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Getting access to the self: Effects of self-management therapy on the development of self-regulation and inhibitory control in obese adolescents

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Background and aims: This study investigated the role of self-regulation competencies in general and specifically in a food-related context for the control of body weight in a three-year weight loss program. *Methods:* The sample consisted of 30 male and female adolescents (age range: 11–18 years) who participated in a three-year therapy program for severe obesity (mean BMI at the beginning of the intervention was 33.6). Assessment of self-regulation competencies was conducted at three different stages (1^{st}–3^{rd} graduation/class year). Therefore, three independent groups of adolescents (N = 10) at these different stages were tested (initial- to final-stage of therapy). At the time of testing the BMI of these groups significantly differed from 38.8 to 28.7. Analyses of covariance were performed to determine whether the adolescents also differed in self-regulation skills like "resistance to temptation" and food-related Stroop interference along with ameliorating their energy-balance regulation. *Results:* In addition to the main effects of age and body mass index, adolescents further displayed significant improvements of executive functions with respect to resistance to temptation and inhibition. *Conclusions:* Interventions aimed at enhancing energy-balance regulation in adolescents may further benefit from efforts to facilitate executive functions such as self-regulation and food-related cognitive inhibition.

Keywords: adolescents, obesity, self-regulation, development of executive functions

To eat is a necessity, but to eat intelligently is an art.
La Rochefoucauld

INTRODUCTION

Eating is one of the greatest passions of human beings all over the world and is subject to great variability and creativity. Whereas the majority of people suffer from hunger, developed countries show continuing growth of the obesity epidemic, with more and more children and adolescents being affected by overweight and obesity whereas obesity is defined as a body weight above the 95^{th} percentile. The US Centre for Disease Control and Prevention (CDC, 2010) estimates that approximately 17% of children and adolescents between the ages of 2 to 19 years are obese (for the years 2007–2008). Childhood obesity is related to low psychological well-being (Braet, Mervielde & Vandereycken, 1997) – including psychosocial problems resulting from social discrimination and associated inferior self-esteem and learning difficulties and inferior physical health (increased risk of cardiovascular disease resulting from high blood pressure, type 2 diabetes and elevated cholesterol; asthma, sleep apnoea and hepatic steatosis cf. CDC, 2010) that extend into later life. In addition to the substantial personal costs of such eating disorders, there is also a financial burden for the community health services.

The most puzzling and frustrating aspect of the obesity epidemic is the contrast between our understanding of the problem's biology/etiology and our inability to prevent this epidemic development whereby some US authorities suggest the pinnacle has been reached. The majority of interventions are based on the assumption that, given the correct information and motivation, "significant others", in this case, parents, can successfully reduce their own or their children's food intake in the long term or increase physical activity to effect energy balance (Reinehr et al., 2001). An alternative view to this is that eating is an automatic behavior, controlled by the environment rather than by the individual. Automatic or motivated behaviors generally occur without awareness, their initiation without intention and their continuation without personal control, as well as their functioning efficiently with minimal effort. Therefore, given the intention to decrease weight, self-regulation of *incentive motivation* and *volitional action control* are relevant in many aspects of daily life, such as the consumption of unhealthy food in a modern "obesogenic" environment.

Numerous different theories stress different aspects of self-regulation such as willpower (e.g. Metcalfe & Mischel, 1999), motivational systems influencing approach and avoidance-related behaviors (e.g. Higgins, 1998), or how different affective states influence behavior regulation (e.g. Kuhl, 2000b). In this study, we will focus on an affect oriented notion of self-regulation (Kuhl, 2001). This recent theory of volition (Kuhl, 2000a, 2001) differentiated two forms of volition: *self-control* and *self-regulation.* Self-control is defined as a coercive form of volitional functioning includ-

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ing the competencies of intention control, planning and control of impulsiveness as well as initiation of an intention. Subjectively, these competencies are associated with tonic volitional effort, which is a finite resource that determines capacity for effortful control over dominant responses, and the awareness of agency. Self-regulation as a self-integrating mode comprises attention- and affect-management, self-motivation, self-calming, self-activation and coping with failure (Kuhl, 1996). Due to the relatively short regulation phase, this second mode is rarely accompanied by awareness and experience of effort.

Whereas self-control, an integral component of behavioral therapies since the 1970s, has demonstrated some effectiveness with regard to reducing (over)weight (McReynolds, 1976; Weiss, 1977), self-regulation has only been rarely included (Fuhrmann & Kuhl, 1998). Recent studies demonstrate that self-regulation competencies display more *long-term* benefits: they are more flexible and "healthier" in the sense of a balanced energy regime and therefore should be preferred to stability-centered self-control competencies in the design of obesity interventions (Forstmeier & Rüddel, 2007).

Both volitional styles refer to a network of executive functions which are associated with the prefrontal cortex (Haggard, 2008). Recent studies using structural and functional MRI reveal evidence for the continued development and organization of this brain region during adolescence, which are associated with developmental improvements in specific cognitive capabilities (Casey, Giedd & Thomas, 2000; Luna & Sweeney, 2001; Pine et al., 2000) and affect regulation (Dahl, 2001). Grounded on these neurocognitive developments adolescence seems to be a sensitive period for interventions which focus on self-management competencies to improve volitional functions. Hence, unhealthy eating behaviors, which already habituated during childhood, under volitional control, require a challenging context which offers opportunities for the developmental improvement of these functions over this entire period. As mentioned earlier these long-term interventions are uncommon and expensive, both personally and financially. Chen-Stute and colleagues (Chen-Stute & Eiserloh-Lückner, 2007; Chen-Stute, Pinnow, Kopczinski, Huttner & Hauner, 2009) developed an child and adolescent intervention to treat obesity, extending over a 3-year period. This therapy of obesity with motivation (T.O.M.) comprised dietary training as well as physical workouts and additional coaching on self-management skills (Kanfer, Reinecker & Schmelzer, 2006). The program was based on the 7-phase model proposed by Kanfer et al. (2006) and includes a weekly nutritional awareness and behavioral educational curricula, as well as a three times weekly physical exercise regimens, organized and structured under the supervision on an interdisciplinary team including a physician, psychologist, nutritional and movement therapist. The primary goal of this therapy program designed for "adipositas" children and adolescents and their parents, was to facilitate self-management in terms of improved eating habits, sport activities and social behavior.

The therapists actively support the patients by offering concrete instructions/guidelines. This enables the individual to better understand and resolve their problems, promoting positive shifts in behavioral changes, increasing the ability to cope with emotions, enhance self-efficacy and self-image, foster self-confidence, as well as develop long-term changes in lifestyle.

Overall, the therapy concept aims at systematic process of change, characterized by specific goals, problem-oriented approach and temporally predetermined. As a result the children and adolescents are able to incorporate their personal desires and needs. The therapists serve to ensure an optimal individually tailored program.

All participants in this study were recruited from this program.

The aim of the present study is to prove the hypothesis that food-related executive functions (a loosely defined collection of brain processes that are responsible for planning, cognitive flexibility, abstract thinking, rule acquisition, initiating appropriate actions and inhibiting inappropriate actions, and selecting relevant sensory information) and self-regulation improve under the aforementioned therapeutic conditions. In order to examine executive functions, we implemented a modification of the Stroop color-naming paradigm with color keys (Schulz & Liebing, 1991; Stroop, 1935), a basic cognitive test, which is often used to assess information biases in psychiatric disorders like substance abuse (Cox, Fadardi & Pothos, 2006). In a Stroop color-naming task, people are required to name the color of a presented word whilst ignoring its word content. Reaction time is considered a measure of the costs of processing word content (Mogg, Mathews & Weinman, 1989). For example, obese children frequently color-name food-related stimuli more slowly than words typically associated with negative emotions or neutral words (Braet & Crombez, 2003). In the past, evidence for Stroop effects have been displayed among adults with eating disorders (Cooper & Fairburn, 1992; Jones-Chesters, Monsell & Cooper, 1998; Walker, Ben-Tovim, Paddick & McNamara, 1995) as well as in nonclinical "high-restraint eaters" (Overduin, Jansen & Lowerse, 1995; Tapper, Pothos, Fadardi & Ziori, 2008) and obese adults (Long, Hinton & Gillespie, 1994).

It is expected that obese adolescents will also exhibit an inhibition deficit of food-related information at the outset of therapy, but that this effect will diminish in the end phase of therapy indicating stronger cognitive control of food-related information. Beside this specific food-related effect a general improvement of resistance to motivational temptation as an indicator of self-regulation skills in the course of therapy should become obvious.

METHODS

Subjects

Thirty adolescents between 11 and 18 years of age participated. With the help of an informative correspondence to their parents, informed consent was obtained from the parents for adolescents under 18 years of age (all patients of the Center of Obesity of Oberhausen (Germany), who were willing to participate, were included). All participants took part in a three-year outpatient therapy for severe obesity (Chen-Stute & Eiserloh-Lückner, 2007); (T.O.M. program: 20 girls, 10 boys; age: M = 14.8 years, SD = 1.63). The proportion of females and males is similar to that of the program. No age differences between the three groups were obvious. The degree of obesity was assessed via body mass index (BMI) at the time of testing and adolescents' attending this program displayed BMIs ranging from 23.7 (mild obesity) to 52.9 kg/m^2 (severe obesity). Regarding the percentiles 26 adolescents reached higher values than 97% and therefore suffered from obesity, 4 were overweight (90% percentile). At the time of the experiment, the participating adolescents were in either their first, second or third year of therapy. As expected, BMI decreased with duration of therapy (1st year: $M = 38.8$, $SD = 8.0$; 2nd year: $M = 31.2$, $SD = 6.2$ and 3rd year: $M = 28.7$, $SD = 7.0$). An analysis of variance revealed a significant effect for duration of treatment ($F(2,24) = 5.499$, $p < .05$). None of the adolescents had received medication for treatment. The study was approved by decision of the ethic's committee of the Ruhr-University of Bochum (No. 3524-09).

Materials

Four different stimulus categories were used in the Stroop task (*food words:* e.g. chocolate, pizza, bread; *body words*: e.g. belly, lean, figure; *neutral words*: e.g. computer, carpet, alarm clock; *control stimuli:* XXXX). The neutral words were assumed to be neutral for individuals who are obese and were semantically unrelated. The material consisted of words which were named most frequently in these categories in the context of a preliminary study. The different word groups were controlled for word length. Every category contained 36 items, so that the Stroop task comprised 144 completely randomized trials altogether.

The words and control stimuli were presented in the colors red, green, yellow and blue in the center of a bright gray screen. Target dimensions lay between 50–150 mm × 10 mm. The lower area of the screen was filled by four color rectangles, each of equal size (59 mm × 32 mm), which defined the colors of the correct response keys. The sequence of these colors (from left to right) changed with each trial. The keys pressed were of a neutral gray color, 12 mm × 18 mm in size and mounted with a space of 7 mm in-between on a separate keyboard (124 mm × 68 mm × 29 mm). The intertrial interval was 3 s. The program was written in the software system ERTS (Experimental Run Time Systems, version 3.05 by [Beringer, 1999]).

The German version computerized of the Self-Regulation Test for Children (SRTC) (Kuhl & Kraska, 1992) was used to measure resistance to temptation. In this test, the children have to work on a very easy attention test to earn some money. While doing this cognitive (tone) and motivational distracters (apes who add or steel money) occur. In the present sample, internal consistency of performance across six baseline and six distracter episodes was $\alpha = .95$ and $\alpha = .93$, respectively.

Procedure

The Stroop test was introduced as a reaction-time task in order to test how fast and accurately people responded to different stimuli. The SRTC was introduced as a visual attention task to find out more about attention and to learn about how to help children with attention-deficit disorder. The SRTC was administered at the beginning of the experiment. The participants were introduced to the computer program and instructed to perform a simple visual discrimination task to earn money. The computer screen was divided into four squares. The task was presented in the lower left-hand square. Participants were requested to push a particular key when one bar appeared and another key when two bars appeared simultaneously. For each correct response, a 'penny' was added to their account and a fixation mark was shown in the center of the task area. As soon as the participants pushed their space bar, the next stimulus was presented. The number of earned pennies was registered above the task area. In addition, in the lower right-hand square, a wallet was displayed. For every ten pennies participants had earned for correctly completing the task, a dime was added in their wallet. During distracter episodes, a climbing competition between a "good" monkey and a "bad" monkey on a tree, accompanied by a clicking noise, appeared in the upper right-hand square. When the good monkey won the competition, it would slide down to the wallet and add randomly a varying amount of money – between one and four dimes – to the account. Whenever the bad monkey won, it stole one to four dimes from the wallet. Participants were informed that they had no personal control over the monkey race and that its outcome was purely coincidental. This condition is intended as a motivational distraction. However, they had full control over the task with the bars. At baseline, neither the distracter nor the wallet was displayed on the screen. Each baseline and distracter episode lasted 15 seconds.

The analysis of the first half of the distracter episode (7.5 s) indicated cognitive temptation whereas the second half suggested motivational temptation because the race was predetermined and the participant would win or lose money during the latter period. Therefore, only the second half of the distracter period was analyzed. The test consisted of four practice and six test blocks each lasting 1 minute (one 15 s baseline and three distracter episodes). The dependent variable of the SRTC was the speed of correct key responses (Baumann & Kuhl, 2005). After which, the Stroop test was administered. Participants were instructed to press the keys as fast and accurately as possible. Dependent variables were speed (of correct responses) and accuracy. According to Schulz and Liebing (1991) reaction times (RTs) shorter than 150 ms and longer than 1500 ms were replaced with mean values for further analysis. Dependent variables for the Stroop task were RTs and food- and body-interference (defined as RT differences of the food-and body-condition: *food* RT – *control* RT respectively *body* RT – *control* RT).

RESULTS

SRTC: Speed

The speed of correct key responses was analyzed using a class (year of treatment) of therapy (first, second, third) x distracter (baseline vs. distracter) mixed ANCOVA, with the latter as within-participant factor, and BMI and age as covariates. Results yielded a significant main effect of distracter, $F(1,24) = 5.14$, $p < .05$. Mean number of key presses was $M = 104.91$ at baseline and $M = 101.00$ during distracter episodes. Results support the presumed distracter effect of the monkey race. Consistent with our hypothesis the graduation × distracter interaction attained statistical significance ($F(2,24) = 8.90$, $p < .01$). As presented in Table 1, only obese adolescents in the third class did not reveal a significant decrease in speed due to the distracter. On a descriptive level, they worked even faster during distracter episodes compared to baseline (see Figure 1). Additionally, both covariates yielded a significant effect of $F(1,24) = 4.65$, $p < .05$ for BMI and $F(1,24) = 5.93$, $p < .05$ for age. Simple comparisons (Winer, 1971) for the various groups yielded significant differences between the first and second graduation group ($t(18) = –2.61$, $p < .05$) and between the second and third graduation group ($t(18) = –3.28$, $p < .01$).

Table 1. Speed (correct key presses) during distracter and baseline episodes as a function of graduation (1st–3rd year of therapy)

Graduate group	1st year (n = 10)		2nd year (n = 9)		3rd year (n = 10)	
	M	SE	M	SE	M	SE
Distracter	102.83	6.03	98.95	5.56	101.20	5.52
Baseline	109.71	6.08	106.43	5.60	98.60	5.56
Diff.[1]	–6.87	2.04	–7.47	1.88	2.60	1.87

[1] High (positive) value in speed difference indicates high resistance to temptation.

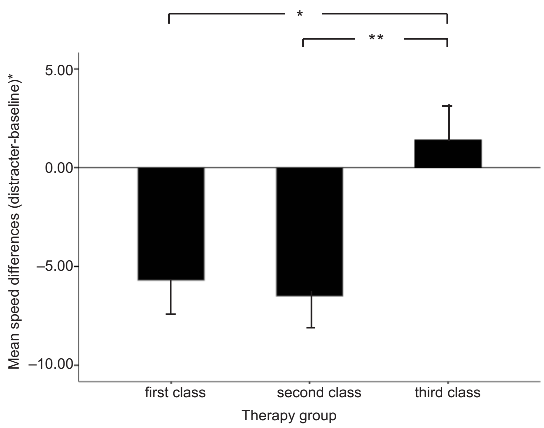

Figure 1. Mean key presses difference (with distractor-baseline) for the different graduation groups

* High (positive) values in speed difference indicate high resistance to temptation
* $p < .05$; ** $p < .01$

Stroop: Reaction times (RTs)

The speed of correct key presses was analyzed using stimuli (food/body/neutral/control) × graduation of therapy (first/second/third) mixed ANCOVA with repeated measures and the two covariates BMI and age. Results yielded a significant main effect for stimuli ($F(3,72) = 6.57$, $p < .01$). Mean RT to food words was $M = 691.68$ ms, to body words $M = 686.82$ ms, to neutral words $M = 676.87$ ms and to control stimuli $M = 675.08$ ms. Results support the presumed effect of food and body stimuli. In addition the stimuli × age interaction attained significance ($F(3,72) = 6.25$, $p < .01$) and a trend for a stimuli × graduation interaction was observed ($F(6,72) = 2.08$, $p = .07$). For the reaction times only the covariate age showed a significant effect ($F(1,24) = 6.45$, $p < .05$). Table 2 presents the mean RTs for the first, second and third class groups of the obesity intervention program to the different types of stimuli (see Table 2).

Table 2. Mean reaction time (ms) and standard error on a motivational stroop task for food words, body words, neutral words and control stimuli in the first, second and third graduate group (highest class scores in bold print)

Graduate group	1st year (n = 10)		2nd year (n = 10)		3rd year (n = 10)	
	M	SE	M	SE	M	SE
Food words	**699.71**	37.83	709.72	34.88	665.61	34.61
Body words	669.01	32.97	**715.10**	30.39	**676.36**	30.16
Neutral words	684.49	31.58	680.94	29.11	665.19	28.89
Control stimuli	666.07	33.11	692.03	30.52	667.14	30.29

The duration of therapy did not have an effect on the (significant) negative correlation observed between reaction time to the presentation of nutritional-related words and the reduction in BMI at the end of the intervention ($r = –.344$, $p < .05$ (one-tailed)).

Stroop: Food and body interference

An univariate analysis of covariance (ANCOVA) was computed separately with food, body and neutral interference scores as dependent variables: It showed a significant decline in food interference during the course of therapy ($F(2,30) = 4.31$, $p < .05$), ($\eta^2 = 0.25$) (see Figure 2 for M and SE). This indicates that adolescents exhibited significantly more interference during trials with food stimuli in the first than in the second and third "graduation" year. No such effects were found for body and neutral stimuli. The mean interference score for body words was 16.17 ms +/– 7.14, and for neutral words, 4.16 ms +/– 7.42. The food-interference score correlated with weight reduction during therapy at $r = –.38$, $p < .05$.

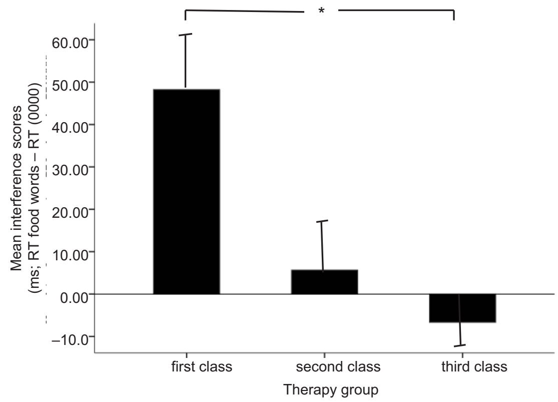

Figure 2. Mean interference scores (ms) due to food words for the three graduation groups

* $p < .05$

DISCUSSION

Recent studies strongly suggest that executive function processes are crucial in both the development and maintenance of effective therapy programs with overweight individuals (Appelhans, 2009). Our study was aimed at evaluating how the maintenance of a healthier lifestyle after a self-management therapy for adipositas (T.O.M.) serve to bring changes in action control mechanisms (attention and motivation), and to reveal which of these specific improvements are associated with therapy success. The results seem to support a general age-related developmental trend for both for the attentional control (Stroop test) and motivational control (SRTC), indicating that older adolescents exhibit a more efficient "action control" than their younger counterparts. Furthermore, the results replicate other research findings suggesting developmental improvements in executive functioning for similar aged groups (Romine & Reynolds, 2005). Finally, youth with an elevated BMI are more likely to be distracted through nutritional information and more impaired in their self-regulatory competency than those young individuals with a lower BMI. This finding is also consistent with other (longitudinal) studies which demonstrate a relationship between deficits in self-control an overweight (Francis & Susman, 2009).

Although previous prevention and intervention programs were mainly focused on self-control with respect to eating and exercise, few approaches emphasize the enhancement of basic cognitive functions such as self-regulation to restore and maintain a healthy diet (Whitaker & Gooze, 2009). Self-regulation failure, or the inability to control an impulse or behavior, however, has been implicated as a basic mechanism of weight gain (Francis & Susman, 2009).

Our study aimed to find some evidence for the hypothesis that an effective therapy based on a self-management concept (Kanfer et al., 2006) does not only have a positive impact on weight reduction but also is accompanied by enhancement of inhibitory control both in general, and more specifically with regard to food-related information processing in adolescents. For this purpose, two different tests measuring inhibitory control – a self-regulation task for children and a modified Stroop test – were implemented during a 36-month intervention program. In both areas and independent of their experiences within the therapy program, we found a main effect attributable to age, for adolescents indicating that older adolescents exhibit more effective executive functions than younger adolescents. Overall, this is consistent with previous studies, augmenting the concept of long-term development of executive functions up into late adolescence (Anderson, 2002; Brocki & Bohlin, 2004). Apart from this predictable trend, the tests also highlighted improvement of resistance to motivational temptation as well as, in particular, of interference control with respect to food stimuli, regardless of therapy outcome. However, only the food-specific control component revealed a positive correlation with therapy success. While the correlation between low cognitive control and overweight is empirically well-documented by now, findings regarding the correlation between executive functions and therapy success seem to be contradictory. Like the present study, Nederkoorn, Jansen, Mulkens and Jansen (2006), for instance, report a positive effect of *low* impulsivity – assessed with a stop-signal task – on therapeutic success. Pauli-Pott, Albayrak, Hebebrand and Pott (2009), on the other hand, provide evidence for a positive effect of *low* cognitive control on therapeutic success. One possible explanation could be that different therapy settings compensate for different disabilities. Consequently interindividual differences should be more investigated in more detail in this context. Apart from the methodological differences exhibited by these studies, the modulatory effect of executive functions appears to be based on the differing approaches concerning therapy setting. The presently investigated therapy program comprises a training of volitional action control with a corresponding training of goal-oriented, novel behavioral patterns, and the inhibition of inadequate, highly involuntary behavioral patterns, processes that demand a high degree of executive control. Conversely, methods which focus on establishing new behavioral patterns through situational control, may represent a "competence-adequate" and therefore effective setting for individuals with both a high susceptibility to rewards and low cognitive control (Allen, Johnston & Campbell, 2008; Pauli-Pott et al., 2009).

This study has some clear limitations. Firstly, it is a cross-sectional view that does not allow us to comment on clear causality. Secondly, given our relatively modest sample size we restricted our measurements to cognitive and regulatory functions that in previous studies had either been found to have been associated to obesity or disinhibition, or those that we had good theoretical reasons to believe could be involved. Therefore, it is possible that there are other cognitive and affective functions and dispositions (e.g. anxiety), which we did not evaluate, that may also be involved.

To better understand the issues described here, future work should evaluate subjects longitudinally, tracking the development of obesity across time while concomitantly measuring cognitive, affective, behavioral, and also neurostructural changes, which may underlie these psychological functions.

CONCLUSIONS

In conclusion programs designed to improve self-regulation skills in general domains of behavior like the T.O.M. program produced significant decreases in weight status and adiposity (Israel, Guile, Baker & Silverman, 1994). Both clinical research and practitioners in the domain of weight management have to account for individual differences and developmental aspects of this basic cognitive functioning (i.e. executive functions) in order to make expensive interventions more efficient. Moreover, research programs should be initiated in order to develop and evaluate specific tools, which can be added to established interventions to compensate for individual differences.

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REFERENCES

Allen, J., Johnston, M. & Campbell, N. (2008). Why do people fail to turn good intentions into action? The role of executive control processes in the translation of healthy eating intentions into action in young Scottish adults. *BMC Public Health, 8,* 123.

Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychology, 8,* 71–82.

Appelhans, B. M. (2009). Neurobehavioral inhibition of reward-driven feeding: implications for dieting and obesity. *Obesity, 17,* 640–647.

Baumann, N. & Kuhl, J. (2005). How to resist temptation: The effects of external control versus autonomy support on self-regulatory dynamics. *Journal of Personality, 73*(2), 443–470.

Beringer, J. (1999). Experimental run time system (Version 3.05). Frankfurt am Main, Germany: BeriSoft Cooperation.

Braet, C. & Crombez, G. (2003). Cognitive interference due to food cues in childhood obesity. *Journal of Clinical Child and Adolescent Psychology, 32*(1), 81–93.

Braet, C., Mervielde, I. & Vandereycken, W. (1997). Psychological aspects of childhood obesity: A controlled study in a clinical and nonclinical sample. *Journal of Pediatric Psychology, 22*(1), 59–71.

Brocki, K. C. & Bohlin, G. (2004). Executive functions in children aged 6–13: A dimensional and developmental study. *Developmental Neuropsychology, 26,* 571–593.

Casey, B. J., Giedd, J. N. & Thomas, K. M. (2000). Structural and functional brain development and its relation to cognitive development. *Biological Psychology, 54*(1–3), 241–257.

CDC (2010) Nutrition, Physical Activity and Obesity. US Centre for Disease Control. http://www.cdc.gov/Features/ObesityAndKids/

Chen-Stute, A. & Eiserloh-Lückner, D. (2007). *Auch Ihr Kind kann abnehmen*. Ratingen: Oberstebrink.

Chen-Stute, A., Pinnow, M., Kopczinski, S., Huttner, A. & Hauner, H. (2009). T.O.M. (Therapie der Obesitas mit Motivation) – Ein dreijähriges, ambulantes Therapieprogramm für adipöse Kinder und Jugendliche. *Adipositas, 1,* 27–32.

Cooper, M. J. & Fairburn, C. G. (1992). Selective processing of eating, weight and shape related words in patients with eating disorders and dieters. *The British Journal of Clinical Psychology, 31*, 363–365.

Cox, W. M., Fadardi, J. S. & Pothos, E. M. (2006). The addiction-Stroop test: Theoretical considerations and procedural recommendations. *Psychological Bulletin, 132,* 443–476.

Dahl, R. E. (2001). Affect regulation, brain development, and behavioral/emotional health in adolescence. *CNS Spectrums, 6*(1), 60–72.

Forstmeier, S. & Rüddel, H. (2007). Improving volitional competence is crucial for the efficacy of psychosomatic therapy: A controlled clinical trial. *Psychotherapy and Psychosomatics, 76,* 89–96.

Francis, L. A. & Susman, E. J. (2009). Self-regulation and rapid weight gain in children from age 3 to 12 years. *Archives of Pediatrics & Adolescent Medicine, 163*(4), 297–302.

Fuhrmann, A. & Kuhl, J. (1998). Maintaining a healthy diet: Effects of personality and self-reward versus self-punishment on commitment to and enactment of self-chosen and assigned goals. *Psychology and Health, 13,* 651–686.

Haggard, P. (2008). Human volition: Towards a neuroscience of will. *Nature Reviews / Neuroscience, 9,* 934–946.

Higgins, E. T. (1998). Promotion and prevention: Regulatory focus as a motivational principle. In M. P. Zanna (Ed.), *Advances in experimental social psychology,* Vol. 30. New York: Academic Press, pp. 1–46.

Israel, A. C., Guile, C. A., Baker, J. E. & Silverman, W. K. (1994). An evaluation of enhanced selfregulation training in the treatment of childhood obesity. *Journal of Pediatric Psychology, 19*(6), 737–749.

Jones-Chesters, M. H., Monsell, S. & Cooper, P. J. (1998). The disorder-salient stroop effect as a measure of psychopathology in eating disorders. *International Journal of Eating Disorders, 24*(1), 65–82.

Kanfer, F. H., Reinecker, H. & Schmelzer, D. (2006). *Selbstmanagement-Therapie. Ein Lehrbuch für die klinische Praxis*. Berlin: Springer.

Kuhl, J. (1996). Wille und Freiheitserleben: Formen der Selbststeuerung. In J. Kuhl & H. Heckhausen (Eds.), *Enzyklopädie der Psychologie, Serie Motivation und Emotion* (Vol. 4: Motivation, Volition und Handlung). Göttingen: Hogrefe, pp. 665–765.

Kuhl, J. (2000a). A functional-design approach to motivation and self-regulation: The dynamics of personality systems interaction. In M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation*. San Diego: Academic Press, pp. 11–169.

Kuhl, J. (2000b). The volitional basis of personality systems interaction theory: Applications in learning and treatment contexts. *International Journal of Educational Research, 33,* 665–703.

Kuhl, J. (2001). *Motivation und Persönlichkeit. Interaktionen psychischer Systeme.* Göttingen: Hogrefe.

Kuhl, J. & Kraska, K. (1992). *Der Selbstregulations-und-Konzentrationstest für Kinder (SRKT-K).* Göttingen: Hogrefe.

Long, C. G., Hinton, C. & Gillespie, N. K. (1994). Selective processing of food and body size words: Application of the Stroop Test with obese restrained eaters, anorexics, and normals. *International Journal of Eating Disorders, 15*(2), 279–283.

Luna, B. & Sweeney, J. A. (2001). Studies of brain and cognitive maturation through childhood and adolescence: A strategy for testing neurodevelopmental hypotheses. *Schizophrenia Bulletin, 27*(3), 443–455.

McReynolds, W. T. (1976). Behavior therapy for obesity: Another fad or a new set of facts? *The Nebraska Medical Journal, 61*(8), 289–290.

Metcalfe, J. & Mischel, W. (1999). A hot/cool system analysis of delay of gratification: Dynamics of willpower. *Psychological Review, 106,* 3–19.

Mogg, K., Mathews, A. & Weinman, J. (1989). Selective processing of threat cues in anxiety states: A replication. *Behaviour Research and Therapy, 27*(4), 317–323.

Nederkoorn, C., Jansen, E., Mulkens, S. & Jansen, A. (2006). Impulsivity predicts treatment outcome in obese children. *Behavior Research and Therapy, 45*, 1071–1075.

Overduin, J., Jansen, A. & Lowerse, E. (1995). Stroop interference and food intake. *International Journal of Eating Disorders, 18*(3), 277–285.

Pauli-Pott, U., Albayrak, O., Hebebrand, J. & Pott, W. (2009). Does inhibitory control capacity in overweight and obese children and adolescents predict success in a weight-reduction program? *European Child and Adolescent Psychiatry, 19,* 135–141.

Pine, D. S., Grun, J., Maguire, E. A., Burgess, N., Zarahn, E., Koda, V. et al. (2000). Neurodevelopmental aspects of spatial navigation: A virtual reality fMRI study. *Neuroimage, 15*(2), 396–406.

Reinehr, T., Kersting, M., Chahda, C., Damschen, U., Dobe, M., Bürk, G. et al. (2001). Ambulante Schulung „Obeldicks" für adipöse Kinder und Jugendliche. *Kinder- und Jugendmedizin, 82,* 26–33.

Romine, C. B. & Reynolds, C. R. (2005). A model of the development of frontal lobe functioning: Findings from a meta-analysis. *Applied Neuropsychology, 12*(4), 190–201.

Schulz, T. & Liebing, D. (1991). Farbe-Wort-Interferenz unter Bedingungen vergleichbarer Kompatibilität: Evidenz für zwei Interferenzquellen. *Zeitschrift für experimentelle und angewandte Psychologie, 38,* 648–668.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643–662.

Tapper, K., Pothos, E. M., Fadardi, J. S. & Ziori, E. (2008). Restraint, disinhibition and food-related processing bias. *Appetite, 51*(2), 335–338.

U.S. Department of Health and Human Services. Final review, Healthy People 2010: Nutrition and overweight. Retrieved from http://www.cdc.gov/nchs/ data/hpdata2010/hp2010_final_ review_focus_area_19.pdf.

Walker, M. K., Ben-Tovim, D. I., Paddick, S. & McNamara, J. (1995). Pictorial adaptation of Stroop measures of body-related concerns in eating disorders. *International Journal of Eating Disorders, 17*(3), 309–311.

Weiss, A. R. (1977). Characteristics of successful weight reducers: A brief review of predictor variables. *Addictive Behaviors, 2*(4), 193–201.

Whitaker, R. C. & Gooze, R. A. (2009). Self-regulation and obesity prevention. *Archives of Pediatrics & Adolescent Medicine, 163*(4), 386–387.

Winer, B. (1971). *Statistical principles in experimental design* (2nd ed.). New York: McGraw-Hill.