

Supplementary material

The effect of fasting on human memory consolidation

Xuefeng Yang^{a,b}, Xiu Miao^{a,b}, Franziska Schweiggart^a, Sophia Großmann^a, Karsten Rauss^a, Manfred Hallschmid^{a,c,d,e}, Jan Born^{a,c,d,e,f,*}, Nicolas D. Lutz^{a,g}

^aInstitute of Medical Psychology and Behavioral Neurobiology, University of Tübingen, Tübingen, Germany; ^bGraduate School of Neural & Behavioural Science, International Max Planck Research School, Tübingen, Germany; ^cGerman Center for Diabetes Research (DZD), Tübingen, Germany

^dInstitute for Diabetes Research & Metabolic Diseases of the Helmholtz Center Munich at the University Tübingen (IDM), Germany; ^eGerman Center for Mental Health (DZPG), Tübingen, Germany; ^fWerner Reichert Center for Integrative Neuroscience, University of Tübingen, Tübingen, Germany; ^gInstitute of Medical Psychology, LMU Munich, Munich, Germany

* Corresponding author at: Institute of Medical Psychology and Behavioral Neurobiology, University of Tübingen, Otfried-Müller-Str. 25, 72076 Tübingen, Germany

E-mail address: jan.born@uni-tuebingen.de (J. B.)

Experiment 1

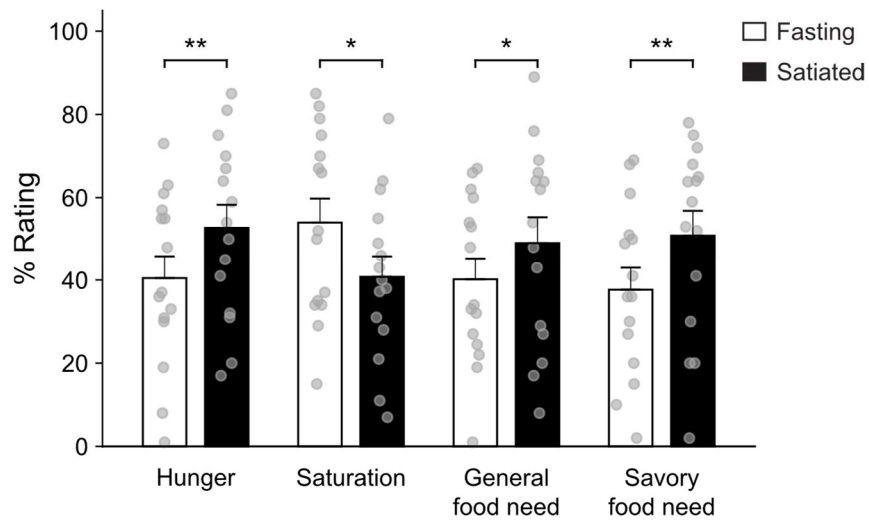


Fig. S1. Hunger ratings before retrieval on day 3 in Experiment 1. In the Fasting condition, participants felt less hungry ($p < 0.01$), more satiated ($p < 0.05$), had a diminished general need for food ($p < 0.05$) and, particularly, for savory food ($p < 0.01$) than in the Satiated condition. $N = 15$.

Table S1. Control variables in Experiment 1.

	Fasting	Satiated
Encoding phase (day 1)		
PVT	355.58 (8.65)	355.95 (10.42)
Digit span	6.93 (0.18)	6.13 (0.38)*
RWT	16.20 (0.92)	15.53 (1.37)
SSS	3.27 (0.27)	3.33 (0.19)
Retrieval phase (day 3)		
PVT	334.54 (8.05)	339.67 (9.46)
Digit span	7.00 (0.24)	6.93 (0.30)
RWT	18.87 (1.81)	17.73 (1.21)
SSS	2.33 (0.16)	2.67 (0.21)*

Note: Data are mean (SEM). The Psychomotor Vigilance Task (PVT) refers to average reaction times (ms). Digit span and word fluency (RWT) are measured by the number of correctly recalled digits and words, respectively. SSS, Stanford sleepiness scale. * $p < 0.05$ for differences between Fasting and Satiated conditions. $N = 15$.

Fatigue. The participants' fatigue was assessed 6 times, with one assessment on days 0 and 3, and 4 assessments on day 1. On day 1, before dinner, rated fatigue in the Fasting condition was higher than in the Satiated condition ($F(1,14) = 6.47$, $p = 0.023$, $\eta_p^2 = 0.32$). However, no significant difference was observed in the assessments conducted at any of the other time points (all $p > 0.1$).

Food quality. The participants ratings of the quality of the food provided during the experiments was closely comparable between the Fasting and Satiated conditions. Specifically, rated palatability of the food was similar between the conditions on day 0 after lunch, day 1 after dinner, and day 3 after dinner (all $p > 0.1$). There was also no significant difference between the conditions in satiety after meals on day 0 and day 3 (all $p > 0.1$). However, on day 1 after dinner, rated satiety was lower in the Fasting than Satiated condition ($F(1,13) = 7.98$, $p = 0.014$, $\eta_p^2 = 0.38$).

Sleep diary. Participants went to bed between 22:00 and 00:30 h and got up between 04:30 and 09:00 h. On day 1, the self-rated sleep quality in the Fasting condition was lower than in the Satiated condition ($F(1,10) = 7.11$, $p = 0.024$, $\eta_p^2 = 0.42$). However, there was no significant difference between the Fasting and Satiated conditions on day 0 and day 3 (all $p > 0.2$).

Debriefing. At the end of each condition, participants were given a debriefing questionnaire. No difference was found between the Fasting and Satiated conditions with respect to the effort of this experiment ($p > 0.3$). The rated difficulty of the three memory tasks (WPA, FTT, DRM) did not differ between the Fasting and Satiated conditions (all $p > 0.3$).

Experiment 2

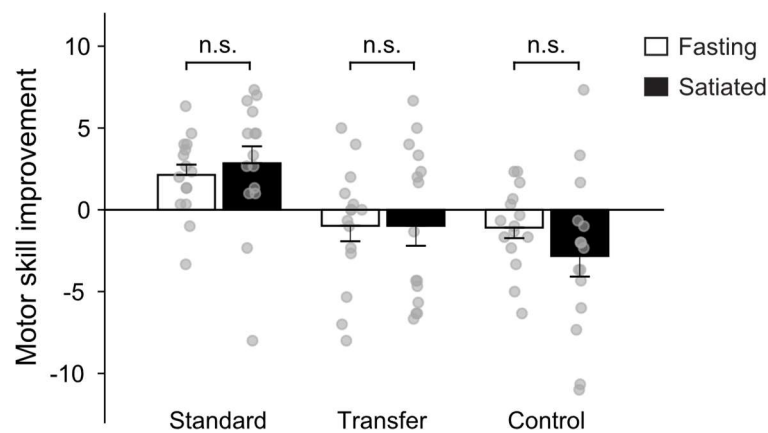


Fig. S2. Finger Tapping Task (FTT) performance in Experiment 2. Means $\pm$ SEM differences in the number of correctly typed sequences between the three test blocks (retrieval) and the last three training blocks (standard, transfer tests) or the first three training blocks (control test), for the Fasting (white bars) and Satiated conditions (black bars), respectively. Dot plots overlaid, n.s., not significant. N = 15.

Table S2. Control variables in Experiment 2.

	Fasting	Satiated
Encoding phase (day 1)		
PVT	341.62 (6.20)	321.59 (11.21)
Digit span	6.63 (0.35)	6.63 (0.29)
RWT	19.94 (1.26)	20.50 (1.00)
SSS	3.25 (0.19)	3.09 (0.25)
Retrieval phase (day 2)		
PVT	325.03 (9.64)	312.90 (8.68)
Digit span	6.88 (0.39)	7.13 (0.38)
RWT	20.13 (1.08)	22.81 (1.35)*
SSS	2.63 (0.24)	2.88 (0.24)

Note: Data are mean (SEM). The Psychomotor Vigilance Task (PVT) refers to average reaction times (ms). Digit span and word fluency (RWT) are measured by the number of correctly recalled digits and words, respectively. SSS, Stanford sleepiness scale. *p < 0.05 for differences between Fasting and Satiated conditions. N = 16.

Fatigue. The participants' fatigue was assessed 6 times, once on days 0 and 2, and 4 times on day 1. There was no difference in fatigue levels between the Fasting and Satiated conditions across the six tests ($F(1,14) = 0.18$, $p = 0.678$) or at any specific time point (all $p > 0.1$).

Food quality. The participants' ratings of food quality did not differ between conditions. On day 0 after lunch and day 1 after dinner, food palatability was comparable between the Fasting and Satiated conditions (all $p > 0.3$). Regarding post-meal satiety, the participants felt less satiated in the Fasting than Satiated condition on day 1 after dinner ($F(1,15) = 7.50$, $p = 0.015$, $\eta_p^2 = 0.33$). There was no difference between the conditions on day 0 before lunch ($p > 0.8$).

Sleep diary and actigraphy. Participants went to bed between 22:00 and 1:00 h and got up between 5:55 and 10:10 h. Self-rated sleep quality did not differ between the Fasting and Satiated conditions on day 0 and day 1 (all $p > 0.1$). In addition to the self-report sleep diary, sleep quality was assessed using actigraphy. There was no difference between the Fasting and Satiated conditions in sleep efficiency on day 0 and day 1 (all $p > 0.4$), sleep bouts on day 0 and day 1 (all $p > 0.3$), and wake bouts on day 0 and day 1 (all $p > 0.4$).

Debriefing. At the end of each condition, participants were given a debriefing questionnaire. Regarding self-rated effort put into performing the experiments, participants reported a higher effort at the end of the Fasting than Satiated condition ($F(1,13) = 9.89$, $p = 0.008$, $\eta_p^2 = 0.43$). The rated difficulty of the three memory tasks (WPA, FTT, WWW) did not differ between the Fasting and Satiated conditions (all $p > 0.3$). When asked at the end of the second condition (i.e., at the very end of the experiment), the number of participants believing that fasting or being satiated would improve memory performance did not differ between conditions (6 vs. 9 for participants in the Fasting vs. Satiated condition, respectively; $\chi^2 = 1.00$, $df = 1$, $p = 0.317$).