## Supplementary

### Figure S1

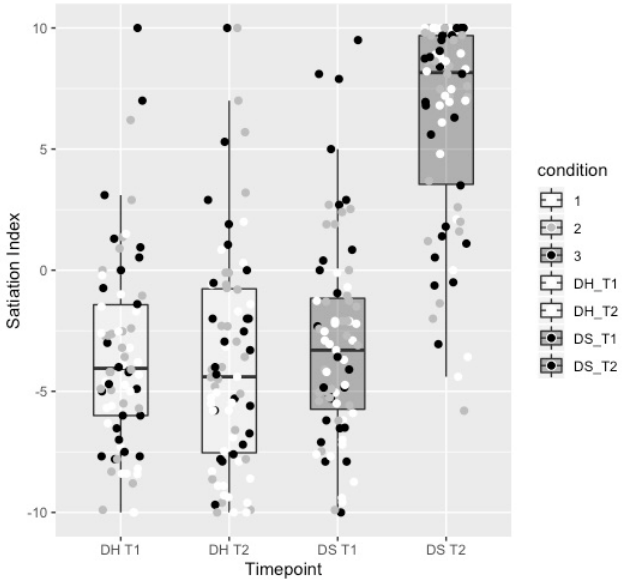


Figure S1 Sanity Check: Subjective hunger depicted by visual analogue ratings. A satiation index was computed by subtracting hunger ratings from fullness ratings at each time point of internal state ratings on visual analog scales (Sun et al., 2016). A high positive index can be interpreted as very sated and a high negative index as very hungry. Because of heterogeneous variances, a Wilcoxon test was performed with satiety index pre- and postprandial under two conditions (day hunger vs. day sated). The Wilcoxon Signed-Ranks Test indicated for the sated condition significantly higher median post-test than the median pre-test scores ($Z=-7.292$, $p<.001$), whereas it was the other way around for the hungry condition ($Z=-2.304$, $p=.021$). Thus, as expected, participants felt sated after meal in the sated condition and perceived more hunger or less fullness in the hungry condition after the break without a meal.

### Figure S2

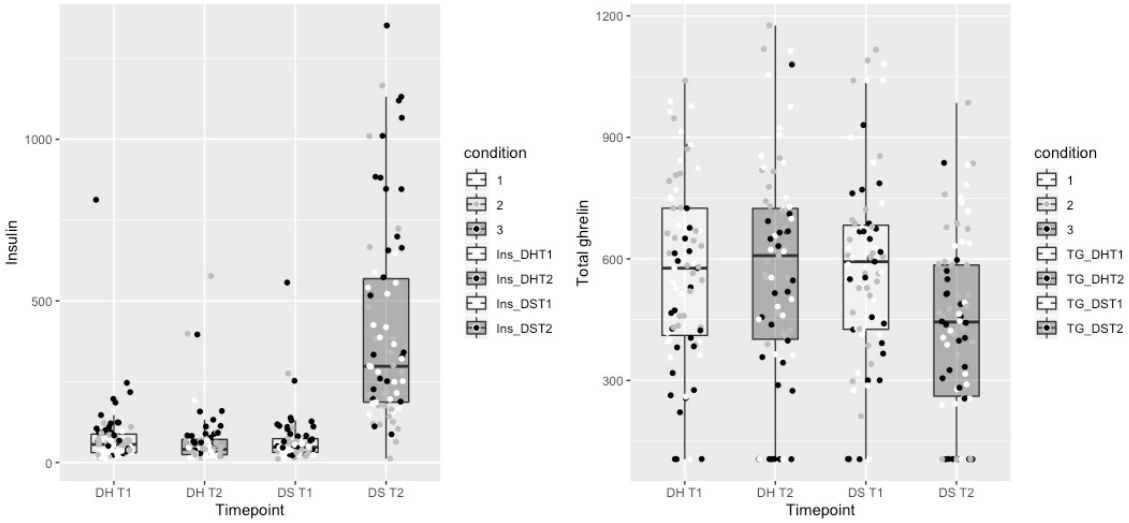


Figure S2 Sanity Check: Physiological hunger depicted by pre- and postprandial insulin and ghrelin levels. Wilcoxon Signed Ranks test over all groups for insulin and total ghrelin levels before and after meal at both test days as proxies of depicting physiological hunger. As expected we could show a significant increase of insulin levels in the sated condition after meal intake ($Z=-6.931$, $p<.001$) and no change of insulin levels in the hungry condition ($Z=-1.447$, $p=.148$). As expected total ghrelin levels decreased in the sated condition after meal intake ($Z=-4.851$, $p<.001$) and did not change in the hungry condition ($Z=-1.686$, $p=.092$).

**Table S1** Olfactory sensitivity and sex/cycle phase in women

| | | | Menstrual cycle phase (in women) | |
|---|---|---|---|---|
| | Male | Female | Luteal phase (n=15) | Follicular phase (n=22) |
| Average ODT | 8.31 ± 1.13<br>5.33 – 10.17 | 8.93 ± 1.27<br>4.89 – 10.89 | 8.77 ± 1.52<br>4.89 – 10.89 | 9.04 ± 1.09<br>6.50 – 10.83 |

**Table S2** Hormonal parameters in weight groups and correlation with BMI

| | Group level | | | | | Correlation analysis | |
|---|---|---|---|---|---|---|---|
| | NW | OW | OB | Test | sig | Corr. with BMI | sig |
| Insulin | 37.01 ± 16.96 (10.60 – 86.95) | 54.85 ± 24.74 (18.85 – 108.80) | 89.34 ± 42.60 (25.10 – 179.90) | ANOVA F = 19.122/df=2 | $p < .001$ | .619** | $p < .001$ |
| *Post hoc: (Tukey) NW+OB (p<.001); OW+OB (p=.001)* | | | | | | | |
| IR | .74 ± .30 (.44 – 1.66) | 1.06 ± .45 (.45 – 2.04) | 1.67 ± .78 (.48 – 3.32) | K-W H test F = 24.228/df=2 | $p < .001$ | .601** | $p < .001$ |
| Leptin | 6.19 ±3.92 (1.20 – 15.00) | 10.88 ± 10.04 (.80 – 33.20) | 18.61 ± 15.02 (3.80 – 52.20) | ANOVA F = 24.76/df=2 | $p < .001$ | .476** | $p < .001$ |
| *Post hoc: (Games Howell, covariate: sex) NW+OB (p=.005)* | | | | | | | |
| Total ghrelin | 604.35 ± 238.32 (182.75 – 1035.00) | 626.46 ± 186.43 (366.50 – 1078.00) | 478.75 ± 204.12 (105.50 – 903.50) | ANOVA F = 3.474/df=2 | $p = .036$ | -.226* | $p = .026$ |
| *Post hoc: (Tukey) OW + OB (p=.030)* | | | | | | | |
| AG | 11.62 ± 7.06 (1.71 – 25.68) | 13.85 ± 9.98 (2.27 – 45.14) | 15.05 ± 16.63 (1.00 – 59.66) | ANOVA F = .526/df=2 | $p = .593$ | .037 | $p = .760$ |
| UAG | 21.40 ± 16.25 (2.71 – 58.48) | 16.22 ± 8.67 (3.27 – 38.27) | 19.75 ± 11.21 (3.00 – 41.20) | ANOVA F = 1.126/df=2 | $p = .330$ | -.004 | $p = .973$ |
| AG/UAG ratio | 1.24 ± 1.51 (.03 – 5.92) | 1.48 ± 1.52 (.10 – 5.78) | 1.25 ± 1.40 (.03 – 4.90) | ANOVA | $p = .818$ | .012 | $p = .923$ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | F = .202/df=2 | | | | |

**Table S3** Mediation analysis. Relationship between BMI and olfaction via hormonal parameters

| | Estimate | SE/MSE | t/F | p | $R^2$ | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|---|---|
| ***FOOD ODT general via metabolic state (BMI as x variable)*** | | | | | | | |
| Path a** | | | | | | | |
| M1: IR | **.61** | .68 | 12.53 | **<.001*** | .37 | | |
| M2: Leptin | **.83** | .30 | 48.98 | ** | .70 | | |
| M3: AG/UAG ratio | .28 | 1.00 | 1.75 | **<.001*** | .08 | | |
| M4: TG | **.31** | .87 | 2.24 | ** | .09 | | |
| | | | | .1656 | | | |
| | | | | .0925 | | | |
| Path b** | | | | | . | | |
| *Model Summary* | .40 | .94 | 1.64 | .1414 | .16 | | |
| X: BMI | .19 | .20 | .93 | .3560 | | -.216 | .591 |
| M1: IR | **-.42** | .15 | -2.77 | **.0075*** | | **-.717** | **-.115** |
| M2: Leptin | -.06 | .22 | -.29 | ** | | -.509 | .380 |
| M3: AG/UAG ratio | -.10 | .12 | -.80 | .7716 | | -.343 | .148 |
| M4: TG | -.20 | .13 | -1.47 | .4312 | | -.461 | .070 |
| Co1: Sex | .50 | .36 | 1.37 | .1458 | | -.229 | 1.221 |
| | | | | .1762 | | | |
| Total effect | -.09 | .13 | -.70 | .4870 | | -.348 | .167 |
| Direct effect | .19 | .20 | .93 | .3560 | | -.216 | .591 |
| Indirect effect** | | | | | | | |
| IR | **-.26** | .10 | | | | **-.496** | **-.087** |
| Leptin | -.04 | .15 | | | | -.385 | .220 |
| AG/UAG ratio | -.02 | .03 | | | | -.090 | .050 |
| TG | .04 | .04 | | | | -.016 | .130 |
| ***FOOD ODT Change via metabolic state (BMI as x variable)*** | | | | | | | |
| Path a** | | | | | | | |
| M1: IR | **.61** | .68 | 12.53 | **<.001*** | .37 | | |
| M2: Leptin | **.83** | .30 | 48.98 | ** | .70 | | |
| M3: AG/UAG ratio | .28 | 1.00 | 1.75 | **<.001*** | .08 | | |
| M4: TG | **.31** | .87 | 2.24 | ** | .09 | | |
| | | | | .1656 | | | |
| | | | | .0925 | | | |
| Path b** | | | | | | | |
| *Model Summary* | **.52** | 2.32 | 2.32 | **.0056*** | .27 | | |
| X: BMI | **.71** | .32 | 2.23 | ** | | **.074** | **1.340** |
| M1: IR | **-.72** | .24 | -3.06 | **.0293*** | | **-1.194** | **-.250** |
| M2: Leptin | **-.72** | .35 | -2.06 | **.0033*** | | -1.414 | -.019 |
| M3: AG/UAG ratio | -.27 | .19 | -1.37 | ** | | -.649 | .109 |
| M4: TG | -.53 | .21 | -2.53 | **.0443*** | | -.942 | -.109 |
| Co1: Sex | **1.49** | .57 | 2.61 | .1745 | | **.348** | **2.621** |
| Co2: Meal ingested | -.39 | .21 | -1.89 | **.0142*** | | -.803 | .0234 |
| | | | | **.0114*** | | | |
| | | | | .0640 | | | |
| Total effect | -.13 | .22 | -.61 | .5471 | | -.563 | .301 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Direct effect* | **.71** | .32 | 2.23 | **.0293*** | | **.074** | **1.340** |
| Indirect effect** | | | | | | | |
| IR | **-.44** | .16 | | | | **-.808** | **-.190** |
| Leptin | **-.44** | .22 | | | | **-.990** | **.117** |
| AG/UAG ratio | -.05 | .06 | | | | -.183 | .046 |
| TG | -.10 | .08 | | | | -.019 | .292 |

***Non FOOD ODT general via metabolic state (BMI as x variable)***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Path a** | | | | | | | |
| M1: IR | **.61** | .68 | 12.53 | **<.001*** | .37 | | |
| M2: Leptin | **.83** | .30 | 48.98 | * | .70 | | |
| M3: AG/UAG ratio | .28 | 1.01 | 1.75 | **<.001*** | .08 | | |
| M4: TG | **.31** | .87 | 2.24 | * | .09 | | |
| | | | | .1656 | | | |
| | | | | **.0435*** | | | |
| Path b | | | | | | | |
| *Model Summary* | .32 | .99 | .95 | .4777 | .10 | | |
| X: BMI | .16 | .21 | .77 | .4431 | | -.254 | .574 |
| M1: IR | -.22 | .15 | -1.41 | .1635 | | -.526 | .091 |
| M2: Leptin | -.02 | .23 | -.09 | .9320 | | -.475 | .436 |
| M3: AG/UAG ratio | -.11 | .13 | -.89 | .3768 | | -.364 | .140 |
| M4: TG | .07 | .14 | .55 | .5839 | | -.197 | .347 |
| Co1: Sex | .45 | .37 | 1.20 | .2356 | | -.298 | .188 |
| Total effect | -.02 | .13 | -.16 | .8751 | | -.273 | .233 |
| Direct effect | .16 | .21 | .77 | .4431 | | -.254 | .574 |
| Indirect effect | | | | | | | |
| IR | -.13 | .09 | | | | -.331 | .030 |
| Leptin | -.01 | .15 | | | | -.287 | .309 |
| AG/UAG ratio | -.02 | .03 | | | | -.099 | .043 |
| TG | -.01 | .03 | | | | -.080 | .037 |

***Non FOOD ODT Change via metabolic state (BMI as x variable)***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Path a** | | | | | | | |
| M1: IR | **.61** | .68 | 12.53 | **<.001*** | .37 | | . |
| M2: Leptin | **.83** | .30 | 48.98 | * | .70 | | |
| M3: AG/UAG ratio | .28 | 1.01 | 1.75 | **<.001*** | .08 | | |
| M4: TG | **.31** | .87 | 2.24 | * | .09 | | |
| | | | | .1656 | | | |
| | | | | **.0435*** | | | |
| Path b | | | | | | | |
| *Model Summary* | .29 | 3.23 | .80 | .5915 | .09 | | |
| X: BMI | .47 | .37 | 1.25 | .2177 | | -.282 | 1.213 |
| M1: IR | -.30 | .28 | -1.08 | .2836 | | -.859 | .256 |
| M2: Leptin | -.64 | .41 | -1.56 | .1248 | | -1.463 | .183 |
| M3: AG/UAG ratio | .13 | .23 | .56 | .5766 | | -.327 | .582 |
| M4: TG | .10 | .25 | .42 | .6736 | | -.387 | .695 |
| Co1: Sex | .86 | .67 | 1.29 | .2029 | | -.478 | 2.201 |
| Co2: Meal ingested | -.15 | .24 | -.63 | .5332 | | -.640 | .335 |
| Total effect | -.11 | .23 | -.476 | .6359 | | -.571 | .352 |
| Direct effect | .47 | .37 | 1.25 | .2177 | | -.282 | 1.213 |
| Indirect effect | | | | | | | |
| IR | -.19 | .17 | | | | -.541 | .123 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Leptin | -.39 | .32 | | | | -1.061 | .214 |
| AG/UAG ratio | .02 | .08 | | | | -.135 | .208 |
| TG | -.02 | .06 | | | | -.156 | .088 |
| ***FOOD ODT general via metabolic state (WHR as x variable)*** | | | | | | | |
| Path a** | | | | | | | |
| M1: IR | **.61** | .68 | 12.53 | **<.001*** | .37 | | |
| M2: Leptin | **.83** | .30 | 48.98 | ** | .70 | | |
| M3: AG/UAG ratio | .28 | 1.00 | 1.75 | **<.001*** | .08 | | |
| M4: TG | **.31** | .87 | 2.24 | ** | .09 | | |
| | | | | .1656 | | | |
| | | | | .0925 | | | |
| Path b** | | | | | . | | |
| *Model Summary* | .40 | .94 | 1.64 | .1414 | .16 | | |
| X: BMI | .19 | .20 | .93 | .3560 | | -.216 | .591 |
| M1: IR | **-.42** | .15 | -2.77 | **.0075*** | | **-.717** | **-.115** |
| M2: Leptin | -.06 | .22 | -.29 | ** | | -.509 | .380 |
| M3: AG/UAG ratio | -.10 | .12 | -.80 | .7716 | | -.343 | .148 |
| M4: TG | -.20 | .13 | -1.47 | .4312 | | -.461 | .070 |
| Co1: Sex | .50 | .36 | 1.37 | .1458 | | -.229 | 1.221 |
| | | | | .1762 | | | |
| Total effect | -.09 | .13 | -.70 | .4870 | | -.348 | .167 |
| Direct effect | .19 | .20 | .93 | .3560 | | -.216 | .591 |
| Indirect effect** | | | | | | | |
| IR | **-.26** | .10 | | | | **-.496** | **-.087** |
| Leptin | -.04 | .15 | | | | -.385 | .220 |
| AG/UAG ratio | -.02 | .03 | | | | -.090 | .050 |
| TG | .04 | .04 | | | | -.016 | .130 |
| ***FOOD ODT Change via metabolic state (WHR as x variable)*** | | | | | | | |
| Path a** | | | | | | | |
| M1: IR | **.61** | .68 | 12.53 | **<.001*** | .37 | | |
| M2: Leptin | **.83** | .30 | 48.98 | ** | .70 | | |
| M3: AG/UAG ratio | .28 | 1.00 | 1.75 | **<.001*** | .08 | | |
| M4: TG | **.31** | .87 | 2.24 | ** | .09 | | |
| | | | | .1656 | | | |
| | | | | .0925 | | | |
| Path b** | | | | | | | |
| *Model Summary* | **.52** | 2.32 | 2.32 | **.0056*** | .27 | | |
| X: BMI | **.71** | .32 | 2.23 | ** | | **.074** | **1.340** |
| M1: IR | **-.72** | .24 | -3.06 | **.0293*** | | **-1.194** | **-.250** |
| M2: Leptin | **-.72** | .35 | -2.06 | **.0033*** | | -1.414 | -.019 |
| M3: AG/UAG ratio | -.27 | .19 | -1.37 | ** | | -.649 | .109 |
| M4: TG | -.53 | .21 | -2.53 | **.0443*** | | -.942 | -.109 |
| Co1: Sex | **1.49** | .57 | 2.61 | .1745 | | **.348** | **2.621** |
| Co2: Meal ingested | -.39 | .21 | -1.89 | **.0142*** | | -.803 | .0234 |
| | | | | **.0114*** | | | |
| | | | | .0640 | | | |
| Total effect | -.13 | .22 | -.61 | .5471 | | -.563 | .301 |
| Direct effect* | **.71** | .32 | 2.23 | **.0293*** | | **.074** | **1.340** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Indirect effect** | | | | | | | |
| IR | **-.44** | .16 | | | | **-.808** | **-.190** |
| Leptin | **-.44** | .22 | | | | **-.990** | **.117** |
| AG/UAG ratio | -.05 | .06 | | | | -.183 | .046 |
| TG | -.10 | .08 | | | | -.019 | .292 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Non FOOD ODT general via metabolic state (WHR as x variable)*** | | | | | | | |
| Path a** | | | | | | | |
| M1: IR | **.61** | .68 | 12.53 | **<.001*** | .37 | | |
| M2: Leptin | **.83** | .30 | 48.98 | ** | .70 | | |
| M3: AG/UAG ratio | .28 | 1.01 | 1.75 | **<.001*** | .08 | | |
| M4: TG | **.31** | .87 | 2.24 | ** | .09 | | |
| | | | | .1656 | | | |
| | | | | **.0435*** | | | |
| Path b | | | | | | | |
| *Model Summary* | .32 | .99 | .95 | .4777 | .10 | | |
| X: BMI | .16 | .21 | .77 | .4431 | | -.254 | .574 |
| M1: IR | -.22 | .15 | -1.41 | .1635 | | -.526 | .091 |
| M2: Leptin | -.02 | .23 | -.09 | .9320 | | -.475 | .436 |
| M3: AG/UAG ratio | -.11 | .13 | -.89 | .3768 | | -.364 | .140 |
| M4: TG | .07 | .14 | .55 | .5839 | | -.197 | .347 |
| Co1: Sex | .45 | .37 | 1.20 | .2356 | | -.298 | .188 |
| Total effect | -.02 | .13 | -.16 | .8751 | | -.273 | .233 |
| Direct effect | .16 | .21 | .77 | .4431 | | -.254 | .574 |
| Indirect effect | | | | | | | |
| IR | -.13 | .09 | | | | -.331 | .030 |
| Leptin | -.01 | .15 | | | | -.287 | .309 |
| AG/UAG ratio | -.02 | .03 | | | | -.099 | .043 |
| TG | -.01 | .03 | | | | -.080 | .037 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Non FOOD ODT Change via metabolic state (WHR as x variable)*** | | | | | | | |
| Path a** | | | | | | | |
| M1: IR | **.61** | .68 | 12.53 | **<.001*** | .37 | | . |
| M2: Leptin | **.83** | .30 | 48.98 | ** | .70 | | |
| M3: AG/UAG ratio | .28 | 1.01 | 1.75 | **<.001*** | .08 | | |
| M4: TG | **.31** | .87 | 2.24 | ** | .09 | | |
| | | | | .1656 | | | |
| | | | | **.0435*** | | | |
| Path b | | | | | | | |
| *Model Summary* | .29 | 3.23 | .80 | .5915 | .09 | | |
| X: BMI | .47 | .37 | 1.25 | .2177 | | -.282 | 1.213 |
| M1: IR | -.30 | .28 | -1.08 | .2836 | | -.859 | .256 |
| M2: Leptin | -.64 | .41 | -1.56 | .1248 | | -1.463 | .183 |
| M3: AG/UAG ratio | .13 | .23 | .56 | .5766 | | -.327 | .582 |
| M4: TG | .10 | .25 | .42 | .6736 | | -.387 | .695 |
| Co1: Sex | .86 | .67 | 1.29 | .2029 | | -.478 | 2.201 |
| Co2: Meal ingested | -.15 | .24 | -.63 | .5332 | | -.640 | .335 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Total effect | -.11 | .23 | -.476 | .6359 | -.571 | .352 |
| Direct effect | .47 | .37 | 1.25 | .2177 | -.282 | 1.213 |
| Indirect effect | | | | | | |
| IR | -.19 | .17 | | | -.541 | .123 |
| Leptin | -.39 | .32 | | | -1.061 | .214 |
| AG/UAG ratio | .02 | .08 | | | -.135 | .208 |
| TG | -.02 | .06 | | | -.156 | .088 |

**Table S4:** Overview: Olfactory sensitivity between participants with normal weight and obesity for age and BMI.

| **Study** | **Normal weight group** | | | **Obese group** | | | **Finding** | **Comment** |
|---|---|---|---|---|---|---|---|---|
| | N | Age | BMI | n | Age | BMI | | |
| **Fernandez-Garcia (2017)** | 77 | 27.1 ±7.3 | 21.6 ±1.7 | 28 | 46.4 ±12.2 | 35.2 ±2.6 | Lower ODT (n-butanol) | |
| **Fernandez-Aranda (2016)** | 36 | 37.3 ±5.9 | 22.4 ±2.6 | 59 | 37.5 ±8.7 | 42.7 ±6.6 | Lower ODT (n-butanol) | |
| **Pastor (2016)** | 70 | 27.4 ±7.36 | 21.7 ±1.62 | 26 | 47.3 ±11.1 | 35.5 ±2.53 | Lower ODT (n-butanol) | |
| **Stafford (2015)** | 20 | 19.4 ±.3 | 20.3 | 20 | 20.4 ±.4 | 31.3 ±.3 | Higher ODT (chocolate) | |
| **Skrandies (2015)** | | | | 7 | 35.5 | 34.4 | Lower ODT in higher BMI participants | Compared to underweight & normal weight |