Journal of Clinical and Experimental Neuropsychology
2001, Vol. 23, No. 4, pp. 520–529

1380-3395/01/2304-520$16.00

Haptic Perception in Anorexia Nervosa Before and After Weight Gain

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ABSTRACT

Haptic perception of patients with anorexia nervosa ($n = 10$) was analyzed in a longitudinal study (T_0–T_1). The haptic explorations consisted of palpating the structure of 12 sunken reliefs in sequence with both hands, eyes closed. After each exploration the structure was reproduced on a piece of paper. In the anorexia group, mean exploration time was significantly shorter than in healthy control subjects. However, the reproductions of complex stimuli submitted by the anorexia group were of notably poorer quality than those of the healthy controls. This was also observed after weight gain (T_1). The results of the haptic explorations can be interpreted as a cortical dysfunction and deficits in somatosensorical integration processing in patients with anorexia nervosa. This may be due to a disorder of tactual–spatial processing in the right parieto-occipital regions.

In 1984, Kinsborne and Bemporad hypothesized that a dysfunction of the right hemisphere of the brain, especially of the right parietal cortex is evident in patients with anorexia nervosa. They hypothesized the dysfunction to be involved in the perception of a distorted body image (''anorexic's neglect''). On the basis of this assumption, Rovet, Bradley, Goldberg and Wachsmuth (1988), Pendleton-Jones, Duncan, Brouwsers and Mirsky (1991) and Bradley et al. (1997) conducted neuropsychological studies exploring perceptual–cognitive functions especially of the right hemisphere in patients with anorexia nervosa. Bradley et al. (1997) found changes in event-related potentials (ERPs) during perceptual–cognitive tasks supporting the hypothesis of a right parietal dysfunction in patients with anorexia nervosa. Thus, they found significant differences in ERP amplitudes between an anorexia group (AN) and a control group (CO) in verbal as well as in nonverbal tasks. Patients with anorexia nervosa (AN) showed no left-right asymmetry for the P3-amplitude in a nonverbal task. However, neither the studies of Bradley et al. (1997) nor the studies of Pendleton-Jones et al. (1991) found significant differences during neuropsychological examination, that is no cognitive deficits were detected in patients with AN.

In contrast to these observations other studies (Brouwers, Duncan, & Mirsky, 1986; Laessle, Fischer, Fichter, Pirke, & Krieg, 1992; Pendleton-Jones et al., 1991; Small, Madero, Teagno, & Ebert, 1983; Szmukler et al., 1992) showed deficits in perceptual–cognitive tasks in patients with AN which could not be explained only by deficits of the right hemisphere. The question

The authors would like to thank I. Thomas, G. Kruse, and U. Kraft for their technical support and Rita Wallace for language advice in undertaking this study. This research project was supported in part by the Deutsche Forschungsinitiative Eßstörungen (DFE e.V.) and by a grant from the Friedrich-Schiller-University Jena.
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Accepted for publication: June 2, 1999.

remains whether patients with AN show deficits in perceptual–cognitive tasks based on deficits of the right hemisphere. Taking into account the electrophysiological results obtained by Bradley et al. (1997) it might be supposed that the neuropsychological inventories used in the studies were not sensitive enough to explore the right hemispheric deficits in patients with AN. It is well known that individuals with AN have higher IQs than age-matched healthy controls as a rule (Blanz, Detzner, Lay, Rose, & Schmidt, 1997; Gordon, Halmi, & Ippolito, 1984; Ranseen & Humphries, 1992; Witt, Ryan, & Hsu, 1985). Thus, the higher IQ might interfere with the perceptual–cognitive dimension and thereby hide the right hemispheric deficits. In order to test the hypothesis of perceptive–cognitive deficits in patients with AN it seems necessary to develop a test which does not allow the use of previous experience and usual strategies to solve the task. Furthermore, such a test should be based on sensory integration and explicit spatial orientation because these processes are known to involve the right hemisphere to a greater extent (Kolb & Whishaw, 1993).

One possible approach consists of the examination of haptic perceptions. Haptic perceptions are distinguished from tactile tasks by their active explorative movements of the exploring limb. The resulting changes in the receptors of the skin, muscles, tendons, and joints lead to successive information about the explored object. This information should be integrated to explain the precise spatial characteristics and the texture of the explored object. It could be postulated that an inadequate cortical integration of this information should result in deficits in haptic perception. Thus, in patients with astereognosis a lesion of the right parietal cortex is associated with deficits in haptic perception (Kolb & Whishaw, 1993). These patients are unable to explore and explain the structure of an object haptically with their eyes closed. Therefore, the aim of our study was to examine whether or not deficits in a haptic perception test could be found in patients with AN during the reduction of weight (T_0) and after weight gain (T_1) as compared to age- and gender-matched controls.

METHODS

Participants

Anorexia Nervosa Group (AN): Ten patients with anorexia nervosa (females), diagnosed in accordance with ICD-10 criteria (Dilling et al., 1993), (mean age = 16.34 years, $SD = 1.30$) participated in the experiment. At the time of testing, all group members were being treated as inpatients at the Clinic of Child and Adolescent Psychiatry, University of Leipzig, Germany. Patients with bulimia nervosa or moderate binge eating and/or vomiting were excluded. Eight subjects had already been treated as inpatients in other clinics of child psychiatry and were diagnosed as suffering from anorexia nervosa. Three subjects were being treated as inpatients for the first time. The duration of the illness varied between only a few months to several years. The demographic data of the participants including medication intake, body weight, BMI (Body Mass Index) and so forth are documented in Table 1. The BMI is calculated as: weight (kg) divided by the square of height (m). A BMI between 20 and 25 is considered optimal and a BMI less than 16 is indicative of significant undernutrition (Beaumont, Al-Alami & Touyz, 1988). Patients were tested after hospital admission (T_0) and 1 month after being released from the clinic (T_1). The time interval between inital testing (T_0) and follow-up (T_1) ranged from 8 to 26 months, with a mean of 17.40 months ($SD = 6.55$). The mean BMI for the AN group was 15.16 ($SD = 1.45$) at T_0 and 16.79 ($SD = 1.75$) at T_1. Three patients from the initial testing (T_0) were being treated as outpatients at the time of T_1 testing. These studies were approved by the Ethics Commission of the University of Leipzig.

Control Group (CO): Ten healthy females, mean age 17.30 years ($SD = 1.25$) participated in the experiment. The age difference between both groups was not significant (AN-CO: $p = .108$, t-test, two-tailed). Mean BMI was 22.44 ($SD = 3.23$). None of the participants in the control group suffered from neurological or psychological disorders. See Table 3 for demographics of the CO group.

Procedure

The haptic task consisted of exploring 12 individual sunken reliefs (13 cm × 13 cm), which were presented to the participants in random order (Fig. 1). All participants were asked to palpate the haptic stimuli with both hands while keeping their eyes closed. Following the haptic explorations, all participants were asked to reproduce the structure of the stimuli as closely as possible on a piece of paper with their eyes open.

Table 1. Data (T_0 and T_1) from 10 Examined Anorexia Nervosa Patients.

	Subjects	K	N	P	G	Ku	Mo	Sj	Su	L	Ne
	Date of Birth	2/78	5/80	6/78	6/78	1/82	1/80	8/80	4/82	11/79	11/80
	Admitted	11/95	10/95	6/95	6/95	1/96	7/96	3/96	3/96	3/95	9/96
T_0	Height (cm)	162	165	166	164	170	165	178	180	168	168
	Weight (kg)	35.3	40.9	47.3	37.4	47.0	42.4	41.9	46.9	43.0	49.0
	BMI*	13.45	15.02	17.16	13.90	16.26	15.57	13.22	14.47	15.23	17.36
	IQ HAWIK/ HAWIE	121	104	126	122	101	120	122	115	112	120
	Date of test (T0)	2/96	2/96	2/96	2/96	2/96	10/96	10/96	10/96	10/96	11/96
	Diagnosis (to ICD-10)	AN	AN	AN	AN	AN	AN	AN	AN	AN	AN
	Previous hospisalization	1	–	1	2	2	2	1	–	–	1
	CT	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	MRT	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
	medication	Opipramol	–	–	–	–	Estradiolvalerat	–	–	Ethinylestradiol Norethisteronacetat Promethazin	–
T_1	Date of test (T1)	12/97	1/98	12/97	4/98	10/97	10/97	10/97	5/97	5/97	7/97
	Height (cm)	164	165	166	166	173	164	178	180	170	169
	Weight (kg)	34	50.0	51.2	46.9	52.3	44.3	48.0	55.0	49.6	51.5
	BMI*	12.68	18.36	18.58	17.02	17.47	16.47	15.14	16.97	17.16	18.03

*Body-Mass-Index (BMI = weight (kg)/height (m^2)).

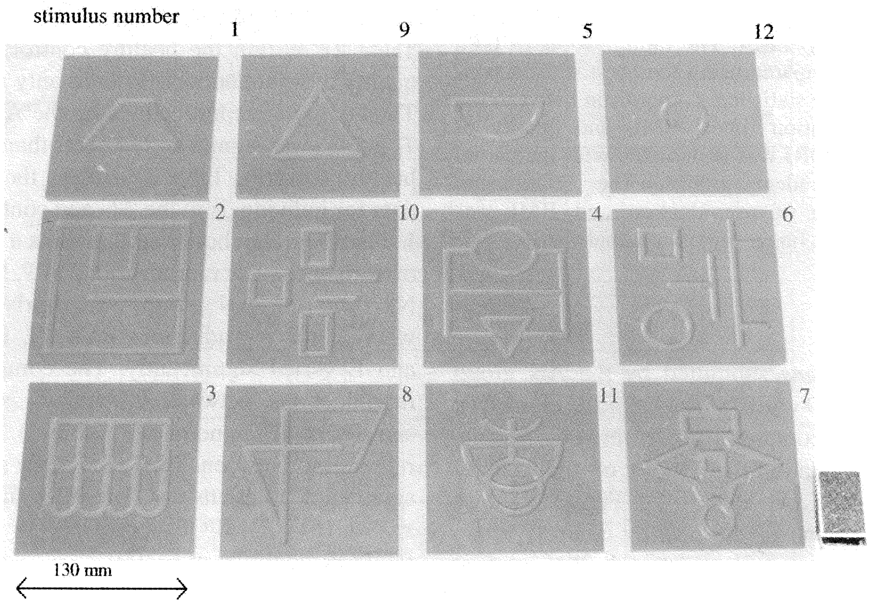

Fig. 1. Twelve haptic sunken reliefs of varying degrees of complexity, made of hard plastic. The engraving design is 7 mm wide and 3 mm deep.

Exploration time per stimulus was not limited. With the help of a strategically placed screen, the participants were prevented from gathering visual information on the stimuli. The participants were not given any feedback on the quality of their reproductions or the stimulus structure. Exploration time per stimulus was registered by means of pressure sensors (in seconds). The participants were allowed to familiarize themselves with the haptic material prior to the experiment by looking at one sample stimulus and practicing the haptic exploration task for a duration of 1 min. The test sequence is described in Figure 2.

Statistical Evaluation

The recorded data were evaluated with the SPSS statistical package (8.0) for Windows 95 (Brosius, 1998). The exploration times of the two groups were analyzed with the t-test for independent groups. The reproductions were evaluated on a scale from 1 to 4 (1 = correct reproduction of stimulus; 2 = correct reproduction of stimulus with one to three mistakes; 3 = failure to reproduce stimuli adequately, correct reproduction of single elements only; 4 = failure to reproduce stimulus or single elements correctly). Two students (A, B) and two technical university staff members (C, D) who were blind to the purposes of the study evaluated each single reproduction. The inter-examiner reliabilities (Douglas, 1991) amounts

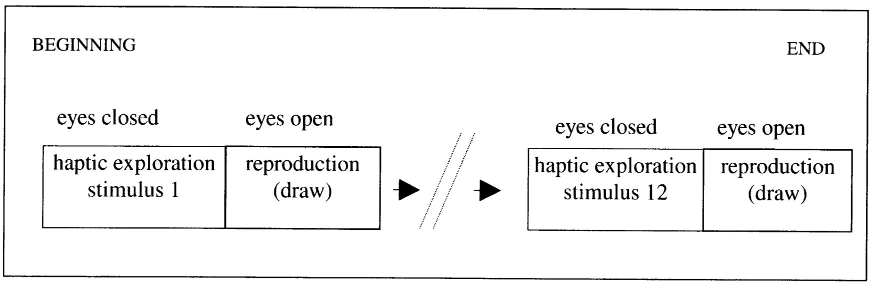

Fig. 2. Test schematic. The 12 stimuli were presented to the test subjects in random sequence. The stimuli were explored with both hands, eyes closed.

to $k_{A/B} = .909$, $k_{A/D} = .810$, $k_{C/B} = .749$, $k_{C/D} = .755$, $k_{A/C} = .765$, $k_{B/D} = .824$. The rating scores of both groups were compared using the t-test for independent groups. The statistical comparison between the pre-post exploration times, BMI, and quality of reproductions (QR) was undertaken with the paired t-test for dependent groups. The relationship between quality of reproduction and BMI was examined with a linear regression analysis.

RESULTS

The *reproductions* submitted by the AN group (QR_{T0}: 1.92, $SD = 1.07$; QR_{T1}: 1.72, $SD = 1.04$), particularly of complex stimuli were of considerably poorer quality than those of the healthy controls (QR: 1.19, $SD = 0.19$). Figure 3 shows the reproductions of the healthy controls group and Figure 4 the reproductions of the AN group at both testings (T_0 and T_1). The mean rating scores applied in evaluating the reproductions differ substantially between the two groups (see Table 2). Within the healthy control group, the quality of reproductions differed only marginally. The quality of reproductions by the AN group at T_0 and T_1 was significantly poorer than that of the healthy controls. Table 3 displays the T_0 and T_1 data for individuals in the AN and control groups. In the AN group, however, there was a wide range of variations. The reproductions of P, Mo, G, and Ne from the AN group were fairly adequate, whereas the reproductions of K, N, Ku, Sj, Su, and L varied significantly. The comparision of reproductions between T_0 and T_1 showed no significant differences (see Table 2). The linear regression between BMI and QR showed no significant relationship (BMI/QR-anorexia[T_0]: $r^2_{T0} = .161$; BMI/QR-anorexia[T_1]: $r^2_{T1} = .00$; BMI/QR-controls: $r^2 = .00$).

Table 2 displays the mean *exploration times* and statistical differences for the patients with

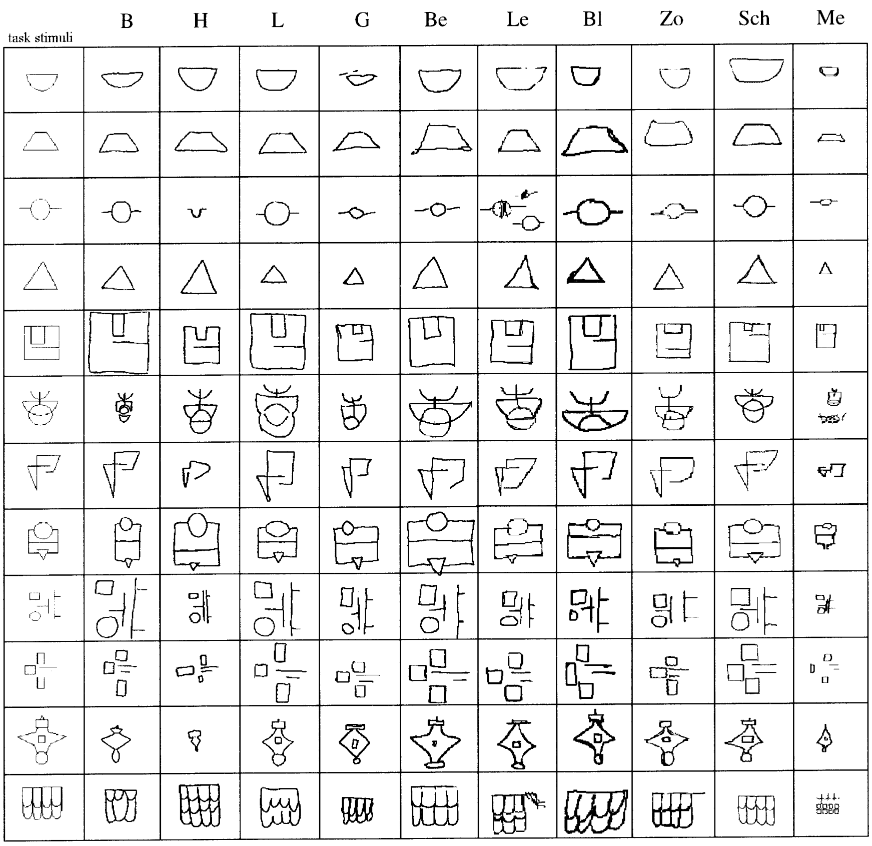

Fig. 3. Reproductions submitted by healthy controls, reduced by 170%.

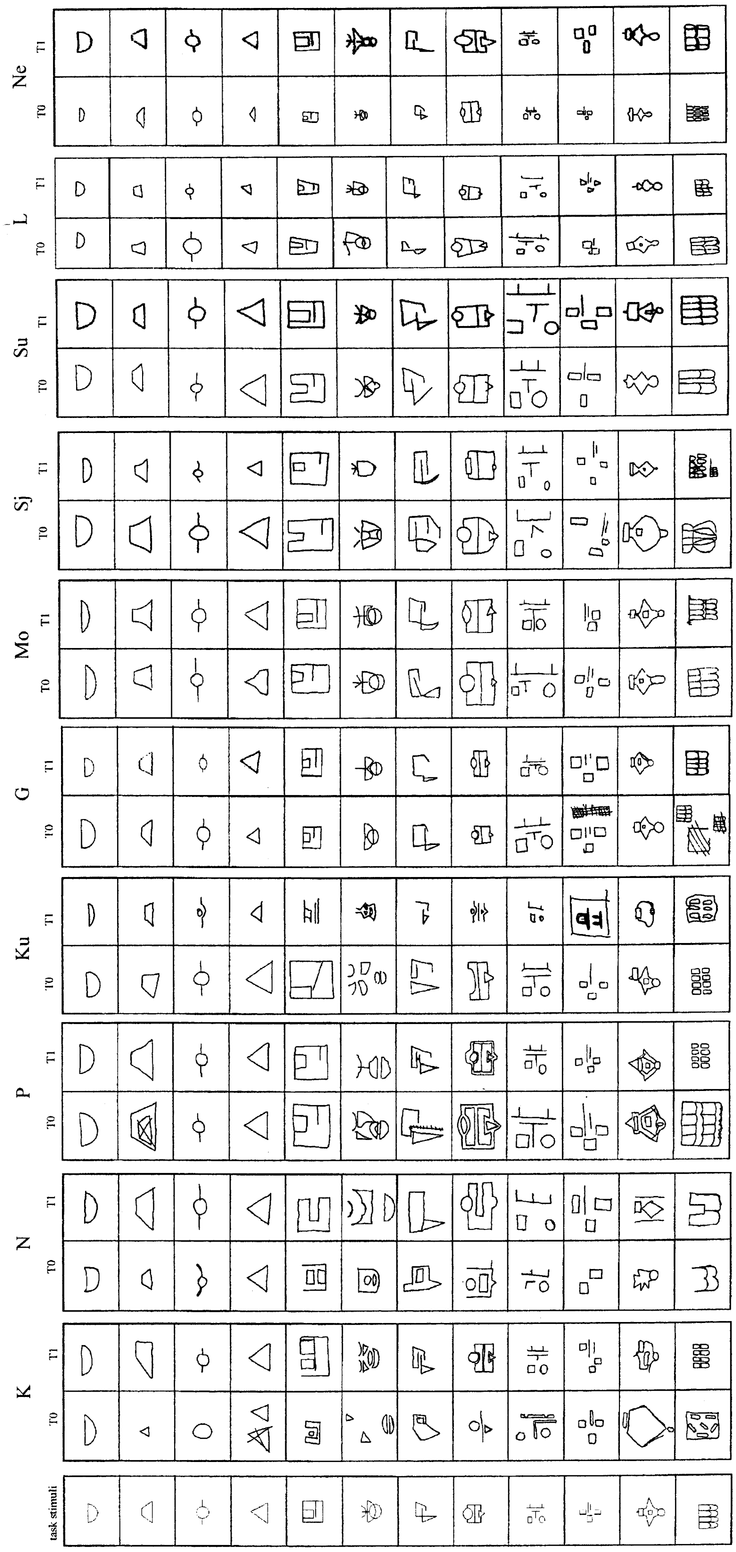

Fig. 4. Reproductions submitted by patients with anorexia nervosa T_0 and T_1 (reduced by 170%).

Table 2. Data from BMI, ET and QR for Control Group and Anorexia Patients as Well as Statistical Results of Inter- and Intra Group Comparisons.

		Controls ($n = 10$)		Anorexia patients ($n = 10$) T_0		Anorexia patients ($n = 10$) T_1	
		Mean	(*SD*)	Mean	(*SD*)	Mean	(*SD*)
BMI	*#§	22.44	(3.23)	15.16	(1.45)	16.79	(1.75)
ET	#§	176.07	(46.82)	120.34	(109.48)	106.73	(93.19)
QR (rating)	#§	1.19	(.19)	1.92	(1.07)	1.72	(1.04)

Comparison anorexia patients T_0–T_1 (*t*-test, two-tailed) $p < .05$*.
Comparison controls – anorexia T_0 (*t*-test, two-tailed) $p < .05$#.
Comparison controls – anorexia T_1 (*t*-test, two-tailed) $p < .05$§.

AN (T_0 and T_1) and the healthy controls. The comparison of group means revealed significant differences. Based on the test results, patients suffering from anorexia nervosa required less time for haptic exploration tasks than healthy control subjects. After weight gain (T_1) the exploration times of patients with AN were even shorter than during the first test altrough they do not differ significantly (T_0–T_1: $p = .387$, *t*-test, two-tailed). Table 3 displays the T_0 and T_1 data for individual patients with AN and healthy controls. The linear regression between QR and mean exploration time (ET), figured separately for both groups, showed no significant relationship between the variables (QR/ET-anorexia[T_0] $r^2_{T0} = .094$; QR/ET-anorexia[T_1]: $r^2_{T1} = .035$; QR/ET-controls: $r^2 = .090$).

DISCUSSION

The test revealed substantial differences between patients with AN and healthy controls with regard to the quality of reproductions as well as the exploration time for haptic stimuli. The lesser quality of reproductions of complex stimuli submitted by patients with AN points to an altered ability in processing perceptions and somatosensorial integrations (Fox, 1981; Gordon, Halmi, & Ippolito, 1984; Laessle et al., 1992; Ploog & Pirke, 1987; Szmukler et al., 1992). Our study, in fact, showed different qualities of reproductions in the AN group. The findings demonstrated that patients with AN have greater problems with complex haptic information than healthy controls. Based on studies in the field of Gestaltpsychology, simple geometric figures are identified on the basis of only a few basic characteristics without comprehensive perceptual–cognitive operations (Appelle, 1991). With increasing complexity, however, greater demand is placed on somatosensorical integration abilities, short-term memory processing, and selective attention (Gibson & Walker, 1984; Grunwald et al., 1999, 2001; Klatzky, Lederman, & Metzger, 1985). It can thus be deduced that patients with AN are unable to forge the complex relations of individual stimuli elements into an overall concept. The haptic requirements of complex stimuli call for the simultaneous sensory integration of a multitude of pieces of information on space and dimensions.

We know from neuropsychological studies that these types of tasks are organized in the parietal cortex (Kolb & Whishaw, 1993; Reed, Caselli, & Farah, 1996). Lesions of the parietal cortex can result in disturbances of tactual–haptic perception (i.e., tactile agnosia, tactile aphasia) (Kolb, Sutherland, & Whishaw, 1983). It is possible that the poorer reproduction abilities displayed by patients with AN spring from a functional disorder of the right parietal lobe. This hypothesis is supported by several studies (Casper & Heller, 1991; Rovet et al., 1988). Bradley et al. (1997) maintain that anorexia nervosa impairs primarily cognitive abilities that are linked to functions of the right-parietal lobe. Kinsbourne and Bemporad

Table 3. Data for Individual Anorexia Patients (AN) and Healthy Controls (CO): BMI, Months Between First (T_0) and Second Test Session (T_1), QR, ET as well as Differences and Statistical Results.

	CO			AN															
	BMI	ET	QR		BMI		Months T_0–T_1	QR T_0		QR T_1		Differences (T_1–T_0)		ET T_0 (sec)		ET T_1 (sec)		Differences (T_1–T_0)	
					Pre	Post		Mean	(*SD*)	Mean	(*SD*)	Δ	*p*	Mean	(*SD*)	Mean	(*SD*)	Δ	*p*
Zo	20,20	120,35	1,16	Ku	16.26	17.47	21	2.00	(.95)	2.98	(1.24)	.98	**	168.67	(199.55)	111.58	(87.28)	−57.08	n.s.
B	22,77	202,48	1,23	K	13.45	12.68	22	2.98	(1.09)	2.06	(1.23)	−.92	*	105.00	(70.83)	98.58	(86.32)	−6.42	n.s.
H	25,96	110,59	1,58	L	15.23	17.16	8	1.67	(.87)	1.23	(.41)	−.44	*	18.97	(121.35)	193.69	(177.30)	74.72	n.s.
L	23,88	159,41	1,10	Mo	15.57	16.47	13	1.21	(.46)	1.23	(.33)	.02	n.s.	104.23	(52.89)	80.08	(66.0)	−24.14	n.s.
Sch	25,67	140,32	1,00	N	15.02	18.36	24	2.71	(1.32)	2.56	(1.30)	−.15	n.s.	70.63	(41.85)	84.08	(55.9)	13.46	n.s.
Bl	18,70	190,34	1,08	Ne	17.36	18.03	9	1.44	(.69)	1.58	(.94)	.15	n.s.	203.21	(152.63)	109.97	(83.6)	−93.24	**
Le	19,50	250,00	1,08	P	17.16	18.58	23	1.81	(1.26)	1.50	(.87)	−.31	n.s.	75.00	(53.58)	74.33	(54.0)	−.67	n.s.
Me	17,60	187,27	1,50	Sj	13.22	15.14	13	2.17	(1.00)	1.58	(.80)	−.58	n.s.	142.47	(102.64)	110.90	(84.4)	−31.57	n.s.
G	26,48	239,65	1,10	Su	14.47	16.97	15	1.94	(1.00)	1.25	(.38)	−.69	*	100.43	(68.02)	98.95	(76.4)	−1.48	n.s.
Be	23,59	160,30	1,08	G	13.90	17.02	26	1.25	(.46)	1.23	(.70)	−.02	n.s.	114.83	(87.79)	105.17	(78.3)	−9.66	*

t-test (two-tailed): $p \leq .05$*; $p \leq .01$**: $p > .05$ n.s.

(1984) suggest that posterior hemisphere dysfunction, involving predominantly the right parietal lobe, is specific to anorexia nervosa and is responsible for the "anorexic's neglect" of her starved body both prior to and during starvation. Our data showed that the poorer quality of haptic reproductions in patients with AN exists as well after weight gain. We can assume that somatosensory deficits in AN are independent of nutritional state. Such somatosensory deficits could possibly be a risk factor for the development of illness. The results obtained so far thus support the notion that patients with AN (during the acute stage of the disease and after weight gain) are obviously impaired when it comes to processing haptic information. This may be due to a disorder of visual-spatial processing in the parieto-occipital regions (Bradley et al., 1997; Kolb & Whishaw, 1993). Furthermore, our own EEG study provided evidence that the brain electrical activity over these areas is reduced in patients with AN during rest and during a haptic perception (Grunwald et al., 1998).

The observation of poorer preformance in a tactile-perceptual task independent from weight gain during medical treatment may be an indication of a general deficit of integrative somatosensory processing in, at least, some patients with AN. Therefore, the heterogeneity in the patients' groups in the quality of reproductions may indicate a different perceptual–cognitive and cortical development in patients with AN. Further studies should be conducted to show whether or not this deficit in integrative somatosensory processing is a stable observation and, if so, whether the differentiation between poor and normal performance in the haptic task is of diagnostic and/or prognostic value. Based on the analysis of exploration times, patients with AN spend, on the average, less time completing haptic exploration tasks than healthy controls. Interestingly, however, there is obviously no correlation between reproduction quality and exploration time. Both phenomena should thus be interpreted separately. A possible explanation for the shorter exploration time of patients with AN may be their strong desire and ambition to accomplish the task as quickly as possible. In various studies, patients with AN were found to be high achievers, ambitious, and of sound or extraordinary intelligence (Schmidt, Lay, & Blanz, 1997; Steinhausen, 1994; Szabo & Blanche, 1997).

In future studies, haptic reproduction abilitites of patients with AN could be used to identify subtypes of eating disorders. However, in order to make any qualified statements on the special nature of this haptic disorder, comparable studies must be performed on patients suffering from other psychiatric disorders. The ability to process tactual haptic information must be thoroughly researched in long-term studies during childhood and the teenage years. Only then will we be able to ascertain whether tactual–haptic disorders are part of the predisposition or sequelae of the illness.

REFERENCES

Appelle, S. (1991). Haptic perception of form: Activity and stimulus attributes. In M.A. Heller & W. Schiff (Eds.), *The Psychology of touch* (pp. 169–187). New Jersey: Lawrence Erlbaum Associates.

Beaumont, P., Al-Alami, M., & Touyz, S. (1988). Relevance of a standard measurement of undernutrition to the diagnosis of anorexia nervosa: Use of Quetelet's Body Mass Index (BMI). *International Journal of Eating Disorders*, *7*, 399–405.

Blanz, B.J., Detzner, U., Lay, B., Rose, F., & Schmidt, M.H. (1996). The intellectual functioning of adolescents with anorexia nervosa and bulimia nervosa. *European Child and Adolescent Psychiatry*, *3*, 129–135.

Bradley S.J., Taylor, M.J., Rovet, J.F., Goldberg, E., Hood, J., Wachsmuth, R., Azcue, M.P., & Pencharz, P.B. (1997). Assessment of brain function in adolescent anorexia nervosa before and after weight gain. *Journal of Clinical and Experimental Neuropsychology*, *19*, 20–33.

Brosius, F. (1998). *SPSS 8.0: Professionelle Statistik unter Windows*. Bonn: MITP-Verlag.

Brouwers, P., Duncan, C.C., & Mirsky, A.F. (1986). Cognitive and personality concomitants of eating disorders. *Journal of Clinical Experimental Neuropsychology*, *8*, 135.

Casper, R.C., & Heller, W. (1991). "La douce indifference" and mood in anorexia nervosa: Neuropsychological correlates. *Progress in Neuro-Psychopharmacology & Biological Psychiatry*, *15*, 15–23.

Douglas, G.A. (1991). *Practical Statistics for Medical Research*. London, New York: Chapman & Hall.

Fox, C.F. (1981). Neuropsychological correlates of anorexia nervosa. *International Journal of Psychiatry in Medicine*, *11*, 285–290.

Gibson, E.J., & Walker, A.S. (1984). Development of knowledge of visual-tactual affordances of substance. *Child Development*, *55*, 453–460.

Gordon, D.P., Halmi, K.A., & Ippolito, P.M. (1984). A comparison of the psychological evaluation of adolescents with anorexia nervosa and of adolescents with conduct disorders. *Journal of Adolescence*, *7*, 245–266.

Grunwald, M., Ettrich, C., Krause, W., Assmann, B., Rost, R., & Gertz, H.J. (1998). Haptic perception and EEG power changes in anorexia nervosa. *European Archives of Psychiatry and Clinical Neuroscience*, Vol. 248, Supl. 2, S. 128 (P 203).

Grunwald, M., Weiss, T., Krause, W., Beyer, L., Rost, R., Gutberlet, I., & Gertz, H.J. (1999). Power of theta waves in the EEG of human subjects increases during recall of haptic information. *Neuroscience Letters*, *260*, 189–192.

Grunwald, M., Weiss, T., Krause, W., Beyer, L., Rost, R., Gutberlet, I., & Gertz, H.-J. (2001). Theta power in the EEG of humans during ongoing processing in a haptic object recognition tasks. *Cognitive Brain Research*, *11*, 33–37.

Heller, M.A., & Schiff, W. (Eds.) (1991). *The Psychology of touch*. New Jersey: Lawrence Erlbaum.

Internationale Klassifikation psychischer Störungen (1993). ICD-10 Kapitel V (F). Klinisch-diagnostische Leitlinien. Weltgesundheitsorganisation. Übers. und hrsg. Dilling, H., Mombour, W., Schmidt, M. H. 2. korr. Auflage. Bern, Göttingen, Toronto, Seattle: Verlag Hans Huber.

Kinsbourne, M., & Bemporad, B. (1984). Lateralization of emotion: A model and the evidence. In N.A. Fox & R.J. Davidson (Eds.), *The psychobiology of affective development* (pp. 259–291). Hillsdale, NJ: Lawrence Erlbaum.

Klatzky, R.L., Lederman, S.J., & Metzger, V.A. (1985). Identifying objects by touch: An "expert system". *Perception and Psychophysics*, *37*, 299–302.

Kolb, B., Sutherland, R.J., & Whishaw, I.Q. (1983). A comparison of the contributions of the frontal and parietal association cortex to spatial localization in rats. *Behavioral Neuroscience*, *97*, 13–27.

Kolb, B., & Whishaw, I.Q. (1993). *Fundamentals of human neuropsychology*. New York: Oxford University Press.

Laessle, R.G., Fischer, M., Fichter, M.M., Pirke, K.M., & Krieg, J.C. (1992). Cortisol levels and vigilance in eating disorder patients. *psychoneuroendocrinology*, *17*, 475–484.

Pendleton-Jones, B., Duncan, C.C., Brouwers, P., & Mirsky, A.F. (1991). Cognition in eating disorders. *Journal of Clinical and Experimental Neuropsychology*, *76*, 711–728.

Ploog, D.W., & Pirke, K.M. (1987). Psychobiology of anorexia nervosa. *Psychological Medicine*, *17*, 843–860.

Ranseen, J.D., & Humphries, M.D. (1992). The intellectual functioning of the eating disorder patients. *Journal of the American Academy of Child and Adolescent Psychiatry*, *31*, 844–846.

Reed, C.L., Caselli, R.J., & Farah, M.J.(1996). Tactile agnosia. Underlying impairment and implications for normal tactile object recognition. *Brain*, *119*, 875–888.

Rovet, J., Bradley, S., Goldberg, E., & Wachsmuth, R. (1988). Hemispheric lateralization in anorexia nervosa. A Pilot Study. *Journal of Clinical and Experimental Neuropsychology*, *10*, 24.

Schmidt, M.H., Lay, B., & Blanz, B. (1997). Verändern sich kognitive Leistungen Jugendlicher mit Anorexia nervosa unter der Behandlung? *Zeitschrift für Kinder- und Jugendpsychiatrie*, *25*, 17–26.

Small, A., Madero, J., Teagno, L., & Ebert, M. (1983). Intellect, perceptual characteristics and weight gain in anorexia nervosa. *Journal of Clinical Psychology*, *39*, 780–782.

Steinhausen, H.C. (1994). Anorexia and bulimia nervosa. In M. Rutter, E. Taylor, & L. Hersov (Eds.), *Child and adolescent psychiatry: Modern approaches* (pp. 425–440). Oxford: Blackwell Scientific Publications.

Szabo, C.P., & Blanche, M.J.T. (1997). Perfectionism in anorexia nervosa. *American Journal of Psychiatry*, *154*, 132–132.

Szmukler, G.I., Anrewes, D., Kingston, K., Chen, L., Stargatt, R., & Stanley, R. (1992). Neuropsychological impairment in anorexia nervosa: Before and after refeeding. *Journal of Clinical and Experimental Neuropsychology*, *14*, 347–352.

Witt, E.D., Ryan, C., & Hsu, L.K. (1985). Learning deficits in adolescents with anorexia nervosa. *Journal of Nervous and Mental Disease*, *173*, 182–184.