AMERICAN PSYCHOLOGICAL ASSOCIATION

Psychological Bulletin

© 2025 The Author(s)
ISSN: 0033-2909

https://doi.org/10.1037/bul0000492

Acute Effects of Fasting on Cognitive Performance: A Systematic Review and Meta-Analysis

Christoph Bamberg[1] and David Moreau[2]

[1] Department of Psychology, Paris Lodron University Salzburg

[2] School of Psychology and Centre for Brain Research, University of Auckland

Although fasting—abstaining from food for several hours to days—is generally considered safe and potentially beneficial for long-term health, concerns persist about its acute effects on cognitive function. Given the importance of sustaining adequate levels of cognitive performance for professional and personal activities, this potential side effect warrants careful examination. Here, we synthesize evidence from experimental studies comparing cognitive performance between fasted and satiated healthy adults using standardized psychological tasks. Analyzing 222 effect sizes across 3,484 participants (median fasting duration = 12 hr), our hierarchical random-effects model revealed no meaningful difference between fasted and satiated participants (g = 0.02, 95% CrI [−0.05, 0.10]), with low between-study heterogeneity (τ = 0.17). Notably, we observed modest reductions in cognitive performance for longer fasting intervals and for younger (vs. older) participants during fasts. Differences across cognitive domains (e.g., attention and inhibitory control) did not reliably explain the heterogeneity in effect sizes. These findings suggest that cognitive performance remains remarkably stable during short-term fasting, supporting the feasibility of fasting practices while highlighting nuanced considerations for implementation in health interventions.

Public Significance Statement

This research synthesizes evidence from more than 70 experimental studies examining how fasting impacts cognitive performance. The analysis reveals that, on average, fasting neither enhances nor impairs mental performance—fasted individuals perform similarly to those who have eaten. Still, three key factors influence outcomes: fasting duration, the context of the cognitive task, and individual characteristics such as age and body composition. These findings suggest that although most adults need not worry about temporary fasting affecting their mental sharpness, implementation across specific populations and situations may require more careful consideration.

Keywords: cognition, executive performance, diet, calorie restriction, intermittent fasting

Supplemental materials: https://doi.org/10.1037/bul0000492.supp

When and what to eat is a contentious topic in public discourse: Sayings like "breakfast is the most important meal of the day" (L. F. Cooper, 1917) or "you're not you when you're hungry" (BBDO, 2012) are ubiquitous, suggesting that satiation is key for optimal performance in a variety of daily activities. Yet the benefit of fasting has also become mainstream (see, e.g., Dart, 2012; Mattson, 2022; Patterson & Sears, 2017): Fasting now stands as one of the most popular contemporary eating regimens (IFIC, 2020), with numerous health professionals endorsing it (de Cabo & Mattson, 2019). The rising prevalence of noncommunicable diseases associated with overeating further underscores the need to better understand the optimal frequency of food intake required to sustain daily performance, as well as the physiological and health effects of fasting (de Cabo & Mattson, 2019; Johnstone, 2015).

Monica Melby-Lervag served as action editor.

David Moreau https://orcid.org/0000-0002-1957-1941

All data and code are available on the Open Science Framework at https://osf.io/nb5mj/. The preparation of this article was supported by the Royal Society of New Zealand Marsden Fund (Grant UOA193) and a University of Auckland Early Career Research Excellence Award to David Moreau.

Open Access funding provided by University of Auckland: This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0; https://creativecommons.org/licenses/by/4.0). This license permits copying and redistributing the work in any medium or format, as well as adapting the material for any purpose, even commercially.

Christoph Bamberg played a lead role in conceptualization, data curation, formal analysis, investigation, validation, visualization, and writing–original draft, a supporting role in writing–review and editing, and an equal role in methodology. David Moreau played a lead role in funding acquisition, supervision, validation, and writing–review and editing, a supporting role in conceptualization, data curation, formal analysis, investigation, project administration, visualization, and writing–original draft, and an equal role in methodology.

Correspondence concerning this article should be addressed to David Moreau, School of Psychology and Centre for Brain Research, University of Auckland, 23 Symonds Street, Auckland 1010, New Zealand. Email: d.moreau@auckland.ac.nz

Physiological Effects of Fasting

The timing of nutritional intake influences several metabolic pathways, with implications for energy availability to the brain. Glycogen, the primary stored form of glucose, serves as the main energy source for individuals who eat regularly throughout the day (Bergström et al., 1967; Brocchi et al., 2022). Consequently, one might hypothesize that glycogen depletion resulting from limited food intake could impair performance on cognitively demanding tasks, as these rely heavily on neuronal activity (Mergenthaler et al., 2013).

Nonetheless, alternative energy sources are typically available; for instance, when glycogen stores are low, ketone bodies—produced from fat tissue—can serve as an alternative fuel (Mattson, 2022). This metabolic flexibility likely supported survival during periods of food scarcity, particularly before the advent of effective food preservation methods (Wilhelmi de Toledo et al., 2020). Furthermore, comparative biological evidence and evolutionary theories suggest that humans developed enhanced fat storage capacity as an adaptive response to resource fluctuations (Zihlman & Bolter, 2015). This energy reserve not only supported daily metabolic demands but also enabled the prolonged development and expansion of the human brain, which requires substantial energy input (Kuzawa, 1998).

In recent years, it has become possible to induce ketone-based metabolism through fasting or adherence to a ketogenic diet (Batch et al., 2020). Emerging evidence suggests that relying on ketones as an energy source may confer broad health benefits and modulate various hormonal systems (Mattson et al., 2017; Paoli et al., 2019). Beyond stimulating ketogenesis, fasting also activates autophagy—a cellular recycling process linked to enhanced cellular function and longevity (Longo et al., 2021). In addition, fasting may counteract metabolic disorders such as diabetes by improving insulin sensitivity (Belkacemi et al., 2012; Hatori et al., 2012). Given the body's ability to use ketone bodies and the potential health benefits associated with ketosis, frequent glycogen replenishment through eating every few hours may be neither necessary nor optimal for overall health.

Despite these potential benefits, fasting may have adverse effects that limit its feasibility as an intervention or long-term lifestyle (Zang et al., 2022). Of particular relevance in modern societies—where cognitive performance is often prioritized over physical labor—fasting-induced declines in mental acuity could diminish its appeal. Investigating such cognitive effects is thus a valuable avenue for public health research. Notably, even null findings—that is, no observable difference in performance between fasted and satiated states—would provide meaningful, and certainly welcome, insight.

Mechanisms and Targets of Fasting's Effects on Cognition

Fasting may impair cognitive performance through multiple metabolic and psychological pathways. Given the brain's disproportionately high energy demands relative to its mass (Göbel et al., 2013; Mergenthaler et al., 2013), cognitive processes are particularly sensitive to fluctuations in nutrient availability. Under typical feeding conditions, glucose serves as the brain's primary energy source, as neural tissue lacks significant glycogen stores (Brocchi et al., 2022). Although ketone bodies can partially substitute for glucose during fasting (O. E. Owen et al., 1967; Vannucci & Simpson, 2003), the transition period—while ketogenesis ramps up—may temporarily deprive the brain of sufficient energy, triggering compensatory mechanisms to restore glucose homeostasis (Grayson et al., 2013). During this metabolic shift, nonessential cognitive functions may be downregulated, potentially impairing performance on certain tasks (Ampel et al., 2018).

Beyond metabolic factors, fasting may also influence cognition through psychological mechanisms. First, prolonged energy expenditure without food intake heightens hunger (Beaulieu & Blundell, 2021), which may divert cognitive resources toward interoceptive awareness (Herbert et al., 2012) and food-seeking behavior (Ombrato & Phillips, 2021). Second, deviations from habitual eating patterns (Mattson et al., 2014) could prove distracting for fasting-naïve individuals. Third, societal emphasis on regular meals may foster negative expectations about fasting—particularly when framed pejoratively (e.g., "breakfast skipping" rather than "intermittent fasting"). Such expectations can independently modulate cognitive outcomes, as demonstrated by Bamberg and Roefs (2025): Fasted participants who believed fasting enhanced performance outperformed participants expecting deficits, mirroring placebo effects observed in satiated controls. These psychological mechanisms may thus interact with metabolic pathways to shape fasting-related cognitive changes.

Cognitive domains—conceptually distinct yet functionally interdependent (Carroll, 1993; Harvey, 2019)—may exhibit differential vulnerability to fasting-induced glucose reductions. Rodent studies, for instance, link hypoglycemia to impairments in cognitive flexibility (Jahagirdar et al., 2012), whereas human research suggests that glucose supports working and long-term memory performance (Gold, 2014; Sommerfield et al., 2003). Nevertheless, systematic reviews report inconsistent evidence for domain-specific fasting effects (Benau et al., 2014, 2021). Clarifying these distinctions remains important, as domain-selective impacts could inform personalized dietary strategies tailored to cognitive task demands. Notably, all cognitive functions are energy-dependent and may be compromised under metabolic stress (Ampel et al., 2018), although domain boundaries are often ambiguous—illustrated by ongoing debates surrounding attention (Hommel et al., 2019) and working memory constructs (Cowan, 2017). Most cognitive tasks engage multiple domains (e.g., long-term memory for instructions, inhibitory control for focus, reasoning for strategic planning), complicating the isolation of specific fasting effects. Similar complexity has been observed in exercise research, where physical activity yields modest domain-general benefits (Chang et al., 2012; Ishihara et al., 2021) alongside more pronounced effects on attention (Swagerman et al., 2015) and processing speed (Browne et al., 2017). In line with this literature, we anticipated broad cognitive effects of fasting and aimed to explore domain-specific variations.

Various Scientific Perspectives on Fasting

Research on fasting and cognition employs diverse methodologies, particularly in fasting duration and cognitive task selection. Studies range from examining the impact of omitting a single meal (e.g., skipping lunch) to assessing full-day fasts, with substantial variability in outcome measurements. For instance, some investigations assess food-related perception in controlled laboratory

settings, whereas others evaluate academic performance in more naturalistic environments. Religious fasting (e.g., during Ramadan) is sometimes grouped with intermittent fasting, but we exclude it from this synthesis for three key reasons: (a) Secular fasting typically extends the overnight fast, whereas Ramadan fasting occurs during daylight hours; (b) secular protocols often permit noncaloric fluids, whereas Ramadan prohibits all intake—including water—a restriction shown to impair cognition (Wittbrodt & Millard-Stafford, 2018); and (c) secular fasting is generally health-motivated, whereas religious fasting is rooted in cultural and spiritual traditions (Pourabbasi et al., 2019). Given these distinct mechanisms and motivations, our meta-analysis focuses exclusively on nonreligious fasting interventions.

Fasting duration plays a critical role in shaping outcomes, as prolonged abstinence depletes glycogen and elevates ketone metabolism (de Cabo & Mattson, 2019). Shorter fasts (e.g., single-meal omission) have produced mixed cognitive effects. For example, Green et al. (1995) reported that 24-hr fasting impaired performance on only one of five attention tasks compared to shorter fasts. Similarly, L. Owen et al. (2012) observed differences in working memory between fasting and placebo conditions; however, no differences emerged between 2-hr and 12-hr fasting conditions, despite participants reporting greater alertness after 12 hr. Other studies have found no fasting-related differences, whether in set-shifting (Piech et al., 2009), perceptual accuracy (Radel & Clément-Guillotin, 2012), or inhibitory control (Stewart & Samoluk, 1997). These inconsistencies highlight the importance of accounting for methodological heterogeneity when interpreting cognitive outcomes associated with fasting.

Research examining short fasting durations has primarily focused on breakfast skipping and its impact on work or school performance (Cueto, 2001; Kanarek, 1997), given breakfast's mainstream role as a key source of energy and nutrients in healthy diets (Reeves et al., 2013; Rogers, 2016). Because overnight fasting typically represents the longest fasting interval within a 24-hr cycle, glucose stores may be significantly depleted by morning (Brocchi et al., 2022; Van Cauter et al., 1997)—a potential concern given the brain's high metabolic demands (Göbel et al., 2013). Breakfast normally replenishes glycogen stores, and delaying this replenishment may impair morning cognitive performance (Adolphus et al., 2016). Studies in schoolchildren suggest that breakfast consumption improves cognitive performance relative to skipping breakfast, particularly among nutritionally at-risk populations (Pollitt et al., 1981). A meta-analysis confirmed that skipping breakfast acutely impairs attention, memory, and executive function in children and adolescents when tested the same day (Adolphus et al., 2016). In contrast, adult studies report more limited effects, with systematic reviews identifying benefits primarily in memory domains (Galioto & Spitznagel, 2016). Not only does this developmental difference suggest age might moderate fasting's cognitive impact (Adolphus et al., 2016), but it also underscores the need for further investigation into the acute cognitive effects of short-term fasting. Notably, such effects appear most consistently when testing occurs in the morning near habitual breakfast times, with weaker or null effects later in the day (Schmidt et al., 2007), indicating an interaction between fasting duration and time of day.

Although most research has focused on single fasting episodes, recent studies have increasingly explored repeated fasting regimens. These include daily or weekly short fasts, with particular emphasis on intermittent fasting protocols such as time-restricted feeding (daily fasts of 12+ hours) and alternate-day fasting (Tinsley & La Bounty, 2015). These approaches induce metabolic shifts relatively quickly, as humans begin transitioning from glucose to ketone metabolism within 12–16 hr of fasting (Mattson et al., 2018). Current findings on cognitive outcomes are mixed. For instance, healthy women following an alternate-day pattern (500 kcal for two consecutive days) reported subjective work-related impairments during fasting periods, although no objective measures were collected for comparison (Appleton & Baker, 2015). In contrast, hypercholesterolemic adults exhibited no cognitive changes after 4 weeks of twice-weekly 24-hr fasts (Bartholomew et al., 2021). Similarly, recent trials reported no cognitive differences following 2 weeks or 2 months of daily 16-hr fasts (Bamberg et al., 2025; Batorek & Hromatko, 2024). Although the literature remains limited, preliminary evidence suggests that intermittent fasting may influence cognitive performance differently than isolated fasting episodes. As scientific interest in these protocols grows, future research will likely clarify their cognitive implications.

Continuous, extended fasting periods (typically 48 hr to 10 days) have yielded intriguing cognitive findings, despite notable methodological challenges. In a 10-day fasting study involving 13 male participants, sustained attention and cognitive flexibility remained stable throughout the fasting period, despite transient increases in negative mood during the initial days that returned to baseline by study end (Yang et al., 2021). In contrast, a 48-hr fast enhanced cognitive flexibility and set-shifting in male amateur weightlifters, although working memory was unaffected (Solianik et al., 2016). Another study reported improved self-reported concentration during 7 days of uninterrupted fasting in a group of 13 participants (Michalsen et al., 2003). Notably, these investigations share methodological characteristics distinct from those of shorter fasting studies: All employed repeated-measures designs with small samples, reflecting the logistical constraints of prolonged fasting research. This contrast in study design—compared to crossover or between-subjects approaches more commonly used in short-term fasting studies—underscores how methodological choices may influence observed outcomes, warranting careful consideration in interpretation.

Furthermore, experimental designs in fasting studies exhibit substantial variation in task stimulus selection. Some studies employ food-related stimuli—for example, assessing hunger's influence on perceived food size (Zitron-Emanuel & Ganel, 2020)—whereas others use neutral tasks to evaluate fasting's general impact on work performance (Appleton & Baker, 2015). These methodological differences may help determine whether cognitive effects are context-specific or generalize across settings. However, the considerable heterogeneity in both fasting protocols (e.g., duration, frequency) and experimental approaches highlights the need for systematic comparisons. A comprehensive review could clarify how key factors—such as age, circadian timing, and fasting duration—influence cognitive outcomes, offering more precise insights into fasting's impact on cognitive performance.

Previous Systematic Reviews

A 2014 systematic review by Benau and colleagues synthesized 10 studies examining various fasting protocols in healthy adults up to 2013, finding no consistent cognitive differences between fasted

and satiated states, while highlighting substantial methodological heterogeneity (Benau et al., 2014). Benau et al.'s (2021) update, which included 21 additional studies, provided stronger evidence for decreases in cognitive performance following single, short-term fasting periods. Focusing specifically on breakfast omission, Galioto and Spitznagel (2016) reported predominantly negative cognitive effects across studies. This aligns with Adolphus et al.'s (2016) meta-analysis, which demonstrated domain-specific cognitive benefits of breakfast consumption in children and adolescents. However, these findings must be interpreted cautiously given two key limitations: (a) Breakfast skipping constitutes a unique fasting context, often accompanied by strong negative expectations, and (b) both recent syntheses noted the generally low methodological quality of the included studies (Adolphus et al., 2016; Galioto & Spitznagel, 2016). Together, these limitations underscore the need for an updated, comprehensive synthesis of the fasting-cognition literature.

The Present Study

In recent years, experimental research on fasting has grown substantially, creating new opportunities for comprehensive synthesis. Unlike previous reviews with narrower scopes, the present meta-analysis includes studies spanning all fasting durations and focuses broadly on healthy populations, rather than limiting inclusion by fasting type or demographic subgroup. This approach serves three primary objectives: (a) to estimate the overall effect of fasting on cognitive performance, (b) to identify sources of variability across studies, and (c) to assess the generalizability of findings. To address these aims, we calculated a pooled effect size across relevant studies, examined key moderators, including cognitive domain and fasting duration, and conducted sensitivity analyses to evaluate the robustness of the results. As noted earlier, establishing the absence of adverse cognitive effects would represent a meaningful outcome, potentially supporting intermittent fasting as a viable health intervention. Given the importance of accurately characterizing potential null effects, we leveraged Bayesian analytical methods to quantify uncertainty around our estimates rigorously.

Method

Literature Search Strategy

We searched the following online databases for relevant literature: SCOPUS, Web of Science (see the Supplemental Material for a complete list of the indices included), Embase, ProQuest, APA PsycInfo, PubMed, and CINAHL. This search covered articles from 1923 to February 15, 2025. In addition, the first 700 relevant citations from Google Scholar were screened. To identify gray literature, we searched ProQuest for unpublished theses and dissertations and reviewed preprints hosted on the Open Science Framework, PubMed preprints, ResearchSquare, SSRN, and preprint.org. One preprint that met inclusion criteria was retained.

Search terms were organized into two conceptual categories: "fasting" and "cognition." To capture lexical variability and interdisciplinary perspectives (e.g., from nutritional science, medicine, and psychology), we used a wide range of synonyms and related terms (e.g., "fasting" or "hunger" for fasting; "cogniti" or "mental" for cognition). Commonly used task names (e.g., "Stroop task") were also included (see Table 1 for the complete list of terms). Terms within each category were combined using Boolean OR operators, and the two categories were connected using AND.

In addition to a structured keyword search, we used several supplementary strategies to maximize coverage. We screened the reference lists of all included articles and examined the first 10 citations of each article on Google Scholar. To further identify relevant unpublished or in-progress work, we also announced the search on the European Health Psychology Society's social media platform. When included studies lacked necessary data, we contacted authors directly for clarification or additional information.

Study Selection

Duplicate records were automatically removed using the Systematic Review Accelerator Deduplicator (Clark et al., 2020). Eligible studies compared cognitive performance between fasted and satiated conditions using standardized cognitive tasks. Studies included both between-subjects and within-subjects designs (e.g., crossover or repeated-measures), involving healthy participants. We did not impose restrictions based on publication year or geographic location.

Studies were excluded if they involved clinical or patient groups (including participants with a body mass index [BMI] > 30), relied on artificial meals (e.g., protein shakes) as the satiation condition, or lacked a clearly defined fasting protocol—such as studies combining fasting with physical exercise. We also excluded studies on religious fasting (e.g., Ramadan), due to the unique confounds discussed elsewhere in the article. Poor methodological quality was not an exclusion criterion and was instead evaluated as a moderator.

Screening was conducted based on titles and abstracts, with full texts and supplementary materials reviewed when eligibility was unclear. Abstracts in languages other than English were translated using Google Translate. Of 38 non-English studies, two met inclusion criteria, but neither provided extractable effect size data. Attempts to contact the corresponding authors were unsuccessful. Reviewers were not blinded to author identities or institutional affiliations.

Data Extraction

From each included study, we extracted all available accuracy and response time measures from cognitive tasks. Where possible, we also extracted variables used in moderator analyses, including fasting duration, cognitive domain, experimental design, mean participant age, proportion of female participants, baseline BMI, use of food-related stimuli, and sample size (see the Supplemental Material for studies that met inclusion criteria but for which necessary information could not be extracted). If only a range of fasting durations was reported, the mean was used; if only a minimum was stated, that value was used. Similarly, for time-of-day data, we used the midpoint of the reported range.

Our preregistration included plans to examine the time between breaking the fast and cognitive testing, but none of the included studies reported this information. Only four studies employed multiday fasting protocols (i.e., intermittent fasting), which was insufficient to evaluate the number of fasting cycles as a moderator. Blood glucose and mood were also omitted as moderators due to low reporting frequency (10 and 11 studies, respectively).

Table 1
Keywords Used in Systematic Search

Fasting	Cognition
fasting	cogniti* (for cognitive, cognition)
"intermittent fasting"	mental
"alternate-day fasting"/"alternate day fasting"	"executive funct*" (for executive function)
"periodic fasting"	"executive control"
"time restricted feeding"	attention
"time restricted diet"	vigilance
"time restricted fasting"	"attentional control"
"time restricted eating"	"inhibitory control"
"food tim*" (for food timing, food time)	memory
"food abstinence"	"working memory"
"food restriction"	recall
"food deprivation"	learning
"calori* restriction" (for calorie restriction, caloric restriction)	processing
"Intermittent calori* restriction"	perception
"energy deprivation"	planning
"continuous energy restriction"	reasoning
"intermittent energy restriction"	"spatial ability"
"intermittent restrictive diet"	"decision making"
"extreme diet"	psychomotor
hunger/hungry	"problem solving"
hypoglycemia	intelligence
starvation	expertise
	distraction
	fatigue
	"psychological task"
	"psychological test"
	"behavioral task"/"behavioral task"
	"behavioral test"/"behavioral test"
	performance
	"reaction time"
	Stroop

Moderator coding involved a degree of subjectivity, which we addressed through double coding by two independent raters. The first coder was the lead author; the second was a trained postgraduate assistant. We calculated Cohen's κ for categorical variables and intraclass correlation coefficients (ICC) for continuous ones. Reliability was acceptable to high for all key moderators: cognitive domain (κ = .78), fasting duration (ICC = .94), experimental design (κ = .93), and use of pictures of food as stimuli (κ = .76). ICC values above .9 can be interpreted as excellent reliability (Koo & Li, 2016); κ values above .61 indicate substantial agreement (Landis & Koch, 1977).

Risk of Bias

Risk of bias was rated as "low," "medium," or "high" using the Cochrane Collaboration's guidelines for both between- and within-subjects designs (Higgins et al., 2011). Criteria included randomization procedures, adherence to intervention, carryover effects (in crossover trials), missing data, measurement quality, and selective reporting. Each study was independently rated by the first author and a second rater not otherwise involved in the project. When multiple studies appeared in one article, they were assessed individually.

Agreement between raters was substantial: 36 ratings matched exactly, and 35 differed by only one level (e.g., "medium" vs. "high"). In all such cases, the more conservative (i.e., lower quality) rating was used in subsequent analyses. One case showed a discrepancy of more than one level ("low" vs. "high") and was resolved through discussion. Full individual ratings are reported in Tables S4 and S5.

Analysis

We used Hedges's g to calculate standardized mean differences (SMDs) between fasted and satiated groups or conditions, correcting for small sample size bias (Hedges, 1981). The primary outcome of this meta-analysis is the pooled SMD across studies, reflecting performance differences at a single time point. Positive SMDs indicate higher performance by satiated participants; negative SMDs represent higher performance by fasted participants. Reported standard deviations were used to compute each effect size. Following this, we conducted moderator analyses and sensitivity checks.

We fitted Bayesian hierarchical models to the data. These types of models offer several advantages: First, they do not require specifying unknown covariances between effect sizes; second, they account for dependency among effect sizes from the same study (Cheung, 2019); and third, they allow for a probabilistic quantification of uncertainty around the pooled estimate (Vuorre, 2016; Williams et al., 2018).

Effect sizes were included at the first (lowest) level of the model, each assigned its own intercept. This approach accommodates the unknown correlations between multiple measures reported within

the same study, such as response time and error rate, which cannot be estimated directly from summary statistics. At the second level, effect sizes were nested within studies, allowing for pooled estimates at the study level. The highest level of the model was then aggregated across studies to yield the overall meta-analytic estimate. Estimates were weighted by their standard error, giving more influence to studies with larger sample sizes.

We specified weakly informative priors for the overall intercept (α, normal distribution with $M = 0$, $SD = 1$), standard deviation (σ, half-Cauchy distribution with scale = 0.5), and metaregression coefficients when applicable (β, normal distribution with $M = 0$, $SD = 10$). Sensitivity analyses for prior specifications are reported in the Supplemental Material.

Models were implemented in R (v4.0.2) using the brms package (Bürkner, 2017). Posterior distributions were sampled using the default No-U-Turn Sampler across four chains with 4,000 iterations each (2,000 warm-up). As measures of heterogeneity, we report the estimated between-study and between-estimate standard deviations (τ) from the Bayesian model. We also report Cochrane's Q and I^2 based on a frequentist version of the hierarchical model to align with conventional meta-analytic reporting standards (Cheung, 2019).

Note that we report 95% credible intervals (95% CrI) of highest posterior density, as opposed to frequentist 95% confidence intervals; the number of effective samples for the posterior median point estimate (Bulk Effective Sample Size [ESS]) and 95% CrI (Tail ESS) as well as $\hat{R}$ diagnostics, which indicates how well the four chains mixed. $\hat{R}$ values between 1.00 and 1.02 were deemed acceptable (Brooks & Gelman, 1998).

Moderator Analyses

We tested whether the difference between fasted and satiated conditions can be explained by a group of categorical moderators in subgroup analyses as well as continuous moderators in metaregressions, as preregistered. To test whether a linear dose–response relation between duration of the fast and the difference in performance in the fasted and satiated state exists, we performed a metaregression with *fasting duration* as the independent variable. We tested a linear relation since it is the most parsimonious assumption without prior arguments for a more complex functional relation. Notwithstanding, we reported the results of a quadratic model in the Supplemental Material. Few fasting durations were longer than 48 hr (see Figure S1 for a histogram). We also reported the regression after removing these outliers to better represent the majority of fasting durations. In addition, we performed a metaregression with *time of day* as a predictor. We separated the effect sizes depending on what *cognitive domain* the used task mainly tests to analyze differences between cognitive domains. For example, effect sizes from Go/No-Go and Eriksen flanker tasks are both in the *inhibitory control* subgroup. The categorization of cognitive domains (attention, cognitive flexibility, general executive function, inhibitory control, long-term memory, perceptual accuracy, and working memory) was based on the following: (a) established neuropsychological frameworks of cognitive architecture (see, e.g., the unity/diversity model of executive functions by Miyake et al., 2000), (b) previous meta-analyses examining fasting or nutritional interventions (Adolphus et al., 2016; Galioto & Spitznagel, 2016), and (c) the most frequently assessed domains in the included studies. This categorization allowed us to test whether fasting effects vary systematically across fundamental cognitive systems while maintaining compatibility with existing literature.

Several studies used *pictures of food as stimuli* in their experiments. We distinguished between four types of studies for the subgroup analysis: first, studies that did not use any food-related stimuli (*no food*); second, studies that included both food-related and neutral stimuli (e.g., landscape pictures), for which we extracted effect sizes only for the neutral stimuli (*neutral control*); third, studies that used both types of stimuli but reported effect sizes jointly for both categories (*mixed*); and finally, studies that used only food-related stimuli (*food only*). In addition, we fitted the main model separately for estimates from *no food* or *neutral control* stimuli and *mixed* and *food only* stimuli. As a follow-up, we calculated a multiple regression with an interaction between *cognitive domain* and *food stimuli*. Studies using between-subjects, crossover, and repeated-measures designs were included in the meta-analysis. We tested the role of these differences in *study design* in a subgroup analysis. The study populations differed in *age* and included underage participants. To test whether the difference between conditions or groups was associated with participants' age, we entered the mean age of a sample as a predictor in a metaregression model. Last, we assessed whether participants' *BMI*, measured at the start of the study, had an influence. Other moderator analyses (including *publication year* and *sex*) are reported in the Supplemental Material.

Sensitivity Analyses

To measure the out-of-sample predictive performance of our main model, we performed approximate leave-one-out cross-validation with Pareto-smoothed importance sampling (Vehtari et al., 2017). Since the Pareto-k diagnostic values were not satisfactory (Vehtari et al., 2024), we also performed leave-one-group-out calculations by, one after the other, removing each study from the data and estimating the pooled effect. Moreover, we refit our main model with different prior specifications to assess the influence of the chosen priors on the posterior estimates (see the Supplemental Material).

Metabiases

We report several bias measures based on frequentist concepts such as statistical significance. We used a trim-and-fill approach to test for asymmetries in the effect sizes (Duval & Tweedie, 2000; Rücker et al., 2011) and the precision effect test–precision effect estimate with standard error (PET-PEESE) method for reporting publication bias as it provides a test of asymmetry with little bias compared to other meta-analytic methods (Stanley & Doucouliagos, 2014). When there is evidence of a true effect, the PEESE is thought to be a more accurate measure; in the absence of evidence of a true effect, the PET is presumed more adequate. Results were reported accordingly (Stanley & Doucouliagos, 2014). Funnel plots showing estimate precision (inverse of the standard error) against effect sizes were used to visualize and evaluate the trim-and-fill procedure.

Furthermore, a *p* curve analysis can be found in the Supplemental Material (Simonsohn et al., 2014).

Transparency and Openness

This meta-analysis follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines according to the PRISMA-P checklist and was preregistered at PROSPERO with the ID CRD42021272822 (Page et al., 2021). Deviations from the registered protocol are reported in Table S1 and the study repository (https://doi.org/10.17605/OSF.IO/NB5MJ). The data are available in the study repository as well (Bamberg & Moreau, 2021). The statistical analysis was performed in R primarily using the *brms* package (Bürkner, 2017); the analysis script was based on the publicly available template provided in Moreau and Gamble (2022) and is available in the study repository.

Results

Study Selection

The literature review yielded 63 articles (222 effect sizes) to be included in the meta-analysis. A summary of the study selection process, including reasons for exclusion, is depicted in Figure 1.

Study Characteristics

Descriptive statistics across studies for several important variables are shown in Table 2 (information for each estimate can be found in the Supplemental Material). The model estimates for each study are displayed in the forest plot in Figure 2. There were 31 studies with between-subjects design, 35 with crossover design, and five with repeated-measures design. The complete data set can be found in the study's repository (https://doi.org/10.17605/OSF.IO/NB5MJ).

How Much Does Cognitive Performance Differ Between Fasted and Satiated Participants?

The main goal of the meta-analysis was to estimate the average difference between fasted and satiated participants. This estimate, *g*, is the intercept of the meta-analysis model, with a median posterior density of $\alpha = .02$, $SE = 0.04$, 95% CI [−0.05, 0.10] (Figure 3). Positive values indicate higher performance by satiated participants relative to fasted participants. Hence, on average, satiated participants' cognitive performance was 0.02 standard units higher than fasted participants' performance. Although the median SMD indicated slightly higher performance of satiated participants, there was considerable variance around this point estimate. For instance, 27.34% of the posterior was below zero, indicating higher performance by fasted participants. The precision of this overall effect can be expressed in terms of the model's heterogeneity, τ, the variance over that expected by sampling error. We estimated heterogeneity on the study level ($\tau = 0.17$, $SE = 0.04$, 95% CrI [0.08, 0.25]) and estimate level ($\tau = 0.38$, $SE = 0.03$, 95% CrI [0.33, 0.43]; Figure 3) as the respective standard deviation in the model. Based on the frequentist main model, we also calculated heterogeneity as Cochrane's Q, $Q(218) = 407.22$ (test for heterogeneity; $p < .001$), and $I^2 = 37.36\%$.

Do Study and Participant Characteristics Moderate the Difference Between Fasted and Satiated?

Although the difference between fasted and satiated participants was small on average with considerable uncertainty around the median, it may be more pronounced in certain subsets of studies. Therefore, we focused on moderator analyses to identify potential explanations for the variance between studies. We first report four moderators based on the studies' designs and then two moderators for the studied populations. The Supplemental Material contains additional moderator analyses.

Fasting Duration and Time of Day

Because *fasting duration* may largely determine the strength of the studies' interventions, our primary metaregression tested whether effect sizes differed meaningfully depending on fasting duration. Seven studies did not specify the *fasting duration* and were excluded from this particular analysis. For the remaining 64 studies, we did not find a linear association between fasting duration and the SMD ($B = -0.001$, $SE = 0.001$, 95% CrI [−0.002, 0.001], $\hat{R} = 1.00$, Bulk ESS = 6,525, Tail ESS = 5,897; see the Supplemental Material for quadratic regression results).

Only three studies had a *fasting duration* of more than 24 hr (48, 216, and 336 hr), with a median of 12 hr in the whole sample (see Figure S2). When removing the two studies with the largest fasting duration (Yang et al., 2021: 216 hr; Wang et al., 2025: 336 hr), the coefficient increased in size ($B = -0.01$, $SE = 0.003$, 95% CrI [−0.02, −0.003], $\hat{R} < 1.01$, Bulk ESS = 2,306, Tail ESS = 4,550). Hence, with every additional fasted hour, the difference between fasted and satiated participants decreased by 0.01 units for studies with fasting durations of less than 49 hr. Figure 4 displays this metaregression after the outlier studies were removed.

Related to the duration of fasting, the time of day when participants did not eat and had to perform cognitive tests may influence the strength of the fasting intervention. We found that with each additional hour of daytime, satiated participants' performance, relative to fasted participants, increased by 0.05 units in the studies where this information was available ($SE = 0.03$, 95% CrI [0.00, 0.10], $\hat{R} = 1.00$, Bulk ESS = 4,028, Tail ESS = 4,688, N studies = 33). Hence, the later in the day fasted participants were tested, the worse their performance was relative to satiated ones.

Cognitive Domain

Cognitive performance during fasting may depend not only on fasting duration but also on the specific cognitive domain being assessed. To examine this, we conducted a moderator analysis that grouped effect sizes by *cognitive domain*. Adding the distinction between cognitive domains in a subgroup analysis only marginally reduced heterogeneity on study ($\tau = 0.16$, reduction = 1.30%) and estimate levels ($\tau = 0.38$, reduction = 1.76%). Posterior estimates for each cognitive domain are presented in Table 3 and Figure 5. This modest reduction in heterogeneity may reflect the fact that grouping by study already partially captured the variance attributable to cognitive domain, as many studies focus on a limited set of domains. To explore how variance was distributed between study

Figure 1
Flow Diagram

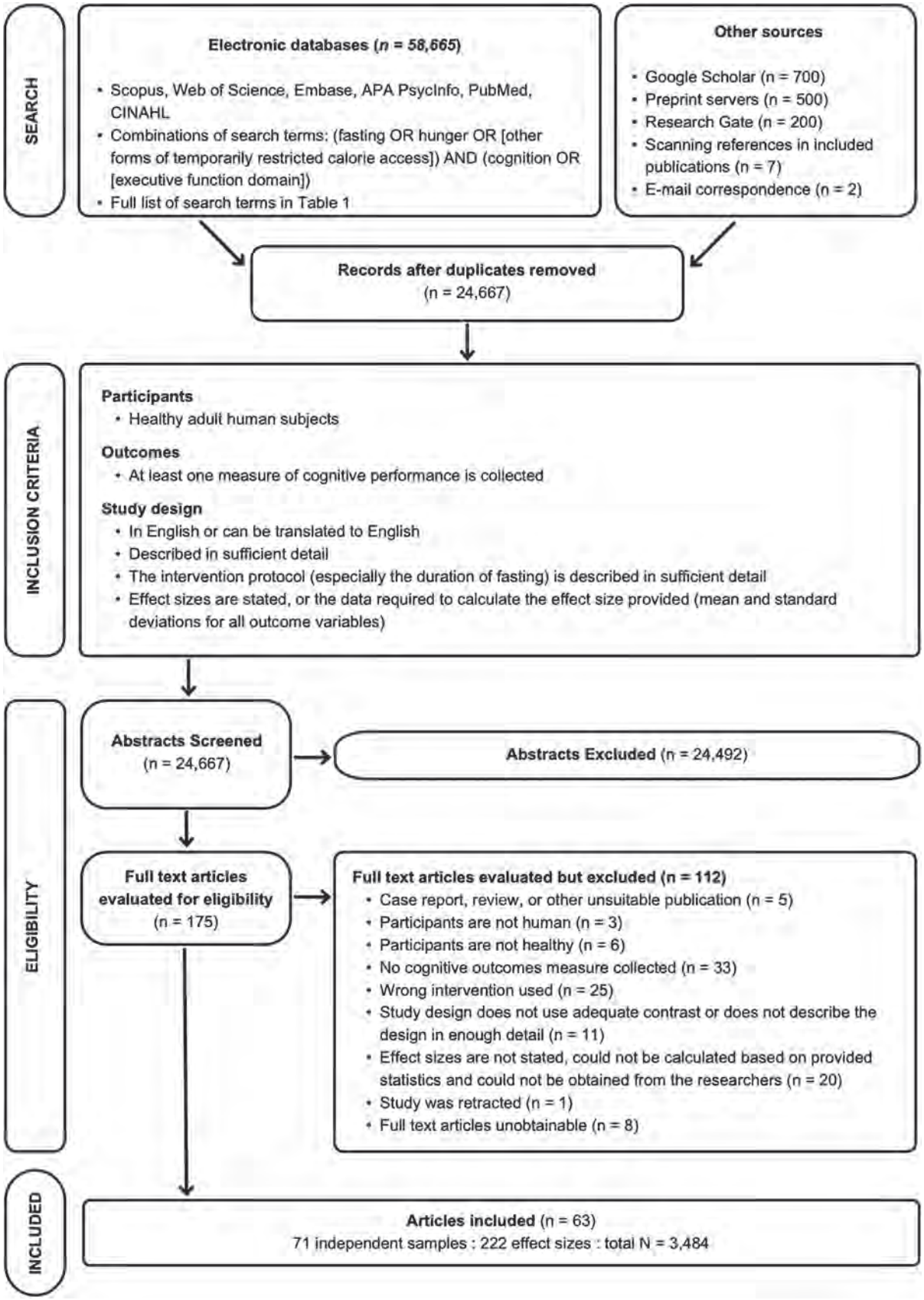


Table 2
Summary Statistics for Main Variables

Variable	*M*	*SD*	*Mdn*	95% quantile range	Range	*N* studies reporting
Sample size	49.07	39.98	38	[11.50, 133.25]	[9, 244]	71
Fasting duration (hr)	18.89	44.17	12	[3.00, 88.80]	[3, 336]	64
Time of day (hh:mm in 24-hr clock)	11:23	02:47	10:30	[08:36, 18:18]	[08:00, 18:30]	33
Proportion female	0.70	0.26	0.69	[.00, 1.00]	[0, 1]	63
Age in years	24.00	4.71	24.30	[13.30, 34.64]	[12.33, 40.12]	61
Baseline body mass index	22.48	1.45	22.40	[20.10, 25.65]	[19.92, 27.30]	41
Publication year	2013	15	2018	[1966, 2025]	[1958, 2025]	71

Note. *Mdn* = median.

and domain, we ran a cross-classified model including both grouping factors. Results indicated that grouping by study and individual effect estimate accounted for more heterogeneity than the cognitive domain distinction (Figure S3).

Food Stimuli

The third aspect of study design we considered was the use of *pictures of food as stimuli* in cognitive tasks. We performed a subgroup analysis for the four different usages of food pictures (see the Method section). No clear difference between subgroups emerged, although performance of satiated groups was slightly higher in studies with any use of food pictures as stimuli (*food only*, *mixed food and neutral*, *neutral control*). This was reversed for studies without food pictures (see Table 4). Figure 6 displays the mean, density, and distributions for the four different categories of stimuli.

We recalculated the mean estimate by combining the groups *no food* with *neutral control* and *mixed* with *food only*. The estimated SMD between fasted and satiated in studies with *no food* stimuli or *neutral control* stimuli was 0.001 ($SE = 0.05$, 95% CrI [−0.09, 0.10], $\hat{R} = 1.00$, Bulk ESS = 4,805, Tail ESS = 5,440; combined sample size, $N = 2{,}382$). The estimated difference for studies with some form of food-related stimuli is 0.09 ($SE = 0.06$, 95% CrI [−0.02, 0.22], $\hat{R} = 1.00$, Bulk ESS = 2,839, Tail ESS = 5,482; combined sample size, $N = 838$).

Multiple Regression With Cognitive Domain and Food Stimuli

Crucially, the two moderators *cognitive domain* and *use of food pictures as stimuli* may be interdependent. For instance, studies using food picture stimuli more often measured perceptual accuracy (e.g., correctly estimating the size of foods compared to objects; Zitron-Emanuel & Ganel, 2020) than studies with neutral stimuli sets. To account for this, we fitted a multiple regression model with both moderators and their interaction (using the combined food stimuli moderator since not all combinations of *cognitive domain* and *food stimuli* occurred, leading to model convergence issues). For all cognitive domains, the estimated difference between fasted and satiated changed depending on whether food stimuli were used (Table 5; Figure 7). Note, however, that for some combinations, there were few effect sizes available, limiting the strength of evidence for these cases.

Study Design

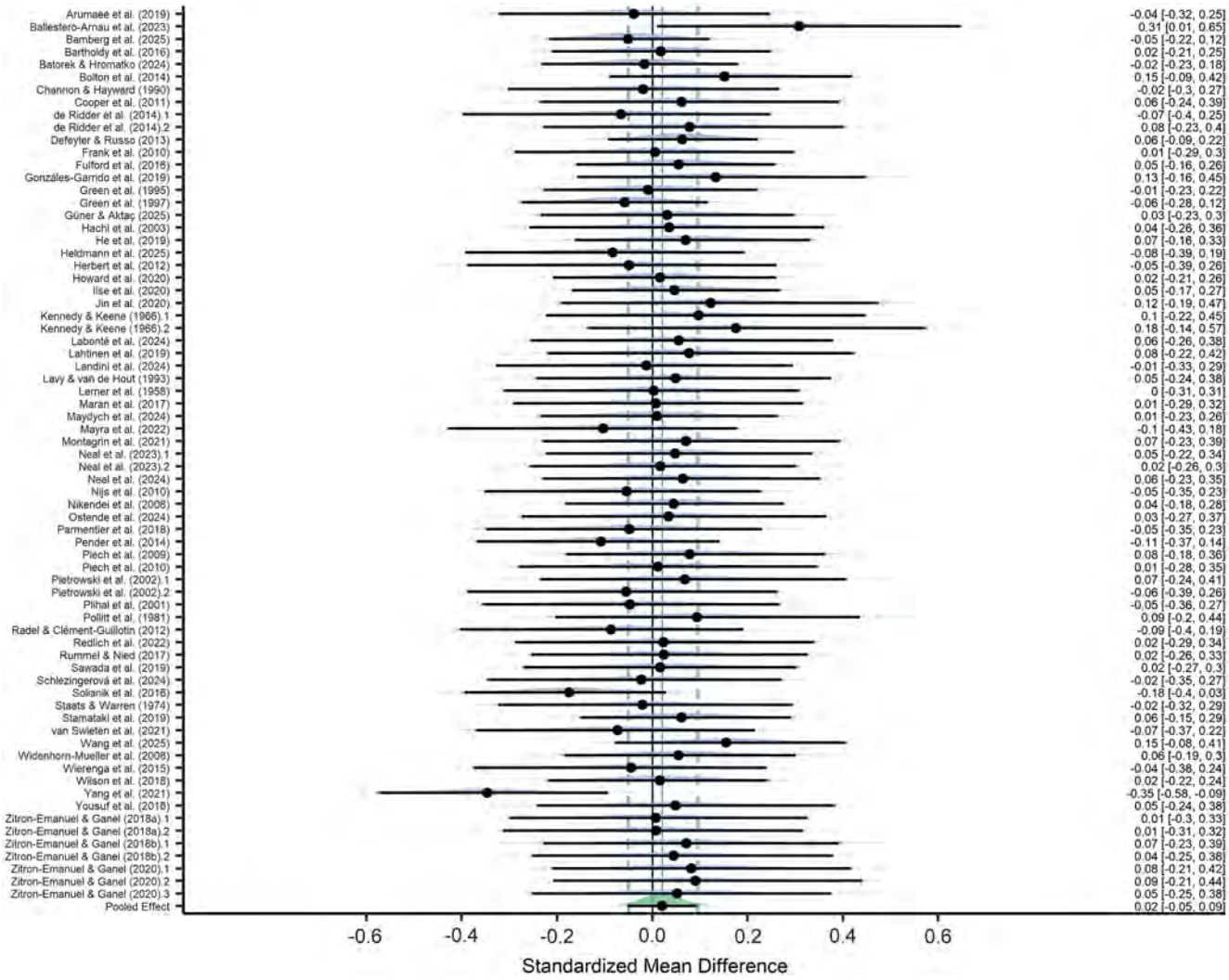
As a fourth moderator, we tested more generally whether the chosen *study design* affected the results. The sample of studies mostly consisted of *between-subjects* and *crossover* studies, with a few *repeated-measures* designs as well (see Table 6; Figure 8). Fasted participants in the four studies with *repeated measures* performed on average better than satiated participants, indicated by 95% of the posterior density in the range of negative SMDs (Table 6), whereas fasted participants in *crossover* studies were estimated to perform marginally worse than satiated participants. The estimated difference for *between-subjects* studies was spread over negative and positive values, indicating no consistent difference between fasted and satiated groups.

Age

Fifth, we assessed whether the studied populations' *age* influences the estimated difference between fasted and satiated cognitive performance in a metaregression. We included studies with a mean age ranging from 12.33 to 40.12 years, including five studies with underage participants. With an increase in the average *age* of participants by a year, the difference between fasted and satiated decreases by 0.01 standard units ($SE = 0.01$, 95% CrI [−0.03, 0.00], $\hat{R} = 1.00$, Bulk ESS = 5,653, Tail ESS = 5,641) in the metaregression. Thus, samples of younger fasted participants perform worse than younger satiated participants, whereas this difference was reduced in older participants.

We refitted the main model separately for adults and underage participants to be able to draw comparisons to previous meta-analyses. When refitting the main model for studies with adult participants only, the estimated SMD between fasted and satiated was $\alpha = -.01$ ($SE = 0.05$, 95% CrI [−0.10, 0.08], $\hat{R} = 1.00$, Bulk ESS = 5,163, Tail ESS = 5,706; combined sample size, $N = 2{,}754$), effectively reversing the direction of the small effect observed when including all *age* groups. When refitting the model for studies with children, the estimated difference was larger with $\alpha = .14$ ($SE = 0.08$, 95% CrI [0.00, 0.31], $\hat{R} = 1.00$, Bulk ESS = 2,257, Tail ESS = 1,040; combined sample size, $N = 268$), representing an increase of 562.44% for the model with children compared to the main model including all participants.

Figure 2
Forest Ridge Plot



Note. The plot shows the estimated effect size for each study, ordered alphabetically according to first author. Positive standardized mean difference values indicate better performance of satiated participants, relative to fasted participants, and negative values indicate higher performance of fasted participants. The dots and bars show the estimated standardized mean difference and 95% credible interval. The pooled effect is plotted in green at the bottom. Dashed green lines indicate the 95% confidence interval of the pooled estimate. The corresponding values are displayed in the right column. Note that the estimates for each study are pooled from all effect sizes reported in that study. See the online article for the color version of this figure.

BMI at Baseline

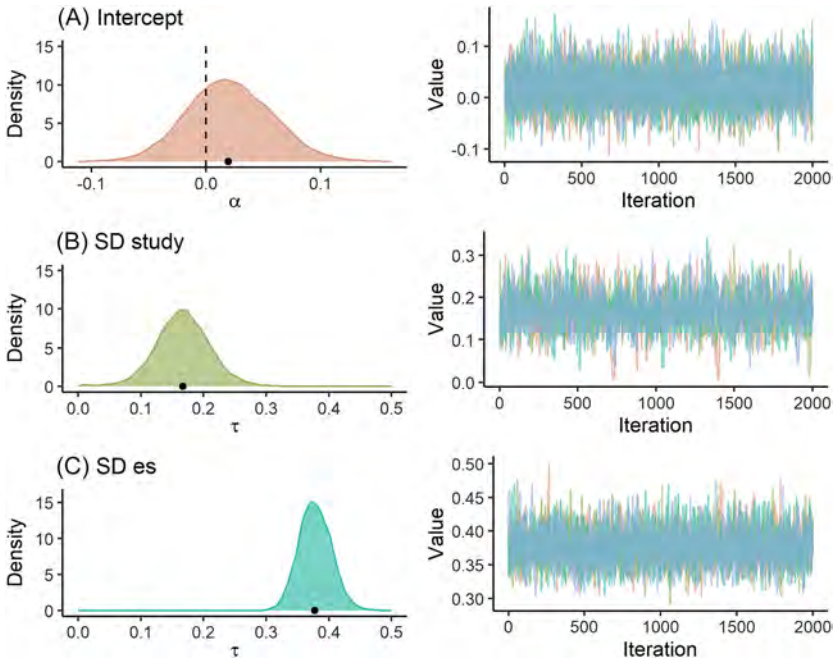
Finally, we explored the role of participants' *BMI* at the start of the studies. There were 41 studies, with a combined sample size of N = 1,931, that measured the BMI of participants before administering the intervention. We tested whether the effect of the intervention differs depending on the BMI of participants, adding the baseline BMI as a moderator. The SMD between fasted and satiated decreases by 0.05 standard units for an increase in participants' BMI by one unit (in units of 1 kg/m^2; SE = 0.03, 95% CrI [−0.11, 0.01], $\hat{R}$ = 1.00, Bulk ESS = 1,691, Tail ESS = 2,366). Hence, with increasing BMI levels in the study population, the relative performance of fasted participants is expected to increase. Crucially, BMI values were all in the healthy range (95% quantile = [20.10, 25.65]), limiting the interpretability of these results.

Are Results Biased?

The aim of the moderator analyses in the previous section was to identify relations between aspects of the included studies and the effect of fasting on cognition. We tested whether the found relations may be biased by shortcomings and idiosyncrasies of the included studies and our analyses. Since the effect sizes stem from frequentist analyses, we also used frequentist concepts and methods such as a PET-PEESE funnel plot and a p curve (see Figure S4).

Figure 3

Posterior Density and Trace Plot for the Main Model



Note. The left column shows the posterior density of the model samples for (A) the intercept, α, with a vertical line at zero indicating no effect (positive values indicate higher performance of satiated compared to fasted participants, and negative values indicate higher performance of fasted participants); (B) standard deviation, σ, on study level; and (C) standard deviation, σ, on estimate level. The black dots are the medians. The right column shows the corresponding chains after warm-up. The *x*-axis represents the sampling step, and the *y*-axis the sample value. All $\hat{R}$s = 1.00, Bulk ESS > 960, and Tail ESS > 934. ESS = Effective Sample Size. See the online article for the color version of this figure.

Leave-One-Out Cross-Validation

We computed approximate leave-one-out measures for our main model to assess its potential out-of-sample prediction performance. The Pareto diagnostic values were relatively poor (53.4% above 0.7), rendering the estimate unreliable. Hence, we calculated a leave-one-group-out cross-validation analysis by refitting our main model, leaving out each study one after the other (Figure S5). We calculated the root-mean-square error between the median posterior estimates of the complete model and the reduced ones (RMSE = 0.004).

Risk of Bias

Each individual study's *risk of being biased* could also influence the overall estimate. We tested this in a subgroup analysis for the three bias severities. Thirty-two studies were rated as having a *high risk* of bias, 27 as *medium risk*, and 13 as *low risk*. The subgroups did not differ in a meaningful way (see Table 7).

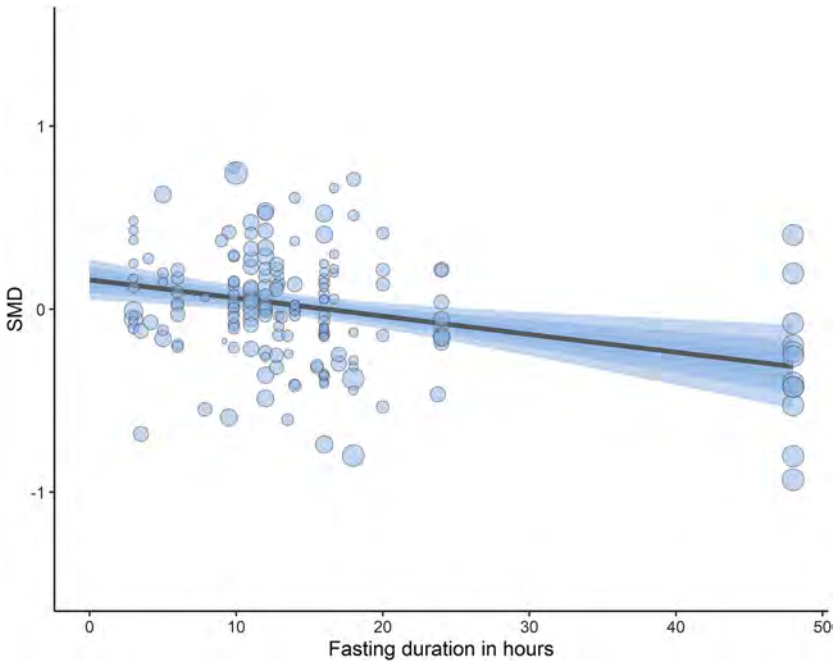
Trim-and-Fill Model and PET-PEESE Procedure

Third, we tested whether the reported effect sizes were evenly distributed over the range of all effect sizes by calculating a trim-and-fill model and the PET-PEESE test for asymmetry. We chose to report these frequentist analyses since they are concerned with the suppression of nonsignificant results according to frequentist tests in the original studies. The trim-and-fill analysis indicates that 19 studies are missing on the side of positive SMDs between fasted and satiated for the distribution to be symmetrical. The estimate based on the trim-and-fill model was $g = 0.06$ ($SE = 0.02$, 95% CI [0.01, 0.10], $p = .019$; Figure S6 shows the distribution of SMDs after adjusting for these missing effect sizes). As the estimated mean difference between fasted and satiated was not significant in the main frequentist model ($g = 0.01$, $p = .592$), the PET model was reported instead of PEESE. The PET-based test for funnel plot asymmetry is $t(217) = -1.03$, $p = .306$.

Discussion

Contrary to widespread assumptions regarding fasting's detrimental cognitive effects, our meta-analysis found no consistent evidence of impaired performance across a broad range of diverse tasks and durations. Bayesian analyses yielded a median posterior estimate indicating marginally worse performance in the fasted state; however, the wide posterior distribution, encompassing both negative and positive values, reflects substantial uncertainty. This nuanced result challenges prevailing beliefs about short-term fasting's cognitive costs and underscores the need to move beyond binary comparisons (i.e., fasted vs. satiated) toward a more context-sensitive framework that considers situational and individual moderators of fasting effects.

Figure 4
Metaregression With Performance as a Function of Fasting Duration, With Outliers Removed



Note. The plot shows the studies' *fasting duration* on the *x*-axis in hours and their effect sizes on the *y*-axis. Positive values indicate higher performance by satiated participants, relative to fasted participants, and negative values imply higher performance of fasted participants. The solid line represents the predicted coefficient for fasting duration, and the shaded areas are the boundaries of the 50%, 80%, and 95% credible intervals. The size of the data points indicates their weight in the model, based on the inverse of their variance. SMD = standardized mean difference. See the online article for the color version of this figure.

Fasting Duration

Moderator analyses offered important insight into contextual factors shaping the cognitive impact of fasting. Notably, the modest performance advantage observed in satiated participants diminished with longer fasting durations but became more pronounced when testing occurred later in the day, highlighting the importance of circadian influence and temporal factors. Although overall differences across cognitive domains did not appear to be meaningful, stimulus type emerged as an important moderator. Specifically, performance deficits in fasted individuals were evident in tasks involving food-related stimuli, whereas no such deficits appeared in tasks with neutral content.

Table 3
Posterior Estimates of Effects for Each Cognitive Domain

Cognitive domain	*Mdn* SMD	*SE*	95% CrI	*N* effect sizes
Attention	0.002	0.06	[−0.11, 0.12]	73
Inhibitory control	0.16	0.08	[0.01, 0.33]	41
Working memory	0.02	0.09	[−0.16, 0.19]	28
Cognitive flexibility	−0.23	0.10	[−0.42, −0.02]	24
Perceptual accuracy	0.15	0.14	[−0.14, 0.41]	9
Long-term memory	0.12	0.08	[−0.05, 0.28]	30
Other executive function	−0.19	0.12	[−0.42, 0.04]	14

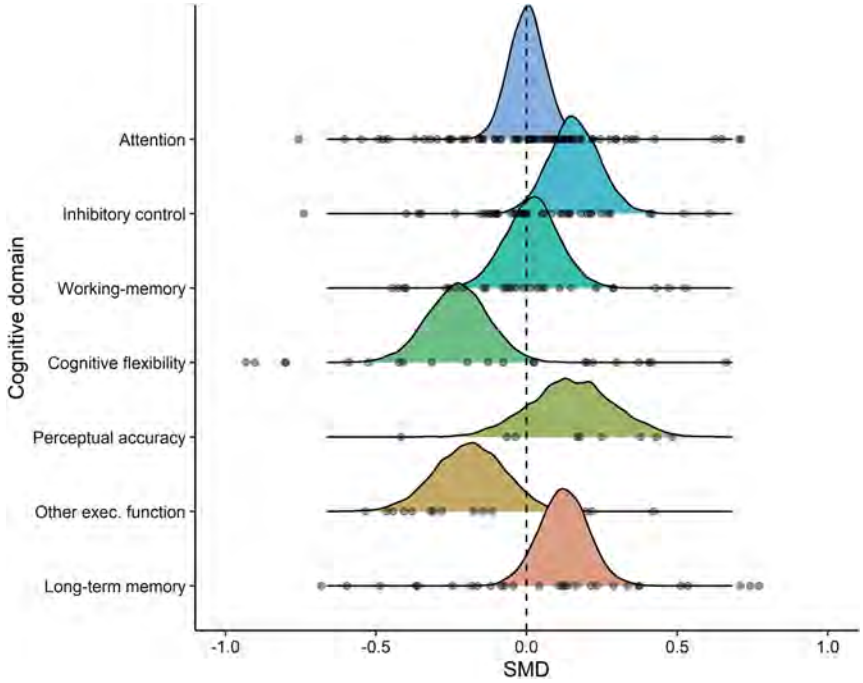
Note. All $\hat{R}$s <1.01, and all effective samples for population-level effects >3,411. Positive SMD values indicate higher performance of satiated participants, relative to fasted participants, and negative values represent higher performance of fasted participants. SMD = standardized mean difference; CrI = credible interval; *Mdn* = median; *SE* = standard error.

To better understand the moderating effects of fasting duration observed in our analyses, it is helpful to consider the underlying physiological and psychological processes associated with extended fasting. Extended fasting produces three fundamental physiological changes: progressive glycogen depletion, increased ketone metabolism, and heightened hunger perception (Beaulieu & Blundell, 2021; de Cabo & Mattson, 2019). As such, fasting duration may be the primary determinant of a fasting intervention's cognitive impact. For this reason, we considered fasting duration a key factor among other aspects of study design. We propose two explanations for the observed *negative* relation between fasting duration and differences in performance between fasted and satiated participants—one metabolic, the other psychological.

From a metabolic perspective, the body's transition to ketone utilization—typically beginning within 8–12 hr after fasting onset (de Cabo & Mattson, 2019)—may enable cognitive recovery following initial glucose depletion. This adaptive mechanism reflects

Figure 5

Ridge Plot of Posterior Density of Effects for Each Cognitive Domain



Note. The plot shows the posterior density distributions for each *cognitive domain*, with the original effect sizes plotted as points. Positive *x*-axis values represent higher performance of satiated relative to fasted participants, and negative values indicate higher performance of fasted participants. There are two effect sizes each for *attention* and *cognitive flexibility* tasks below –1 and one effect size each for *inhibitory control* and *long-term memory* tasks above 1, which are not displayed in the plot for better visibility. SMD = standardized mean difference. See the online article for the color version of this figure.

humans' evolutionary capacity to maintain mental performance using ketone-based energy during prolonged fasting (Cahill, 1976; Prentice, 2005). In parallel, circadian glucose rhythms, marked by nocturnal declines and postprandial increases (Mattson et al., 2017), may interact with fasting interventions. Notably, the particularly pronounced effects we observed later in the day suggest that fasting may amplify rather than override these endogenous rhythms. From a psychological standpoint, an alternative explanation is that individuals gradually habituate to the sensation of hunger. That is, fasting participants may initially experience distraction due to hunger (Oh et al., 2002), but over time, this discomfort may diminish, reducing its interference with cognitive performance. As a result, performance deficits may only occur if tasks are administered early in the fasting window, when hunger is most salient.

Table 4

Food Stimuli Subgroup Analysis

Subgroup	*Mdn* SMD	*SE*	95% CrI	*N* effect sizes
No food	−0.05	0.05	[−0.15, 0.06]	126
Food but neutral control	0.07	0.07	[−0.06, 0.20]	52
Mixed food and neutral	0.10	0.09	[−0.07, 0.28]	28
Food only	0.08	0.12	[−0.17, 0.31]	13

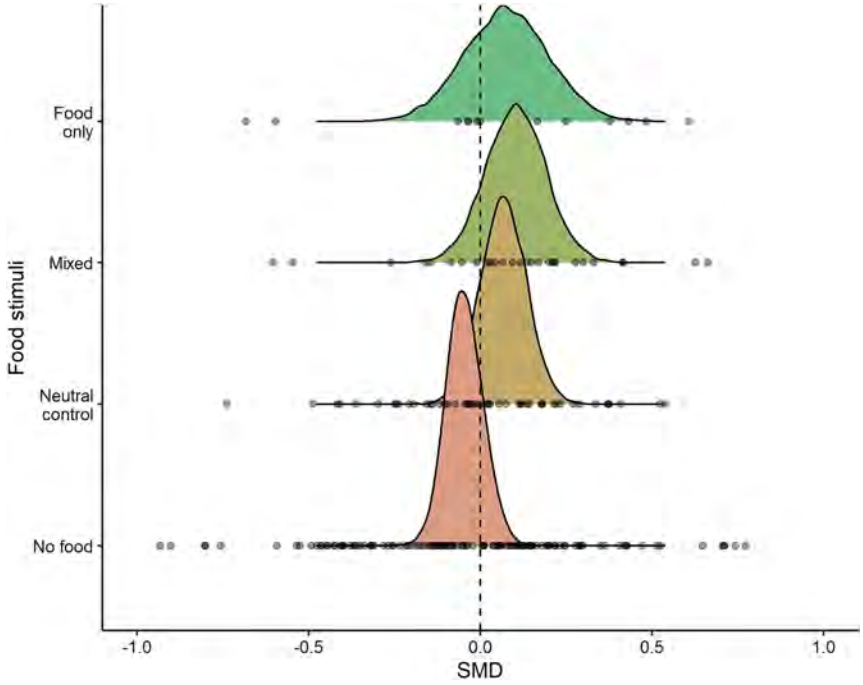
Note. All $\hat{R}$s <1.01, and all effective samples for population-level effects >4,335. Positive SMD values indicate higher performance of satiated participants, relative to fasted participants, and negative values represent higher performance of fasted participants. SMD = standardized mean difference; CrI = credible interval; *Mdn* = median; *SE* = standard error.

Together, metabolic and psychological mechanisms provide a provisional framework for understanding how fasting duration, diurnal timing, and attentional demands interact to influence cognitive performance. Both our findings and prior literature support a U-shaped relationship between fasting duration and cognitive function: Brief fasts exert minimal effects, moderate durations—when hunger peaks and metabolic transition occurs—may impair performance (i.e., the U-curve's trough), and longer fasts appear to allow recovery as ketosis stabilizes and hunger subsides. However, this pattern has natural limits, as sustained fasting eventually degrades performance, particularly in fasting-naive individuals (Ma et al., 2021). Importantly, although fasting duration emerged as a meaningful moderator, it explained only modest variance in cognitive differences between fasted and satiated states. More definitive insight may emerge from future studies employing rigorously controlled, systematically varied fasting protocols with precise duration reporting.

Cognitive Domain and Stimulus Specificity

Beyond the overall magnitude of effects, the specificity of fasting's cognitive impact warrants attention. In contrast to physical

Figure 6
Ridge Plot of Effects for Each Stimulus Subgroup



Note. The plot shows the posterior density distributions for each subgroup of food pictures used as stimuli, with the original effect sizes plotted as points. Positive *x*-axis values represent higher performance of satiated relative to fasted participants, and negative values indicate higher performance of fasted participants. There are five effect sizes for no food and one for neutral control above 1 or below −1, which are not shown in the plot for better visibility. SMD = standardized mean difference. See the online article for the color version of this figure.

exercise, which typically shows domain-specific cognitive effects (Ishihara et al., 2021; Moreau & Chou, 2019), our meta-analysis found largely consistent fasting effects across cognitive domains. Some variation did emerge when comparing phasic versus stable domains: Inhibitory control showed slightly larger fasting effects, whereas attention and working memory showed minimal differences. Stable domains such as long-term memory and executive function yielded inconsistent patterns. Stimulus context

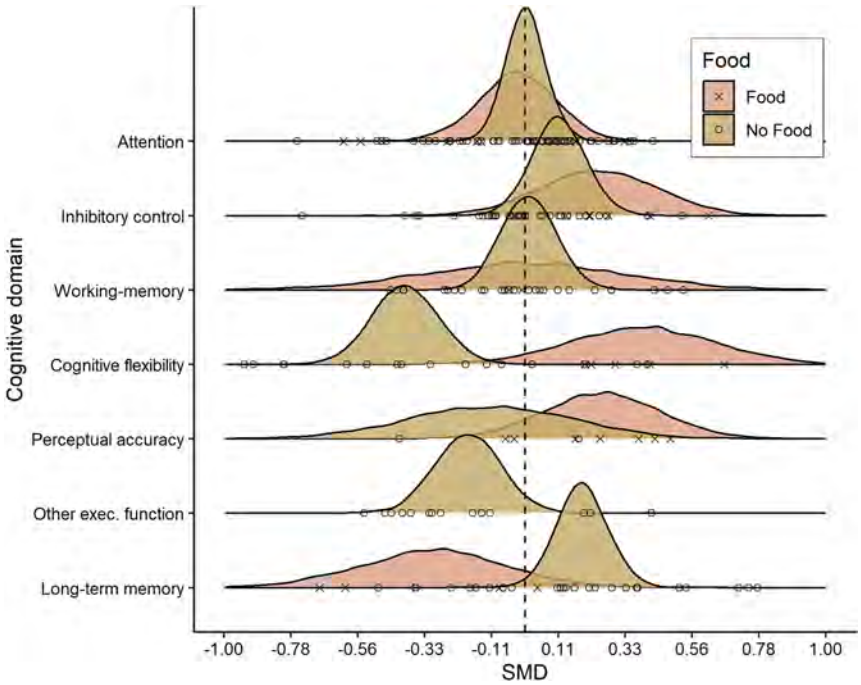
Table 5
Posterior Estimates as a Function of Joint Effects of Cognitive Domain and Food Stimuli

Cognitive domain	Food stimuli	*Mdn* SMD	*SE*	95% CrI	*N* effect sizes
Attention	No	0.00	0.06	[−0.13, 0.13]	59
	Yes	−0.03	0.13	[−0.30, 0.22]	14
Inhibitory control	No	0.11	0.09	[−0.06, 0.29]	32
	Yes	0.24	0.19	[−0.12, 0.64]	9
Working memory	No	0.01	0.09	[−0.16, 0.20]	26
	Yes	−0.01	0.34	[−0.70, 0.65]	2
Cognitive flexibility	No	−0.39	0.11	[−0.61, −0.18]	19
	Yes	0.39	0.24	[−0.09, 0.87]	5
Perceptual accuracy	No	−0.11	0.27	[−0.65, 0.41]	2
	Yes	0.26	0.19	[−0.13, 0.63]	7
Long-term memory	No	0.19	0.08	[0.02, 0.35]	26
	Yes	−0.30	0.24	[−0.78, 0.16]	4
Other executive function	No	−0.19	0.10	[−0.40, 0.02]	14
	Yes				0

Note. All $\hat{R}$s < 1.01, and all effective samples for population-level effects >4,251. Positive SMD values indicate higher performance of satiated participants, relative to fasted participants, and negative values represent higher performance of fasted participants. SMD = standardized mean difference; CrI = credible interval; *Mdn* = median; *SE* = standard error.

Figure 7

Pairwise Ridge Plot for the Posterior Estimates as a Function of Cognitive Domain and Food Stimuli



Note. The plot shows the posterior density distributions for each *cognitive domain* and *food stimulus* combination, with the original effect sizes plotted as points. Positive *x*-axis values represent higher performance of satiated relative to fasted participants, and negative values indicate higher performance of fasted participants. There were no data points for *other exec. function* and *food stimuli.* Six effect sizes are not shown since they were outside the displayed range. SMD = standardized mean difference. See the online article for the color version of this figure.

(food-related vs. neutral) helped clarify these results—fasted participants showed enhanced memory for food stimuli but impaired performance on neutral memory tasks, with the reverse observed for cognitive flexibility. Other domains (attention, inhibitory control, working memory) showed minimal stimulus-related modulation. These results suggest that fasting produces primarily domain-general effects, though task context and domain type may introduce small, systematic variations. Future studies that systematically manipulate both cognitive domain and stimuli could help confirm our findings more definitively.

The distinction between food-related and neutral stimuli emerged as a particularly influential factor. Prior research indicates that hunger alters cognitive responses to food cues (Ballestero-Arnau et al., 2023; Seibt et al., 2007)—a finding partially echoed in our subgroup analysis. Specifically, fasted individuals performed worse on tasks using food images compared to satiated participants. However, many of these studies centered on eating-related cognition, such as food-specific inhibitory control (Howard et al., 2020), limiting generalizability beyond dietary contexts. In contrast, fasted participants showed a slight performance advantage on neutral tasks. Taken together, these findings suggest that fasting may selectively impair cognition in food-relevant contexts, whereas general cognitive functioning remains largely unaffected. This highlights the importance of

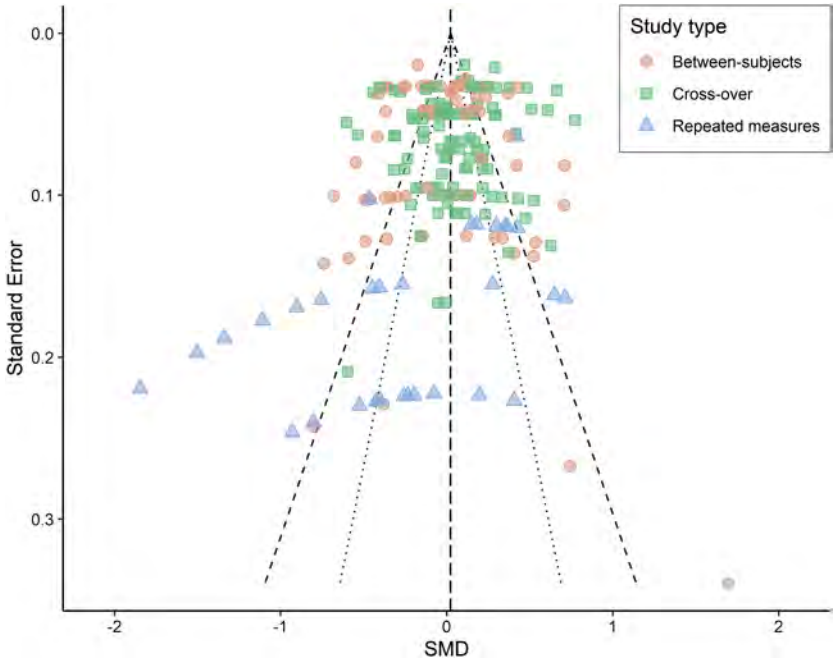
Table 6

Effects as a Function of Study Design

Subgroup	*Mdn* SMD	*SE*	95% CrI	*N* effect sizes	*N* studies
Between-subjects	−0.02	0.05	[−0.12, 0.09]	77	31
Crossover	0.09	0.05	[0.00, 0.18]	108	35
Repeated-measures	−0.21	0.11	[−0.42, −0.01]	32	5

Note. All $\hat{R}$s < 1.01, and all effective samples for population-level effects >2,341. Positive SMD values indicate higher performance of satiated participants, relative to fasted participants, and negative values represent higher performance of fasted participants. Excluding the five studies with *repeated-measures* design, the estimated difference between satiated and fasted participants was 0.04 (*SE* = 0.03, 95% CrI [−0.02, 0.10], $\hat{R}$ = 1.01, Bulk ESS = 1,182, Tail ESS = 2,717). SMD = standardized mean difference; CrI = credible interval; *Mdn* = median; *SE* = standard error; ESS = Effective Sample Size.

Figure 8
Funnel Plot of Effects Differentiating Study Designs



Note. A funnel plot of SMDs plotted against their standard error (on an inverted scale) is shown. Positive *x*-axis values represent higher performance of satiated relative to fasted participants, and negative values indicate higher performance of fasted participants. Higher *y*-axis values indicate lower precision (i.e., larger standard error) of the effect size. The 95% confidence interval is indicated by the dashed lines, and the 99% confidence interval by the dotted lines. The long-dashed line shows the main model's estimate. *Between-subjects* studies are shown as red circles, *crossover* studies as green squares, and *repeated-measures* studies as blue triangles. SMD = standardized mean difference. See the online article for the color version of this figure.

careful stimulus selection when designing and interpreting fasting studies.

Participant Characteristics

In addition to task-level variables, individual characteristics may explain variance in fasting effects—though such inferences are limited by group-level reporting (Sedgwick, 2015). Age emerged as a particularly salient moderator of fasting effects, with children exhibiting clear performance decrements when fasted, whereas adults showed minimal differences between fasted and satiated conditions. This finding aligns with prior literature demonstrating the heightened vulnerability of developing brains to energy availability (Das et al., 2017) and the consistent cognitive benefits of breakfast consumption in children, especially for working memory, attention, and executive function (Adolphus et al., 2016). In contrast, adult studies show more modest cognitive effects from fasting (Benau et al., 2014, 2021; Galioto & Spitznagel, 2016). Our analysis found fasting's negative impact to be approximately twice as pronounced in children compared to adults, likely reflecting both higher metabolic demands and greater hunger sensitivity in younger individuals (Pollitt et al., 1981). These results suggest that pediatric populations may require particular consideration when evaluating the cognitive effects of fasting, whereas for healthy adults—especially those engaged in intermittent fasting—the modest cognitive trade-offs may be outweighed by potential health benefits. Future research should continue to examine how age interacts with fasting context and task demands, particularly in ecologically valid settings. Body composition, measured crudely via BMI (Ireton-Jones, 2005), also moderated outcomes: Participants with higher BMI exhibited weaker fasting effects, suggesting physiological reserves may buffer cognitive impact. However, more granular data are needed to interpret this finding with confidence.

Table 7
Risk of Bias Subgroup Analysis

Subgroup	*Mdn* SMD	*SE*	95% CrI
Low	0.07	0.07	[−0.08, 0.21]
Medium	−0.03	0.10	[−0.22, 0.16]
High	−0.08	0.09	[−0.27, 0.11]

Note. All $\hat{R}$s = 1.00, and all effective samples for population-level effects >4,602. Positive SMD values indicate higher performance of satiated participants, relative to fasted participants, and negative values represent higher performance of fasted participants. SMD = standardized mean difference; CrI = credible interval; *Mdn* = median; *SE* = standard error.

A critical but underreported factor is participants' prior fasting experience. Most studies treated fasting experience as an exclusion criterion rather than a variable of interest. Yet early evidence suggests that fasting-naive individuals report more negative psychological states than those with prior exposure (Ma et al., 2021). Only four studies in our sample implemented repeated intermittent fasting protocols, all published between 2022 and 2025—too few to isolate adaptation effects from novelty. This gap underscores the need for longitudinal designs that allow participants to habituate to fasting regimens (e.g., time-restricted eating, alternate-day fasting) while tracking cognitive performance over time. Such designs would allow participants to acclimate to fasting sensations and researchers to track cognitive changes across multiple fasting cycles, providing clearer insight into adaptation effects.

Beyond physiological mechanisms, cognitive performance during fasting may be shaped by participants' expectations about hunger's effects. Expectancy effects are particularly relevant in studies involving food-related tasks, where strong societal beliefs about breakfast and mental performance may bias outcomes. Bamberg and Roefs (2025) demonstrated that experimentally induced expectations about hunger can directly influence task performance. Given the impossibility of blinding participants to their fasting state, researchers should assess and account for such expectations. Following Boot et al. (2013), pretask questionnaires capturing beliefs about fasting could be incorporated as covariates. In parallel, collecting physiological markers such as blood glucose would serve as both a compliance check and an important metabolic correlate, helping to disentangle expectancy from physiological effects.

Limitations and Methodological Considerations

Despite the breadth of studies included, several reporting gaps in the current literature limit mechanistic interpretation. Only 10 studies in our sample reported blood glucose levels—an important physiological marker for understanding fasting effects. Documentation of fasting duration was also inconsistent: Seven studies omitted this information entirely, whereas 18 reported only vague ranges or minimum thresholds. Even more strikingly, 35 studies failed to specify the time of cognitive testing, hindering any systematic analysis of circadian influences.

These reporting limitations were compounded by incomplete statistical data. Many otherwise eligible studies could not be included due to missing effect sizes or insufficient detail to calculate them. Attempts to obtain this information via author contact were only partially successful—just eight of 28 researchers (29%) provided usable data. In addition, most studies were conducted in Western populations, raising questions about cross-cultural generalizability. Addressing these issues—through better reporting of fasting parameters, physiological measures, and full statistical results, as well as expanding research into more diverse cultural contexts—would substantially enhance future syntheses.

To assess the impact of these limitations, we conducted several sensitivity analyses. Leave-one-out analyses revealed negligible shifts in effect estimates, and high risk-of-bias ratings in nearly half the included studies did not meaningfully influence the overall findings. Although publication bias analyses indicated minor asymmetry (with fewer small positive effects), the key finding—no consistent cognitive difference between fasted and satiated states—remained robust across models. Given that fasting's cognitive effects have been examined using diverse paradigms (ranging from single-meal studies to prolonged intermittent-fasting interventions) and with conflicting a priori assumptions (e.g., hypothesizing enhancing, null, or impairing effects), publication biases in one subfield could counterbalance those in another. For instance, investigators who approach fasting with a "skipping breakfast is harmful" mindset might underreport cognitive benefits, whereas those who view intermittent fasting as health-promoting may discount null or negative effects. Consequently, such biases in individual studies are likely mitigated by the meta-analytic aggregation of these varied approaches, resulting in the observed balanced estimate of the fasting–cognition relationship. Thus, the strength of this meta-analytic conclusion stems not from the impartiality of any single study or paradigm, but from the convergence of multiple methodological perspectives across the literature.

In addition to study-level limitations, some of our analytical choices also shape generalizability. We deliberately excluded religious fasting protocols to avoid confounds related to motivation, water restriction, and extended abstention. This limits applicability to secular contexts but increases internal validity. Several justified deviations from the preregistered protocol also strengthened our analysis. We refined search terms to reduce irrelevant hits (e.g., removing "behavior," "appetite"), excluded redundant or inaccessible databases (e.g., ScienceDirect, Global Health), and implemented a more rigorous hierarchical Bayesian model that allowed for partial pooling of all reported effect sizes. These improvements enhanced analytical precision while maintaining transparency.

Finally, prior research has highlighted substantial interindividual variability in cognitive responses to fasting interventions (Bamberg et al., 2025). Some individuals appear more resilient to fasting-induced cognitive strain, whereas others experience pronounced decrements in attention, memory, or mood. These differences may reflect a range of factors, yet because the present meta-analysis aggregates group-level effect sizes, it cannot fully capture this underlying heterogeneity. Traditional meta-analytic methods are optimized for estimating average effects across populations, but they are less suited for identifying distinct subgroups or patterns of individual susceptibility. Compounding this limitation is the assumption that task reliability is uniformly beneficial: Although high reliability is generally desirable, it may mask meaningful state-dependent variability in cognitive performance, particularly in response to transient physiological states like fasting. Tasks that are too stable may fail to detect genuine, situational fluctuations, whereas moderately reliable tasks may better reflect dynamic responses (Moreau, 2025), such as those crucial to understanding how fasting impacts cognition. To address these challenges, future work could incorporate individual participant data meta-analyses (Johnson, 2021), which allow for more granular modeling of within- and between-person variability. Such efforts will be essential for developing a nuanced, personalized understanding of fasting's cognitive consequences—one that moves beyond average effects and toward tailored recommendations based on individual profiles (Moreau & Corballis, 2019).

Conclusion and Future Directions

Our meta-analysis found no consistent evidence that short-term fasting impairs cognitive performance across a broad range of tasks,

populations, and fasting durations. Although Bayesian estimates suggested marginally lower performance in the fasted state, this effect was small and uncertain, with considerable variability across contexts. These findings challenge the common belief that fasting inherently compromises cognition and instead underscore the importance of situational and individual moderators. To advance the field, future research must move beyond binary comparisons of fasted versus satiated states and toward more mechanistically informed, context-sensitive approaches.

Several methodological improvements are essential for deepening our understanding of how fasting influences cognition. First, studies should rigorously standardize and report fasting durations. Our results suggest that the cognitive effects of fasting are highly sensitive to the timing and length of fasting intervals, yet many studies lacked precise documentation of these parameters. Clear reporting of both intended and actual fasting durations would improve reproducibility and cross-study comparability. Second, integrating multimodal assessment strategies—combining objective physiological markers such as blood glucose or ketone levels with subjective measures of hunger, fatigue, or mood—would clarify the pathways through which fasting affects mental performance (Green et al., 1997). Such approaches are critical for disentangling metabolic effects from psychological or expectancy-driven influences. Third, future research should prioritize examining individual differences in fasting response. Most existing studies rely on group-level averages, which may obscure substantial heterogeneity across participants in meta-analysis. Analytical frameworks that account for this variability, such as hierarchical or mixture models that capture multimodal response distributions (e.g., Moreau, 2021), could reveal meaningful subgroups for whom fasting has cognitive benefits or costs.

Longitudinal designs represent another important frontier. Tracking participants over multiple fasting cycles would provide insight into adaptation effects (Ma et al., 2021), allowing researchers to distinguish initial discomfort from long-term adjustment. These designs could clarify whether cognitive responses stabilize, improve, or worsen with repeated fasting exposure and whether prior fasting experience modulates this trajectory. Finally, careful experimental design remains crucial. The frequent discrepancies observed between within- and between-subjects studies in this literature point to the need for methodological rigor and alignment between research questions and design choices. Consistent protocols, transparent preregistration, and comprehensive reporting, including effect sizes and nonsignificant outcomes, will be vital for future synthesis efforts. Addressing these complexities through improved methodology and more nuanced theory will be key to advancing both scientific understanding and practical applications of fasting protocols.

Beyond its relevance as a public health intervention, fasting offers a valuable tool for probing the architecture of cognitive functioning (Moreau & Wiebels, 2021). Because fasting alters a broad range of physiological and psychological states in a predictable time course—glucose depletion, ketone elevation, hunger perception—it serves as a naturalistic perturbation that can reveal which cognitive constructs covary in response to metabolic change and which remain stable. Studying the dynamics of cognitive performance under fasting can therefore generate falsifiable predictions about the interdependence or independence of cognitive abilities (Moreau & Wiebels, 2022). For instance, if attention and working memory decline in parallel during early fasting but decouple during ketogenesis, this pattern could inform debates about whether these domains rely on shared versus distinct energy resources. In this way, fasting provides not only an ecologically valid stressor but also a tractable experimental framework for adjudicating between competing theories of cognitive architecture. Leveraging such interventions can help move the field beyond static trait models toward a more dynamic understanding of cognition as contextually embedded and physiologically modulated.

References

References marked with an asterisk indicate studies included in the meta-analysis.

Adolphus, K., Lawton, C. L., Champ, C. L., & Dye, L. (2016). The effects of breakfast and breakfast composition on cognition in children and adolescents: A systematic review. *Advances in Nutrition*, *7*(3), 590S–612S. https://doi.org/10.3945/an.115.010256

Ampel, B. C., Muraven, M., & McNay, E. C. (2018). Mental work requires physical energy: Self-control is neither exception nor exceptional. *Frontiers in Psychology*, *9*, Article 1005. https://doi.org/10.3389/fpsyg.2018.01005

Appleton, K. M., & Baker, S. (2015). Distraction, not hunger, is associated with lower mood and lower perceived work performance on fast compared to non-fast days during intermittent fasting. *Journal of Health Psychology*, *20*(6), 702–711. https://doi.org/10.1177/1359105315573430

*Arumäe, K., Kreegipuu, K., & Vainik, U. (2019). Assessing the overlap between three measures of food reward. *Frontiers in Psychology*, *10*, Article 883. https://doi.org/10.3389/fpsyg.2019.00883

*Ballestero-Arnau, M., Rodríguez-Herreros, B., Nuño-Bermúdez, N., & Cunillera, T. (2023). Sporadic fasting reduces attentional control without altering overall executive function in a binary classification task. *Physiology & Behavior*, *260*, Article 114065. https://doi.org/10.1016/j.physbeh.2022.114065

Bamberg, C., & Moreau, D. (2021). *A meta-analysis of the effects of temporary calorie restriction on cognitive performance*. [Dataset]. OSF. https://osf.io/nb5mj/?view_only=97346a4e4827436faf48ec20236a4ca2

*Bamberg, C., Reichenberger, J., & Blechert, J. (2025). Stable cognitive performance while adapting to intermittent fasting: A randomised controlled trial. *Journal of Health Psychology*. Advance online publication. https://doi.org/10.1177/13591053251351204

Bamberg, C., & Roefs, A. (2025). The impact of dietary claims on behaviour: Expectations qualify how actual satiety affects cognitive performance. *Appetite*, *206*, Article 107823. https://doi.org/10.1016/j.appet.2024.107823

*Bartholdy, S., Cheng, J., Schmidt, U., Campbell, I. C., & O'Daly, O. G. (2016). Task-based and questionnaire measures of inhibitory control are differentially affected by acute food restriction and by motivationally salient food stimuli in healthy adults. *Frontiers in Psychology*, *7*, Article 1303. https://doi.org/10.3389/fpsyg.2016.01303

Bartholomew, C. L., Muhlestein, J. B., May, H. T., Le, V. T., Galenko, O., Garrett, K. D., Brunker, C., Hopkins, R. O., Carlquist, J. F., Knowlton, K. U., Anderson, J. L., Bailey, B. W., & Horne, B. D. (2021). Randomized controlled trial of once-per-week intermittent fasting for health improvement: The WONDERFUL trial. *European Heart Journal Open*, *1*(2), Article oeab026. https://doi.org/10.1093/ehjopen/oeab026

Batch, J. T., Lamsal, S. P., Adkins, M., Sultan, S., & Ramirez, M. N. (2020). Advantages and disadvantages of the ketogenic diet: A review article. *Cureus*, *12*(8), Article e9639. https://doi.org/10.7759/cureus.9639

*Batorek, M., & Hromatko, I. (2024). Cognitive functions, mood and sleep quality after two months of intermittent fasting. *Journal of Trial and Error*. Advance online publication. https://doi.org/10.36850/e71f-5cff

BBDO, A. M. V. (Director). (2012). *Snickers, You're not you when you're hungry* [Broadcast]. Mars.

Beaulieu, K., & Blundell, J. (2021). The psychobiology of hunger—A scientific perspective. *Topoi*, *40*(3), 565–574. https://doi.org/10.1007/s11245-020-09724-z

Belkacemi, L., Selselet-Attou, G., Hupkens, E., Nguidjoe, E., Louchami, K., Sener, A., & Malaisse, W. J. (2012). Intermittent fasting modulation of the diabetic syndrome in streptozotocin-injected rats. *International Journal of Endocrinology*, *2012*, Article 962012. https://doi.org/10.1155/2012/962012

Benau, E. M., Makara, A., Orloff, N. C., Benner, E., Serpell, L., & Timko, C. A. (2021). How does fasting affect cognition? An updated systematic review (2013–2020). *Current Nutrition Reports*, *10*(4), 376–390. https://doi.org/10.1007/s13668-021-00370-4

Benau, E. M., Orloff, N. C., Janke, E. A., Serpell, L., & Timko, C. A. (2014). A systematic review of the effects of experimental fasting on cognition. *Appetite*, *77*, 52–61. https://doi.org/10.1016/j.appet.2014.02.014

Bergström, J., Hermansen, L., Hultman, E., & Saltin, B. (1967). Diet, muscle glycogen and physical performance. *Acta Physiologica Scandinavica*, *71*(2–3), 140–150. https://doi.org/10.1111/j.1748-1716.1967.tb03720.x

*Bolton, H. M., Burgess, P. W., Gilbert, S. J., & Serpell, L. (2014). Increased set shifting costs in fasted healthy volunteers. *PLOS ONE*, *9*(7), Article e101946. https://doi.org/10.1371/journal.pone.0101946

Boot, W. R., Simons, D. J., Stothart, C., & Stutts, C. (2013). The pervasive problem with placebos in psychology: Why active control groups are not sufficient to rule out placebo effects. *Perspectives on Psychological Science*, *8*(4), 445–454. https://doi.org/10.1177/1745691613491271

Brocchi, A., Rebelos, E., Dardano, A., Mantuano, M., & Daniele, G. (2022). Effects of intermittent fasting on brain metabolism. *Nutrients*, *14*(6), Article 1275. https://doi.org/10.3390/nu14061275

Brooks, S. P., & Gelman, A. (1998). General methods for monitoring convergence of iterative simulations. *Journal of Computational and Graphical Statistics*, *7*(4), 434–455. https://doi.org/10.1080/10618600.1998.10474787

Browne, S. E., Flynn, M. J., O'Neill, B. V., Howatson, G., Bell, P. G., & Haskell-Ramsay, C. F. (2017). Effects of acute high-intensity exercise on cognitive performance in trained individuals: A systematic review. In M. R. Wilson, V. Walsh, & B. Parkin (Eds.), *Progress in brain research* (Vol. 234, pp. 161–187). Elsevier. https://doi.org/10.1016/bs.pbr.2017.06.003

Bürkner, P.-C. (2017). brms: An *R* package for Bayesian multilevel models using *Stan*. *Journal of Statistical Software*, *80*(1), 1–28. https://doi.org/10.18637/jss.v080.i01

Cahill, G. F., Jr. (1976). Starvation in man. *Clinics in Endocrinology and Metabolism*, *5*(2), 397–415. https://doi.org/10.1016/S0300-595X(76)80028-X

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies* (1st ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511571312

Chang, Y. K., Labban, J. D., Gapin, J. I., & Etnier, J. L. (2012). The effects of acute exercise on cognitive performance: A meta-analysis. *Brain Research*, *1453*, 87–101. https://doi.org/10.1016/j.brainres.2012.02.068

*Channon, S., & Hayward, A. (1990). The effect of short-term fasting on processing of food cues in normal subjects. *International Journal of Eating Disorders*, *9*(4), 447–452. https://doi.org/10.1002/1098-108X(199007)9:4<447::AID-EAT2260090411>3.0.CO;2-0

Cheung, M. W.-L. (2019). A guide to conducting a meta-analysis with non-independent effect sizes. *Neuropsychology Review*, *29*(4), 387–396. https://doi.org/10.1007/s11065-019-09415-6

Clark, J., Glasziou, P., Del Mar, C., Bannach-Brown, A., Stehlik, P., & Scott, A. M. (2020). A full systematic review was completed in 2 weeks using automation tools: A case study. *Journal of Clinical Epidemiology*, *121*, 81–90. https://doi.org/10.1016/j.jclinepi.2020.01.008

Cooper, L. F. (1917). *How to cut food costs*. Good Health Publishing Company.

*Cooper, S. B., Bandelow, S., & Nevill, M. E. (2011). Breakfast consumption and cognitive function in adolescent schoolchildren. *Physiology & Behavior*, *103*(5), 431–439. https://doi.org/10.1016/j.physbeh.2011.03.018

Cowan, N. (2017). The many faces of working memory and short-term storage. *Psychonomic Bulletin & Review*, *24*(4), 1158–1170. https://doi.org/10.3758/s13423-016-1191-6

Cueto, S. (2001). Breakfast and performance. *Public Health Nutrition*, *4*(6a), 1429–1431. https://doi.org/10.1079/PHN2001233

Dart, K. (Director). (2012, August 6). *Eat, fast and live longer* (Nos. 3, 2012–2013) [Broadcast]. Horizon-BBC. https://www.bbc.co.uk/programmes/b01lxyzc

Das, J. K., Salam, R. A., Thornburg, K. L., Prentice, A. M., Campisi, S., Lassi, Z. S., Koletzko, B., & Bhutta, Z. A. (2017). Nutrition in adolescents: Physiology, metabolism, and nutritional needs. *Annals of the New York Academy of Sciences*, *1393*(1), 21–33. https://doi.org/10.1111/nyas.13330

de Cabo, R., & Mattson, M. P. (2019). Effects of intermittent fasting on health, aging, and disease. *The New England Journal of Medicine*, *381*(26), 2541–2551. https://doi.org/10.1056/NEJMra1905136

*de Ridder, D., Kroese, F., Adriaanse, M., & Evers, C. (2014). Always gamble on an empty stomach: Hunger is associated with advantageous decision making. *PLOS ONE*, *9*(10), Article e111081. https://doi.org/10.1371/journal.pone.0111081

*Defeyter, M. A., & Russo, R. (2013). The effect of breakfast cereal consumption on adolescents' cognitive performance and mood. *Frontiers in Human Neuroscience*, *7*, Article 789. https://doi.org/10.3389/fnhum.2013.00789

Duval, S., & Tweedie, R. (2000). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics*, *56*(2), 455–463. https://doi.org/10.1111/j.0006-341X.2000.00455.x

*Frank, S., Laharnar, N., Kullmann, S., Veit, R., Canova, C., Hegner, Y. L., Fritsche, A., & Preissl, H. (2010). Processing of food pictures: Influence of hunger, gender and calorie content. *Brain Research*, *1350*, 159–166. https://doi.org/10.1016/j.brainres.2010.04.030

*Fulford, J., Varley-Campbell, J. L., & Williams, C. A. (2016). The effect of breakfast versus no breakfast on brain activity in adolescents when performing cognitive tasks, as assessed by fMRI. *Nutritional Neuroscience*, *19*(3), 110–115. https://doi.org/10.1179/1476830515Y.0000000011

Galioto, R., & Spitznagel, M. B. (2016). The effects of breakfast and breakfast composition on cognition in adults. *Advances in Nutrition*, *7*(3), 576S–589S. https://doi.org/10.3945/an.115.010231

Göbel, B., Oltmanns, K. M., & Chung, M. (2013). Linking neuronal brain activity to the glucose metabolism. *Theoretical Biology & Medical Modelling*, *10*(1), 50. https://doi.org/10.1186/1742-4682-10-50

Gold, P. E. (2014). Regulation of memory—From the adrenal medulla to liver to astrocytes to neurons. *Brain Research Bulletin*, *105*, 25–35. https://doi.org/10.1016/j.brainresbull.2013.12.012

*González-Garrido, A. A., Brofman-Epelbaum, J. J., Gómez-Velázquez, F. R., Balart-Sánchez, S. A., & Ramos-Loyo, J. (2019). Skipping breakfast affects the early steps of cognitive processing: An event-related brain potentials study. *Journal of Psychophysiology*, *33*(2), 109–118. https://doi.org/10.1027/0269-8803/a000214

Grayson, B. E., Seeley, R. J., & Sandoval, D. A. (2013). Wired on sugar: The role of the CNS in the regulation of glucose homeostasis. *Nature Reviews Neuroscience*, *14*(1), 24–37. https://doi.org/10.1038/nrn3409

*Green, M. W., Elliman, N. A., & Rogers, P. J. (1995). Lack of effect of short-term fasting on cognitive function. *Journal of Psychiatric Research*, *29*(3), 245–253. https://doi.org/10.1016/0022-3956(95)00009-T

*Green, M. W., Elliman, N. A., & Rogers, P. J. (1997). The effects of food deprivation and incentive motivation on blood glucose levels and cognitive function. *Psychopharmacology*, *134*(1), 88–94. https://doi.org/10.1007/s002130050429

*Güner, E., & Aktaç, Ş. (2025). Time-restricted feeding can increase food-related impulsivity: A randomized controlled trial. *Nutritional*

Neuroscience, *28*(1), 28–36. https://doi.org/10.1080/1028415X.2024.2344139

*Hachl, P., Hempel, C., & Pietrowsky, R. (2003). ERPs to stimulus identification in persons with restrained eating behavior. *International Journal of Psychophysiology*, *49*(2), 111–121. https://doi.org/10.1016/S0167-8760(03)00099-0

Harvey, P. D. (2019). Domains of cognition and their assessment. *Dialogues in Clinical Neuroscience*, *21*(3), 227–237. https://doi.org/10.31887/DCNS.2019.21.3/pharvey

Hatori, M., Vollmers, C., Zarrinpar, A., DiTacchio, L., Bushong, E. A., Gill, S., Leblanc, M., Chaix, A., Joens, M., Fitzpatrick, J. A. J., Ellisman, M. H., & Panda, S. (2012). Time-restricted feeding without reducing caloric intake prevents metabolic diseases in mice fed a high-fat diet. *Cell Metabolism*, *15*(6), 848–860. https://doi.org/10.1016/j.cmet.2012.04.019

*He, Q., Huang, X., Zhang, S., Turel, O., Ma, L., & Bechara, A. (2019). Dynamic causal modeling of insular, striatal, and prefrontal cortex activities during a food-specific go/nogo task. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, *4*(12), 1080–1089. https://doi.org/10.1016/j.bpsc.2018.12.005

Hedges, L. V. (1981). Distribution theory for Glass's estimator of effect size and related estimators. *Journal of Educational Statistics*, *6*(2), 107–128. https://doi.org/10.3102/10769986006002107

*Heldmann, M., Müller-Miny, L., Wagner-Altendorf, T., & Münte, T. F. (2025). Automatic attentional capture by food items in a visuospatial attention task—A study with event-related brain potentials. *Behavioural Brain Research*, *484*, Article 115514. https://doi.org/10.1016/j.bbr.2025.115514

*Herbert, B. M., Herbert, C., Pollatos, O., Weimer, K., Enck, P., Sauer, H., & Zipfel, S. (2012). Effects of short-term food deprivation on interoceptive awareness, feelings and autonomic cardiac activity. *Biological Psychology*, *89*(1), 71–79. https://doi.org/10.1016/j.biopsycho.2011.09.004

Higgins, J. P. T., Altman, D. G., Gotzsche, P. C., Juni, P., Moher, D., Oxman, A. D., Savovic, J., Schulz, K. F., Weeks, L., Sterne, J. A. C., Cochrane Bias Methods Group, & Cochrane Statistical Methods Group. (2011). The cochrane collaboration's tool for assessing risk of bias in randomised trials. *The BMJ*, *343*, Article d5928. https://doi.org/10.1136/bmj.d5928

Hommel, B., Chapman, C. S., Cisek, P., Neyedli, H. F., Song, J.-H., & Welsh, T. N. (2019). No one knows what attention is. *Attention, Perception, & Psychophysics*, *81*(7), 2288–2303. https://doi.org/10.3758/s13414-019-01846-w

*Howard, M., Roiser, J. P., Gilbert, S. J., Burgess, P. W., Dayan, P., & Serpell, L. (2020). Short-term fasting selectively influences impulsivity in healthy individuals. *Frontiers in Psychology*, *11*, Article 1644. https://doi.org/10.3389/fpsyg.2020.01644

IFIC. (2020). *Health survey. The International Food Information Council (IFIC) Foundation*. https://foodinsight.org/2020-food-and-health-survey/

*Ilse, A., Donohue, S. E., Schoenfeld, M. A., Hopf, J. M., Heinze, H.-J., & Harris, J. A. (2020). Unseen food images capture the attention of hungry viewers: Evidence from event-related potentials. *Appetite*, *155*, Article 104828. https://doi.org/10.1016/j.appet.2020.104828

Ireton-Jones, C. (2005). Adjusted body weight, con: Why adjust body weight in energy-expenditure calculations? *Nutrition in Clinical Practice*, *20*(4), 474–479. https://doi.org/10.1177/0115426505020004474

Ishihara, T., Drollette, E. S., Ludyga, S., Hillman, C. H., & Kamijo, K. (2021). The effects of acute aerobic exercise on executive function: A systematic review and meta-analysis of individual participant data. *Neuroscience and Biobehavioral Reviews*, *128*, 258–269. https://doi.org/10.1016/j.neubiorev.2021.06.026

Jahagirdar, V., Ramcharitar, J., Cotero, V. E., & McNay, E. C. (2012). Moderate recurrent hypoglycemia markedly impairs set-shifting ability in a rodent model: Cognitive and neurochemical effects. *The Open Diabetes Journal*, *5*(1), 1–7.

*Jin, Z., Wang, G., Hu, S., & Speakman, J. R. (2020). No impact of hunger on male perception of female physical attractiveness in relation to adiposity: A randomized controlled trial. *International Journal of Obesity*, *44*(2), 418–427. https://doi.org/10.1038/s41366-019-0392-2

Johnson, B. T. (2021). Toward a more transparent, rigorous, and generative psychology. *Psychological Bulletin*, *147*(1), 1–15. https://doi.org/10.1037/bul0000317

Johnstone, A. (2015). Fasting for weight loss: An effective strategy or latest dieting trend? *International Journal of Obesity*, *39*(5), 727–733. https://doi.org/10.1038/ijo.2014.214

Kanarek, R. (1997). Psychological effects of snacks and altered meal frequency. *British Journal of Nutrition*, *77*(S1), S105–S118. https://doi.org/10.1079/BJN19970108

*Kennedy, R. A., & Keene, A. G. (1966). The effect of short periods of food-deprivation on human performance. *British Journal of Psychology*, *57*(1–2), 93–97. https://doi.org/10.1111/j.2044-8295.1966.tb01008.x

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine*, *15*(2), 155–163. https://doi.org/10.1016/j.jcm.2016.02.012

Kuzawa, C. W. (1998). Adipose tissue in human infancy and childhood: An evolutionary perspective. *American Journal of Physical Anthropology*, *107*(S27), 177–209. https://doi.org/10.1002/(SICI)1096-8644(1998)107:27+<177::AID-AJPA7>3.0.CO;2-B

*Labonté, K., Fantino, M., & Nielsen, D. E. (2024). Disentangling inhibition toward food and non-food stimuli across two hunger levels: An fNIRS study. *Appetite*, *203*, Article 107678. https://doi.org/10.1016/j.appet.2024.107678

*Lahtinen, A., Juvonen, K., Lapveteläinen, A., Kolehmainen, M., Lindholm, M., Tanila, H., Kantanen, T., Sinikallio, S., Karhunen, L., & Närväinen, J. (2019). Metabolic state as a modulator of neural event-related potentials for food stimuli in an implicit association test. *Physiology & Behavior*, *209*, Article 112589. https://doi.org/10.1016/j.physbeh.2019.112589

*Landini, A., Segovia, M., Palma, M., & Nayga, R. M., Jr. (2024). Food for thought: The impact of short term fasting on cognitive ability. *PLOS ONE*, *19*(11), Article e0312811. https://doi.org/10.1371/journal.pone.0312811

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159–174. https://doi.org/10.2307/2529310

*Lavy, E. H., & Van den Hout, M. A. (1993). Attentional bias for appetitive cues: Effects of fasting in normal subjects. *Behavioural and Cognitive Psychotherapy*, *21*(4), 297–310. https://doi.org/10.1017/S1352465800011632

*Lerner, R. G., Singer, I., & Triandis, H. C. (1958). Serial verbal learning under two conditions of hunger motivation. *Journal of Experimental Psychology*, *55*(6), 572–574. https://doi.org/10.1037/h0046675

Longo, V. D., Di Tano, M., Mattson, M. P., & Guidi, N. (2021). Intermittent and periodic fasting, longevity and disease. *Nature Aging*, *1*(1), 47–59. https://doi.org/10.1038/s43587-020-00013-3

Ma, Q., Yang, C., Wu, R., Wu, M., Liu, W., Dai, Z., & Li, Y. (2021). How experiences affect psychological responses during supervised fasting: A preliminary study. *Frontiers in Psychology*, *12*, Article 651760. https://doi.org/10.3389/fpsyg.2021.651760

*Maran, T., Sachse, P., Martini, M., & Furtner, M. (2017). Benefits of a hungry mind: When hungry, exposure to food facilitates proactive interference resolution. *Appetite*, *108*, 343–352. https://doi.org/10.1016/j.appet.2016.10.023

Mattson, M. P. (2022). *Intermittent fasting revolution: The science of optimizing health and enhancing performance*. MIT Press. https://doi.org/10.7551/mitpress/13461.001.0001

Mattson, M. P., Allison, D. B., Fontana, L., Harvie, M., Longo, V. D., Malaisse, W. J., Mosley, M., Notterpek, L., Ravussin, E., Scheer, F. A. J. L., Seyfried, T. N., Varady, K. A., & Panda, S. (2014). Meal frequency and timing in health and disease. *Proceedings of the National Academy of Sciences of the United States of America*, *111*(47), 16647–16653. https://doi.org/10.1073/pnas.1413965111

Mattson, M. P., Longo, V. D., & Harvie, M. (2017). Impact of intermittent fasting on health and disease processes. *Ageing Research Reviews*, *39*, 46–58. https://doi.org/10.1016/j.arr.2016.10.005

Mattson, M. P., Moehl, K., Ghena, N., Schmaedick, M., & Cheng, A. (2018). Intermittent metabolic switching, neuroplasticity and brain health. *Nature Reviews Neuroscience*, *19*(2), 81–94. https://doi.org/10.1038/nrn.2017.156

*Maydych, V., Pöschel, H., Kübler, S., & Schubert, T. (2024). The impact of food stimuli and fasting on cognitive control in task switching. *Psychological Research*, *88*(3), 921–935. https://doi.org/10.1007/s00426-023-01884-y

*Mayra, S. T., Kravat, N., Chondropoulos, K., De Leon, A., & Johnston, C. S. (2022). Early time-restricted eating may favorably impact cognitive acuity in university students: A randomized pilot study. *Nutrition Research*, *108*, 1–8. https://doi.org/10.1016/j.nutres.2022.10.002

Mergenthaler, P., Lindauer, U., Dienel, G. A., & Meisel, A. (2013). Sugar for the brain: The role of glucose in physiological and pathological brain function. *Trends in Neurosciences*, *36*(10), 587–597. https://doi.org/10.1016/j.tins.2013.07.001

Michalsen, A., Schlegel, F., Rodenbeck, A., Lüdtke, R., Huether, G., Teschler, H., & Dobos, G. J. (2003). Effects of short-term modified fasting on sleep patterns and daytime vigilance in non-obese subjects: Results of a pilot study. *Annals of Nutrition & Metabolism*, *47*(5), 194–200. https://doi.org/10.1159/000070485

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

*Montagrin, A., Martins-Klein, B., Sander, D., & Mather, M. (2021). Effects of hunger on emotional arousal responses and attention/memory biases. *Emotion*, *21*(1), 148–158. https://doi.org/10.1037/emo0000680

Moreau, D. (2021). Shifting minds: A quantitative reappraisal of cognitive-intervention research. *Perspectives on Psychological Science*, *16*(1), 148–160. https://doi.org/10.1177/1745691620950696

Moreau, D. (2025). Temporal stability in measurements matters only for stable constructs. *Nature Reviews Psychology*, *4*(5), Article 361. https://doi.org/10.1038/s44159-025-00435-z

Moreau, D., & Chou, E. (2019). The acute effect of high-intensity exercise on executive function: A meta-analysis. *Perspectives on Psychological Science*, *14*(5), 734–764. https://doi.org/10.1177/1745691619850568

Moreau, D., & Corballis, M. C. (2019). When averaging goes wrong: The case for mixture model estimation in psychological science. *Journal of Experimental Psychology: General*, *148*(9), 1615–1627. https://doi.org/10.1037/xge0000504

Moreau, D., & Gamble, B. (2022). Conducting a meta-analysis in the age of open science: Tools, tips, and practical recommendations. *Psychological Methods*, *27*(3), 426–432. https://doi.org/10.1037/met0000351

Moreau, D., & Wiebels, K. (2021). Assessing change in intervention research: The benefits of composite outcomes. *Advances in Methods and Practices in Psychological Science*, *4*(1), Article 2515245920931930. https://doi.org/10.1177/2515245920931930

Moreau, D., & Wiebels, K. (2022). Psychological constructs as local optima. *Nature Reviews Psychology*, *1*(4), 188–189. https://doi.org/10.1038/s44159-022-00042-2

*Neal, C., Pepper, G., Allen, C., Shannon, O., & Nettle, D. (2024). No effect of hunger on the memory of food images and prices. *Adaptive Human Behavior and Physiology*, *10*(3), 303–323. https://doi.org/10.1007/s40750-024-00247-0

*Neal, C., Pepper, G. V., Allen, C., & Nettle, D. (2023). No effect of hunger on attentional capture by food cues: Two replication studies. *Appetite*, *191*, Article 107065. https://doi.org/10.1016/j.appet.2023.107065

*Nijs, I. M. T., Muris, P., Euser, A. S., & Franken, I. H. A. (2010). Differences in attention to food and food intake between overweight/obese and normal-weight females under conditions of hunger and satiety. *Appetite*, *54*(2), 243–254. https://doi.org/10.1016/j.appet.2009.11.004

*Nikendei, C., Weisbrod, M., Schild, S., Bender, S., Walther, S., Herzog, W., Zipfel, S., & Friederich, H. C. (2008). Anorexia nervosa: Selective processing of food-related word and pictorial stimuli in recognition and free recall tests. *International Journal of Eating Disorders*, *41*(5), 439–447. https://doi.org/10.1002/eat.20518

Oh, S. Y., Kim, B. S., & Choue, R. (2002). Appetite sensations and eating behaviors to complete fasting in obese and non-obese individuals. *European Journal of Clinical Nutrition*, *56*(1), 86–89. https://doi.org/10.1038/sj.ejcn.1601285

Ombrato, M. D., & Phillips, E. (2021). The mind of the hungry agent: Hunger, affect and appetite. *Topoi*, *40*(3), 517–526. https://doi.org/10.1007/s11245-020-09733-y

Owen, L., Scholey, A. B., Finnegan, Y., Hu, H., & Sünram-Lea, S. I. (2012). The effect of glucose dose and fasting interval on cognitive function: A double-blind, placebo-controlled, six-way crossover study. *Psychopharmacology*, *220*(3), 577–589. https://doi.org/10.1007/s00213-011-2510-2

Owen, O. E., Morgan, A. P., Kemp, H. G., Sullivan, J. M., Herrera, M. G., & Cahill, G. F., Jr. (1967). Brain metabolism during fasting. *The Journal of Clinical Investigation*, *46*(10), 1589–1595. https://doi.org/10.1172/JCI105650

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *The BMJ*, *372*(71), Article n71. https://doi.org/10.1136/bmj.n71

Paoli, A., Tinsley, G., Bianco, A., & Moro, T. (2019). The influence of meal frequency and timing on health in humans: The role of fasting. *Nutrients*, *11*(4), Article 719. https://doi.org/10.3390/nu11040719

*Parmentier, F. B. R., Pacheco-Unguetti, A. P., & Valero, S. (2018). Food words distract the hungry: Evidence of involuntary semantic processing of task-irrelevant but biologically-relevant unexpected auditory words. *PLOS ONE*, *13*(1), Article e0190644. https://doi.org/10.1371/journal.pone.0190644

Patterson, R. E., & Sears, D. D. (2017). Metabolic effects of intermittent fasting. *Annual Review of Nutrition*, *37*(1), 371–393. https://doi.org/10.1146/annurev-nutr-071816-064634

*Pender, S., Gilbert, S. J., & Serpell, L. (2014). The neuropsychology of starvation: Set-shifting and central coherence in a fasted nonclinical sample. *PLOS ONE*, *9*(10), Article e110743. https://doi.org/10.1371/journal.pone.0110743

*Piech, R. M., Hampshire, A., Owen, A. M., & Parkinson, J. A. (2009). Modulation of cognitive flexibility by hunger and desire. *Cognition and Emotion*, *23*(3), 528–540. https://doi.org/10.1080/02699930802012153

*Piech, R. M., Pastorino, M. T., & Zald, D. H. (2010). All I saw was the cake. Hunger effects on attentional capture by visual food cues. *Appetite*, *54*(3), 579–582. https://doi.org/10.1016/j.appet.2009.11.003

*Pietrowsky, R., Krug, R., Fehm, H. L., & Born, J. (2002). Food deprivation fails to affect preoccupation with thoughts of food in anorectic patients. *British Journal of Clinical Psychology*, *41*(3), 321–326. https://doi.org/10.1348/014466502760379172

*Plihal, W., Haenschel, C., Hachl, P., Born, J., & Pietrowsky, R. (2001). The effect of food deprivation on ERP during identification of tachistoscopically presented food-related words. *Journal of Psychophysiology*, *15*(3), 163–172. https://doi.org/10.1027/0269-8803.15.3.163

*Pollitt, E., Leibel, R. L., & Greenfield, D. (1981). Brief fasting, stress, and cognition in children. *The American Journal of Clinical Nutrition*, *34*(8), 1526–1533. https://doi.org/10.1093/ajcn/34.8.1526

Pourabbasi, A., Ebrahimnegad Shirvani, M. S., & Shams, A. H. (2019). Does Islamic fasting affect cognitive functions in adolescents? A

systematic review. *The Journal of the Pakistan Medical Association*, *69*(8), 1164–1169.

Prentice, A. M. (2005). Starvation in humans: Evolutionary background and contemporary implications. *Mechanisms of Ageing and Development*, *126*(9), 976–981. https://doi.org/10.1016/j.mad.2005.03.018

*Radel, R., & Clément-Guillotin, C. (2012). Evidence of motivational influences in early visual perception: Hunger modulates conscious access. *Psychological Science*, *23*(3), 232–234. https://doi.org/10.1177/0956797611427920

*Redlich, D., Memmert, D., & Kreitz, C. (2022). Does hunger promote the detection of foods? The effect of value on inattentional blindness. *Psychological Research*, *86*(1), 98–109. https://doi.org/10.1007/s00426-021-01480-y

Reeves, S., Halsey, L. G., McMeel, Y., & Huber, J. W. (2013). Breakfast habits, beliefs and measures of health and wellbeing in a nationally representative UK sample. *Appetite*, *60*(1), 51–57. https://doi.org/10.1016/j.appet.2012.09.024

Rogers, P. J. (2016). Breakfast: How important is it really? *Public Health Nutrition*, *19*(9), 1718–1719. https://doi.org/10.1017/S1368980015003705

Rücker, G., Carpenter, J. R., & Schwarzer, G. (2011). Detecting and adjusting for small-study effects in meta-analysis. *Biometrical Journal. Biometrische Zeitschrift*, *53*(2), 351–368. https://doi.org/10.1002/bimj.201000151

*Rummel, J., & Nied, L. (2017). Do drives drive the train of thought?-Effects of hunger and sexual arousal on mind-wandering behavior. *Consciousness and Cognition*, *55*, 179–187. https://doi.org/10.1016/j.concog.2017.08.013

*Sawada, R., Sato, W., Minemoto, K., & Fushiki, T. (2019). Hunger promotes the detection of high-fat food. *Appetite*, *142*, Article 104377. https://doi.org/10.1016/j.appet.2019.104377

*Schlezingerová, N., Málková, P., Kocourek, M., & Telenský, P. (2024). Mild hunger elicits attentional desensitization to visual food cues in healthy, non-obese individuals. *Frontiers in Psychology*, *15*, Article 1441184. https://doi.org/10.3389/fpsyg.2024.1441184

Schmidt, C., Collette, F., Cajochen, C., & Peigneux, P. (2007). A time to think: Circadian rhythms in human cognition. *Cognitive Neuropsychology*, *24*(7), 755–789. https://doi.org/10.1080/02643290701754158

Sedgwick, P. (2015). Understanding the ecological fallacy. *The BMJ*, *351*, Article h4773. https://doi.org/10.1136/bmj.h4773

Seibt, B., Häfner, M., & Deutsch, R. (2007). Prepared to eat: How immediate affective and motivational responses to food cues are influenced by food deprivation. *European Journal of Social Psychology*, *37*(2), 359–379. https://doi.org/10.1002/ejsp.365

Simonsohn, U., Nelson, L. D., & Simmons, J. P. (2014). p-Curve and effect size: Correcting for publication bias using only significant results. *Perspectives on Psychological Science*, *9*(6), 666–681. https://doi.org/10.1177/1745691614553988

*Solianik, R., Sujeta, A., Terentjevienė, A., & Skurvydas, A. (2016). Effect of 48 h fasting on autonomic function, brain activity, cognition, and mood in amateur weight lifters. *BioMed Research International*, *2016*, Article 1503956. https://doi.org/10.1155/2016/1503956

Sommerfield, A. J., Deary, I. J., McAulay, V., & Frier, B. M. (2003). Moderate hypoglycemia impairs multiple memory functions in healthy adults. *Neuropsychology*, *17*(1), 125–132. https://doi.org/10.1037/0894-4105.17.1.125

*Staats, A., & Warren, D. (1974). Motivation and 3-functioning learning—Food-deprivation and approach-avoidance to food words. *Journal of Experimental Psychology*, *103*(6), 1191–1199. https://doi.org/10.1037/h0037417

Stanley, T. D., & Doucouliagos, H. (2014). Meta-regression approximations to reduce publication selection bias. *Research Synthesis Methods*, *5*(1), 60–78. https://doi.org/10.1002/jrsm.1095

Stewart, S. H., & Samoluk, S. B. (1997). Effects of short-term food deprivation and chronic dietary restraint on the selective processing of appetitive-related cues. *International Journal of Eating Disorders*, *21*(2), 129–135. https://doi.org/10.1002/(SICI)1098-108X(199703)21:2<129::AID-EAT3>3.0.CO;2-N

Swagerman, S. C., de Geus, E. J. C., Koenis, M. M. G., Hulshoff Pol, H. E., Boomsma, D. I., & Kan, K.-J. (2015). Domain dependent associations between cognitive functioning and regular voluntary exercise behavior. *Brain and Cognition*, *97*, 32–39. https://doi.org/10.1016/j.bandc.2015.04.001

Tinsley, G. M., & La Bounty, P. M. (2015). Effects of intermittent fasting on body composition and clinical health markers in humans. *Nutrition Reviews*, *73*(10), 661–674. https://doi.org/10.1093/nutrit/nuv041

Van Cauter, E., Polonsky, K. S., & Scheen, A. J. (1997). Roles of circadian rhythmicity and sleep in human glucose regulation. *Endocrine Reviews*, *18*(5), 716–738. https://doi.org/10.1210/edrv.18.5.0317

*van den Hoek Ostende, M. M., Schwarz, U., Gawrilow, C., Kaup, B., & Svaldi, J. (2024). Modality matters: Fasted individuals inhibit food stimuli better than neutral stimuli for words, but not for pictures. *Nutrients*, *16*(14), Article 2190. https://doi.org/10.3390/nu16142190

*van Swieten, M. M. H., Bogacz, R., & Manohar, S. G. (2021). Hunger improves reinforcement-driven but not planned action. *Cognitive, Affective & Behavioral Neuroscience*, *21*(6), 1196–1206. https://doi.org/10.3758/s13415-021-00921-w

Vannucci, S. J., & Simpson, I. A. (2003). Developmental switch in brain nutrient transporter expression in the rat. *American Journal of Physiology. Endocrinology and Metabolism*, *285*(5), E1127–E1134. https://doi.org/10.1152/ajpendo.00187.2003

Vehtari, A., Gelman, A., & Gabry, J. (2017). Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC. *Statistics and Computing*, *27*(5), 1413–1432. https://doi.org/10.1007/s11222-016-9696-4

Vehtari, A., Simpson, D., Gelman, A., Yao, Y., & Gabry, J. (2024). *Pareto smoothed importance sampling*. arXiv. https://arxiv.org/abs/1507.02646

Vuorre, M. (2016). *Bayesian meta-analysis with R, Stan, and Brms*. https://vuorre.com/posts/2016-09-29-bayesian-meta-analysis/

*Wang, C., Cao, Z., Qin, H., Tian, L., Jiang, Y., Dai, Z., Chi, L., & Wu, B. (2025). The effects of 15-day complete fasting on the attentional network: An ERP study. *Brain Research*, *1849*, Article 149343. https://doi.org/10.1016/j.brainres.2024.149343

*Widenhorn-Müller, K., Hille, K., Klenk, J., & Weiland, U. (2008). Influence of having breakfast on cognitive performance and mood in 13- to 20-year-old high school students: Results of a crossover trial. *Pediatrics*, *122*(2), 279–284. https://doi.org/10.1542/peds.2007-0944

*Wierenga, C. E., Bischoff-Grethe, A., Melrose, A. J., Irvine, Z., Torres, L., Bailer, U. F., Simmons, A., Fudge, J. L., McClure, S. M., Ely, A., & Kaye, W. H. (2015). Hunger does not motivate reward in women remitted from anorexia nervosa. *Biological Psychiatry*, *77*(7), 642–652. https://doi.org/10.1016/j.biopsych.2014.09.024

Wilhelmi de Toledo, F., Grundler, F., Sirtori, C. R., & Ruscica, M. (2020). Unravelling the health effects of fasting: A long road from obesity treatment to healthy life span increase and improved cognition. *Annals of Medicine*, *52*(5), 147–161. https://doi.org/10.1080/07853890.2020.1770849

Williams, D. R., Rast, P., & Bürkner, P.-C. (2018). *Bayesian meta-analysis with weakly informative prior distributions*. PsyArXiv. https://doi.org/10.31234/osf.io/7tbrm

*Wilson, T. J., Gray, M. J., Van Klinken, J.-W., Kaczmarczyk, M., & Foxe, J. J. (2018). Macronutrient composition of a morning meal and the maintenance of attention throughout the morning. *Nutritional Neuroscience*, *21*(10), 729–743. https://doi.org/10.1080/1028415X.2017.1347998

Wittbrodt, M. T., & Millard-Stafford, M. (2018). Dehydration impairs cognitive performance: A meta-analysis. *Medicine & Science in Sports & Exercise*, *50*(11), 2360–2368. https://doi.org/10.1249/MSS.0000000000001682

*Yang, C., Ma, Q., Zhang, H., Wu, F., Wu, M., Yang, C., Chen, Y., Xiong, J., Liu, W., Wang, H., Wu, R., Dai, Z., & Li, Y. (2021). Ten days of

complete fasting affected subjective sensations but not cognitive abilities in healthy adults. *European Journal of Nutrition*, *60*(5), 2747–2758. https://doi.org/10.1007/s00394-020-02450-7

*Yousuf, M., Heldmann, M., Göttlich, M., Münte, T. F., & Doñamayor, N. (2018). Neural processing of food and monetary rewards is modulated by metabolic state. *Brain Imaging and Behavior*, *12*(5), 1379–1392. https://doi.org/10.1007/s11682-017-9811-y

Zang, B.-Y., He, L.-X., & Xue, L. (2022). Intermittent fasting: Potential bridge of obesity and diabetes to health? *Nutrients*, *14*(5), Article 981. https://doi.org/10.3390/nu14050981

Zihlman, A. L., & Bolter, D. R. (2015). Body composition in *Pan paniscus* compared with *Homo sapiens* has implications for changes during human evolution. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(24), 7466–7471. https://doi.org/10.1073/pnas.1505071112

*Zitron-Emanuel, N., & Ganel, T. (2018a). Food deprivation reduces the susceptibility to size-contrast illusions. *Appetite*, *128*, 138–144. https://doi.org/10.1016/j.appet.2018.06.006

*Zitron-Emanuel, N., & Ganel, T. (2018b). The effect of food deprivation on human resolving power. *Psychonomic Bulletin & Review*, *25*(1), 455–462. https://doi.org/10.3758/s13423-017-1296-6

*Zitron-Emanuel, N., & Ganel, T. (2020). Food deprivation disrupts normal holistic processing of domain-specific stimuli. *Psychological Research*, *84*(2), 302–312. https://doi.org/10.1007/s00426-018-1062-z

Received November 14, 2024
Revision received August 15, 2025
Accepted August 21, 2025 ■