

# Nootropics — The Evidence and an Honest Appraisal

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## An Open Science Review

*English parallel version of the German original (FORSCH-PROV0446\_nootropika\_v0.9\_2026-10-06\_paper-de.md, v0.8). In case of discrepancy the German text is authoritative.*

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## Summary

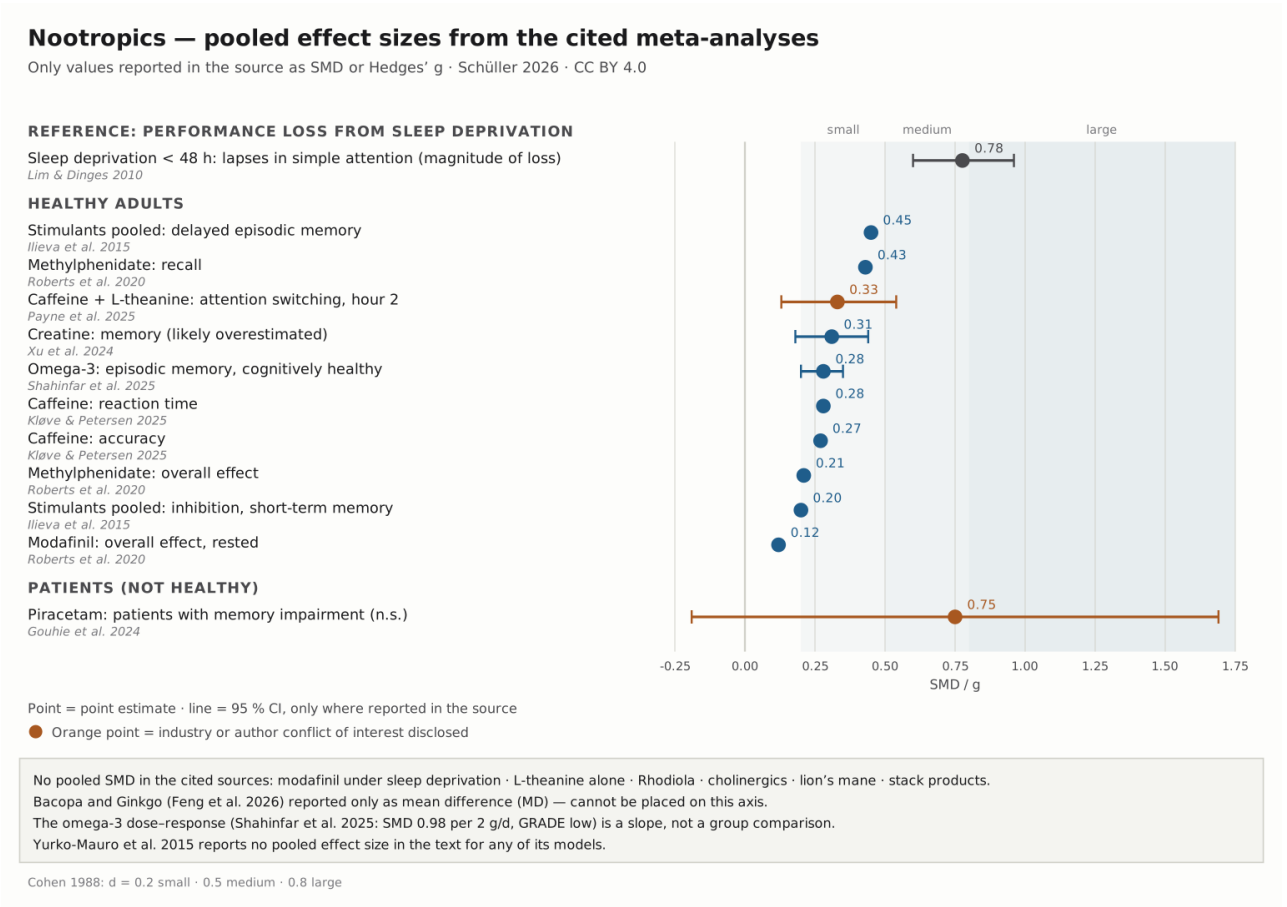
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The market for "nootropics" is growing at roughly 8 % per year. The scientific evidence behind it is very unevenly distributed: a small number of substances have a solid RCT base with small to moderate effects (caffeine:  $g = 0.27\text{--}0.28$ ; caffeine + L-theanine:  $SMD = 0.33$ ; modafinil under sleep deprivation, here without a pooled effect size); most have small to very small effects with high heterogeneity (Bacopa monnieri, omega-3, creatine); a substantial share has no robust effect in healthy adults, or the literature is methodologically too weak to support clear statements (racetams, many "stack" products).

This paper keeps three strands strictly apart: **(1) what RCT meta-analyses actually show, (2) which mechanisms are plausible and which are marketing, (3) which regulatory, safety and ethical aspects are real.** The focus is on healthy adults without a clinical indication — by far the most frequently studied and the least ethically justified application.

Effect sizes are given as **Cohen's d** or **standardised mean difference (SMD)**:  $d = 0.2$  small ·  $d = 0.5$  medium ·  $d = 0.8$  large. In practice:  $SMD < 0.2$  is usually not perceptible under everyday conditions.

**Figure 1.** Pooled effect sizes from the cited meta-analyses — only values reported in the source as SMD or Hedges' g. Point = point estimate, line = 95 % confidence interval where reported in the source.



# 1. Methodological Preliminaries

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## 1.1 What counts as evidence?

This work applies a hierarchy following the GRADE standard:

1. **Cochrane reviews / current peer-reviewed systematic reviews with meta-analysis** (highest evidence quality)
2. **Individual high-quality randomised controlled trials** (RCTs) with a pre-registered hypothesis and adequate power
3. **Mechanistic plausibility from animal or in-vitro studies** (explanatory only, not probative)
4. **Anecdote, case report, manufacturer marketing** (not treated as evidence)

## 1.2 Recurring failure modes — pattern library

Recurring problems in the nootropics literature that must be kept apart during appraisal:

- **HARKing** — *hypothesising after results are known*. A study is launched, several endpoints are measured, the significant ones are published and the non-significant ones withheld. Prediction and test are no longer separable. Remedy: pre-registration of the hypothesis before data collection.
- **Compound-context ignorance** — a substance is considered in isolation, without regard to matrix, preparation, route, dosage or co-administration. Particularly relevant for plant extracts: standardising Bacopa to bacoside A is not sufficient, because other saponins modulate the effect.
- **Frame overreach** — from "improves Stroop-test reaction time by 50 ms" one infers "makes you more intelligent / more productive / a better student". A test effect is not a life effect.
- **Survival-of-validation bias** — industry-funded or marketing-adjacent reviews preferentially cite positive studies. Negative or ambivalent studies appear less often.
- **Argument from ancient use** — "Bacopa has been used in Ayurveda for 3,000

years" is not evidence of efficacy. Tradition demonstrates tolerability across generations, not a specific effect size on modern cognitive tests.

- **Unfalsifiability** — "works subtly over several weeks" (not testable against a placebo-controlled RCT).

### 1.3 What this paper is not

This is not a treatment guide, not a recommendation, and not medical advice. It is a review of the published evidence to support independent judgement.

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## 2. Substance Profiles

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Ordered by evidence quality, from robust to speculative.

### 2.1 Caffeine

**Status:** The best-studied psychoactive substance worldwide. Adenosine A1/A2A antagonist, secondarily dopaminergic via disinhibition.

**Effect sizes:** - Meta-analysis in rested healthy adults (Kløve & Petersen 2025, 31 RCTs, n = 1,455, pure caffeine): accuracy g = 0.27, reaction time g = 0.28 (small). Doses ≥ 200 mg work better; linearly for reaction time, as an inverted U for accuracy (accuracy declines again at high doses). No relationship with habitual consumption, task complexity or the attention network taxed. - Narrative review (McLellan et al. 2016): consistent improvements in alertness, vigilance, reaction time and attention, less consistent for memory and higher executive functions; more pronounced under sleep deprivation. - Sports context (Lorenzo Calvo et al. 2021): only 5 studies in the meta-analysis, athletes under exertion; significant only for attention, accuracy and speed, simple reaction time SMD -0.05 (95 % CI -0.59 to 0.49, n.s.). Not transferable to everyday conditions. - *Versions 0.1–0.6 gave ranges of SMD 0.3–0.5 (attention), 0.2–0.4 (reaction time) and 0.1–0.3 (working memory) here without a source. They have been removed.*

**Dosage:** 1–3 mg/kg body weight ( $\approx$  75–250 mg). Half-life 3–7 h, highly variable between individuals via CYP1A2 polymorphism.

**Risks:** - Tolerance within 1–4 days - Withdrawal headache and fatigue on discontinuation after regular use - Sleep disturbance with late intake (detectable up to 6 h before sleep) - Anxiety and tachycardia in sensitive individuals, particularly slow CYP1A2 metabolisers

**Appraisal:** Clinically and practically effective, well studied, well tolerated at moderate doses. The only nootropic with uncontested evidence in healthy adults. The effect size is nevertheless modest: not an increase in cognitive capacity, but acute activation.

**Sources:** - Kløve K, Petersen A (2025), *A systematic review and meta-analysis of the acute effect of caffeine on attention*, *Psychopharmacology* 242(9):1909-1930. PMID 40335666. DOI 10.1007/s00213-025-06775-1. (University of Copenhagen; no conflicts of interest declared) - Lorenzo Calvo J, Fei X, Domínguez R, Pareja-Galeano H (2021), *Caffeine and Cognitive Functions in Sports: A Systematic Review and Meta-Analysis*, *Nutrients* 13(3):868. DOI 10.3390/nu13030868. PMC8000732. - McLellan TM, Caldwell JA, Lieberman HR (2016), *A review of caffeine's effects on cognitive, physical and occupational performance*, *Neurosci Biobehav Rev* 71:294-312.

## 2.2 Caffeine + L-theanine (combination)

**Status:** The most plausible sensible combination in the OTC space. L-theanine ( $\gamma$ -glutamylethylamide) is an amino acid from *Camellia sinensis*, GABA-modulatory and alpha-wave promoting.

**Effect sizes (RCT meta-analyses):** - Camfield et al. (2014, 11 RCTs, *Nutr Rev*): attention-switching accuracy and alertness (Bond-Lader) show moderate effect sizes in the first 2 h post-dose, favouring the combination over either component alone. - Payne et al. 2025 (Nutrition Reviews, 50 RCTs, 15 of them in the meta-analysis): SMD for attention-switching accuracy at hour 2 = 0.33 (95 % CI 0.13–

0.54); choice reaction at hour 1 SMD = -0.48 (95 % CI -1.01 to 0.05). *Industry COI: co-authors at Lipton Teas (Unilever) and the Unilever Foods Innovation Centre — to be read against the survival-of-validation-bias pattern flagged in §1.2.* - L-theanine as monotherapy: meta-analysis by Mátyus et al. (2025, 5 RCTs, 148 participants, University of Szeged): effects "promising, but not completely conclusive".

**Dosage:** Typical ratio 1:2 — 100 mg caffeine + 200 mg L-theanine, or 50 mg caffeine + 100 mg L-theanine.

**Mechanistic hypothesis:** L-theanine attenuates caffeine-induced sympathetic activation (tremor, palpitations) while the cognitive effects are preserved or add up.

**Risks:** Rare. L-theanine is regarded as very well tolerated. Energy-drink stacks (with taurine, sugar, B vitamins) are not equivalent — there the caffeine effects dominate.

**Appraisal:** Together with caffeine, the only substance or combination with consistently positive peer-reviewed evidence in the OTC range for healthy adults. The effects nevertheless sit in the "small to medium SMD" band — no quantum leap.

**Sources:** - Camfield DA, Stough C, Farrimond J, Scholey AB (2014), *Acute effects of tea constituents L-theanine, caffeine, and epigallocatechin gallate on cognitive function and mood: a systematic review and meta-analysis*, Nutr Rev 72(8):507-522. PMID 24946991. - Payne ER, Aceves-Martins M, Dubost J, Greyling A, de Roos B (2025), *Effects of Tea or its Bioactive Compounds L-theanine or L-theanine plus Caffeine on Cognition, Sleep, and Mood in Healthy Participants: SR and MA of RCTs*, Nutrition Reviews 83(10):1873-1891. PMID 40314930. — *Industry COI: co-authors Dubost (Lipton Teas / Unilever) and Greyling (Unilever Foods Innovation Centre).* - Mátyus RO, Szikora Z, Bodó D, Vargáné Szabó B, Csupor É, Csupor D, Tóth B (2025), *Promising, but Not Completely Conclusive — The Effect of L-Theanine on Cognitive Performance: SR and MA of Placebo-Controlled RCTs*, J Clin Med 14(21):7710. PMID 41227106. (University of Szeged, Hungary) - Owen GN, Parnell H, De Bruin EA, Rycroft JA (2008), *The combined effects of L-theanine and caffeine on cognitive performance and mood*, Nutritional Neuroscience 11(4):193-

198. PMID 18681988. — *Industry COI: all four authors at Unilever Research & Development (Colworth House and Vlaardingen).*

## 2.3 Modafinil

**Status:** A eugeroic; prescription-only in Germany and Austria (indication: narcolepsy). Presumed to act via dopamine reuptake inhibition and orexin / histamine modulation. Off-label use as a "smart drug" is widespread and *not legal* without an indication.

**Effect sizes (healthy, non-sleep-deprived adults):** - Repantis D, Schlattmann P, Laisney O, Heuser I (2010, *Pharmacol Res* 62(3):187-206, PMID 20416377, Charité Berlin): small effects on wakefulness, working memory and attention; user expectations exceed the actual effects. - Battleday & Brem (2015, *Eur Neuropsychopharmacol*, 24 studies): effects mainly on longer, complex tasks (planning, pattern recognition); no consistent effects on simple psychometric tests. - Roberts et al. (2020, *Eur Neuropsychopharmacol*, 14 studies, 64 effect sizes): overall modafinil effect SMD = 0.12,  $p = 0.01$  — *statistically significant, clinically small*. Specific effect on memory updating: SMD = 0.28 (95 % CI 0.02–0.54;  $I^2 = 71\%$ ). For the overall and recall values the paper reports only p-values in the abstract; those intervals were not carried over.

**Under sleep deprivation:** Repantis et al. (2010): modafinil maintained wakefulness, memory and executive function significantly better than placebo; repeated doses could not prevent performance decline over longer sleep deprivation, however, and possibly induced overconfidence in one's own performance. No pooled effect size is available in the cited sources. *Versions 0.1–0.6 stated "d ≈ 0.4–0.8" here without a source and added "this is the original indication" — in Germany and Austria modafinil is licensed for narcolepsy.* The individual studies come mainly from military research: Wesensten et al. 2002 (54.5 h awake, Walter Reed Army Institute of Research), Caldwell et al. 2000 (n = 6 helicopter pilots, U.S. Army Aeromedical Research Laboratory).

**Risks:** - Headache, insomnia, nausea (common) - Skin reactions including Stevens–Johnson syndrome (rare but life-threatening) - Risk of psychiatric reactions in predisposed individuals - Dependence potential lower than for classical stimulants, but not zero - Modafinil has a half-life of 12–15 h, so residual effects persist into the following day

**Appraisal:** In healthy, rested adults the average effect is small. It becomes more noticeable under sleep deprivation or on long, cognitively demanding tasks. The discrepancy between the marketing ("smart drug") and the evidence is considerable. Prescription-only status in Germany and Austria makes any acquisition without an indication legally problematic.

**Sources:** - Battleday RM, Brem AK (2015), *Modafinil for cognitive neuroenhancement in healthy non-sleep-deprived subjects: A systematic review*, Eur Neuropsychopharmacol 25(11):1865-1881. PMID 26381811. - Roberts CA, Jones A, Sumnall H, Gage SH, Montgomery C (2020), *How effective are pharmaceuticals for cognitive enhancement in healthy adults? A series of meta-analyses of cognitive performance during acute administration of modafinil, methylphenidate and D-amphetamine*, Eur Neuropsychopharmacol 38:40-62. PMID 32709551. - Repantis D, Schlattmann P, Laisney O, Heuser I (2010), *Modafinil and methylphenidate for neuroenhancement in healthy individuals: A systematic review*, Pharmacol Res 62(3):187-206. PMID 20416377. - Wesensten NJ, Belenky G, Kautz MA, Thorne DR, Reichardt RM, Balkin TJ (2002), *Maintaining alertness and performance during sleep deprivation: modafinil versus caffeine*, Psychopharmacology 159(3):238-247. DOI 10.1007/s002130100916. - Caldwell JA Jr, Caldwell JL, Smythe NK 3rd, Hall KK (2000), *A double-blind, placebo-controlled investigation of the efficacy of modafinil for sustaining the alertness and performance of aviators: a helicopter simulator study*, Psychopharmacology 150(3):272-282. PMID 10923755.

## 2.4 Methylphenidate

**Status:** A controlled substance in Germany and Austria (BtMG / SMG), prescription-only, indicated for ADHD and narcolepsy. Off-label use is widespread in university

settings and is a criminal offence when obtained without a prescription. Acts via dopamine and noradrenaline reuptake inhibition.

**Effect sizes (healthy, non-ADHD adults):** - Roberts et al. (2020, 24 studies, 47 effect sizes): overall effect SMD = 0.21,  $p = 0.0004$  - By domain: recall SMD = 0.43; sustained attention SMD = 0.42 (both moderate) - Linssen et al. (2014, *Int J Neuropsychopharmacol*): improvements in 65 % of studies for working memory and 48 % for processing speed, clearly dose-dependent - Ilieva IP, Hook CJ, Farah MJ (2015, *J Cogn Neurosci*, 48 studies,  $n = 1,409$ ): stimulants pooled produced Hedge's  $g = 0.20$  for inhibitory control and short-term episodic memory,  $g = 0.45$  for delayed episodic memory

**Risks:** - Tachycardia and raised blood pressure (relevant with pre-existing cardiac conditions) - Insomnia, appetite loss, irritability - Dependence potential — more strictly scheduled under narcotics law than modafinil. Misuse and diversion are widespread: Wilens et al. 2008 (21 studies,  $n = 113,104$ ) found past-year non-prescribed stimulant use of 5–9 % among school-age children and adolescents and 5–35 % among college-age individuals. - Cardiovascular risk: the evidence is inconsistent. Two large cohort studies found **no** increased risk (Cooper et al. 2011, *NEJM* 365:1896-1904: HR 0.96, 95 % CI 0.31–2.97 for methylphenidate; Habel et al. 2011, *JAMA* 306:2673-2683, adults). Schelleman et al. 2012 (*Am J Psychiatry* 169:178-185) found roughly a 1.8-fold rate of sudden death or ventricular arrhythmia among adult initiators, **but without a dose-response relationship**, which argues against causality. A Danish registry study (*Eur Heart J* 2023, PMID 37070942, 46,578 cases) found OR 1.78 (95 % CI 1.32–2.40) for out-of-hospital cardiac arrest, highest among recent starters ( $\leq 180$  days: OR 2.59). The absolute risk increase is small in all studies. - Tolerance with chronic use - *Legally*: possession without a prescription is a criminal offence in Germany and Austria

**Appraisal:** More effective than modafinil on average (SMD 0.21 vs 0.12), but with a heavier risk profile. Off-label use "for the exam" is viewed critically in the research literature, both because of the adverse-effect profile and because of the

competence–state distinction (see the ethical discussion below).

**Sources:** - Roberts CA et al. (2020), as above. - Linssen AMW, Sambeth A, Vuurman EFPM, Riedel WJ (2014), *Cognitive effects of methylphenidate in healthy volunteers: a review of single dose studies*, *Int J Neuropsychopharmacol* 17(6):961-977. PMID 24423151. - Ilieva IP, Hook CJ, Farah MJ (2015), *Prescription Stimulants' Effects on Healthy Inhibitory Control, Working Memory, and Episodic Memory: A Meta-analysis*, *J Cogn Neurosci* 27(6):1069-1089. PMID 25591060. - Smith ME, Farah MJ (2011), *Are prescription stimulants "smart pills"? The epidemiology and cognitive neuroscience of prescription stimulant use by normal healthy individuals*, *Psychol Bull* 137(5):717-741. PMID 21859174. (See also the published comments by Swanson et al. and Elliott & Elliott in the same issue.) - Wilens TE, Adler LA, Adams J, Sgambati S, Rotrosen J, Sawtelle R, Utzinger L, Fusillo S (2008), *Misuse and diversion of stimulants prescribed for ADHD: a systematic review of the literature*, *J Am Acad Child Adolesc Psychiatry* 47(1):21-31. PMID 18174822.

## 2.5 Omega-3 (DHA / EPA)

**Status:** Essential fatty acids, structurally relevant in the neuronal membrane. Marketing for "brain boost" is very aggressive; the evidence is nuanced.

**Effect sizes:** - Yurko-Mauro et al. (2015, *PLOS ONE*, 15 intervention studies, 62 data points): the overall model across all doses and participants was **not significant**, nor was the subgroup without cognitive complaints. Two subgroups were significant: adults with mild memory complaints (5 studies, Hedges'  $g$ ,  $z = 2.86$ ,  $p = 0.004$ ) and, regardless of cognitive status, doses above 1 g/d DHA + EPA (6 studies,  $z = 2.05$ ,  $p = 0.04$ ). The paper reports no pooled effect sizes for these models in the text. *Versions 0.1–0.7 stated "meta-analysis of 4 RCTs,  $g = 0.15$ ,  $p = 0.02$ , at  $\geq 18$  weeks" — none of those four claims appears in the paper.* - Suh et al. (2024, *BMC Medicine*, 24 RCTs,  $n = 9,660$ ): improvement in executive function at  $\geq 500$  mg/d, chiefly in populations with a low baseline DHA + EPA level. - Shahinfar et al. (2025, *Sci Rep*, 58 RCTs): episodic memory in cognitively healthy individuals SMD = 0.28 (95 % CI 0.20–0.35); per 2,000 mg/d total omega-3 dose, SMD = 0.98 for attention (95 % CI

0.41–1.54; GRADE = low); SMD = 0.50 for processing speed (GRADE = moderate).

**Important:** The positive effects are small on average and often concern older adults or people with an inadequate supply. In young, healthy, well-nourished adults there is frequently no effect.

**Dosage:** 250 mg–2 g DHA + EPA per day. Safety is high. Source: algal oil (vegan-compatible, no heavy-metal risk) or fish oil.

**Risks:** At very high doses, increased bleeding tendency, fishy reflux and gastrointestinal complaints. Oxidised fish oil (storage matters) is potentially harmful.

**Appraisal:** Sensible with a demonstrated deficiency; an adequate baseline supply should take priority. Overrated as a "smart pill" — the effects are small and slow.

**Sources:** - Yurko-Mauro K, Alexander DD, Van Elswyk ME (2015), *Docosahexaenoic Acid and Adult Memory: A Systematic Review and Meta-Analysis*, PLOS ONE 10(3):e0120391. PMC4364972. — *Industry COI: all three authors employed by or funded by DSM Nutritional Products (an omega-3 manufacturer); the funding statement is openly declared in the paper.* - Suh SW, Lim E, Burm SY, Lee H, Bae JB, Han JW, Kim KW (2024), *The influence of n-3 polyunsaturated fatty acids on cognitive function in individuals without dementia: A systematic review and dose-response meta-analysis*, BMC Medicine 22:109. DOI 10.1186/s12916-024-03296-0. PMC10929146. - Shahinfar H, Yazdian Z, Asgari Avini N, Torabinasab K, Shab-Bidar S (2025), *A systematic review and dose-response meta-analysis of Omega-3 supplementation on cognitive function*, Sci Rep 15(1):30610. PMID 40836005.

## 2.6 Creatine

**Status:** Produced endogenously (kidney and liver); the phosphocreatine system buffers ATP in muscle *and* brain. Long treated as a purely sports supplement; newer data show cognitive effects particularly under stress, sleep deprivation and in vegans.

**Effect sizes:** - Xu et al. (2024, *Front Nutr*, 16 RCTs, n = 492): memory SMD = 0.31

(95 % CI 0.18–0.44, small to moderate); attention time SMD = -0.31 (an improvement); processing speed SMD = -0.51. - *Methodological caveat*: Eckert & Pascher (2026, commentary) point to a unit-of-analysis error — several correlated endpoints from the same study were treated as independent. The true effect is probably smaller. - Prokopidis et al. (2023, *Nutr Rev*): in a memory-specific analysis, a significant but small effect; considerably stronger in vegetarians and vegans (low baseline) and under sleep deprivation.

**Dosage:** 3–5 g creatine monohydrate per day, continuously. A loading phase is not required for cognitive outcomes.

**Risks:** Very well tolerated. Water retention in muscle (1–2 kg). Occasional gastrointestinal complaints at high single doses.

**Appraisal:** Solid evidence, small to moderate, strongest at a low baseline (vegan diet, sleep deprivation). A favourable risk–benefit ratio.

**Sources:** - Xu C, Bi S, Zhang W, Luo L (2024), *The effects of creatine supplementation on cognitive function in adults: a systematic review and meta-analysis*, *Front Nutr* 11:1424972. PMC11275561. — *Note: corrigendum of 17 February 2025 (Front Nutr 12:1570800) concerning a Chinese-to-English translation error in the attention section. The Eckert & Pascher 2026 commentary (Front Nutr 13:1716285) criticises a unit-of-analysis error.* - Prokopidis K, Giannos P, Triantafyllidis KK, Kechagias KS, Forbes SC, Candow DG (2023), *Effects of creatine supplementation on memory in healthy individuals: a systematic review and meta-analysis of randomized controlled trials*, *Nutr Rev* 81(4):416–427. PMID 35984306. DOI 10.1093/nutrit/nuac064. — *Note: an Eckert & Pascher letter to the editor (Nutr Rev 81(11):1495–1496, PMID 36644917) and the authors' reply (81(11):1497–1500, PMID 36644912) discuss a double-counting problem.*

## 2.7 *Bacopa monnieri*

**Status:** An Ayurvedic plant (brahmi). Active saponins: bacosides A and B. Presumed mechanism: cholinergic, antioxidant, modulation of stress markers.

**Effect sizes:** - Network meta-analysis (Tiemtad et al. 2026, *Phytomedicine*, 29 RCTs, n = 2,107): direct comparison of Bacopa and Ginkgo. - Network meta-analysis in healthy older adults (Feng et al. 2026, *Front Pharmacol*, 25 RCTs, n = 1,861, 10 plant substances): Bacopa extract memory MD = 0.49 (95 % CI 0.07–0.90; 3 studies). The value MD = 0.75 (95 % CI 0.29–1.21) for language applies to a **combination product** of Bacopa, lycopene, astaxanthin and vitamin B12, not to Bacopa alone, and rests on only 4 studies in that domain. For complex attention, no plant substance significantly outperformed placebo. *These are mean differences (MD), not standardised effect sizes, and are therefore not comparable with the SMD values in other sections. Versions 0.4–0.6 wrongly attributed them to Wang et al. 2025.* - The effect appears only after **8–12 weeks** of intake, not acutely. - Dose: 300–450 mg/d of standardised extract ( $\approx$  50 % bacosides). - Stough C, Downey LA, Lloyd J, Silber B, Redman S, Hutchison C, Wesnes K, Nathan PJ (2008, *Phytother Res* 22(12):1629-1634, PMID 18683852): 90-day RCT, the classic chronic-administration trial. *Note: the CDRI 08 research line is funded by Soho Flordis International, a commercial extract supplier.*

**Risks:** - Common: gastrointestinal complaints (cramps, diarrhoea) when taken on an empty stomach — take with food - Rare: maculopapular rash (reported in trials) - Long term: no sufficiently long RCTs (> 6 months)

**Appraisal:** Consistent but small effects across several meta-analyses. A long intake period is required. Standardisation of the extract is critical (bacoside A content). No acute effect — anyone looking for an immediate result is in the wrong place.

**Sources:** - Tiemtad P et al. (2026), *Comparative effects of Bacopa monnieri and Ginkgo biloba on cognitive functions: A systematic review and network meta-analysis*, *Phytomedicine*. DOI 10.1016/j.phymed.2026.157715. - Feng X, Fan S, Wei F (2026), *The effect of plant active substances on cognitive function in healthy older adults: a systematic review and network meta-analysis of randomized controlled trials*, *Front Pharmacol* 16:1672171. DOI 10.3389/fphar.2025.1672171. PMID 41640686. PMC12864429. (Shandong University of Traditional Chinese Medicine;

public funding, no conflicts of interest declared) - Stough C et al. (2008), *Phytother Res* 22(12):1629-1634. PMID 18683852.

## 2.8 Ginkgo biloba

**Status:** Standardised extract (EGb 761, 24 % flavone glycosides, 6 % terpene lactones). Licensed in Germany as a phytopharmaceutical for organic cerebral performance disorders. Vasodilatory and antioxidant.

**Effect sizes:** - In healthy adults: inconsistent, very small on average. - In MCI and dementia: small to moderate effects on cognitive symptoms (Yang et al. 2016). - Network meta-analysis in healthy older adults (Feng et al. 2026): memory MD = 0.21 (95 % CI -0.09 to 0.50, n.s.), executive function MD = 0.30 (95 % CI 0.01-0.59, narrowly significant). - Acute (single-dose) effects on reaction time and memory: significant in some studies, clinically small.

**Dosage:** 120-240 mg/d EGb 761. The effect appears only after 4-8 weeks.

**Risks:** Increased bleeding tendency (PAF inhibition); interaction with anticoagulants (warfarin, DOACs). Discontinue one week before surgery.

**Appraisal:** Little evidence of a meaningful effect in healthy adults. Moderate data in older people with incipient complaints. The best-known herbal medicine in this field, but effect sizes are frequently exaggerated in marketing.

**Sources:** - Yang G, Wang Y, Sun J, Zhang K, Liu J (2016), *Ginkgo Biloba for Mild Cognitive Impairment and Alzheimer's Disease: A Systematic Review and Meta-Analysis of Randomized Controlled Trials*, *Curr Top Med Chem* 16(5):520-528. PMID 26268332.

## 2.9 Rhodiola rosea

**Status:** An adaptogen from arctic regions. Active constituents: rosavin, salidroside. The presumed effect concerns stress resilience and burnout rather than primary cognitive enhancement.

**Effect sizes:** - The evidence is inconsistent, with many small studies. - Aslanyan G, Amroyan E, Gabrielyan E, Nylander M, Wikman G, Panossian A (2010, *Phytomedicine* 17(7), preparation ADAPT-232): reduction of mental fatigue under stress in a single-dose RCT. **Industry COI: Wikman and Panossian are associated with the Swedish Herbal Institute, the manufacturer of SHR-5 / ADAPT-232.** - Systematic reviews note heterogeneity, methodological weaknesses and frequent manufacturer sponsorship. - Effects are most likely *under stress or exhaustion*, not in rested participants.

**Dosage:** 200–600 mg/d of standardised extract (3 % rosavin, 1 % salidroside).

**Risks:** Generally well tolerated. Activating effect — unfavourable in the evening.

**Appraisal:** Plausible in specific stress contexts, with a weak RCT base. Cannot be treated as a universal cognitive booster. Better placed under "stress modulation" than "smart drug".

## **2.10 Racetams (piracetam, aniracetam, oxiracetam, phenylpiracetam)**

**Status:** Piracetam is the parent compound (Giurgea 1972, who coined the term "nootropic"). Prescription-only in Germany and Austria, with prescription restricted to specific indications such as myoclonus. In healthy adults: **no established efficacy.**

**Effect sizes:** - Gouhie et al. (2024, meta-analysis of 18 RCTs, 886 patients with memory impairment): SMD = 0.75 (95 % CI –0.19 to 1.69),  $p = 0.12$ ,  $I^2 = 96\%$  — *not significant*, with extreme heterogeneity. - Older meta-analysis by Waegemans T, Wilsher CR, Danniau A, Ferris SH, Kurz A, Winblad B (2002, *Dement Geriatr Cogn Disord* 13(4):217-224, PMID 12006732, 19 studies): a positive odds ratio for improvement (most conservative estimate in a five-study subset: OR 2.89, 95 % CI 1.01–8.24). **Industry COI and methodological defect: the three first authors worked in the research and development division of UCB SA (Pharma Sector), the manufacturer of Nootropil, and the literature search was run on UCB's proprietary database including internal reports and protocols.** The Cochrane review (Flicker &

Grimley Evans 2001) issues no recommendation for Alzheimer's disease or dementia. - In healthy adults: no robust data.

**Risks:** Generally well tolerated; headache is the most common adverse effect, with occasional irritability.

**Appraisal:** Considerable hype, very weak evidence. Illegal to import into Germany or Austria without a prescription. *Myth versus data:* piracetam is the opposite of "solidly proven" — it is "long on the market, never unambiguously shown to work". The other racetams are studied even less well.

**Sources:** - Gouhie F, Barbosa K, Cruz A, Wellichan M, Zampolli T (2024), *Cognitive effects of piracetam in adults with memory impairment: A systematic review and meta-analysis*, Clin Neurol Neurosurg 243:108358. PMID 38878641. — *Author COI: the first author declares consultancy fees from Marjan Farma (Neurology disclosure 2024).* - Flicker L, Grimley Evans J (2001), *Piracetam for dementia or cognitive impairment*, Cochrane Database Syst Rev Issue 2, Art. No. CD001011. PMID 11405971. DOI 10.1002/14651858.CD001011. - Waegemans T, Wilsher CR, Danniau A, Ferris SH, Kurz A, Winblad B (2002), *Dement Geriatr Cogn Disord* 13(4):217-224. PMID 12006732.

## 2.11 Cholinergic substances (alpha-GPC, citicoline, CDP-choline)

**Status:** Precursors of acetylcholine and phosphatidylcholine. Mechanistically plausible for cholinergic function (attention, memory consolidation).

**Effect sizes:** - Citicoline in MCI: small to moderate positive effects across several RCTs. - In healthy adults: sparse data, small effects on isolated tests, no consistent meta-analysis. - Alpha-GPC: a few RCTs in sports contexts (attention under fatigue), but methodologically limited.

**Risks:** Generally well tolerated. *Important:* choline metabolism produces TMAO (trimethylamine N-oxide), which is associated with cardiovascular risk. Causal relevance is unresolved, but this warrants attention at higher doses over long

periods.

**Appraisal:** Mechanistic plausibility exceeds clinical evidence. No recommendation is possible for healthy adults.

## 2.12 Adaptogenic mushrooms (lion's mane, *Hericium erinaceus*)

**Status:** Presumed neurotrophic effects via NGF (nerve growth factor) — the animal and in-vitro evidence is solid, the human evidence weak.

**Effect sizes:** - Mori K, Inatomi S, Ouchi K, Azumi Y, Tuchida T (2009, Phytother Res 23(3):367-372, PMID 18844328): improvement on a cognitive scale (HDS-R) in MCI after 16 weeks. Small study, n = 30 (2 × 15). **Industry COI: four of the five authors are at the Mushroom Laboratory of the Hokuto Corporation — the mushroom producer itself.** The effect disappeared four weeks after discontinuation. - Saitsu Y, Nishide A, Kikushima K, Shimizu K, Ohnuki K (2019, Biomed Res 40(4):125-131): cognition and mood, small study. Proximity to an extract manufacturer remains to be checked. - No large meta-analyses and no replication by independent laboratories in Western settings.

**Appraisal:** Considerable hype, very thin evidence. The mechanism is interesting but clinical translation is open. Marketing advertises a "neurogenesis booster", which is not demonstrated in humans.

## 2.13 Other frequently promoted substances — brief appraisal

- **Noopept:** Russian patent, not licensed in Germany or Austria. Very narrow RCT base, effects unclear.
- **Phenylpiracetam:** A stimulating racetam, prescribed in Russia, not legally obtainable in Germany or Austria. On the WADA prohibited list.
- **Vinpocetine:** Prescription-only in Germany, OTC in some countries. A vasodilator with small effects in MCI and no evidence in healthy people.
- **Tianeptine:** An atypical antidepressant (licensed in France), not licensed in Germany or Austria. Substantial addiction potential — *not a nootropic but a*

*psychoactive substance with a risk profile.*

- **NSI-189:** An experimental compound; RCT data were disappointing and commercial acquisition is borderline.
- **Stack products (Mind Lab Pro, Alpha Brain and similar):** Multi-component mixtures. A compound-context methodology is required — the effects of individual components are not additive. Industry-funded studies exist; independently replicated peer-reviewed ones barely do.

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## 3. Safety and Risk Overview

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### 3.1 Categorisation by risk profile

| Substance       | Acute risk              | Long-term risk      | Dependence potential | Legal status DE/AT       |
|-----------------|-------------------------|---------------------|----------------------|--------------------------|
| Caffeine        | low–medium              | low with moderation | medium (mild)        | OTC                      |
| L-theanine      | very low                | very low            | none                 | OTC                      |
| Omega-3         | very low                | very low            | none                 | OTC                      |
| Creatine        | very low                | very low            | none                 | OTC                      |
| Bacopa monnieri | low (GI)                | little studied      | none                 | OTC                      |
| Ginkgo biloba   | low (bleeding tendency) | low                 | none                 | OTC, phytopharmaceutical |
| Rhodiola rosea  | low                     | little studied      | none                 | OTC                      |
| Modafinil       | medium                  | little studied      | in low–medium        | Rx                       |

| Substance       | Acute risk  | Long-term risk | Dependence potential | Legal status DE/AT     |
|-----------------|-------------|----------------|----------------------|------------------------|
|                 |             | healthy people |                      |                        |
| Methylphenidate | medium-high | medium         | high                 | BtMG / SMG             |
| Piracetam       | low         | unclear        | none                 | Rx                     |
| Phenylpiracetam | unclear     | unclear        | low                  | not legally obtainable |

### 3.2 Shared marketing deficiencies

- Manufacturer-funded studies are over-represented in efficacy reviews
- "Proprietary blend" declarations conceal the dosages of individual ingredients
- Missing standardisation of plant extracts (bacoside content varies between 5 % and 55 %)
- US market: numerous FDA warnings between 2010 and 2019 to manufacturers over unsupported advertising claims
- Stack products tested in a clinically relevant way are the exception

### 3.3 Legal status in Germany and Austria

- **OTC without restriction:** caffeine, L-theanine, omega-3, creatine, Bacopa, Rhodiola, Ginkgo (via pharmacy), lion's mane.
  - **Prescription-only:** modafinil, piracetam, vinpocetine, methylphenidate (additionally under BtMG / SMG).
  - **Not legally obtainable:** noopept, phenylpiracetam (prohibited list), tianeptine (not licensed in Germany or Austria).
  - **Important:** importing prescription substances without a prescription is a criminal offence. Online vendors ("modafinil from India") operate in a grey zone and buyers risk prosecution.
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## 4. Ethical and Epistemological Remarks

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### 4.1 Effect size versus marketing perception

An SMD of 0.2–0.3 is statistically small. In practice (Cohen's  $U_3$ ,  $\Phi(d)$ ): of 100 treated people, 58–62 fall above the median of the placebo group instead of 50, i.e. 8–12 additional people. *Versions 0.1–0.6 wrongly stated "four to six" here.* In an individual case it is barely perceptible. Nootropics marketing typically works with expectations of an immediate effect that not even modafinil can meet.

### 4.2 Competence versus state

Stimulants change the *state* of the brain acutely. They do not create *competence*. Someone who sits an exam on methylphenidate has not learned the material better — they are merely more focused while retrieving it. The learning effect does not carry forward. Someone who uses modafinil for a project has extended their attention but gained no additional analytical depth.

### 4.3 Distributive justice

When pharmacological cognitive enhancers are widespread in academic or professional competitive contexts, a pressure effect arises on those who do not participate. This has been debated in bioethics since around 2008 (Greely et al., *Nature*). There is no consensus position, but the question is a serious one: competitive fairness, equity of access, and social coercion.

### 4.4 Sleep deprivation as a background factor

Part of the measured stimulant effect is *compensation for a sleep deficit* rather than an "increase above the normal level": modafinil and caffeine effects are more pronounced under sleep deprivation than in rested people (Repantis et al. 2010; McLellan et al. 2016). The magnitude of the counterpart is shown by the meta-analysis of Lim & Dinges (2010, 70 articles, 147 tests): short-term total sleep deprivation (< 48 h) worsens performance from  $g = -0.13$  (reasoning, n.s.) to  $g = -0.78$  (lapses in simple attention, 95 % CI  $-0.96$  to  $-0.60$ ). In the attention domains,

the loss from one sleepless night therefore exceeds every pooled substance effect in healthy adults in this review (g or SMD 0.12–0.45); the only exception is the omega-3 dose–response slope (Shahinfar et al. 2025, GRADE low), which is not a group comparison. *Versions 0.1–0.6 claimed that 7–9 h of sleep produce "larger effect sizes than any substance", and the figure showed a sleep value of SMD 1.0 — both without a source. Sleep-deprivation and substance effects also measure different things: loss relative to rested people versus gain relative to placebo.* The question "which nootropic should I take?" is often a poorly posed version of the question "why am I not sleeping enough?".

**Sources:** - Lim J, Dinges DF (2010), *A meta-analysis of the impact of short-term sleep deprivation on cognitive variables*, Psychol Bull 136(3):375-389. DOI 10.1037/a0018883. — *Funding: U.S. Air Force Office of Scientific Research, NIH, NASA (National Space Biomedical Research Institute).*

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## 5. Practical Orientation — Not a Recommendation

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Anyone making their own decision on the basis of this review should consider the following order:

1. **Clarify the background factors first:** sleep, exercise, diet, micronutrient status (vitamin D, B12, iron, omega-3 index via blood test). Supplementation in the case of a deficiency is the only area with large effects.
2. **If acute alertness is wanted:** caffeine in moderation (up to 400 mg/d, not after 14:00), optionally with L-theanine in a 1:2 ratio. A tolerance break every 4–6 weeks.
3. **If a low-risk long-term effect is being considered:** creatine 3–5 g/d, or omega-3 where a low supply has been demonstrated. Bacopa only if there is patience for 8–12 weeks, and with attention to gastrointestinal tolerability.
4. **Prescription substances (modafinil, methylphenidate) only with an indication and a prescription.** Off-label acquisition is legally non-trivial and

medically hard to assess without clinical supervision.

5. **Remain sceptical of stack products and "nootropics brands".** Multi-component effects are not additive and are usually not supported by peer-reviewed evidence.
6. **Pre-register for yourself:** before starting a substance, write down *what* is to be measured and *when* that will count as success. Otherwise you are doing HARKing on your own account.

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## 6. Open Questions and Research Gaps

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- Effects in women across the menstrual cycle are systematically under-represented.
- Polymorphism stratification (CYP1A2 for caffeine, COMT for stimulants) is rare in study designs.
- Long-term RCTs (> 12 months) are missing for most substances.
- Compound-context effects between nootropics (stacking) are barely investigated under controlled conditions.
- Mechanistic studies on psychological domains beyond attention and memory (creativity, judgement, self-control) are rare.
- Unresolved: the trade-off between "more performance in the short term" and "an altered baseline in the long term".

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## 7. Methodological Footer

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**Search procedure:** PubMed, Cochrane Library, Web of Science, Scopus, Nature, Frontiers, ScienceDirect, NCBI Bookshelf. Coverage to April 2026. Meta-analyses and systematic reviews were preferred; individual RCTs were included only where methodologically outstanding. Manufacturer-funded reviews are cited with reservation and marked accordingly.

**Conflict of interest:** None. The author receives neither direct nor indirect funding from manufacturers or distributors of nootropics.

**Limitations:** - **Source verification status (v0.9, 6 October 2026):** All 40 source entries in the source blocks (39 unique identifiers: 25 PMID, 5 PMC, 9 DOI) have been individually verified against PubMed, Crossref and PMC (author list, year, journal, pages, PMID/DOI). In v0.1 six author names were wrong — consistently in meta-analyses from the 2024–2026 period, while older standard citations were correct; the associated PMIDs, DOIs and effect sizes were correct in those six cases. All in-text mentions have also been checked. This surfaced a seventh error of a different kind: an effect size (RR 1.46 for sudden cardiac death under methylphenidate, attributed to Coghill 2014) could not be substantiated and was replaced by the actual, inconsistent state of the evidence. Hallucinations therefore affect not only author names but, in individual cases, numbers as well. In v0.7 a check of the figure and of all numbers without a source revealed further errors: the figure still carried three of the corrected false names and several freely set or misattributed values; the text contained unsourced effect ranges for caffeine and for modafinil under sleep deprivation, an arithmetic error in §4.1 and a misattribution of the Bacopa values. All have been corrected (changelog v0.7). - Language restriction: only English-language peer-reviewed sources were included. Russian research on racetams is under-represented. - The legal situation is restricted geographically to Germany and Austria. - Literature cut-off September 2026 — the evidence changes. (The statement "April 2026" in v0.1–v0.8 was wrong: the corpus includes work up to 2026 and the search ran to 24 September 2026.) - No primary patient contact and no clinical experience on the part of the author.

**Follow-on:** The nodes identified here (substances, effect sizes, mechanistic hypotheses) are provided as a JSON node set for the MYZEL engine (myzel\_schliessung\_v7). There they can be linked further with cross-domain bridges, the Hansson pseudoscience filter, a replication tracker and hash-lock pre-registration.

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## Closure Type

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**QUESTION-CLOSURE:** This review paper delivers an evidence synthesis with a clear classification (robust / suggestive / interpretive / speculative) plus a pattern library. It is not an "open workbench" — the scope is fixed: 13 substances × a four-class appraisal using the sources named. Extension to new substances or studies leads to v0.9 and beyond, not to structural re-engineering.

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## Changelog

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**v0.9 (6 October 2026) — metadata errors and literature cut-off corrected, rule status brought up to date:**

- **The version string had drifted.** The title line and footer of every HTML and PDF output still read "v0.7" in v0.8, because version and bundle date were maintained in the build script separately from the filenames. Both are now derived from the file prefix and can no longer diverge.
- **The frontmatter date field was wrong.** The German version carried date: 2026-04-29 (the date of the first release), the English one date: 2026-05-13 — neither matching the other nor the bundle date. The field now carries the bundle date; the first release is recorded separately in `date_erstfassung`.
- **"As of April 2026" was wrong.** The corpus includes work up to 2026 and the search ran to 24 September 2026. The limitation now states a literature cut-off of September 2026.
- **The source count differed between two places and both were wrong.** The paper said 20, the work card 22. Recounted: 40 source entries with 39 unique identifiers (25 PMID, 5 PMC, 9 DOI). Both places now state this figure.
- No substantive statement, no effect size and no citation was changed in this version.

**v0.8 (24 September 2026) — omega-3 values corrected:**

- **Yurko-Mauro et al. 2015 misreported.** The full text shows 15 intervention studies with 62 data points, not 4 RCTs, and reports neither " $g = 0.15$ " nor " $p = 0.02$ " nor a subgroup by duration. Only two subgroups were significant (memory complaints  $p = 0.004$ ;  $> 1$  g/d  $p = 0.04$ ), while the overall model and the no-complaints subgroup were not.

The section now reports the actual findings. - **Sourced replacement added:** Shahinfar et al. 2025 report SMD = 0.28 (95 % CI 0.20–0.35) for episodic memory in cognitively healthy individuals. This value now replaces the unsubstantiated one in Figure 1. - Added: confidence interval for the modafinil updating value from the full text of Roberts et al. 2020 (0.02–0.54;  $I^2 = 71\%$ ). English flyer created.

**v0.7 (24 September 2026) — figure and unsourced numbers, bundle renamed to the naming pattern: - Figure 1 rebuilt.** The old figure had not been checked in any correction round. It still carried three of the corrected false names (Zhang 2020, Sun 2025, Stachowicz 2025), showed freely set values (L-theanine, cholinergics, Rhodiola, Ginkgo, lion's mane, stack products), an unsourced sleep value of SMD 1.0, a mean difference on the SMD axis (Bacopa) and wrong subgroup labels (creatine, omega-3). The SVG file was also not valid XML. The new figure shows only values reported in the source as SMD or g and marks conflicts of interest. - **Unsourced effect ranges removed:** caffeine SMD 0.3–0.5 / 0.2–0.4 / 0.1–0.3 replaced by Kløve & Petersen 2025 (31 RCTs,  $g = 0.27$  and  $0.28$ ); modafinil under sleep deprivation  $d \approx 0.4$ – $0.8$  replaced by the qualitative finding of Repantis et al. 2010; "original indication" deleted. - **Misattribution corrected:** the Bacopa values (MD 0.49 memory, MD 0.75 language) come from Feng et al. 2026, not Wang et al. 2025; the language value applies to a combination product. Wang et al. 2025 removed, as it no longer supports any statement. - **Arithmetic error §4.1:** 8–12 rather than 4–6 additional people above the placebo median (Cohen's  $U_3$ ). - **§4.4 made precise:** sleep statement based on Lim & Dinges 2010 ( $g$  down to  $-0.78$ , not " $d > 1.0$ "), U.S. Air Force funding disclosed. - Added: Wilens et al. 2008 (misuse and diversion), Wesensten et al. 2002 and Caldwell et al. 2000 as sources, Feng et al. 2026 for Ginkgo. - MYZEL dataset cleaned (see its `_meta.changelog`); identifier FORSCH-PROV0446 (provisional) assigned; all files renamed to the naming pattern.

**v0.6 (13 May 2026) — language-version alignment and full citations:** - English parallel version created, satisfying rule #27. The German version remains authoritative, noted on both sides. - The alignment revealed that three verified works were not cited in the German text at all: Ilieva et al. 2015 and Smith & Farah 2011

(§2.4) and Stough et al. 2008 (§2.7). All three are now in both versions. - Source lists completed: Repantis 2010 (§2.3) and Waegemans 2002 (§2.10) previously appeared only in running text. - Full author lists and PMIDs added for McLellan 2016, Linssen 2014, Roberts 2020 and Yang 2016.

**v0.5 (13 May 2026) — completion of verification, seventh error corrected:** - **Unsubstantiated effect size removed:** the figure RR 1.46 (95 % CI 1.03–2.07) for sudden cardiac death under methylphenidate, attributed to Coghill 2014, could not be found in any traceable publication. It was replaced by the actual, inconsistent evidence (Cooper et al. 2011, Habel et al. 2011, Schelleman et al. 2012, Danish registry study 2023). This is the first demonstrated hallucination of an **effect size** rather than an author name. - **Waegemans 2002 verified and COI sharpened:** beyond the UCB affiliation already noted, the literature search itself was run on the manufacturer's proprietary database including internal reports — a methodological defect, not merely a conflict of interest. - All source-list citations and all in-text mentions are now verified.

**v0.4 (13 May 2026) — full verification of the source list:** - All 20 source-list citations individually checked against PubMed, Crossref and PMC. The six author names corrected in v0.2 and v0.3 were the only errors of that kind. - Full citations and industry COIs added for Wang et al. 2025, Mori et al. 2009 (Hokuto Corporation), Aslanyan et al. 2010 (Swedish Herbal Institute), Saitsu et al. 2019 and Repantis et al. 2010.

**v0.3 (13 May 2026) — extended ground-truth correction:** - Three further author names corrected: "Zhang 2020" → Lorenzo Calvo et al. 2021; "Kim JS 2024" → Suh SW et al. 2024; "Lorca 2026" → Tiemtad et al. 2026. - Industry COI marked for Owen 2008 (Unilever R&D); Prokopidis 2023 page reference corrected; Flicker 2001 co-author initial corrected.

**v0.2 (6 May 2026) — ground-truth correction:** - Three author names corrected: "Sun L 2025" → Payne ER et al. 2025; "Stachowicz K 2025" → Mátyus RO et al. 2025; "Karakas 2025" → Shahinfar H et al. 2025. The studies (PMIDs, DOIs, effect

sizes, sample sizes) were referenced correctly in v0.1; only the author names were confused. - Conflict-of-interest declarations added (Lipton/Unilever, DSM Nutritional Products, Marjan Farma) and the Xu 2024 corrigendum noted.

**v0.1 (29 April 2026):** first release as a preprint.

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Closure

QUESTION-CLOSURE

Master version

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