

Supplementary Material S7: Tables and Figures

Table 1

Inclusion and exclusion criteria for studies in the systematic review.

Criterion	Inclusion	Exclusion
1. Language	English	Other
2. Population	Adult human participants	Non-human participants, children, or single-case/case series observations
3. Study type	Peer-reviewed empirical studies describing original experimental designs	Reviews, meta-analyses, theoretical papers, study protocols, or reports of experiments already reported in another included paper
4. Training design	Working memory training intervention with pre-post testing using working memory tasks	Interventions not targeting working memory, no pre-post testing, or assessing non-working memory outcomes only
5. Sensory modality	Description of sensory modality of stimuli used during training and testing	No information about sensory modality or no use of external sensory stimuli during training or testing

Working Memory Training Across the Senses: A Systematic Review

Table 2

Number and percentage of studies using each WM task type during training and testing. Task types are organized hierarchically, beginning with the four functional task families (maintenance, manipulation, updating, complex span), followed by classical WM paradigms (Oberauer et al., 2018) and task subtypes where applicable. Values represent the number of studies using the task (n) and the percentage of all included studies (%). Task batteries (e.g., Cogmed, Lumosity) are presented as a single group at the bottom.

Task paradigm	Subtype	Training		Testing	
		studies	%	studies	%
Maintenance					
Item recognition		11	3.22 %	14	4.09 %
Change detection		4	1.17 %	21	6.14 %
Relational recognition		5	1.46 %	10	2.92 %
Probed recall		5	1.46 %	4	1.17 %
Brown-Peterson		0	0.0 %	3	0.88 %
Continuous reproduction		1	0.29 %	1	0.29 %
Reconstruction of order		2	0.59 %	0	0.0 %
Other maintenance		3	0.88 %	9	2.63 %
Total		28	8.19 %	53	15.5 %
Manipulation					
Memory updating	Digit span (backw./order.)	11	3.22 %	147	43.0 %
(with transformation)	Spatial span (backw.)	7	2.05 %	68	19.9 %
	Letter-number sequencing	2	0.59 %	32	9.36 %
	Other memory updating	4	1.17 %	17	4.97 %
Other manipulation		3	0.88 %	10	2.92 %
Total		23	6.73 %	185	54.1 %
Updating					
N-back	Single n-back	84	24.6 %	117	34.2 %
	Dual n-back	49	14.3 %	13	3.8 %
	Operation n-back	3	0.88 %	1	0.29 %
Memory updating	PASAT	1	0.29 %	13	3.80 %
(with replacement)	Keep-track task	5	1.46 %	6	1.75 %
	Other memory updating	15	4.39 %	28	8.19 %
Running memory span	Letter running span	10	2.92 %	11	3.22 %
	Digit running span	3	0.88 %	14	4.09 %
	Spatial running span	7	2.05 %	5	1.46 %
	Other running span	10	2.92 %	19	5.56 %
Other updating		1	0.29 %	3	0.88 %
Total		154	45.0 %	157	45.9 %
Complex span					
Complex span	Operation span	7	2.05 %	41	12.0 %
	Symmetry span	6	1.75 %	16	4.68 %
	Reading span	1	0.29 %	20	5.85 %
	Other complex span	30	8.77 %	45	13.2 %
Total		37	10.8 %	88	25.7 %
Batteries					
Total		147	43.0 %	37	10.8 %

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Table 3

Cross-modal transfer effects in working memory training studies.

Authors (Year)	Task	Outcome	<i>n</i>	Training modality	Testing modality	Effect size (<i>d</i>)	Sig.	Cross-modal transfer (CMT)
Au et al. (2016) ^a	n-back	hits minus false alarms	62	visual → visual visual → auditory	visual → visual visual → auditory	0.41 0.69	- -	CMT not tested: vis→aud
Buschkuhl et al. (2014) ^b	n-back	hits minus false alarms	27	visual → visual visual → auditory	visual → visual visual → auditory	1.28 0.65	* *	No CMT: vis→aud
Guo et al. (2021) ^c	orientation sequence	proportion correct	16	tactile → tactile tactile → visual	tactile → tactile tactile → visual	1.34 1.25	* *	CMT: tac→vis
Kimura & Matsuura (2020) ^d	n-back	percent correct	11	auditory → auditory	auditory → auditory	1.21	*	Symmetric CMT: aud→vis and vis→aud
				auditory → visual	auditory → visual	1.07	*	
			11	visual → visual	visual → visual	1.97	*	
				visual → auditory	visual → auditory	0.86	*	
Olofsson et al. (2020) ^e	matched spatial memory	n trials to complete	41	olfactory → olfactory	olfactory → olfactory	1.06	*	Asymmetric CMT: olf→vis., but not vis→olf
				olfactory → visual	olfactory → visual	0.82	*	
			31	visual → visual	visual → visual	1.73	*	
				visual → olfactory	visual → olfactory	0.16	*	
Schneiders et al. (2012) ^f	n-back	proportion correct	16	auditory → auditory auditory → visual	auditory → auditory auditory → visual	1.83 0.34	* *	No CMT: aud→vis
Zhu et al. (2024)	n-back	adaptive n-back level	15	auditory → auditory	auditory → auditory	1.97	*	Asymmetric CMT: vis→aud., but not aud→vis
				auditory → visual	auditory → visual	0.59	*	
			15	visual → visual	visual → visual	1.77	*	
				visual → auditory	visual → auditory	0.95	*	

Notes. Effect sizes (*d*) were calculated as within-group pre-post standardized mean changes (formula below).

$$d = (M_{pre} - M_{post}) / SD_{pooled} \text{ where } SD_{pooled} = \sqrt{(SD_{pre}^2 + SD_{post}^2) / 2}$$

These estimates illustrate the relative magnitude of improvement across modalities within each study. They do not account for practice or test-retest effects and should be interpreted descriptively. Full extracted data, formulas, and calculations are available in Supplementary Material S8.

^a Effect sizes calculated using pooled means and SDs across stimulation conditions.

^b Values extracted from figure; SEM converted to SD; effect size calculated from the 4-back condition.

^c SEM converted to SD.

^d Means and SDs collapsed across load levels using within-load variability.

^e Effect size direction reversed.

^f Values extracted from figure; SEM converted to SD.

* indicates $p < .05$. "-" indicates no statistical test reported.

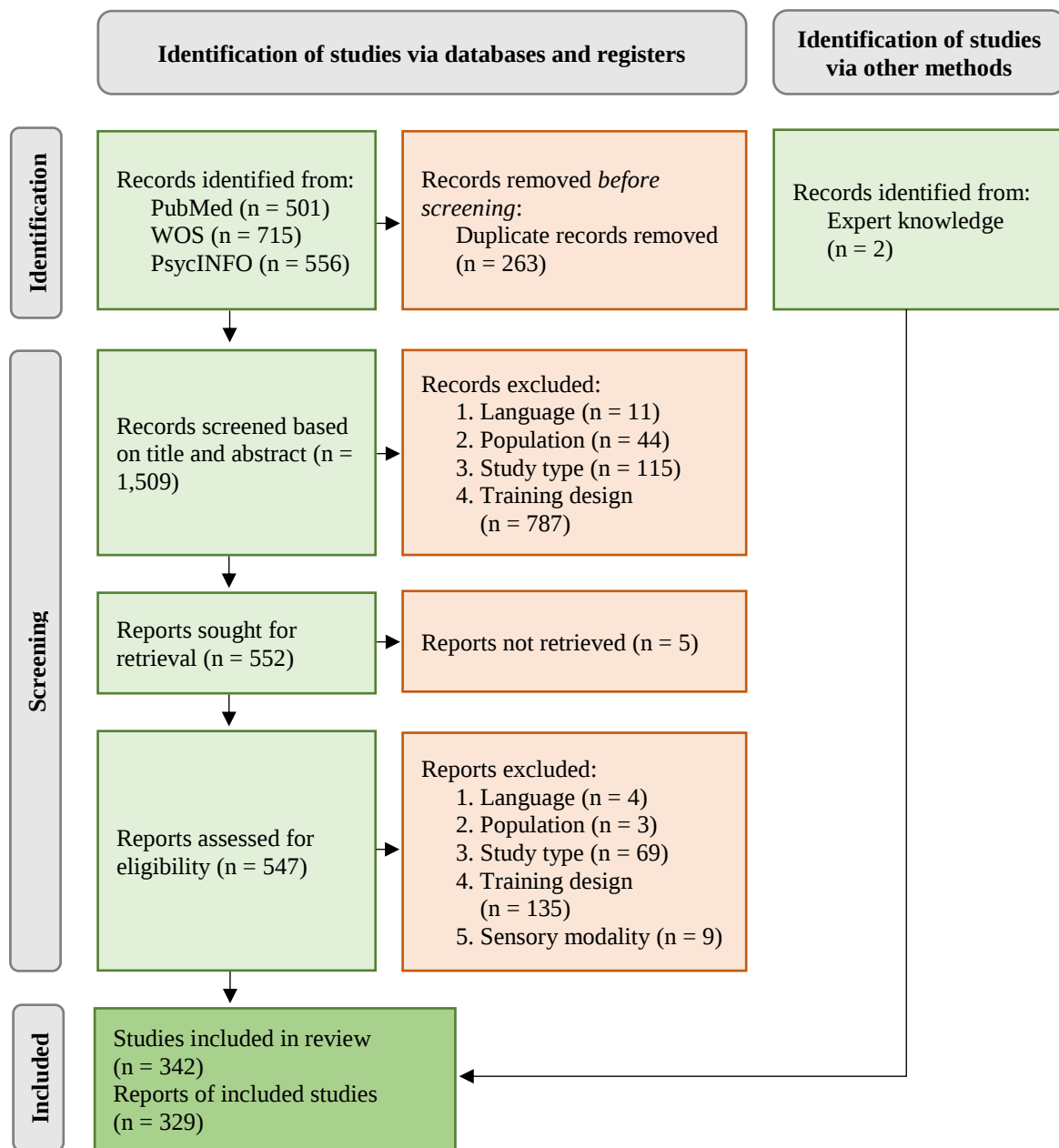


Figure 1

Flow diagram showing the number of records identified, screened, and included. Numbers refer to reports (i.e., individual papers) rather than distinct studies. In total, 329 reports describing 342 studies were included in the review.

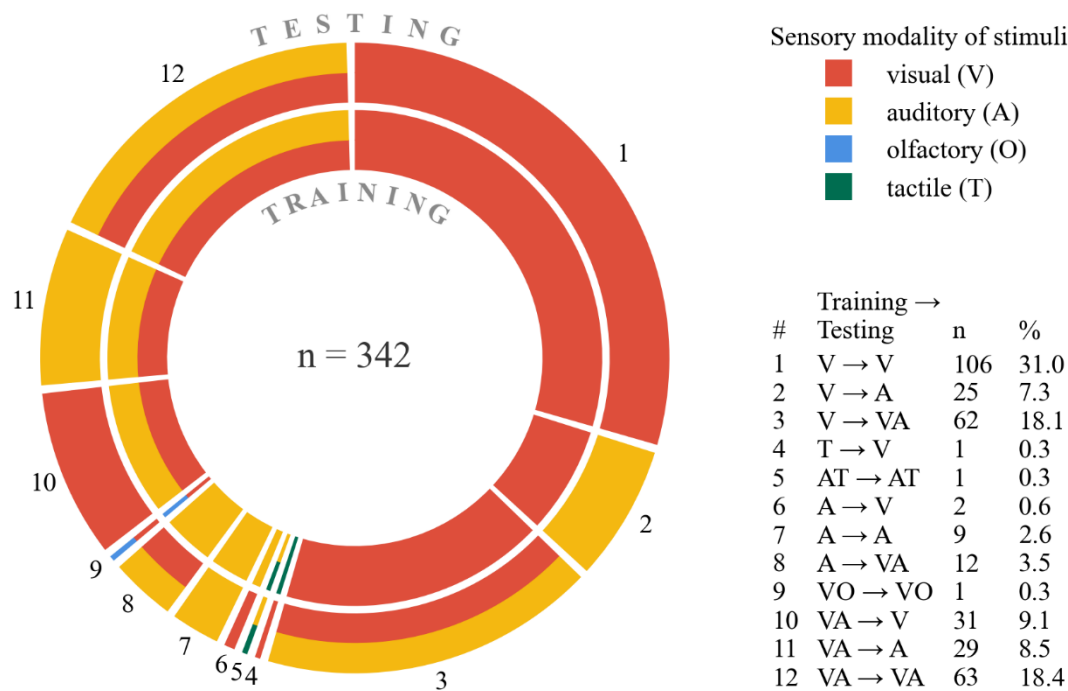


Figure 2

Summary of studies included in the review grouped by the combination of sensory modalities used during training (inner ring) and testing (outer ring). In the lower-right panel, each type of study is listed with a number, sensory modalities used at training and testing, and counts and percentages of studies.