Effects of Short-Term Energy Deprivation on Stress Reactions in Humans

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Food deprivation has marked effects on somatic and psychic processes. The intensity and the pattern of the effects depend on the type and duration of the deprivation. In a study with humans carried out by Schultz-Gambard and one of us (Janke) at the Department of Psychology of Düsseldorf University, food deprivation of 12 to 24 hours already induced changes of psychophysiological variables, e.g., heart rate and subjective ratings of hunger and appetite (Schultz-Gambard, 1988). Processes within the feeding system are affected predominantly, but responses to stimuli that primarily affect other motivational-emotional systems may be influenced as well, e.g., emotional reactivity and responses to stressors. Studies with laboratory rats demonstrate that responses to aversive stimuli can be altered by food deprivation, i.e., nociceptive thresholds are elevated (Bodnar, Kelly, Spaggia, & Glusman, 1978). This experiment was conducted to investigate the effects of a short-term reduction of energy intake on psychophysiological reactivity in humans. It was planned as an exploratory study.

Method

24 male students with a mean age of 24 years (range: 19-30) and normal weight were randomly allocated to experimental conditions: normal and low energy intake (energy deprivation) with n=12 subjects in each group. The design was

"blind", i.e., the subjects did not know to which group they belonged. Moreover they were not informed about the fact of energy deprivation at all. The experiment was carried out by two female psychologists (Dipl.-Psych. K. Buresch and Dipl.-Psych. K. Reder), each having the same number of subjects. Energy deprivation was induced without depriving subjects of eating behavior. Two meals with different energy content were given: breakfast at 8.45 a.m. (110 vs. 500 kcal) and lunch at 1.00 p.m. (70 kcal vs. 1000 kcal). Under both conditions three laboratory stressors were applied. The first stress period started at 11.00 a.m., the second at 3.00 p.m. (see Figure 1). Measurements were taken during a baseline at the beginning of the stress period as well as before and after each of the three laboratory stressors, each lasting 5 minutes: emotionally arousing pictures, mental arithmetic (subtracting a small number from a big one successively) and intermittent white noise (95 dB). The stressors have been proved as stressful in earlier experiments. They were applied in counter-balanced order and the sequence was the same in the first and second stress period for a given subject. Physiological measures were heart rate, blood pressure, skin conductance level, skin temperature, sublingual temperature and cortisol in saliva. Subjective somatic state was assessed with a list of 10 items describing bodily symptoms (Erdmann & Janke, 1981), subjective emotional

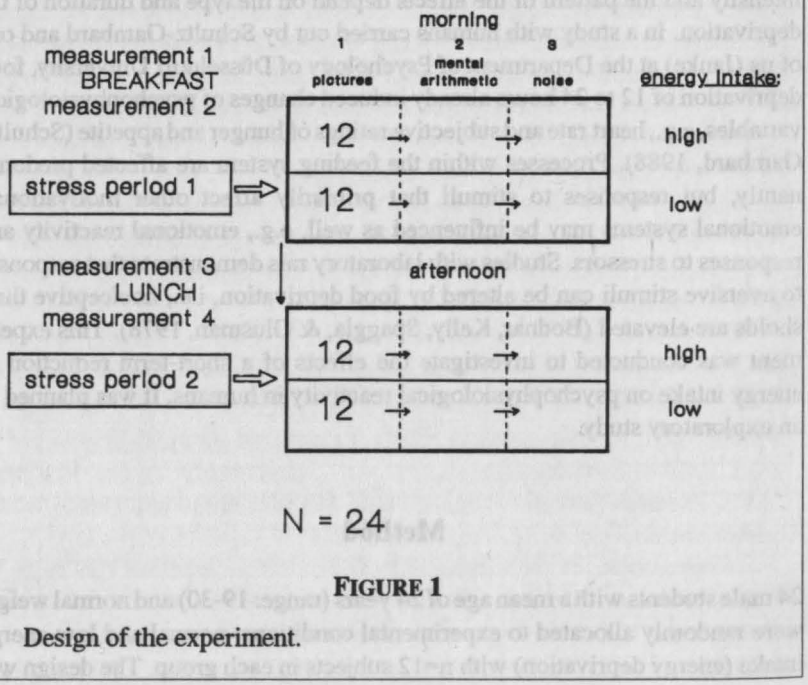

FIGURE 1

Design of the experiment.

state under resting conditions with an adjective checklist, the EWL (Janke & Debus, 1978). Before and after stressors a list of 6 nouns referring to emotional states was used. Furthermore, self-report measures on hunger, appetite and satiety were administered. Psychophysiological state under resting conditions was measured before and after meals. To reveal differences between experimental groups and between baseline and stress responses within groups, nonparametric tests (Mann-Whitney U tests, Wilcoxon tests) were computed. The analysis of data is descriptive (Abt, 1987).

Results

Psychophysiological State Under Resting Conditions

Self-ratings indicate increased feelings of hunger and appetite under low energy intake in the morning as well as in the afternoon ($p<.05$). Subjects under deprivation reported reduced body temperature, reduced peripheral blood flow, reduced regular heart beat and more sensations of stomach activity ($p<.05$). No substantial effects of deprivation on subjective emotional state could be shown under resting conditions. A few physiological measures were changed, i.e., heart rate was increased after lunch in the control group, but not in the deprivation group ($p<.05$), and additionally, sublingual temperature was reduced slightly under deprivation in the afternoon ($p<.10$).

Responses to Stressors

Emotional responses to pictures and noise were reduced under energy deprivation for the item "excitement" in the first stress period ($p<.05$, Figure 2). This difference could not be observed in the second stress period, although subjects responded to stressors after normal and low energy intake ($p<.05$). For the item "irritation" a nearly significant difference in the same direction was found in responses to noise in the first stress period ($p<.10$), but again not in the second. Other indicators of subjective emotional state were affected by the stressors as well, but no differences between groups were present. No differences in baseline levels of subjective emotional state and physiological measures were found, with the exception of heart rate, which was lower under deprivation in the second stress period. This difference was found during baseline and after each of the stressors ($p<.10$ for baseline and mental arithmetic, $p<.05$ for pictures and noise) and reflects the post-lunch alteration of heart rate under resting conditions. Whereas no effects of stressors on heart

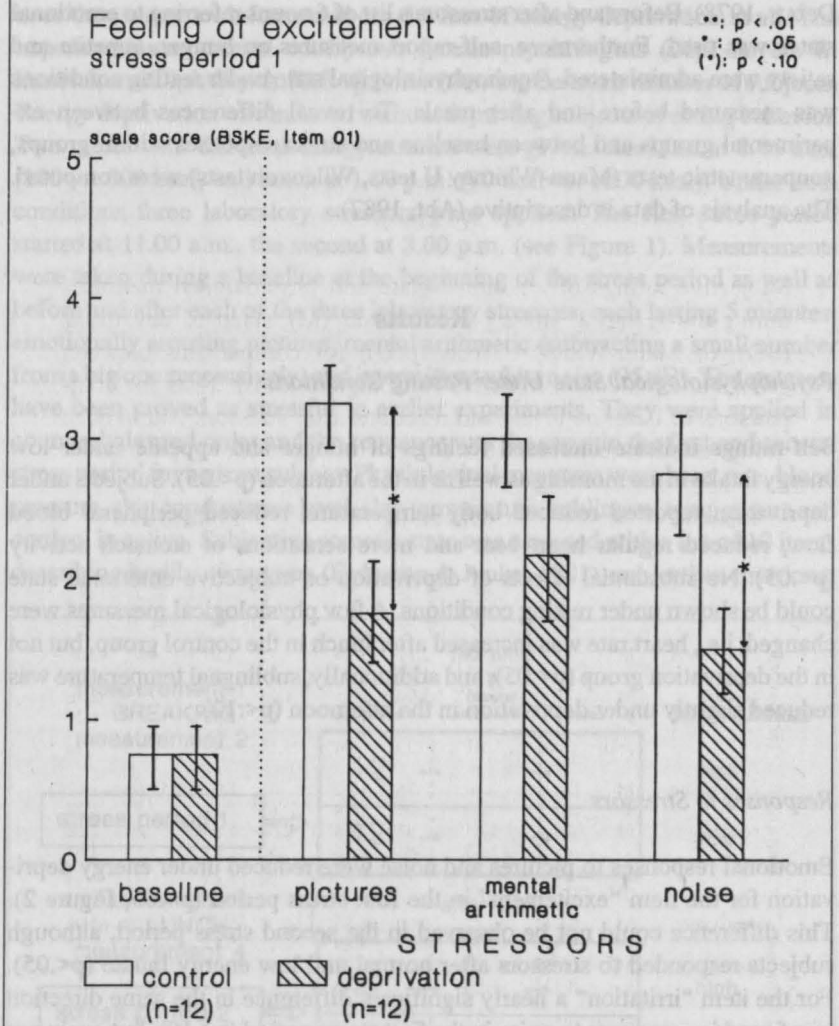

FIGURE 2

Subjective ratings of excitement (mean ± SEM) in the first stress period during baseline and after each stressor. Differences between groups (control, deprivation) were tested with Mann-Whitney U Tests.

rate could be detected, under both deprivation conditions skin conductance level increased after all of the three stressors in the first and second stress period ($p<.01$) and skin temperature was heightened as well in both experimental groups, above all in the second stress period ($p<.05$). Details can be seen from Table 1.

TABLE 1

Subjective ratings of emotional state and physiological measures during the 1. and 2. stress period: means (M), standard deviations (SD), of Mann-Witney-U-Tests (p(U)) for comparisons between groups and Wilcoxon Matched-Pairs Signed-Ranks Tests for comparisons of baseline levels and reactions after stressors within each group (asterisks behind means: (*): $p<.10$, *: $p<.05$, **: $p<.01$).

	Experimental Group		1. Stress Period				2. Stress Period			
			baseline	pictures	mental arithmetic	noise	baseline	pictures	mental arithmetic	noise
EXCITEMENT	deprivation	M	.75	1.75(*)	2.17*	1.50	.75	2.50**	1.42*	2.08**
		s	.75	1.42	1.53	1.00	.87	.80	1.17	1.51
	control	M	.75	3.25**	3.00**	2.75**	1.25	2.67**	2.33**	2.58**
		s	.75	.97	1.13	1.49	.97	1.30	1.56	1.24
		p(U)	1.00	.01*	.23	.04*	.14	.88	.15	.34
IRRITATION	deprivation	M	.25	.50	.75(*)	1.42*	.42	1.08(*)	.58	1.42(*)
		s	.62	.80	1.06	1.38	.67	1.17	.52	1.73
	control	M	.25	1.25*	.83*	2.58**	.50	1.50(*)	.83	2.08*
		s	.45	1.55	.84	1.56	.80	1.45	.84	1.68
		p(U)	.71	.20	.64	.07(*)	.89	.49	.51	.27
HEART RATE (bpm)	deprivation	M	64.48	66.27	68.00	66.86*	63.38	65.63(*)	66.00	64.93
		s	9.95	10.34	11.43	8.89	6.42	6.17	8.11	7.13
	control	M	66.39	68.23	69.27*	68.77(*)	75.65	75.33	76.73	75.68
		s	8.32	9.60	11.43	9.43	13.41	12.45	12.93	13.12
		p(U)	.81	.41	.85	.83	.08(*)	.04*	.09(*)	.04*
SKIN TEMPERATURE (°C)	deprivation	M	23.60	27.11**	26.86*	26.45	23.60	28.90**	28.27**	28.52**
		s	4.24	4.09	3.90	3.92	4.28	4.94	4.94	4.60
	control	M	24.61	27.13*	26.50	26.30	25.92	29.56*	29.29*	29.46*
		s	4.22	4.21	4.38	3.55	4.07	4.01	4.36	3.27
		p(U)	.60	.98	.95	.951	.14	.86	.82	.82
SCL (microS)	deprivation	M	15.27	26.94**	29.49**	28.04**	11.83	24.83**	23.35**	25.44*
		s	10.12	14.04	15.17	15.24	6.94	13.80	12.84	16.33
	control	M	9.38	20.29**	20.22**	19.24**	11.73	22.85**	24.48**	20.20**
		s	4.75	12.29	11.51	12.86	5.65	11.33	13.53	11.33
		p(U)	.13	.18	.12	.18	.77	.91	.82	.45

Discussion

Psychophysiological state was altered by short-term energy deprivation. Certain aspects of subjective somatic state were changed. Differences between groups in food-related subjective responses, e.g., an increased feeling of hunger, preceded both stress periods. Additionally, a slight reduction of body temperature and heart rate in the afternoon were found. A reduction of heart rate has already been shown for total food deprivation with a duration of 12 to 24 hours (Schultz-Gambard, 1988). Physiological and psychological responses could be detected after all of the three stressors. Interestingly, energy deprivation reduced subjective emotional responses ("excitement") after pictures and noise in the first stress period. Physiological responses to stressors, however, were not influenced significantly by food deprivation. The results point to reduced emotional reactivity in the state of hunger, which may depend on the type of stressor and may occur only in certain aspects of the stress response.

Acknowledgements

This experiment was carried out as part of a larger project on psychobiology of stress and was supported by the Bundesministerium des Inneren.

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