al., 2003). In an explicit condition, children were asked to rank each of the four avatar groups as a function of their preference to play with during a school break. The characteristics of the virtual avatar groups (constituted of four avatar children) were manipulated. Independent variables of our design were body shape (normal weight vs. overweight) and activity (eating unhealthy food vs. playing) of the avatar groups. We used virtual reality (VR) technology, as it has been proven to be useful for social and behavior based research (McCall and Blascovich, 2009). The advantage of VR is the high degree of experimental control and simultaneously a high degree of external validity and experimental replicability (Blascovich et al., 2002). VR is appropriate for measuring interpersonal distance (approach/avoidance behavior).

Along with child-based variables such as their BMI, sex and age, an important focus of this study is the influence of parental BMI on the child's peer selection assessed via the minimal distance to the avatar groups. This is based on findings showing a dominant influence of parents on children's eating behavior (Munsch et al., 2011). Additionally, a child's social network depends on the social network of their parents, which is again influenced by bio-psycho- and sociological factors (Parke et al., 2002; Ragan et al., 2013). Previous research revealed contradicting results regarding the role of parent's sex on the development of children's overweight and obesity. Some studies report a strong influence of either mother's (Brion et al., 2010; Kral and Rauh, 2010; Zimmermann et al., 2004) or father's BMI (Freeman et al., 2012), comparable effects of father's and mother's BMI (Patel et al., 2011) or a sex specific influence with the mother's BMI being more important for

girls and the father's BMI being more important for boys (Perez-Pastor et al., 2009). There is evidence that this same sex link is not genetic, but rather due to complex modelling mechanisms in the social environment (Perez-Pastor et al., 2009). We expect the minimal distance to an avatar to depend on a child's sex, BMI, self-perception, eating behavior, and especially on the BMI of the child's parents. Indeed, parents are social mediators because they model social behavior and influence the timing and frequency of peer contact as well as the quality of peer activities of their children (Profiler and Hart, 1992).

Previous research showed that overweight children have negative attitudes toward overweight people (Lerner and Korn, 1972). For example, they placed a figure representing themselves farther away from an overweight child than from normal weight figures (Iwawaki et al., 1977; Lerner, 1973), and when asked explicitly, they preferred to play with normal weight children and children with disabilities compared to overweight children (Brylinsky and Moore, 1994). What is more, the consumption of unhealthy food is perceived as negative by normal weight and overweight persons alike (Czyzewska and Graham, 2008). Thus, we expected that children, regardless of their own body weight would express a preference to spend the break with normal weight avatars that play, when asked explicitly. The more implicit behavioral measure (minimal distance to the avatar peers) should give more precise, online, and differentiated information about children's social approach or avoidance behavior, not biased by social variables. Given the importance of familiar role modelling, a predominant role of parental BMI in the approach/avoidance behavior is expected. We presume parental BMI to be a significant predictor for the minimal distance to the avatars, and we explore the role of other biological and psychological variables such as BMI, sex, age, self-perception and eating behavior of the

child. We expected the child's behavior in VR to shed light on detail aspects of peer selection in real world situations.

2. Methods

2.1. Participants

Fifty-seven children took part in the study. They were recruited through public primary schools and sport programs for overweight children. They visited our lab group wise, and participated in the VR experiment individually. The mean age of the children was 10.19 years (*SD* = 1.58, range: 7 - 13 years), they were Caucasian and from middle class families living in the German-speaking part of Switzerland. The study was approved by the ethics committee of the University of Bern. Informed written parental approval was obtained prior to the study and children gave oral consent to participate.

All children were weighed on a Seca electronic balance (Seca, Vogel + Halke, Germany) and height was measured without shoes to the nearest 0.1 cm by means of a stadiometer. BMI was calculated as weight in kilograms divided by the square of height in meters. The mean BMI of the children was 19.06 (*SD* = 3.97, range: 14.23 – 30.08). Based on age- and sex-specific norms (Cole et al., 2000), children can be assigned to one of two categories: normal range (corresponding to BMI ≤ 25 at age 18) and overweight (corresponding to BMI > 25 at age 18). For the cut off points, centile curves corresponding to the BMI 25 at age 18 were calculated (Cole et al., 2000). Forty-one children (20 boys) had normal body weight and 16 children (8

boys) were overweight. Social acceptance, physical appearance and global self-worth were assessed via Harter's self-perception scale for children (Asendorpf and Aken, 1993). Furthermore, we assessed eating behavior in terms of restrictive, external and emotional eating behavior using the Dutch eating behavior questionnaire (DEBQ, Van Strien et al., 1986; German translation of Grunert, 1989).

Parental BMI was assessed through self-report of height and weight (questionnaire). The mean reported BMI was 24.97 (*SD* = 4.95, range: 18.21 – 47.63) for the mothers, and 26.48 (*SD* = 3.11, range: 20.02 – 36.13) for the fathers. For further analyses, parents were classified in two categories: normal weight (BMI ≤ 25) and overweight (BMI > 25). Twelve children had both parents in the normal weight category, 14 children had both parents in the overweight category, 10 children had the father in the normal weight category and the mother in the overweight category and 16 children had the mother in the normal weight category and the father in the overweight category. Three mothers and five fathers did not report their height and weight.

2.2. Stimulus material

We created a virtual schoolyard (St. Claire High School, sketchup.google.com), which was accessed by children via head-mounted display (HMD, nVisor SX60). They were presented four scenarios including four types of children avatar groups: normal weight and eating avatars, normal weight and playing avatars, overweight and eating avatars, overweight and playing avatars. See Figure 1 for an example (normal weight and eating avatars).

All participants were exposed to the four conditions, the order of which was counterbalanced. Apart from body shape and activity, each condition included four identical avatars (two girls and two boys, body height 1.40 m, taken from Vizard Complete Characters), allowing controlling for other characteristics of the avatars that could influence the child's preference, such as their outfit. The overweight avatars were adapted from the original avatars using 3D Studio Max (2010). Vizard Live Characters and Motionbuilder software (Autodesk, 2010) were used to create the motion of the avatars. Sound (.wav file) from a real schoolyard was presented over the headphones that were integrated into the head mounted display. In order to produce eating or drinking avatars we used photographs of palatable but unhealthy food (sandwich, toast and donut) and soft drinks (cola) taken from Google SketchUp (sketchup.google.com). The four avatars held on to one of these items while they were raising and lowering their arm toward their mouth.

The playing avatars placed one foot in the middle and they all said "sigg-sagg-sugg" (a traditional Swiss schoolyard game) after which they either withdraw the foot or left it in place. The trial is lost for that child whose foot is the only one that remained in the center or the only one that was removed from the center. The participants heard children's voices saying "sigg-sagg-sugg", which were prerecorded from four children matched to the avatars' sex and age.

The position of the participant inside the VR laboratory was steadily tracked (PPT Studio, 2008), and later in analysis, the minimal distance to the closest avatar was extracted. After the VR task, participants were asked: "which avatar group would you prefer to play with in the schoolyard?"

2.3. Procedure

Children spent on average 12 minutes immersed in VR. In order to rule out hunger or satiety influencing their behavior, all children ate a snack two hours prior to the VR task. The height and weight of the children were measured before the VR experiment began. The experiment consisted of four conditions described above (see stimulus material), each lasting one minute. All children participated in the four conditions. Participants first familiarized with the VR environment (around one minute in the schoolyard scenario without the avatar groups). Each schoolyard situation began with the sound of a school bell (2 seconds). The avatars appeared on the schoolyard, approached the child and stopped in a predefined position in front of the child. Participants were instructed to move freely and explore the virtual schoolyard once the avatar group reached the predefined position. After each condition, the participant was guided back to the starting position by the experimenter. The extension of the real room was 5 x 5.6 meters. See Figure 1 for an illustration of the setup.

Insert Figure 1 about here

After the VR task, participants were presented with the images of the four groups (screenshots) and asked with which avatar group they would prefer to play

with in the schoolyard. Hunger was assessed with a five-point Likert scale (children were shown five images of a plate, ranging from an empty plate to a full plate and had to answer the question “how hungry are you?”). Also the immersion in the schoolyard situation was measured with a five-point Likert scale (“how similar did it feel to being on a real school-yard?”). No significant differences were found between normal weight (N = 41, M_{hunger}= 2.78, SD_{hunger} = 1.15; $M_{immersion}$ = 3.61, $SD_{immersion}$ = 0.92) and overweight children (N = 16, M_{hunger}= 2.75, SD_{hunger} = 1.34; $M_{immersion}$ = 3.94, $SD_{immersion}$ = 1.23).

The normal weight participants completed the two questionnaires (self-perception first, followed by eating behavior) in their classrooms within a one-month period after the experiment, whereas the overweight children completed the questionnaires in a separate room immediately after the VR task. An experimenter explained the questionnaires and helped the children in case clarification was needed. The completion of the questionnaires took about 30 minutes.

3. Results

First, descriptive statistics (correlations, means and standard deviations) are presented. We further report the results of four hierarchical regression analyses with the distances to the four avatar groups as dependent variables and children’s biological variables (age, BMI and sex), psychological variables (self-perception and eating behavior) and the BMI of father and mother as predictors. The latter represent both genetics of weight regulation but also a correlate of parental eating and especially social behavior (modeling). In order to better understand the

significant results of the regression analyses, a *GLM* analysis of variance was calculated, allowing for the investigation of possible interactions between the different variables. We report partial eta-squared as measure of effect size. Finally, we investigated the explicit choice (preferred avatar) with c^2 tests.

3.1. Descriptive statistics

The subscales of self-perception (social acceptance, physical appearance and global self-worth) correlate positively (r between 0.60 and 0.85, $p < 0.001$), and thus, we computed a total score by averaging the three subscales. Table 1 summarizes the correlations between the dependent and independent variables. Significant correlations were found between the distances to the avatar groups and BMI of the child's father and mother. The BMI of the child correlated negatively with child's self-perception and positively with the BMI of the mother. In children, self-perception correlated positively with restrictive eating behavior. In our sample, BMI of the child's father and mother did not correlate.

Insert Table 1 about here

3.2. Approach/avoidance behavior and bio-psycho-social variables

Table 2 and 3 summarize the results of four hierarchical regression analyses. In accordance with the bio-psycho-social model of obesity in childhood, we entered first the biological information (age, sex and BMI of the child) in the statistical

model. Then, we added the psychological information, i.e. self-perception and the three subscales of eating behavior of the child. Finally, BMIs of the child's father and mother were entered in the model. The dependent variables were the distances to the four avatar groups as an implicit measure of behavior. The four models explain between 25% and 47% of the variance.

Insert Table 2 and Table 3 about here

With respect to the distance to the *normal weight eating avatars*, BMI of the child's mother (beta = 0.41***), self-perception (beta = -0.39*) and external eating behavior (beta = 0.45*) were significant predictors. This means, the higher the BMI of the mother and the higher the values on the external eating behavior, the larger the distance to the normal weight eating avatars. However, the smaller the values on the self-perception factor, the larger the distance to the normal weight eating avatars. Results showed that after statistically controlling for other variables, the child's mother's BMI still significantly contributed to the prediction of approach/avoidance behavior. The model explained 47% of the variance (F (9, 37) = 3.66, $p < 0.001$). When it comes to the distance to *normal weight playing avatars*, BMI of the child's father (beta = -0.32*), emotional (beta = -0.39*) and external eating behavior (beta = 0.43*) turned out to be significant predictors. The higher the BMI of the father and the higher the values on the emotional eating behavior dimension, the smaller the distance to the normal weight playing avatar group. In contrast, the higher the values on external eating behavior, the larger the distance to

this avatar group. In this model 34% of the variance is explained (F (9, 38) = 2.16, p = 0.05). Taking the distance to the *overweight eating avatars* as dependent variable showed a similar pattern, however none of the predictors yielded significant results (BMI of father = -0.29, p = 0.07). In this model 27% of the variance was explained (F (9, 38) = 1.42, p = 0.21). Finally, the distance to the *overweight playing avatars* was predicted by sex (beta = -0.33*) and external eating behavior (beta = 0.38*). BMI of the child's mother was close to statistical significance (beta = 0.30*, p = 0.06). The higher the score on the external eating behavior (and the BMI of the mother) the larger the distance to the overweight playing group, whereas the distance to this group became smaller with girls. This model explained 35% of the variance (F (9, 36) = 2.19, p = 0.05).

3.3. Influence of paternal and maternal BMI on the approach/avoidance behavior

Due to the important relation between the distance measured in VR and the BMI of the parents, we conducted a *GLM* analysis of variance, with two repeated factors and two between factors: weight of the avatars (normal vs. overweight) x activity of the avatars (eating vs. playing) x BMI of father (normal vs. overweight) x BMI of mother (normal vs. overweight). This approach allows considering the four distances to the avatars groups in the same model (two repeated factors).

The three-way interaction weight x activity x BMI father was significant (F (1,46) = 4.16, p = 0.047, η_p^2 = 0.083). When correcting for multiple comparisons (significance threshold after Bonferroni correction: $p \leq 0.0125$), only two differences remain significant. The distance to the *normal weight playing avatars* was larger for children with normal weight fathers (M = 2.45 m, SEM = 0.25) than children with overweight

fathers (*M* = 1.45 m, SEM = 0.22), *p* = 0.005. The distance to the *overweight eating avatars* was higher for children with normal weight fathers (*M* = 2.14 m, *SEM* = 0.24) than children with overweight fathers (*M* = 1.28 m, *SEM* = 0.21), *p* = 0.011. Moreover, the three-way interaction weight x activity x BMI mother was significant (*F* (1,46) = 4.48, *p* = 0.04, η_p^2 = 0.089). When correcting for multiple comparisons (significance threshold after Bonferroni correction: $p \leq 0.0125$), only two differences remain significant. The distance to the *normal weight eating avatars* was lower for children with normal weight mothers (*M* = 1.35 m, *SEM* = 0.22) than children with overweight mothers (*M* = 2.41 m, *SEM* = 0.25), *p* = 0.003. The distance to the *overweight playing avatars* was lower for children with normal weight mothers (*M* = 1.47 m, *SEM* = 0.23) than children with overweight mothers (*M* = 2.42 m, *SEM* = 0.26), *p* = 0.008. The interactions are illustrated in Figure 2.

Insert Figure 2 about here

The analysis also revealed a significant main effect of BMI father (*F* (1,42) = 6.01, *p* = 0.018, η_p^2 = 0.116). The distance to all the avatar groups was higher for children with normal weight fathers (*M* = 2.17 m, *SEM* = 0.18) than children with overweight fathers (*M* = 1.57 m, *SEM* = 0.16). BMI mother was significant by trend (*F* (1,46) = 7.45, *p* = 0.09, η_p^2 = 0.139). The distance to all the avatar groups was higher for children with overweight mothers (*M* = 2.2 m, *SEM* = 0.18) than children with normal weight mothers (*M* = 1.53 m, *SEM* = 0.16).

3.4. The explicit choice (preference of an avatar group)

After the VR task, each child was asked explicitly with whom it would like to spend the break. This explicit measure showed highly consistent responses: 41 children out of 57 explicitly choose the normal weight playing avatar group (preferred group), 9 children choose the normal weight eating avatar group, 2 choose the overweight playing avatar group and 5 the overweight eating avatar group. To test whether the explicit choice (one out of the four avatar groups) interacted with the BMI of the child, the BMI of the mother and the BMI of the father, three c^2 tests were computed and yielded non-significant results ($p > 0.203$), thus illustrating that the choice did neither depend on the BMI of the child nor of the mother's and the father's BMI.

4. Discussion

There is increasing evidence that psychosocial factors play an important role in the spread of obesity in both adults and children (Christakis and Fowler, 2007; Valente et al., 2009), we therefore investigated peer selection, an important factor in developing social networks in 7- to 13-year-old children (Anderson, 2009). Peer groups relate to activities such as eating behavior and nutrition intake and hence are linked to the development or maintenance of a healthy or unhealthy body weight (Grube et al., 2013; Parke et al., 2002). Specific knowledge about modifiable psychosocial characteristics might help improving prevention efforts with respect to obesity. In the VR paradigm, we expected to find the minimal distance to the avatars to depend on the child's sex, BMI, self-perception, eating behavior, and on the BMI of child's

parents. Interestingly, it turned out that the most important predictors of the minimal distance of the child to the four avatar groups were parental BMI and none of the child variables.

The findings revealed that children with overweight mothers kept a larger distance to all the avatar groups compared to children with normal weight mothers. In contrast, the distance was smaller for children with overweight fathers compared to children with normal weight fathers. This finding is in line with Sikorski et al. (2011) showing that overweight and obesity are less stigmatized in men. Therefore, fathers with a higher BMI may not be seen as overweight, but rather as muscular and physically strong; overweight is especially stigmatized in females, as indicated by Hilbert et al. (2013). The avoiding behavior of children with overweight mothers could reflect the peer selection habits of their own mothers, possibly conveyed through mechanisms of stigmatization at the early age leading to the experience of exclusion of peer groups (Parke et al., 2002). It is possible that children interpret the overweight of their father as a symbol of physical strength (Wertheim et al., 2004), hence as something that is rather positive and desirable. Another conceivable interpretation is that children with overweight fathers might have perceived the social stigma of overweight more strongly than children with normal weight fathers. As a result of a coping strategy children with overweight fathers may have tried to approach normal weight rather than overweight avatars.

When approaching *normal weight eating avatars* we found an important impact of maternal BMI. The higher the mother's BMI the longer the distance to these avatars. With respect to the *normal weight playing avatars* higher BMI of the father significantly reduced distance. The BMI of the mother might relate to her

specific social interaction experiences and style and thus to her approach/avoidance behavior in social situations. This could be transmitted via daily repeated modelling to the child (Munsch et al., 2011). Mothers with higher BMI who avoid social groups with lower BMI and are ashamed to eat in public, do not act as role models to engage in proactive social behavior on how to join (especially normal weight) peers (de Brun et al., 2014). This might in turn inhibit engagement in playful activities during repetitive daily activities and contribute to the maintenance of disturbed eating behavior such as avoiding to eat in public (Ball et al., 2012).

With respect to *overweight avatars*, a higher BMI of the father was marginally linked to a smaller distance of the child to the *overweight eating* avatars. The distance to the *overweight playing* group was larger in children with higher maternal BMI. Again the results indicate that in general, a higher BMI of the father does not seem to inhibit the approach behavior of the child to the avatar peers, whereas the opposite is true for the mother's BMI. A higher BMI of the mother seems to inhibit approach behavior toward playing avatars, which might in turn impede health promoting activities (Lane et al., 2013). This could either be due to a lack of maternal model of such approach behavior, to maternal sedentary behavior, or negative body image and low self-esteem. Although a comparable influence of mothers' and fathers' BMI on children's BMI has been reported in large survey studies (e.g. Patel et al., 2011), the experimental approach in VR revealed specific approach measures indicative of maternal and paternal role modelling of social behavior. Furthermore, our findings might point to gender related differences in beauty ideal that are already established at this age. While thinness is important for

women, a higher BMI in men might also be associated with physical strength and muscularity (Tylka, 2011).

Interestingly, children with high scores on the external eating scale kept a larger distance from almost all groups, with the exception of the overweight eating group. The external eating scale of the DEBQ comprises items such as "I feel eating something when I see others eating" or "whenever I smell food, I want to eat". Whereas emotional eating has been associated with impulsivity and emotion regulation problems, external eating has been associated with the susceptibility to environmental food stimuli. Hence, it is astonishing that seeing other children eating is not triggering approaching behavior. To the contrary, it is associated with a larger distance to normal weight peers in virtual reality. Future VR designs could incorporate olfactory aspects such as the smell of food to test whether this aspect induces approaching behavior (Jansen et al., 2003).

As expected, when asked explicitly, all children regardless of their own and their parents' BMI showed a clear preference for normal weight avatars engaged in a playful activity. No interaction between the child's BMI, maternal and paternal BMI was found in the explicit condition. These findings indicate the influence of various mechanisms of social desirability, such as impression management (Salvy et al., 2007) on the child's explicit behavior. Impression management describes an individual attempt of self-presentation. In order to convey a good impression, all children choose a peer group of lower body weight who plays, thus avoiding the attribution to a group with several negative characteristics that are already highly stigmatized in young children (Salvy et al., 2007).

The findings from this study underline the advantage of a combined assessment of both implicit and explicit correlates of approach/avoidance behavior.

While explicit measures can present a rich source of data, reflecting self-evaluation in the context of social norms, VR can offer a more accurate measure of social behavior. In contrast to the explicit measurement of preferences, the implicit assessment of distance regulation is less influenced by social desirability and might be more valid and reliable when it comes to approximate daily behavior of the children.

There are limitations of the study that need to be considered. For example, further research will need to be carried out in order to include a more systematic assessment of children's and parental variables such as parents' self-esteem and social anxiety. These factors might influence the children's approach/avoidance behavior in social situations. In our study, we assessed social anxiety by means of the Social Anxiety Scale for Children – Revised (SASC-R, La Greca and Stone, 1993). Unfortunately, we had missings in our assessment and could only use the data of 43 out of 57 children (the SASC-R is appropriate for 9-13 year-olds, the age of the sample in this study ranged from 7 to 13 years). In addition to this, we could not replicate the factorial structure proposed by the authors. Nevertheless, we included the SASC-R in an exploratory analysis but did not find this predictor to significantly influence our results. Future studies, including a larger sample size should reevaluate the factorial structure of the SASC-R and reinvestigate the influence of social anxiety with respect to approaching behavior in VR and daily life situations. In this study we used self-reported BMI of parents. Several studies have showed erroneous reporting on weight and height, but recent research suggests that height rather than weight is incorrectly indicated (Keith et al., 2011; White et al., 2010). Further research with a larger and more balanced BMI sample is desirable.

Strengths of our study include the novelty of the VR approach in order to shed light on children's social interaction behavior, which might influence their eating behavior and energy intake. Our findings highlight the importance of parental BMI and might stimulate future research, detailing out the link between the parents' BMI and their role model behavior. Based on our findings, parental behavior should be considered and individual adjustments made (Cesa et al., 2013) when developing prevention strategies and programs for child obesity treatment. Recent research is promising and shows a relevant increase of efficacy when adding VR components to e.g. cognitive behavioral treatment of negative body image in adults, which is equally present in obese children and often a reason for a lack of engagement in playful activities with peers (Cesa et al., 2013).

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Contributors

F. W. Mast, S. Munsch, N. Borter, and C. S. Martarelli developed the study concept and study design. Testing and data collection were performed by N. Borter. C. S. Martarelli performed the data analysis. C. S. Martarelli drafted the introduction, methods, and results sections of the manuscript, and S. Munsch the discussion. F. W. Mast and J. Bryjova provided critical revisions. All authors approved the final version of the manuscript for submission.

Conflict of interest

The authors declare that there is no conflict of interest.

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Table 1. *Summary of intercorrelations, means and standard deviations.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14	Mean	SD	N
1. Normal weight eating	--														1.78	1.26	55
2. Normal weight playing	0.34*	--													1.94	1.26	57
3.Overweight eating	0.32*	0.61**	--												1.70	1.21	56
4. Overweight playing	0.58**	0.50**	0.33*	--											1.86	1.26	55
5. Age	0.03	0.06	0.18	0.15	--										10.19	1.58	57
6. Sex	-0.03	0.00	-0.14	-0.19	-0.26	--									0.51	0.5	57
7. BMI	0.13	-0.04	0.04	0.02	-0.02	-0.03	--								19.06	3.97	57
8. Self-perception	-0.26	0.06	-0.09	-0.09	0.08	0.08	-0.44**	--							3.10	0.60	53
9. Restrictive EB	0.04	0.23	0.10	0.12	0.20	0.05	-0.18	0.44**	--						15.02	8.10	55
10. Emotional EB	-0.17	-0.13	-0.18	-0.14	0.25	-0.02	-0.02	0.18	0.36**	--					22.25	8.17	55
11. External EB	0.08	0.10	-0.13	0.03	0.25	-0.05	0.03	0.12	0.19	0.60**	--				13.62	6.68	55
12. BMI father	-0.23	-0.36**	-0.29*	-0.14	0.14	0.02	0.27	-0.04	-0.23	0.12	0.23	--			26.48	3.11	52

13. BMI mother	0.36**	0.20	-0.03	0.21	-0.08	0.12	0.31*	-0.09	0.13	-0.13	0.01	-0.04	--		24.97	4.95	54
14. SES	0.01	-0.01	0.06	-0.07	-0.19	0.37**	-0.10	0.03	0.09	0.10	0.23	-0.15	-0.20	--	10.55	2.43	56

Note. Variables 1 to 4 represent the distance to the normal weight eating avatars (1), the distance to the normal weight playing avatars (2), the distance to the overweight eating avatars (3), and the distance to the overweight playing avatars (4). Sex is coded as 0 for boy and 1 for girl. Variables 9 to 10 represent the three subscales of eating behavior. Child's mother and child's father number of years of school were found to correlate positively, $r = .54$, $p < .001$, so we computed the mean school-years (variable 14. parent's level of education as indicator of SES).

*$p < .05$ **$p < .01$

Table 2

Hierarchical regression analyses with distances to the normal weight eating avatars and distances to the normal weight playing avatars as dependent variables. Predictors are biological (age, sex, and BMI), psychological (self-perception, restrictive, emotional, and external eating behavior) and parental BMI (BMI of father and mother).

	Distance to normal weight eating avatars		Distance to normal weight playing avatars	
	t	ΔR^2	t	ΔR^2
Step 1		0.02		0.01
Age	-0.05		0.03	
Sex	-0.09		-0.07	
BMI	0.09		0.04	
Step 2		0.26*		0.23*
Age	-0.21		-0.04	
Sex	-0.12		-0.10	
BMI	-0.08		-0.07	
Self-perception	-0.46*		-0.12	
Restrictive EB	0.41*		0.36*	
Emotional EB	-0.25		-0.44*	
External EB	0.43*		0.38*	
Step 3		0.20***		0.10
Age	-0.19		0.02	
Sex	-0.18		-0.08	
BMI	-0.17		-0.04	
Self-perception	-0.39*		-0.06	

	Restrictive EB	0.23	0.23
	Emotional EB	-0.12	-0.39*
	External EB	0.45*	0.43*
	BMI father	-0.24	-0.32*
	BMI mother	0.41***	0.13
Total	R^2	0.47	0.34

Note. Standardized coefficients (β), ΔR^2 and total amount of explained variance (R^2) are reported.

*$p < 0.05$. **$p < 0.01$. *** $p < 0.001$

Table 3

Hierarchical regression analyses with distances to the overweight eating avatars and distances to the overweight playing avatars as dependent variables. Predictors are biological (age, sex, and BMI), psychological (self-perception, restrictive, emotional, and external eating behavior) and parental BMI (BMI of father and mother).

	Distance to overweight eating avatars		Distance to overweight playing avatars	
	t	ΔR^2	t	ΔR^2
Step 1		0.08		0.07
Age	0.18		-0.02	
Sex	-0.17		-0.25	
BMI	0.04		-0.10	
Step 2		0.10		0.18
Age	0.16		-0.15	
Sex	-0.16		-0.29	
BMI	-0.01		-0.19	
Self-perception	-0.24		-0.28	
Restrictive EB	0.32		0.37*	
Emotional EB	-0.20		-0.27	
External EB	0.06		0.36*	
Step 3		0.07		0.11
Age	0.23		-0.12	
Sex	-0.10		-0.33*	
BMI	0.09		-0.25	

	Self-perception	-0.20	-0.23
	Restrictive EB	0.26	0.24
	Emotional EB	-0.22	-0.18
	External EB	0.11	0.38*
	BMI father	-0.29	-0.19
	BMI mother	-0.11	0.30
Total	R^2	0.25	0.35

Note. Standardized coefficients (β), ΔR^2 and total amount of explained variance (R^2) are reported.

*$p < 0.05$. **$p < 0.01$.

Figure 1. Schematic representation of the virtual reality setup. The participant (lower right-hand corner) viewed the virtual environment wearing an nVisor SX60 stereoscopic head-mounted display (HMD) with a resolution of 1280x1024 and a diagonal field of view of 60 degrees in each eye. Head rotations were tracked using an InertiaCube3 three-axis orientation tracker attached to the head-mounted display. A LED marker on top of the HMD signaled the participant's position in the virtual environment to a system (Precision Position Tracking, PPT X) of four optical cameras mounted on tripods in each corner of the lab (two shown at the left- and right-hand). The orientation and position information gathered was transferred to the rendering machine via HMD and camera cables to update the graphics displayed in the HMD. The avatars (Vizard Complete Characters) were placed in a 3D model of a schoolyard around 7 meters in front of the participant.

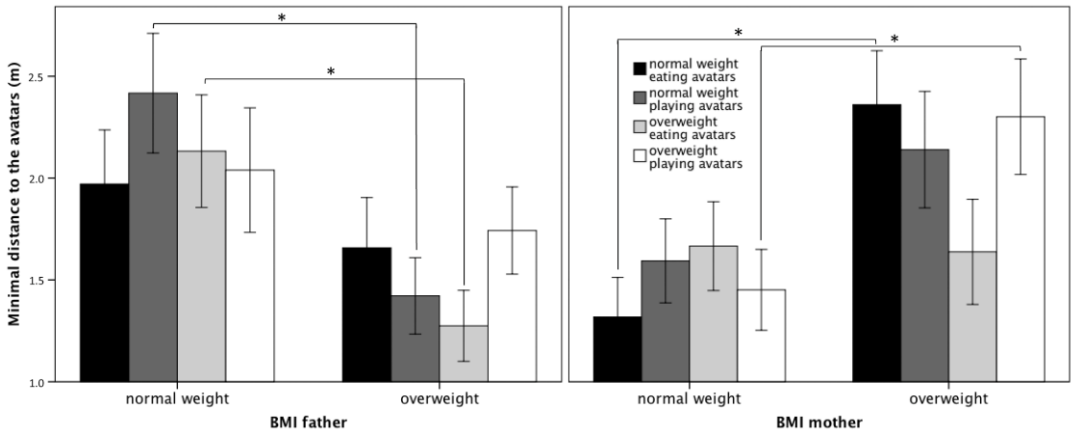

Figure 2. The effects of the child's father's (left side) and mother's BMI (right side) on the minimal distance to the four avatar groups. Bars represent the minimal distance (mean in meters) and served as a behavioral measure of approach/avoidance. Errors bars indicate standard errors of the mean. Significant post-hoc differences are marked by asterisks.

B) Publication 2

Wyssen, A., Bryjova, J., Meyer, A. H. & Munsch, S. (submitted). A Model of Disturbed Eating Behavior in Men: The Role of Body Dissatisfaction, Emotion Dysregulation and Cognitive Distortions.

A Model of Disturbed Eating Behavior in Men: The Role of Body Dissatisfaction, Emotion Dysregulation and Cognitive Distortions

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ABSTRACT (196 words)

Body dissatisfaction (BD) is an established factor leading to the development and maintenance of disturbed eating in women and men. Due to the lack of comprehensive models regarding the development of eating pathology in males, we propose a mediator model of disturbed eating and compensatory behavior (DECB) for men, suggesting that emotion dysregulation and the susceptibility to body-related cognitive distortions such as Thought-Shape Fusion (TSF) mediate the relationship between BD and DECB. Using data from a cross-sectional online-survey we tested our model in a community sample of healthy young men living in Switzerland (n=123, 18–37 years old). We found a significant positive association between BD and DECB, accounting for participant's body mass index (BMI), age and depressive symptoms. While TSF partially mediated the relationship between BD and DECB, we did not detect a corresponding mediation effect for emotion dysregulation. Based on our findings, we concluded that TSF, which describes a tendency to a distorted body perception, contributes to the pathological eating- and shape-related behavior in men who are dissatisfied with their body. We suggest that TSF should be included in etiological models as a relevant aspect of cognitive information processing with emotional and behavioral consequences.

Key words: eating disorder pathology, males, body image, thought-shape fusion, emotion regulation, cross-sectional, mediation model

HIGHLIGHTS

- Men's body dissatisfaction significantly predicted disturbed eating.
- This association was partially mediated by body-related cognitive distortions (TSF).
- The susceptibility to cognitive distortions is etiologically relevant.
- Cognitive distortions may be triggered in everyday life by e.g. food exposure.

A Model of Disturbed Eating Behavior in Men: The Role of Body Dissatisfaction, Emotion Dysregulation and Cognitive Distortions

1. INTRODUCTION

Despite the relatively low prevalence of eating disorders (EDs) in men (e.g., Hudson, Hiripi, Pope, & Kessler, 2007; Preti et al., 2009; Schnyder, Milos, Mohler-Kuo, & Dermota, 2012), symptoms of disordered eating on a subclinical level and most notably body dissatisfaction (BD) among men are quite frequent (e.g., Dominé, Berchtold, Akre, Michaud, & Suris, 2009; Fiske, Fallon, Blissmer, & Redding, 2014). Lifetime prevalence of EDs among males in the general population ranging up to 0.3% for anorexia nervosa, 0.9% for bulimia nervosa, and 2.0% for binge-eating disorder (Hudson et al., 2007; Preti et al., 2009; Schnyder et al., 2012). Although full-blown EDs are rarely manifested, a significant proportion of male adolescents and young adults show symptoms of ED pathology on a subclinical level: based on representative samples, lifetime prevalence of repeated episodes of binge-eating, without fulfilling the criteria of an ED in men, range from 2.9 to 4% (Hudson et al., 2007; Schnyder et al., 2012). Symptoms of disordered eating, such as overeating, loss of eating control, body checking and excessive exercising are frequent among young men, with a prevalence ranging up to 26% (Dominé et al., 2009; Striegel-Moore et al., 2009).

Dysfunctional eating and weight regulation behaviors have been linked to BD, both in men and women (Fiske et al., 2014; McCabe & Ricciardelli, 2004). BD is a negative attitude towards one's own body including thoughts and feelings about the size, shape, muscularity, and body

weight. It is conceptualized as the perceived discrepancy between a person's evaluation of his or her own body and the individual's concept of an ideal body (Cash & Szymanski, 1995). The prevalence of BD among men varies widely (8–61%) (Fiske et al., 2014). Apart from ED pathology, BD is known to be associated with impaired psychological well-being such as increased feelings of shame, low self-esteem, and depressive feelings in both women and men (e.g., Paxton, Neumark-Sztainer, Hannan, & Eisenberg, 2006; Stice & Shaw, 2002). In a longitudinal study, Neumark-Sztainer and colleagues (2006) found that BD among US-male adolescents predicted dysfunctional weight control strategies such as fasting or inappropriate use of food supplements, binge eating, and further correlates of an unhealthy lifestyle such as smoking and lack of physical activity. Besides unhealthy dieting, BD promotes a number of other health risk behaviors aiming at increasing muscularity and reducing body fat, such as steroid abuse and supplement intake (Blashill, 2014; Brower, Blow, & Hill, 1994; Cafri et al., 2005; Ricciardelli & McCabe, 2003). In contrast to women, whose primary goal is to achieve thinness, men's concerns regarding their body image seem more complex, as an increase in muscularity and/or weight loss/body fat reduction is desired. Accordingly, BD in men may either result in muscularity increasing behavior or in efforts to lose weight (e.g., Tylka, 2011).

There has been very little research done on the relationship between BD and ED pathology in men as well as the psychological mechanisms involved. Based on studies done in young women, Stice (2001) suggested the "Negative Affect Regulation Pathway". Since appearance is an important evaluation component for individuals, especially in western societies, this pathway suggests that BD contributes to negative affect, which in turn increases the risk of developing ED pathology in terms of restricting, dieting, binge eating and compensatory behaviors as an attempt to regulate the negative emotions (Stice, 2001). Similar to the "Negative Affect Regulation Pathway", Lavender and Anderson (2010) conclude that in their sample of young college students, men who experience negative mood related to their dissatisfaction with the own body are more likely to engage in maladaptive behaviors, such as

binge eating, purging and excessive exercise, especially when they report not being able to accept or regulate those negative states. our study we therefore expected that men who are dissatisfied with their body image are more likely to experience difficulties in regulating their emotions, which might lead to dysfunctional compensatory behaviors and disturbed eating habits.

In addition to emotion dysregulation, body-related cognitive distortions are known to contribute to the development and maintenance of EDs (e.g., Fairburn, Cooper, & Shafran, 2003). Cognitive distortions are characterized by skewed and non-veridical thoughts related to affective experiences and behavior that have been linked to psychological problems and mental disorders (Rachman & Shafran, 1999). Shafran and colleagues (1999) proposed a specific cognitive distortion mechanism regarding thoughts about food, weight and shape; the "Thought-Shape Fusion" (TSF). TSF was developed according to the "Thought-Action Fusion" (TAF) concept in obsessive-compulsive disorder (OCD) (Shafran, Thordarson, & Rachman, 1996). Transferred to the ED domain, TSF includes imagining of eating fattening, or "forbidden foods"; and/or of abstaining from compensatory behavior such as exercising or dieting. Not only can these thoughts trigger negative feelings about one's own body (e.g., Coelho et al., 2013), they are also directly related to dysfunctional behavior, such as the urge to engage in body checking or to restrict food intake (Shafran et al., 1999). Associations between TSF and the severity of ED symptoms as well as general psychopathology have been found in healthy women (Shafran et al., 1999) and women with EDs (Shafran & Robinson, 2004). When imagining specific fattening/forbidden food, TSF can be experimentally induced in healthy women (Coelho, Roefs, & Jansen, 2010), and is more pronounced in women with EDs (Coelho, Carter, McFarlane, & Polivy, 2008; Radomsky, de Silva, Todd, Treasure, & Murphy, 2002). Dubois et al. investigated TSF in an Australian community sample and found that TSF significantly predicted ED pathology as well as BD (Dubois, Altieri, & Schembri, 2013). However, this finding remains preliminary, as the male sample was relatively small.

To conclude, the current research suggests several factors contributing to the development and maintenance of EDs, such as body dissatisfaction, emotion dysregulation or thought-shape fusion (TSF). These factors have been investigated in men only sporadically and even less frequently within a comprehensive framework. Identifying and testing the interrelationships of these factors is of importance for advancing theoretical assumptions about the role of psychological factors in the development of disordered eating behavior in men.

In the present study, we tried to further clarify the association between body dissatisfaction (BD) and disturbed eating and compensatory behavior (DECB) among men, while considering emotion dysregulation and the susceptibility to cognitive distortions (TSF) as mediators, while controlling for participant's age, body mass index (BMI) as well as depressive symptoms. On the basis of the literature reviewed, we hypothesized that men with increased BD are more likely to endorse higher levels of cognitive distortions as well as emotion dysregulation, compared to men with lower levels of BD. Subsequently, these two mediators were expected to be positively associated with DECB (see Figure 1).

Insert Figure 1 here

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2. METHOD

2.1. Participants and Procedure

Participants were recruited for the survey through mailing lists, flyers and an advertisement on the website of the University of Fribourg, Switzerland. The online survey was carried out at the Department of Clinical Psychology at the University of Fribourg and took approx. 40 to 50 minutes to complete. The local ethical committee approved the study design, procedure, and materials. Students received course credits as compensation. Other non-student participants were not compensated for their participation; however they were offered the possibility to

receive a summary of the results. Altogether 123 men were registered for the online survey. The mean age was 23.7 (SD=3.2) years and the mean BMI of participants was 23.3 (SD=3.1). One third of the sample had Swiss nationality, 63.4% was German and 3.3% were of other nationality. More than two thirds (68.3%) of the participants were students, 27.6% were employed, and 4.1% did not indicate their occupation. Eighteen participants (12.8%) did not finish the online survey and were not included into the analyses. Men who terminated the survey prematurely scored significantly higher on the shape-concern scale of the Eating Disorder Examination Questionnaire (EDE-Q) ($t(140)=-2.75$, $p=.013$), as well as in global symptoms of ED pathology according to the EDE-Q ($t(140)=-2.30$, $p=.033$) compared to the completers. No significant differences were found regarding BMI, age and depressive symptoms between completers and non-completers.

2.2. Measures

Standardized questionnaires in German were presented via an online survey platform (Umfrageonline; Enuvo) during 2012–2014. The original format and content of the questionnaires were not altered.

Body Mass Index (BMI): BMI (kg/m^2) was calculated relying on self-reported body weight and height as assessed in the EDE-Q. A BMI below 18.5 refers to underweight, above 25 indicates overweight, and above 30 obesity.

Depressive symptoms (BDI-II): To assess correlates of general psychopathology we measured depressive symptoms using the *Beck Depression Inventory* (BDI-II), which consists of 21 items and measures the severity of depressive symptoms during the previous two weeks (Beck, Steer, & Brown, 1996). The instrument has good validity and reliability (Beck et al., 1996; Hautzinger, Keller, & Kuehner, 2009). Cronbach's alpha of the German version is ≥ .84 (Kühner, Bürger, Keller, & Hautzinger, 2007), the corresponding value in this sample was .90.

Body dissatisfaction (BD): To assess body shape preoccupations the short-version of the *Body Shape Questionnaire* (BSQ-8C; original English version by Evans & Dolan, 1993; German

version by Pook, Tuschen-Caffier, & Stich, 2002) was used. This self-report questionnaire relates to the last four weeks. The approved shortened form of the BSQ shows good convergent and discriminant validity as well as reliability (Evans & Dolan, 1993). Cronbach's alpha for this sample was .90. Values below 19 indicate no concerns with shape, scores from 19 to 25 refer to mild concerns with shape, and for values above 25 moderate to marked concerns with shape have to be considered (Evans & Dolan, 1993).

Disturbed Eating and Compensatory Behavior (DECB): In order to avoid a conceptual overlap between the variable BD and the weight- and shape concerns from the *Eating Disorder Examination Questionnaire* (EDE-Q; original English version by Fairburn & Beglin, 1994; German version by Hilbert & Tuschen-Caffier, 2006), we created a new variable named *Disturbed Eating and related Compensatory Behaviors* (DECB). This DECB scale describes symptoms of ED pathology such as restrained eating (items 1–5), binge-eating (item 15), self-induced vomiting (item 16), taking laxatives (item 17) and excessive exercising (item 18), while omitting items regarding shape and weight-concerns. Items 1–5 were scored on a scale from 0 to 6; items 15–18 were coded based on the given occurrences of binge-eating (number of days in the last month), as well as purging, exercising and use of laxatives (number of events in the last month). The EDE-Q has demonstrated good psychometric properties and has shown to be suitable to detect significant symptoms of EDs in individuals of the general population (Mond, Hay, Rodgers, Owen, & Beumont, 2004). Cronbach's alpha for the global score is .97 and subscale values range from .85 to .93 (Hilbert, Tuschen-Caffier, Karwautz, Niederhofer, & Munsch, 2007). Corresponding values in our sample were .82 for the global score and .80 for the new DECB scale.

Emotion dysregulation: The *Difficulties with Emotion Regulation Scale* (DERS; Gratz & Roemer, 2004) (German version by Ehring, Fischer, Schnulle, Bosterling, & Tuschen-Caffier, 2008) is a 36-item self-report questionnaire assessing six dimensions of emotion regulation: none acceptance of emotions, difficulties in engaging in goal directed behavior, impulse control difficulties, lack of

emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity. All scales showed good internal consistencies (α = .81–.95) and validity (Ehring et al., 2008; Gratz & Roemer, 2004). Cronbach's alpha of the DERS global score in the present sample was .93.

Cognitive distortions (TSF): The *Short Trait Thought Shape Fusion Scale* (TSF trait scale; Coelho et al., 2013) provides an assessment of eating and body image related cognitions. Coelho and colleagues (2013) developed a short version of the original trait TSF scale (Shafran et al., 1999) consisting of 14 items assessing the TSF concept and 4 items to measure the clinical impact. The scale was translated into German and back translated (German version, available from the authors). Cronbach's alpha for the 14-items scale "concept" in this sample was .87. This scale has not yet been validated for the male population.

2.3. Data analysis

We conducted a multiple mediation model with two mediators operating in parallel and being allowed to correlate with each other (see model 4 in Hayes, 2012). In this model, the variable body dissatisfaction (BD) was the independent variable, dysfunctional eating and compensatory behavior (DECB) the dependent variable, and variables cognitive distortions and emotion dysregulation the two mediators (see Figure 1). Participants' age, BMI as well as depressive symptoms were included as covariates since they were previously shown to be associated with disturbed eating. Variables BD, cognitive distortions, DECB and the covariates were all log-transformed, and the variable emotion dysregulation was square-root transformed. Confidence limits were estimated using bootstrapped samples (*N* = 5000) with adjusted bootstrap percentiles (BCa). Statistical analyses were conducted with the statistical software R version 3.1.3 (2015), including the R package "lavaan" (Rosseel, 2012).

3. RESULTS

3.1. Descriptive Analysis

Descriptives of the assessed variables are listed in Table 1. Mean global score of the EDE-Q was 0.53 (SD=0.63). Three participants (2.4%) scored higher than 2.09 on the EDE-Q global score, which refers to elevated ED psychopathology (Lavender, De Young, & Anderson, 2010). According to the cut-off values for the BSQ, 14 participants (11.4%) reported elevated BD. Twelve participants (9.8%) scored above the cut-off of the BDI-II. Regarding the dependent variable DCEB, 18 (14.6%) participants scored above the mean value plus one standard deviation (M=0.35, SD=0.61), which refers to a comparatively distinct tendency to disturbed eating and compensatory behavior in this subgroup.

Insert Table 1 here

3.2. Mediator Model

In the following, we report unstandardized coefficients including standard errors and *p*-values in the text, whereas standardized coefficients and additional statistics are reported in **Error! Reference source not found.** The total effect of BD on DECB was significant (c = 0.37, SE = 0.07, p <.001). Moreover, BD was significantly associated with increased body-related cognitive distortions (TSF) (a_1 = 1.49, SE = 0.25, p <.001), as well as with increased emotion dysregulation (a_2 = 1.42, SE = 0.35, p <.001). Furthermore, increased level of TSF was significantly associated with increased DECB (b_1 = 0.09, SE =0.03, p <.001), but there was no significant association between emotion dysregulation and DECB (b_2 =–0.03, SE =0.02, p = 0.09). The direct effect of BD on DECB, controlling for TSF and emotion dysregulation, was smaller compared to the total effect, but remained significant (c' = 0.29, SE =0.08, p =.001). To quantify the difference between the total and the direct effect, indirect effects of the two mediators on DECB were assessed. While the indirect pathway of BD on DECB through TSF was significant (a_1*b_1 = 0.13, SE =0.04, p

=.001, the indirect pathway of BD on DECB through emotion dysregulation was not (a_2*b_2 =– 0.05, *SE* =0.03, *p* = 0.12). Thus, the pathway via TSF was of higher magnitude than the pathway via emotion dysregulation (a_1*b_1– a_2*b_2 = 0.18, *SE* =0.05, p=.001). The correlation between the two mediators TSF and emotion dysregulation was *0.10* (*p* = 0.076). The mediator model explained 43% of the total variance in DECB.

Insert Table 2 here

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4. DISCUSSION

While only 2.4% of men in our study reported clinically significant symptoms of EDs, a larger proportion of men (14.6%) reported symptoms of disturbed eating and compensatory behavior on a subclinical level. Previous studies have shown that such symptoms might lead to the development of clinically significant ED pathology (e.g., Fiske et al., 2014; Neumark-Sztainer et al., 2006; Paxton et al., 2006). In order to better understand the mechanisms underlying the relationship between BD and DECB, we proposed a model of disturbed eating behavior in men, in which emotion dysregulation and the susceptibility to body-related cognitive distortions such as TSF act as mediators. We tested the model in a cross-sectional online survey on a sample of healthy young men living in Switzerland, and included participant's age, BMI and depressive symptoms as covariates.

In accordance with the proposed theoretical model, we found a significant positive association between BD and DECB, which is consistent with previous findings describing BD as a risk factor for disturbed eating and unhealthy weight and shape regulation strategies in women and men (e.g., Neumark-Sztainer et al., 2006).

It is worthy of note that of the covariates BMI, age, and depressive symptoms in our model none were significantly related to the DECB. This might be due to an overall good mental

and physical condition of our sample consisting mostly of young male students, as indicated by relatively low variance in BMI, depression scores and emotion regulation skills. Only 9.8% of our participants showed any significant depressive symptoms and only 13% exceeded a critical value regarding emotion regulation difficulties. It would be desirable if our model could be reevaluated in a more representative, and probably less homogenous sample.

Consistent with our hypothesis, we demonstrated for the first time, the mediating effect of TSF on the association between BD and DECB in a sample of young men. This emphasizes the importance of TSF in relation to disordered eating in men. It has been demonstrated in studies with female populations that the experience of such body-related cognitive distortions can be induced by the exposure to food items or thin ideals (e.g., Coelho et al., 2008; Wyssen, Coelho, Wilhelm, Zimmermann, & Munsch, submitted). Since exposure to fattening foods and body ideals occur repeatedly on a daily basis, future studies should emphasize the role of cognitive processes such as TSF as maintenance factors of EDs and especially focus on behavioral consequences such as the urge to diet or frequent body checking (e.g., Coelho et al., 2008).

Our analysis did not reveal a relation of depressive symptoms with DECB nor a significant association between the correlates of an overall disturbed emotion regulation capacity and ED symptoms (e.g., Stice, 2001). These findings are in contrast to previous theories such as the escape-theory (Heatherton & Baumeister, 1991), where disinhibited eating in women is seen as an attempt to regulate negative affective states and thus represents a dysfunctional emotion regulation strategy. Previous literature (Svaldi, Griepenstroh, Tuschen-Caffier, & Ehring, 2012) showed that according to the DERS, women suffering from EDs more often report higher emotion intensity and lower acceptance of emotions, less emotional awareness and clarity and use rarely functional but more frequently dysfunctional strategies than healthy controls. Also in men, Lavender and Anderson (2010) found that disordered eating and BD were both predicted by BMI, negative affect and the DERS global score. In our sample we could not confirm these findings, even though scorings of our sample were comparable to those of the slightly younger

sample of male college students in the Lavender and Anderson's study., Future studies should assess emotion regulation difficulties also on a behavioral level in order to better understand the different aspects of emotion regulation and their relation with disordered eating behavior. Additionally, dysfunctional emotion regulation tendencies such as ruminating about one's own body shape may lead to further clarification. This is supported by the recent finding that rumination induction increased ED pathological behavior in women suffering from EDs (Naumann, Tuschen-Caffier, Voderholzer, Caffier, & Svaldi, 2015). In the same vein, it remains unclear, whether men's tendency to engage in automatic and non-conscious emotion regulation processes (Nolen-Hoeksema, 2012), which are not addressed by the DERS, might represent a more gender-specific emotion regulation attribute relating to ED symptoms. Therefore, future studies should adopt a multimethod approach including not only self-reported emotion regulation strategies, but also the manipulation of automatic emotion regulation processes (such as through priming or training) in order to investigate the influence of non-conscious emotion regulation processes on disturbed eating in young men.

The present study has several limitations that warrant attention. First of all, the cross-sectional design of our study does not allow drawing any conclusions about the causality of the relationship among the variables involved. Future studies should therefore investigate the proposed model in a longitudinal setting to examine whether BD subsequently affects susceptibility to TSF and whether TSF in turn affects disturbed eating behavior. Secondly, the sexual orientation of men in our sample was not assessed. Evidence has shown that homosexual compared to heterosexual male adolescents and young adults tend to be more dissatisfied with their appearance (e.g., Jankowski, Diedrichs, & Halliwell, 2014). It would therefore be interesting to investigate whether the coefficients in our model differ depending on men's sexual orientation. Sociocultural factors, such as exposure to mass media presenting unrealistic male body ideals and the associated degree of internalization of the ideal as well as the perceived pressure to conform to this ideals may have further impact on the variables in our model and

should be included in future models (Barlett, Vowels, & Saucier, 2008). Another drawback of this study is the use of some questionnaires that have been originally developed for women and then adapted for men (such as the BSQ), as they focus on the drive for thinness and possibly neglect specific male concerns about losing body fat and gaining muscles (e.g., McCreary, Sasse, Saucier, & Dorsch, 2004; Tylka, Bergeron, & Schwartz, 2005). Finally, the present sample does not represent the general Swiss population, as it predominantly consists of young students of Swiss and German nationality, which may explain the somewhat lower prevalence of BD in our male sample (11.4%) compared to representative previous studies (Fiske et al., 2014). Moreover, the present sample exhibited lower scores on the EDE-Q, when compared to those reported by Lavender et al. (2010). Compared to other online-studies in which dropout rates amount up to 42.7% (e.g., Jankowski et al., 2014), the dropout rate of 12.8% in our study is relatively low. Nevertheless, the comparably lower BD and DECB in our sample might partly be due to the fact that participants, who prematurely terminated the online survey were distinguished by higher levels of shape concern and general symptoms of disordered eating.

To conclude, our model confirmed the role of TSF as a potential mediator in the relationship between BD and disturbed eating, but did not identify emotion regulation as a corresponding mediator. Overall, the model explained 43% of the variance in disturbed eating and compensatory behavior of men. Even though the present findings have to be reassessed in larger samples and based on a longitudinal design, in the present sample of young and healthy male participants TSF seems to represent a cognitive vulnerability that needs to be taken into account when describing underlying mechanisms associated with BD and disordered eating behavior. It is assumed that the susceptibility to TSF impacts self-related information processing and has emotional and behavioral consequences. Men with high BD may be prone to experience fear of weight gain following a simple confrontation with e.g. food or the prospect of physical inactivity (such as described in the TSF concept). The resulting negative affect may increase the risk of dysfunctional weight and shape regulation behavior. While it has already been shown

that in women food items and thin ideals may provoke such reactions it has yet to be investigated, whether similar processes are present in men. As TSF has emerged to be an important mediator in the relationship between BD and DECB, research is needed to examine which gender-specific triggers induce such cognitive processes and behavioral reactions in men (e.g. specific food items or muscularity ideals). Future research should also include samples of the clinical as well as the general population.

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CONFLICT OF INTEREST

None.

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TABLES AND FIGURES

FIGURE 3: THE MEDIATION MODEL OF DISTURBED EATING IN MEN.

Note. Standardized regression coefficients. Direct effect of Body dissatisfaction (BD) to DECB (*Beta*=0.43, *SE*=0.09, *z*=4.67, *p*<.001). Global indirect effect: BD – (Thought-Shape Fusion & Emotion dysregulation) – DECB (*Beta*=0.56, *SE*=0.08, *z*=7.09, *p*<.001). The covariance between Emotion Dysregulation and Thought-Shape Fusion is 0.10 (*SE*= 0.06, *z*= 1.77, *p*= 0.08).

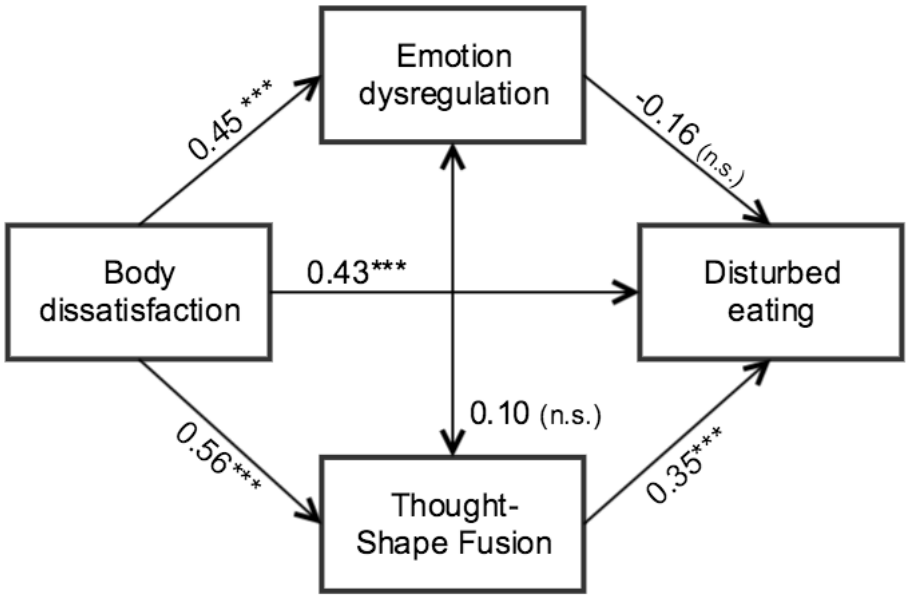

TABLE 1. DESCRIPTIVE STATISTICS. Range, means, standard deviations, and clinical cut-off for all variables involved in the study.

Variable	Range	Mean	SD	Cut-off
Age	18–37	23.75	3.17	-
BMI	18.22–41.58	23.27	3.05	18.5<x>25[1]
BDI-II	0–38	5.98	6.74	>13[2]
EDE-Q global	0–3.91	0.53	0.63	>2.09[3]
EDE-Q DECB	0–4.22	0.35	0.61	-
BSQ short	8–39	12.85	6.02	>18.00[4]
DERS global	37–141	78.50	20.43	>99.45[5]
TSF	0–28	2.99	5.49	-

Note: 1) Body Mass Index; Normal weight according to the World Health Organization (WHO); 2) Beck Depression Inventory; Values from 0–13 refer to none or minimal, 14–19 to mild, 20-28 to moderate, and 29 or above to severe depressive symptoms (Hautzinger et al., 2009); 3) Eating Disorder Examination Questionnaire; Mean plus one standard deviation according to (Lavender et al., 2010); 4) Body Shape Questionnaire; cut-off according to (Evans & Dolan, 1993); 5) Difficulties in Emotion Regulation Scale; Mean plus one standard deviation according to (Gratz & Roemer, 2004)

TABLE 2. RESULTS OF THE PATH ANALYSIS testing the coefficients of the proposed Model of Disturbed Eating in Men. Note: standardized coefficients, bootstrapped by N=5000.

Outcome	Predictor[1]	Path	Estimate	z-Value	LCI	UCI
Cognitive distortions (TSF)	BD	a_1	0.56	6.05^{***}	0.36	0.73
Emotion dysregulation (DERS)	BD	a_2	0.45	4.11^{***}	0.20	0.63
DECB	TSF	b_1	0.35	3.51^{***}	0.15	0.54
	DERS	b_2	–0.16	$-1.66^{(n.s.)}$	–0.34	0.03
	BD	c'	0.43	3.41^{**}	0.20	0.70
	BMI		0.04	$0.52^{(n.s.)}$	–0.11	0.21
	Age		0.04	$0.60^{(n.s.)}$	–0.10	0.19
	BDI-II		–0.00	$–0.05^{(n.s.)}$	–0.14	0.14
Indirect effect 1 (via TSF)		a_1*b_1	0.20	3.30^{**}	0.08	0.31
Indirect effect 2 (via DERS)		a_2*b_2	-0.07	$–1.57^{(n.s.)}$	–0.17	0.01
Difference in indirect effects		$a_1*b_1 – a_2*b_2$	0.27	3.37^{**}	0.10	0.42
Total effect *c*		$a_1*b_1 + a_2*b_2 + c'$	0.56	5.66^{***}	0.36	0.75

[1] Terms written in italics denote covariates

*** = p<.001;** = p<.01; n.s. = non-significant; DECB Disturbed Eating and Compensatory Behavior; BD Body Dissatisfaction; TSF = Thought Shape Fusion; BDI = Beck Depression Inventory; DERS = Difficulties in Emotion Regulation Scale; LCI/ UCI =lower/upper confidence interval.

C) Publication 3

Bryjova, J., Gross, J.J., Meyer, A.H., Kurz, S., Dremmel, D., Hilbert, A. & Munsch, S. (in preparation). Self-Control Strategies during the Delay of Gratification.

Self-Control Strategies during the Delay of Gratification

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Self-Control Strategies during the Delay of Gratification

Abstract

While attentional deployment is an effective strategy to increase success during the delay of gratification (DOG) task, the role of self-touch has not been investigated in context of self-control yet. In the present study, we observed attentional deployment and the self-touch behavior in children aged 8-13 with clinical diagnosis of Binge Eating and/or Attention-Deficit/Hyperactivity Disorder during the DOG. We tested group differences regarding the success during DOG; and the employment of the two self-control strategies. Subsequently, we conducted penalized survival analysis to predict the probability of snacking during the DOG from attentional deployment and the left-handed self-touch and included the child's age, sex, body mass index (BMI), clinical diagnosis, impulsivity, and the right-handed self-touch as covariates. We did not find any significant difference between the two groups regarding the ability to delay gratification; neither did the two groups differ in the use of the two self-control strategies. However, the probability of snacking significantly decreased with greater proportions of attentional deployment and left-handed self-touch; and the female sex significantly increased the risk of snacking during the DOG. We conclude that besides attentional deployment, the left-handed self-touch is an effective strategy that impulsive children can acquire and use in situations requiring self-control.

Keywords: impulsivity, attentional deployment, self-touch, self-control, delay of gratification.

Self-Control Strategies during the Delay of Gratification

Introduction

The choice between a less preferred but immediately available option and a more preferred but delayed option is frequently experienced by school-age children, for example when they are saving their allowance for a purchase, or studying in order to excel at school. Coping with situations like this requires self-control, which can be defined as the voluntary regulation of attentional, emotional, and behavioral impulses that conflict with more enduringly valued goals (Duckworth, Gendler & Gross, 2014).

Self-Control in Childhood and Adolescence

Self-control is a capacity that emerges in infancy (Kochanska, Coy & Murray, 2001; Vaughn, Kopp & Krakow, 1984) and continues to develop throughout early school years (Posner & Rothbart, 2000). Unlike state self-control, which varies as a function of factors such as mood (Fishbach & Labroo, 2007), working memory load (Hofmann et al., 2007), and motivation (Muraven, 2008), dispositional self-control is relatively stable across situations and over time (Hay & Forrest, 2006) and has been equated with low trait impulsiveness (de Ridder et al., 2012).

In childhood, the self-control capacity can be assessed via the delay of gratification (DOG) paradigm. During the DOG, children who are able to resist an immediately available, but less preferable gratification, achieve a more preferred but delayed outcome (Mischel, Shoda & Rodriguez, 1989). Thus, delay of gratification occurs whenever a child chooses e.g. studying over a more tempting activity in short-term perspective such as e.g. playing with friends or watching TV. Indeed, a successful delay of gratification in preschool children predicted attentiveness, ability to concentrate and

control over negative affect, as reported by parents when the children were adolescents (Mischel, 1983; Shoda, Mischel & Peake, 1990). The ability to delay gratification in childhood is further associated with long-term outcomes in adulthood such as financial success, and physical and mental well-being (Moffitt et al., 2011). On the other hand, inability to successfully delay gratification in adolescence is associated with poor self-concept, poor academic performance and a greater use of substances such as nicotine, alcohol and marihuana (Wulfert et al., 2002).

Clinical Impairment of Self-Control

In clinical context, poor self-control is related to the Attention-Deficit/Hyperactivity Disorder (ADHD). School-aged children with ADHD are known to prefer smaller immediate rewards over a larger delayed reward compared to healthy controls, an effect that is even more pronounced when choosing the smaller reward reduces the duration of the trial (Marco et al., 2009; Schweitzer & Sulzer-Azaroff, 1995; Sonuga‐Barke et al., 1992). Poor inhibitory control, delay aversion, as well as deficits in executive functions in ADHD is frequently associated with dysfunctional eating behavior patterns, such as binge eating (Cortese, Dalla Bernardina & Mouren, 2007; Davis et al., 2006; de Zwaan et al., 2011; Müller et al., 2014b). Indeed, the co-occurrence of binge-eating symptoms in children with ADHD is relatively frequent and amounts up to 61% in children and adolescents (Biederman et al., 2007; Erhart et al., 2012; Neumark-Sztainer et al., 1995). This relationship can be explained by the heightened reward sensitivity and an impaired capability of controlling impulses, which is known to be associated with both binge eating and ADHD (Dawe & Loxton, 2004; Nederkoorn et al., 2006).

A second clinical disorder associated with diminished self-control is Binge Eating Disorder (BED). One of the most prominent symptoms of BED is the experience of loss

of control over eating, i.e. a feeling that one cannot stop eating, or control what or how much is one eating (APA, 2013). Several studies in adults have demonstrated impaired self-control and diminished ability to delay gratification in adults and young adolescents with binge eating (Davis et al., 2010; Müller et al., 2014a; Nederkoorn et al., 2007; Svaldi et al., 2014; Woznica, 1990), while a significant reduction of binge eating symptoms was associated with gaining flexible control over eating (Downe, Goldfein & Devlin, 2009; Goodrick et al., 1998; Stice et al., 2005; Tangney, Baumeister & Boone, 2004; Williamson et al., 2008).

To sum up, studies demonstrate diminished self-control including impaired ability to delay gratification in children and adolescents with clinical symptoms of BED and ADHD. Particularly binge eating is associated with experienced difficulties in delay of gratification in form of loss of control over eating. In this study, the reward was present in form of an immediately available palatable snack. Therefore we expected that children with a clinical diagnosis of BED and/or ADHD would demonstrate an equally reduced ability to delay gratification, compared to the healthy control group.

Besides impulsivity and psychiatric symptoms, failure in self-control can be related to an insufficient use of self-control strategies such as e.g. attentional deployment (Bourget & White, 1984; Rodriguez, Mischel & Shoda, 1989) and self-touch (Barroso, Freedman & Grand, 1980). In this study, we aimed at investigating how these strategies affect child's ability to delay gratification.

Attentional Deployment and Self-Touch as Strategies of Self-Control

In school-aged children, effortful self-control has been shown to be fostered by employing attentional deployment (Duckworth et al., 2014; Mischel et al., 1989). Attentional deployment is an individually varying ability to voluntarily sustain focus or

shift the attention away from distracting elements (Fox & Calkins, 2003), that emerges early in infancy (Sethi et al., 2000) and can assume a more or less active form, ranging from gaze aversion (Fox, 1989) to engagement in alternative activities (Braungart & Stifter, 1991). Attentional deployment in form of distraction prolonged the delay duration in preschoolers, even if the reward was present, whereas actively attending to reward significantly reduced the delay time regardless of the nature of distraction (Peake, Hebl & Mischel, 2002).

Despite some studies pointing out that healthy controls seem to generally adopt more adaptive self-control strategies compared to individuals with ADHD and BED (Schweitzer & Sulzer-Azaroff, 1995; Solanto et al., 2001; Tangney et al., 2004; Young, 2005), other studies show that children with adjustment and impulsivity-related problems can succeed in DOG once they assume the strategy of attentional deployment, and their success is proportional to the time spent distracting themselves from the tempting elements (Bourget & White, 1984; Rodriguez et al., 1989).

While there is research on attentional deployment and other cognitive self-control strategies in school-age children (Duckworth et al., 2014), the influence of body-oriented self-control strategies is much less evaluated in children and adults. Self-touch, defined as any touching of the own body (Barroso et al., 1980; Kimura, 1973a; Kimura, 1973b; Trevarthen, 1996) is considered a nonverbal regulatory strategy that contributes to stabilization of the state of emotion and arousal (Freedman & Bucci, 1981; Lausberg, 2013b; Trevarthen, 1996).

Tactile self-stimulation in form of self-touch has been observed in several studies with infants whose age ranged from zero to twelve months, especially in situations of tiredness and mild distress (Moszkowski & Stack, 2007; Toda & Fogel, 1993; Trevarthen,

1996), and thus can be seen as an attempt of the infant to regulate it's affective state. In school-aged children, observational studies show a peak of self-regulatory self-touch while performing cognitive tasks such as vocabulary task (Freedman, 1977), or the Stroop test (Barroso et al., 1978). Studies indicate that the self-directed movements in situations requiring self-control are predominantly performed with the left side of the body (Montirosso et al., 2012; Saucier & Elias, 2001; Trevarthen, 1996). Grounded in the empirical evidence on the spontaneous left-hand preference for self-touch indicating the hemispheric specialization of the right hemisphere in the generation of self-touch (Blonder et al., 1995; Kimura & Harshman, 1984) as well as in the regulation of stress responses and emotional engagement (Henry, 1993; Schore, 2005); it has been suggested, that this in turn triggers the left-hand use (Lausberg, 2013b; Trevarthen, 1996).

Based on the empirical research presented above, we argue that the left-handed self-touch, like attentional deployment, constitutes a strategy that extends the capacity of self-control in emotionally or cognitively challenging situations. While there is an ample empirical evidence demonstrating the effectiveness of attentional deployment as a self-control strategy in delay of gratification, this is the first time that the left-handed self-touch was investigated as a self-control strategy during the DOG experiment. Additionally, the current state of knowledge does not allow any conclusions whether individuals with BED and/or ADHD differ from healthy controls when it comes to the use of these two strategies during the DOG.

The Present Study

Our goal in the present study was to examine the performance of children with self-control impairments and healthy controls during the DOG experiment. Furthermore, we aimed at investigating the effectiveness of attentional deployment and the left-handed

self-touch as strategies of self-control during the DOG. First, we expected to find in children with clinical diagnoses of BED and/or ADHD a greater preference for an immediately available reward, compared to their sex- and BMI matched healthy peers. Second, we expected the attentional deployment and the left-handed self-touch to predict the successful delay of gratification. Finally, we aimed at clarifying whether children in the clinical group differ from the children in the control group with regard to the use of the two self-control strategies.

Methods

Participants

Altogether, data from 69 children aged 8-13 years (57% female, 97% Caucasian) were analyzed; with a mean age of 11.04 (SD=1.31), and a mean BMI of 20.23 (SD=3.97). Children in the clinical group (N=47) had either a clinical diagnosis of BED, and/or a clinical diagnosis of ADHD (see Table 1 for overview). The healthy children in the control group (N=22) were matched with the children from the clinical group according to sex, age, and BMI.

The present study was embedded in the Swiss University Study of Nutrition (SUN, Munsch & Hilbert, 2010), approved by the Ethics Committee of the Canton Fribourg, Switzerland, as well as the Department of Psychology of the University of Fribourg, Switzerland. A total of 1,741 school-age children (3^{rd} to 6^{th} grade) were recruited from 35 primary schools in Switzerland (Cantons Bern, Fribourg, and Lausanne) and screened for ADHD symptoms via Conners ADHD-Index-Self-Report-Form (Conners, 2001; Dremmel, De Albuquerque & Munsch, in preparation-a) and symptoms of BED with the Eating Disorder Examination-Questionnaire for Children (EDE-Q, Carter, Stewart & Fairburn, 2001; Dremmel, De Albuquerque & Munsch, in

preparation-b). Children that screened positively for BED and/or ADHD symptoms (N=559) were further contacted in order to complete the telephone diagnostic screening that involved assessment of ADHD symptoms via the revised Conners' Parent Rating Scale (CPRS-R, Conners et al., 1998a) and teacher's report (CTRS-R, Conners et al., 1998b), and assessment of the child's BED symptoms via Child's EDE-Q (ChEDE-QMarcus & Kalarchian, 2003). A total of 104 children who met the inclusion criteria, and the diagnostic criteria for BED-and/or ADHD symptoms, as well as age-, sex- and BMI-matched controls with no present or lifetime diagnosis of mental disorder according to the Kiddie-SADS assessment (K-SADS-PL, Kaufman et al., 1997) participated in the experimental part of the study. Because of technical difficulties, only 70 videos were obtained from the final sample of 104 children, and since only videos that showed the whole body of the child facing the camera were included in the coding procedure (Lausberg & Sloetjes, 2009), one participant was excluded, resulting in the final sample of 69.

Procedure

The delay of gratification (DOG) task was embedded within the experimental session of the SUN study. The experiment was video recorded and the videos were rated subsequently. In the following sections, we first describe the experimental procedure, followed by description of the movement behavior coding.

The delay of gratification (DOG) task. The experimental session in the lab took place in the mid-afternoon, approximately 3 hours after lunch; in a small and relatively scarcely furnished room with little distractors containing a table, a chair, a mirror, a TV screen, and a weight scale. In the first part of the experiment that was concealed as the 'smelling test', small samples of potato chips, Yupi gummy apple rings, and chocolate

chip cookies were presented to the child on a tray separately. The child was then prompted by the experimenter to smell the presented items and declare which one of them he or she preferred the most, as well as to indicate how many packages (up to three possible packages) of the preferred snack he/she would like to be rewarded with at the end of the experimental session. After the "smelling test", two computer experiments addressing the reward sensitivity followed, interrupted by a short five-minute break. The DOG task followed as the last experiment in the sequence. At the beginning, the child filled out a brief questionnaire containing questions addressing their current state of hunger and satiety as well as the craving for the chosen snack. Then the child was told that he/she is now going to be rewarded for his or her participation with the snack item that they had identified as most desirable during the "smelling test". The experimenter put a small sample of the snack on a table in front of the child and indicated that she is going to get the rest from the other room, however, she must make an urgent phone call first. She said to the child: *"You can either wait for me to return or start eating right away. However, if you begin to eat before I come back, you will only receive the rest of the snack that had already been opened during the 'smelling test'".* After the instruction, the experimenter left the room for fifteen minutes. The entire waiting period was video recorded. There was no clock present in the room, however some of the children were wearing a wristwatch.

Behavioral coding in ELAN. Child's movement behavior was coded according to the NEUROGES gesture coding system (Lausberg, 2013b) with the ELAN annotation tool (Auer et al., 2010; Lausberg & Sloetjes, 2009) by five independent raters previously trained in the coding system. Besides child's movement behavior, the duration of delay and the attentional deployment were also coded with the ELAN annotation tool. For inter-rater reliability, each rater dyad coded 15% percent of the video footage independently.

The raw agreement, as well as Cohen's Kappa values were established for each movement category of the NEUROGES coding system (Holle & Rein, 2014).

Measures Derived from the Behavioral Coding

Attentional deployment. Attentional deployment was determined by child's active aversion of his/her gaze away from the table on which the desired snack was placed (Metcalfe & Mischel, 1999). Thus, we coded attentional deployment for the period of time during which the participants turned their head or the whole body at least 45 degrees in any direction away from the table, or were covering their eyes with hands.

Self-touch. Self-touch was coded as the *on body* movement focus category in the NEUROGES gesture coding system (Lausberg, 2013b; Lausberg & Sloetjes, 2009). The NEUROGES coding system is a tool for empirical research on movement behavior, that is based on a kinetic and functional analysis of arm movements (Lausberg & Sloetjes, 2009). In the NEUROGES-ELAN gesture coding system, the *on body* movement can have a phasic, irregular or repetitive structure. The NEUROGES-ELAN coding system has been validated in several studies, demonstrating good psychometric properties, with reported Cohen's Kappa values for the intra-rater reliability for the *on body* movement ranging from .79 to 1.0 (Lausberg, 2013b). In the present study, the mean raw inter-rater agreement across five rater dyads for the *on body* category was .90 (SD=.08) and the Cohen's Kappa was .57 (SD=.28). The values are equivalent to those reported by the developers of the coding system (Lausberg, 2013a).

Other Measures

Body Mass Index (BMI). Body mass index was computed as child's weight in kg divided by height in m^2. Weight and height were measured using a standardized balance and a stadiometer.

Impulsivity. The trait impulsivity was assessed in the present study with the UPPS impulsive behavior scale (Lynam et al., 2006) that had been translated and back-translated from English into German and French language and adopted for children. The scale consists of 60 items, and comprises five subscales (positive urgency, negative urgency, lack of premeditation, lack of perseverance, and sensation seeking). Each item is provided with child-appropriate example that can be rated on a visual analogue scale ranging from 1 (agree) to 4 (do not agree at all). In the present sample, the Cronbach's alpha for the total score in the UPPS scale was .93.

Craving. In order to control for the extent of child's hunger and craving for the selected snack at the beginning of the DOG experiment, we created a short self-report scale which consisted of four items: "Are you feeling hungry?"; "Are you feeling satiated?"; "How bad do you want to eat right now?"; and "Do you like the food?". All four items were rated on a visual analogue scale ranging from 1 (not at all) to 7 (extremely). The second item was reversed for the purpose of building the composite score. The overall Cronbach's α for this scale was .73.

Data Reduction and Statistical Analysis

A successful delay of gratification occurred, when the child did not eat during the absence of the experimenter at the DOG. The delay was coded as unsuccessful, when the child was eating, licking or nibbling on the snack that was present on the tray in front of him/her. The variable Duration of Delay was established as time that passed from the start

of DOG, after experimenter's leave until the onset of eating in case the child ate; or until the return of the experimenter, in case the child did not eat.

In order to establish comparable values for the duration of self-touch as well as the duration of attentional deployment for children that either did/or did not eat, the parameter proportion of time (PoT) was established, as seconds of the value per video minute (Lausberg, 2013b).

An initial analysis was performed in order to test the group differences regarding the success in DOG, Duration of Delay, Attentional Deployment, and the Left-Handed (LH) Self-Touch. We analyzed the dichotomous variables with the Pearson's Chi-Square Test; and the continuous variables with the T-test for independent samples.

In the main analysis, we tested the Cox proportional hazard (PH) model for time-to-event-data in order to assess the absolute risk of snacking for of the LH Self-Touch and the Attentional Deployment. The event was defined as eating or snacking during the DOG; and the survival time was defined as milliseconds until onset of snacking or the end of experiment (Duration of Delay). Both linear and curvilinear fits of the LH Self-Touch were examined using orthogonal polynomial transforms, in order to assess the independent effects of these two types of trends. Child's age, sex, BMI, impulsivity, craving and the right-handed self-touch were added to the model as covariates (sequentially, first to last). For the purpose of testing the Cox PH model, we created a dummy variable named "Clinical Content" that indicated the presence of clinical symptoms of the child such as BED, and/or ADHD. All other variables were z-standardized. To avoid effects of overfitting, the predicted risks were calculated using the LASSO penalized regression technique, with the lambda for quadratic penalty parameter referring to Ridge regression set to zero (Friedman, Hastie & Tibshirani, 2010).

The statistical analyses were performed using the statistical software R, version 3.1.3. (2015). We used the "survival" package for conducting the time-to-event analysis; and the "penalized" package for the LASSO model selection. The orthogonal polynomials of LH Self-Touch were computed using the package "stats" for R.

Results

Insert Table 1 here

Preliminary Analyses

As indicated in the Table 1, the clinical group did not differ significantly from the healthy control group regarding the mean age ($t(67)=-1.75$; $p=0.09$), sex ($\chi^2(1,69)=1.79$; $p=0.20$), and BMI ($t(67)=-0.06$; $p=0.10$). There was no significant difference between the two groups regarding the success in DOG ($\chi^2(1,69)=1.25$; $p=0.26$); and the groups did not differ significantly in the mean duration of delay ($t(67)=-0.78$; $p=0.44$). Furthermore, the mean impulsivity scores in the clinical group were significantly higher, compared to the control group ($t(67)=3.78$; $p<.001$). We did not find any significant difference between the two groups regarding craving ($t(67)=0.76$; $p=0.45$); the PoT of the right-handed self-touch ($t(67)=-0.58$; $p=0.56$); the PoT of the left-handed self-touch ($t(67)=-0.13$; $p=0.89$); and the PoT of attentional deployment ($t(64)=-0.65$; $p=0.52$).

Insert Table 2 here.

Main Analyses

Results from the Cox PH analysis indicated that the left-handed self-touch significantly predicted the risk of snacking with a negative linear trend (β=-8.27, $p<.01$), and a positive quadratic trend (β=10.77, $p<.001$), suggesting that the risk of snacking during the DOG significantly decreased with increased PoT of the LH self-touch. As indicated by the survival curve depicted in the Figure 2; the probability of snacking in children with high levels of the LH self-touch (>75th percentile, corresponding to the proportion of time of 31% and higher) was significantly lower compared to children with low levels of the LH self-touch (<25th percentile, corresponding to the proportion of time of 8% and less; $\chi^2(10,69)=41.62$; $p<.001$). Similarly, the risk of snacking decreased significantly with increased attentional deployment (β=-0.66, $p<.05$). Additionally, the female sex significantly increased the risk of snacking during the DOG (hazard ratio=1.92, $p<.05$). The overall model had a good fit (Wald test (10) = 28.48; $p<.001$) and explained approximately 45% of the variance (see Table 2). Following variables were selected according to the LASSO penalization as a solution for the Cox PH model with nonzero parameter values and corresponding estimates: LH Self-Touch (quadratic term; 0.431), LH Self-Touch (linear term; -0.425), and Attentional Deployment (-0.003).

Insert Table 3 here

Insert Figure 1 here

Discussion

The aim of the present study was to investigate the ability to delay gratification in children with self-control impairment and the effectiveness of attentional deployment and the left-handed self-touch as self-control strategies.

Clinical Impairment of Self-Control and Success in DOG

Although we found that children in the clinical group had significantly higher impulsivity scores, we did not find any significant differences between the clinical group and the healthy group with regard to the mean duration of delay or their success in delay during the DOG. Similarly, the survival analysis indicated that child's clinical diagnosis of BED and/or ADHD did not significantly predict the success during the DOG, after accounting for child's age, sex, BMI, impulsivity, and the self-control strategies. A possible reason for the insignificant finding might be the fact that the clinical group consisted of children with two distinct clusters of psychiatric symptoms (BED and/or ADHD). In a post-hoc analysis, we found that the symptoms of ADHD, but not of BED were associated with a decreased probability of success during the DOG, which is comparable to previous findings on decreased ability to delay gratification in ADHD (Marco et al., 2009; Schweitzer & Sulzer-Azaroff, 1995; Sonuga‐Barke et al., 1992). On the other hand, the BED symptoms were not associated with an impaired ability to delay of food-related gratification during the DOG. This could be because children with BED are "trained" at self-control in the presence of adults, as they often experience food-related restrictions in their home environments (Carper, Orlet Fisher & Birch, 2000) but cannot resist when being alone in daily life situations. A further possible reason for the comparable performance of the clinical group compared to the healthy control group during the DOG could be that children in the clinical group compensated their high

impulsivity with adopting effective self-control strategies, such as attentional deployment and left-handed self-touch.

Attentional Deployment and Left-Handed Self-Touch as Self-Control Strategies

We found that both attentional deployment and the left-handed self-touch significantly predicted the success in the DOG; even when accounting for child's clinical diagnosis and other factors that might influence the ability to delay, such as age, sex, BMI, impulsivity and craving for the selected snack.

In line with results from other studies (Mischel, Shoda & Peake, 1988; Rodriguez et al., 1989), we conclude that attentional deployment in form of diverting one's gaze away from the tempting snack demonstrates an effective strategy facilitating self-control in school-age children, as suggested in the process model of self-control (Duckworth et al., 2014). Besides the attentional deployment, our results demonstrate for the first time that the left-handed self-touch is an equally effective strategy to facilitate self-control during delay of gratification. Nevertheless, the experimental setup in the present study does not allow us to make any conclusions about the causal relationship between the left-handed self-touch and success in DOG. Future studies should implement brain imaging methods and an experimental manipulation e.g. in form of active inhibition of the use of the left hand in order to better comprehend the underlying mechanism of the left-handed self-touch as a self-control strategy. Furthermore, our results establish the relevance of the laterality of self-touch in context of self-control, as suggested in previous studies (Lausberg & Kryger, 2011; Montirosso et al., 2012; Trevarthen, 1996). The right-handed self-touch did not have any significant predictive value on the risk of snacking during the DOG; despite a significant association between the left- and the right-handed self touch (Pearson's r=0.40, $p<.001$), which probably results from bilateral movements.

Interestingly, we did not find any significant differences between the clinical group and the healthy control group with regard to employment of the two self-control strategies. In order to determine whether these non-significant results favor the null hypothesis of no difference between the groups, we calculated the Bayes factors and obtained values of 0.74 for the PoT of attentional deployment and 0.6 for the PoT of the left-handed self-touch, leading to the conclusion that there is no substantial support in our data for the assumption that children in the clinical group used attentional deployment and the left-handed self-touch equally to their healthy peers (Dienes, 2014). Subsequent studies with a greater sample size are needed in order to clarify this matter.

Gender and Self-Control

Among other variables that are assumed to have an effect on the ability to delay gratification and were included in the Cox PH model as covariates; only the female sex significantly increased the risk of an unsuccessful delay in the present study; somewhat inconsistently with results from a meta-analysis reported by Silverman (2003). In a post-hoc analysis, we did not find any significant differences between the two genders with respect to the use of the self-control strategies. A possible reason for this finding could be that gratification in the present study constituted a palatable snack. Since females perceive sweet snacks as more pleasurable; and at the same time they exhibit significantly more restraint towards snacking, when compared to men (Grogan, Bell & Conner, 1997); we argue that the increased restrained towards a highly desirable snack might have resulted in a break-down of self-control in girls during the DOG (Muraven & Baumeister, 2000). Thus, despite the female gender being known as the one with more self-discipline (Duckworth & Seligman, 2006), it seems that girls experience increased difficulties especially when it comes to exhibiting self-control in context of calorie-intake.

Limitations, Opportunities for Future Research and Clinical Implications

In the following, we wish to address several limitations of the present study. Since the analysis of movement behavior was not originally planned in the study design, child's handedness was not assessed. Some of the analyzed video footage, however, captured the child filling out forms before or after the experiment, or wearing a watch. Based on this information, the hand dominance of the child was estimated. Out of the total 69 children, we were able to estimate the handedness in 54 children. After entering estimate of handedness into the Cox PH model as a covariate, the predictive value of the left-handed self-touch remained significant ($Beta_{LT}$= -7.916; p<.001; $Beta_{QT}$ =11.78; p<.001; R^2=0.46; Logrank test = 38.79 on 11 df; p<.001). Nevertheless, a consequent assessment of child's hand preference, for example via the Edinburgh inventory (Oldfield, 1971) needs to be implemented in future studies. Furthermore, we decided to operationalize self-touch as seconds of the observed body-oriented movement per video minute (proportion of time, PoT). Generally, every movement category of the NEUROGES coding system can be also operationalized in terms of frequency, i.e. the relative number of units of the movement category per a time unit. Because of the continuous structure of body-focused movements that can last for several minutes, several authors suggest that considering PoT in analyses has a higher informative value than frequency (Freedman & Bucci, 1981; Lausberg, 2013b). Contradictory to this argument, neurological findings suggest, that the brain response to unchanging stimuli diminishes over time due to neuronal adaptation, compared to the consistently changing proprioceptive input from dynamic movements that create a stronger effect (Shafir et al., 2013). Bearing this in mind, we conducted a post-hoc analysis with the left-handed self-touch conceptualized as frequency (i.e. number of movement units per minute), and obtained comparable results. Thus, the probability of snacking in children with high frequency of the left handed self-

touch (up to 2.52 left-handed self-touch units per minute; corresponding to the 90th percentile) was significantly lower compared to the children with low frequency of left-handed self-touch (i.e. frequency of <0.36 corresponding to the 25th percentile; $\chi^2(10,69)=41.32$; $p<.001$).

With respect to clinical implications of our findings, we conclude that children with impaired self-control and a clinical diagnoses of BED and/or ADHD can succeed in tasks demanding self-control, such as when preparing for a school exam or engaging in a healthy diet; as long as they employ efficient self-control strategies such as diverting their focus and attention away from tempting elements, and/or performing simple self-touch movements. The left-handed self-touch could be trained and applied in a similar way as the cognitive strategies in the process model of self-control proposed by Duckworth and colleagues (2014). Development and implementation of short exercises involving self-touch movements in a therapy setting or during a class at school could constitute a valuable and cost-effective method facilitating self-control in child's everyday life.

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Table 1. Sample Characteristics. BED: Binge Eating Disorder; ADHD: Attention-deficit/hyperactivity disorder; DOG: Delay of Gratification; BMI: Body Mass Index; RH: Right Hand; LH: Left-Hand.

	BED	**ADHD/BED**	**ADHD**	**Control**	**Analysis**
N (Female)	19 (12)	7 (4)	21 (8)	22 (15)	χ^2 (3, 69) = 4.40 (n.s.)
DOG (N ate)	3	4	10	5	χ^2 (3, 69) = 7.34 (n.s.)
	M (SD)				
BMI (kg/m^2)	21.69 (5.04)	21.10 (2.82)	18.57 (3.00)	20.27 (3.66)	F (3, 68) = 2.32 (n.s.)
Age	11.47 (1.02)	11.28 (1.38)	10.14 (1.20)	11.43 (1.26)	F (3,68) = 5.72**
Duration of Delay (min)	12.85 (5.73)	6.97 (5.30)	8.68 (7.17)	11.41 (5.91)	F (3,65) = 2.42 (n.s.)
Craving	3.79 (1.56)	3.89 (0.93)	3.23 (1.37)	3.30 (1.02)	F (3,65) = 0.99 (n.s.)
RH Self-Touch	20.27 (16.23)	18.65 (11.25)	29.54 (30.89)	20.80 (9.27)	F (3,68) = 0.85 (n.s.)
LH Self-Touch	23.64 (15.77)	19.53 (15.52)	18.22 (18.72)	21.18 (15.57)	F (3,68) = 0.37 (n.s.)
Att. Deployment	20.80 (17.58)	37.73 (34.36)	37.26 (32.82)	35.35 (27.25)	F (3,65) = 1.42 (n.s.)
Impulsivity	28.24 (3.88)	30.34 (6.34)	29.27 (3.50)	24.77 (4.81)	F (3. 68) = 5.15**

Table 2. Results from the Cox Proportional Hazard Model Predicting the Risk of Snacking during the Delay of Gratification Experiment in a Sample of Children with Clinically Relevant Self-Control Impairments and Healthy Controls of Age 8-13 years. BMI: Body Mass Index; RH: Right Hand; LH: Left Hand; LT: Linear Trend; QT: Quadratic Trend

	Coeff.	Exp (Coeff.)	SE (Coeff.)	z	p	LLCI	ULCI
Clinical Content	-0.84	0.43	0.69	-1.21	0.227	0.11	1.69
Sex (female)	0.65	1.92	0.29	-2.28	0.023*	0.30	0.91
Age	-0.56	0.57	0.37	-1.51	0.131	0.28	1.18
BMI	0.25	1.28	0.23	1.10	0.273	0.82	2.01
Att. deployment	-0.66	0.51	0.27	-2.48	0.013*	0.30	0.87
Craving	0.14	1.15	0.30	0.45	0.650	0.64	2.06
Impulsivity	0.17	1.19	0.28	0.63	0.528	0.69	2.04
RH Self-touch	0.27	1.31	0.27	1.03	0.305	0.78	2.21
LH Self-touch^{LT}	-8.27	2.56^{e-04}	2.42	-3.43	<.001***	0.00	0.03
LH Self-touch^{QT}	10.77	4.76^{e+04}	2.44	4.41	<.001***	3.96^{e+02}	5.73^{e+06}

Concordance=0.81 (SE=0.066), R^2=0.446 (max possible=0.92), Likelihood ratio test=37.18 (df=10), p<.001; Wald test=28.48 (df=10), p<.001; Score (logrank) test=41.62 (df=10), p<.001.

Figures

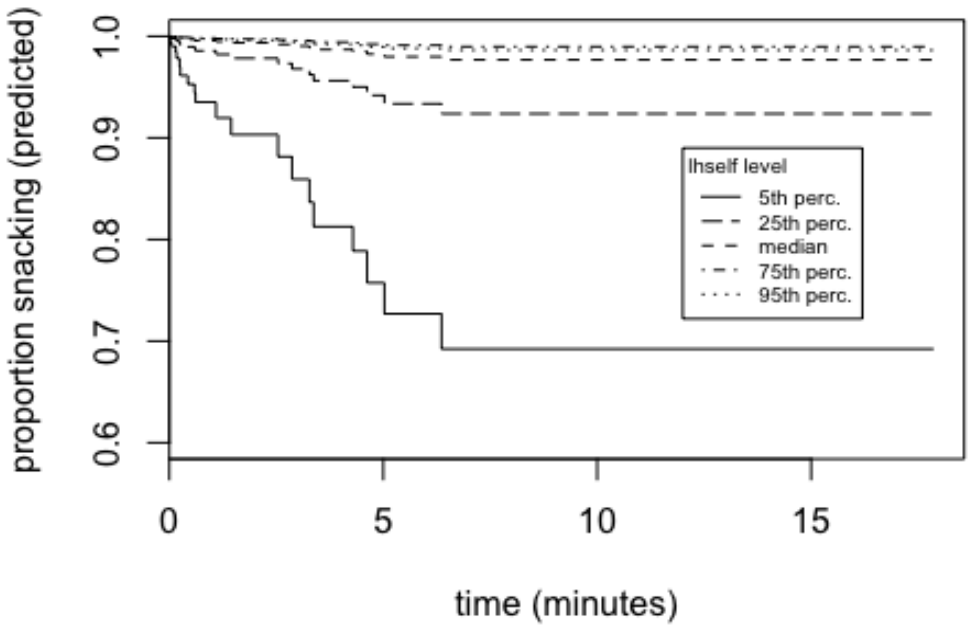

Figure 4 Survival Curve of the Cumulative Probability of Snacking during the Delay of Gratification Experiment according to the Level of the Left-Handed Self-Touch, Adjusted for Child's Diagnosis, Sex, Age, BMI, Impulsivity, Craving, Attentional Deployment, and Right-Handed Self-Touch. Higher Levels of the Left-Handed Self-Touch are associated with Greater Probability of a Successful Delay.