

Supplementary Material S8: Effect Size Calculations

This document contains details about how data was extracted from cross-modal effect studies and what formulas were applied to calculate values and effect sizes for Table 3.

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S8.1 Table 3

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	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	1.28 0.65	* *	No CMT: vis→aud
Guo et al. (2021) ^c	orientation sequence	proportion correct	16	tactile tactile	→ tactile → visual	1.34 1.25	* *	CMT: tac→vis
Kimura & Matsuura (2020) ^d	n-back	percent correct	11 11	auditory auditory visual visual	→ auditory → visual → visual → auditory	1.21 1.07 1.97 0.86	* * * *	Symmetric CMT: aud→vis and vis→aud
Olofsson et al. (2020) ^e	matched spatial memory	n trials to complete	41 31	olfactory olfactory visual visual	→ olfactory → visual → visual → olfactory	1.06 0.82 1.73 0.16	* * *	Asymmetric CMT: olf→vis., but not vis→olf
Schneiders et al. (2012) ^f	n-back	proportion correct	16	auditory auditory	→ auditory → visual	1.83 0.34	* *	No CMT: aud→vis
Zhu et al. (2024)	n-back	adaptive n- back level	15 15	auditory auditory visual visual	→ auditory → visual → visual → auditory	1.97 0.59 1.77 0.95	* * * *	Asymmetric CMT: vis→aud., but not aud→vis

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

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

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.

S8.2 Formulas

S8.2.1 Formula 1: Effect size (d) – within-group pre-post

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

S8.2.2 Formula 2: Effect size (d) – within-group pre-post (reversed)

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

S8.2.3 Formula 3: Pooled mean - sample-size-weighted for 3 conditions

$$M_{pooled} = (n_1 * M_1 + n_2 * M_2 + n_3 * M_3) / (n_1 + n_2 + n_3)$$

S8.2.4 Formula 4: Pooled SD - sample-size-weighted for 3 conditions

$$SD_{pooled} = \sqrt{(((n_1 - 1) * SD_1^2) + ((n_2 - 1) * SD_2^2) + ((n_3 - 1) * SD_3^2)) / (n_1 - 1 + n_2 - 1 + n_3 - 1)}$$

S8.2.5 Formula 5: Convert SEM to SD

$$SD = SEM * \sqrt{n}$$

S8.2.6 Formula 6: Pooled mean – unweighted for 3 conditions

$$M_{pooled} = (M_1 + M_2 + M_3) / 3$$

S8.2.7 Formula 7: Pooled SD – unweighted for 3 conditions

$$SD_{pooled} = \sqrt{(SD_1^2 + SD_2^2 + SD_3^2) / 3}$$

S8.3 Au et al. (2016)

S8.3.1 Data extraction

Table 2. Descriptive Data of Training and Transfer Measures

	Active Right (n = 20)				Active Left (n = 20)				Sham (n = 22) ^a			
	Pre	Post	r	d	Pre	Post	r	d	Pre	Post	r	d
<i>Trained n-Back</i>												
n-Level	3.68 (.80)	5.28 (1.39)	.56	1.30	4.07 (1.17)	5.48 (1.35)	.66	1.10	3.77 (1.21)	4.52 (1.77)	.75	0.45
<i>Untrained n-Back (P_R)</i>												
Auditory n-back	0.57 (0.12)	0.69 (0.13)	.18	1.01	0.61 (0.17)	0.72 (0.16)	.69	0.64	0.58 (0.15)	0.66 (0.16)	.59	0.53
Visual n-back	0.64 (0.16)	0.81 (0.14)	.44	1.14	0.69 (0.17)	0.73 (0.19)	.79	0.23	0.60 (0.20)	0.62 (0.22)	.60	0.13
Forward digit span	8.90 (1.97)	8.60 (2.33)	.34	-0.14	9.15 (2.56)	10.30 (2.47)	.80	0.46	8.41 (2.38)	8.60 (2.63)	.64	0.07
Backward digit span	5.90 (2.02)	6.20 (2.42)	.76	0.13	7.35 (2.64)	7.35 (2.98)	.62	0.00	5.36 (2.11)	5.41 (1.74)	.66	0.02
Forward block-tapping	12.70 (2.40)	12.80 (2.09)	.27	0.04	12.25 (2.02)	12.90 (2.83)	.38	0.26	12.45 (3.10)	12.91 (2.56)	.55	0.16
Backward block-tapping	10.55 (2.26)	12.35 (1.95)	.45	0.85	10.65 (3.03)	10.55 (2.91)	.23	-0.03	10.64 (3.13)	10.82 (2.13)	.53	0.07
<i>Inhibitory Control (% Accuracy)</i>												
Visual lures	0.78 (0.12)	0.91 (0.14)	.43	0.98	0.84 (0.11)	0.92 (0.05)	.24	0.95	0.72 (0.17)	0.83 (0.16)	.81	0.62
AX-CPT	0.68 (0.20)	0.66 (0.14)	.45	-0.09	0.64 (0.19)	0.61 (0.18)	.70	-0.17	0.60 (0.17)	0.61 (0.22)	.70	0.07
<i>Positive and Negative Affect Schedule Scales</i>												
Positive affect	31.61 (5.90)	29.83 (6.42)	.68	-0.29	31.47 (10.45)	30.39 (9.87)	.85	-0.11	32.41 (6.40)	28.14 (5.55)	.43	-0.71
Negative affect	15.78 (4.73)	14.78 (2.96)	.52	-0.24	17.26 (6.93)	17.32 (6.11)	.81	0.01	18.59 (6.42)	17.23 (5.94)	.52	-0.22

Values in parentheses are standard deviations. *r* = correlation between pre- and posttest. For the trained *n*-back, pre and post refer to Session 1 and Session 7, respectively.

Cohen's *d* effect sizes for correlated samples were calculated as $(\text{Mean}_{\text{post}} - \text{Mean}_{\text{pre}}) / \sqrt{(\text{SD}_{\text{pre}}^2 + \text{SD}_{\text{post}}^2 - 2r * \text{SD}_{\text{pre}} * \text{SD}_{\text{post}}) / 2(1-r)}$.

^aAll *n*s for Sham = 22, except for Auditory *n*-back and AX-CPT where *n* = 21.

Time	Modality	Condition	Mean	SD	Comment
Pre	Auditory	Right	0.57	0.12	
Pre	Auditory	Left	0.61	0.17	
Pre	Auditory	Sham	0.58	0.15	
Post	Auditory	Right	0.69	0.13	
Post	Auditory	Left	0.72	0.16	
Post	Auditory	Sham	0.66	0.16	
Pre	Visual	Right	0.64	0.16	
Pre	Visual	Left	0.69	0.17	
Pre	Visual	Sham	0.60	0.20	
Post	Visual	Right	0.81	0.14	
Post	Visual	Left	0.73	0.19	
Post	Visual	Sham	0.62	0.22	

S8.3.2 Pooling Means and SDs across conditions

Effect sizes are calculated on pooled means and sds across stimulation conditions.

Formula 3 (S8.2.3) Pooled mean - sample-size-weighted for 3 conditions

Pre – Auditory – pooled Mean: $(20 * 0.57 + 20 * 0.61 + 22 * 0.58) / (20 + 20 + 22) = 0.58645$

Post – Auditory – pooled Mean: $(20 * 0.69 + 20 * 0.72 + 22 * 0.66) / (20 + 20 + 22) = 0.68903$

Pre – Visual – pooled Mean: $(20 \times 0.64 + 20 \times 0.69 + 22 \times 0.60) / (20 + 20 + 22) = 0.64194$

Post – Visual – pooled Mean: $(20 \times 0.81 + 20 \times 0.73 + 22 \times 0.62) / (20 + 20 + 22) = 0.71677$

Formula 4 (S8.2.4) Pooled SD - sample-size–weighted for 3 conditions

Pre – Auditory – pooled SD: $\text{Square}(((20-1) \times 0.12^2 + (20-1) \times 0.17^2 + (22-1) \times 0.15^2) / ((20-1) + (20-1) + (22-1))) = 0.14816$

Post – Auditory – pooled SD: $\text{Square}(((20-1) \times 0.13^2 + (20-1) \times 0.16^2 + (22-1) \times 0.16^2) / ((20-1) + (20-1) + (22-1))) = 0.15099$

Pre – Visual – pooled SD: $\text{Square}(((20-1) \times 0.16^2 + (20-1) \times 0.17^2 + (22-1) \times 0.20^2) / ((20-1) + (20-1) + (22-1))) = 0.17829$

Post – Visual – pooled SD: $\text{Square}(((20-1) \times 0.14^2 + (20-1) \times 0.19^2 + (22-1) \times 0.22^2) / ((20-1) + (20-1) + (22-1))) = 0.18752$

S8.3.3 Effect size calculation

Formula 1 (S8.2.1) Effect size (d) – within-group pre-post

Auditory pre-post: $(0.68903 - 0.58645) / \text{square}((0.14816^2 + 0.15099^2) / 2) = 0.69$

Visual pre-post: $(0.71677 - 0.64194) / \text{square}((0.17829^2 + 0.18752^2) / 2) = 0.41$

S8.3.4 Significance testing

Aud pre-post: not tested

Vis pre-post: not tested

S8.3.5 Note

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

S8.3.6 CM transfer comment

CM transfer not tested: vis→aud

S8.3.7 Narrative review

Au et al. (2016) trained participants on a visuospatial n-back task with either active or sham transcranial direct current stimulation (tDCS). Pre-post performance was assessed on untrained n-back transfer tasks in both visual and auditory modalities. Across stimulation conditions, participants showed improvements on both tasks. However, statistical analyses focused on differences between stimulation groups and revealed a significant effect only for the visual n-back task, driven by the right prefrontal stimulation group. Because the present

review focuses on modality-specific transfer from WM training rather than stimulation effects, effect sizes were calculated using sample-size-weighted pooled means and SDs from all tDCS conditions. These pooled estimates suggested improvements in both transfer tasks and yielded a somewhat larger effect size for the untrained auditory n-back task than for the untrained visual n-back task. However, the authors did not report statistical tests of pre–post training effects collapsed across tDCS conditions.

S8.4 Buschkuehl et al. (2014)

S8.4.1 Data extraction

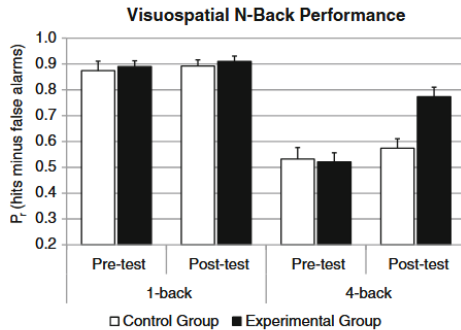


Fig. 2 Performance in the visuospatial n -back task as a function of test session, n -back level, and group. As was expected, all participants performed near ceiling level at 1-back in both sessions, but there was a significant improvement in the experimental group in the 4-back condition from pre- to posttest that was not reliably present in the control group

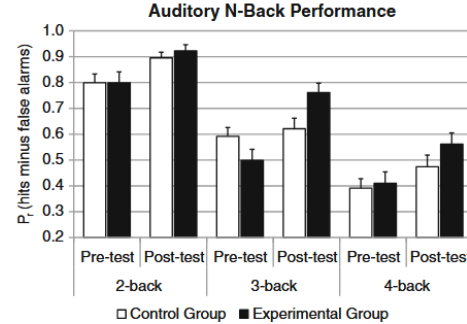


Fig. 3 Performance in the untrained auditory n -back task as a function of test session, n -back load, and group. The benefit of visuospatial n -back training was especially pronounced in the 3-back condition

For comparison between modalities, only values from the 4-back condition was extracted, since this was the only load level tested in both modalities. Values were extracted from the figures using an image measurement tool.

Error bars in the figure are standard errors (SEM) and were converted to SD (S8.2.5 Formula 5: Convert SEM to SD)

Time	Modality	Mean	SEM	SD (converted)	Comment
Pre	Auditory	0.41	0.044	0.23	
Post	Auditory	0.56	0.044	0.23	
Pre	Visual	0.52	0.036	0.19	
Post	Visual	0.77	0.038	0.20	

S8.4.2 Effect size calculation

Formula 1 (S8.2.1) Effect size (d) – within-group pre-post

Vis training – Aud task: $(0.56 - 0.41) / \sqrt{((0.23^2 + 0.23^2) / 2)} = 0.65$

Vis training – Vis task: $(0.77 - 0.52) / \sqrt{((0.19^2 + 0.20^2) / 2)} = 1.28$

S8.4.3 Significance testing

Vis training – Vis task: *

Vis training – Aud task:

S8.4.4 Note

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

S8.4.5 CM transfer comment

No CM transfer: vis→aud

S8.4.6 Narrative review

Buschkuehl et al. (2014) trained participants on a visuospatial n-back task and found clear improvement on the trained task. They also reported cross-modal transfer to an auditory n-back task, reflected in a greater pre–post improvement in the training group compared with an active control group. This transfer effect was most pronounced at intermediate load levels (particularly the auditory 3-back), whereas the auditory 4-back condition did not show a significant interaction despite numerical improvement in the training group. However, for comparability across modalities, effect sizes in the present review were derived from the visual and auditory 4-back conditions only, as the visual n-back was only assessed at 1-back and 4-back. The study therefore provides limited evidence for cross-modal transfer from visual to auditory WM.

S8.5 Guo et al. (2021)

S8.5.1 Data extraction

Table 1. Means and Standard Errors for the Training and Evaluation Tasks.

Group	Task	Modality	Experiment type	Stage	M ± SE	Result type
Control group	Visual orientation sequence task	Visual	Evaluation experiment	Pre	0.69 ± 0.04	Accuracy
				Post	0.75 ± 0.04	
	Visuospatial task			Pre	9.25 ± 0.69	Item capacity
				Post	8.25 ± 0.63	
Training group	Visual orientation sequence task		Evaluation	Pre	0.64 ± 0.33	Accuracy
	Visuospatial task			experiment	Pre	8.75 ± 0.52
	Tactile orientation sequence task	Tactile	Training experiment	Session 1	0.62 ± 0.03	Accuracy
				Session 2	0.71 ± 0.04	
				Session 3	0.72 ± 0.04	
				Session 4	0.74 ± 0.05	
				Session 5	0.81 ± 0.04	
	Visual orientation sequence task			Evaluation	Post	0.79 ± 0.03
	Visuospatial task	Visual	experiment	Post	10.12 ± 0.57	Item capacity

Standard errors (SEM) from the table were converted to SD (S8.2.5 Formula 5: Convert SEM to SD)

Time	Modality	Mean	SEM	SD (converted)	Comment
Pre	Tactile	0.62	0.03	0.12	
Post	Tactile	0.81	0.04	0.16	
Pre	Visual	0.64	$0.03 (0.33)^*$	0.12	Incorrect value
Post	Visual	0.79	0.03	0.12	

* The SEM appears as 0.33 in the table. This value is mathematically impossible given that the SD would be larger than 1. The value was corrected using error bars in another figure in the paper.

S8.5.2 Effect size calculation

Formula 1 (S8.2.1) Effect size (d) – within-group pre-post

Tac train – tac task: $(0.81 - 0.62) / \sqrt{((0.12^2 + 0.16^2) / 2)} = 1.34$

Tac train – vis task: $(0.79 - 0.64) / \sqrt{((0.12^2 + 0.12^2) / 2)} = 1.25$

S8.5.3 Significance testing

Tac train – tac task: *

Tac train – vis task: *

S8.5.4 Note

SEM converted to SD.

S8.5.5 CM transfer comment

CM transfer: tac→vis

S8.5.6 Narrative review

Guo et al. (2021) trained participants on a tactile orientation-sequence WM task and observed significant improvement on the trained task from the first to the final training session. Performance also improved on an analogous visual orientation-sequence task at post-test relative to pre-test, indicating cross-modal transfer from tactile to visual WM. The training group also showed higher visuospatial item capacity at post-test compared to pre-test, whereas the control group did not, indicating additional transfer to a broader visual WM task.

S8.6 Kimura & Matsuura (2020)

S8.6.1 Data extraction

Table 3 The Result of N-Back Task Performance (Absolute Value [in Percentage]) of Each WM Training Group in the Evaluation Session

Group	1-back task		2-back task		3-back task	
	Pre	Post	Pre	Post	Pre	Post
Auditory N-back task performance						
Auditory WM	94.4 (5.4)	95.7 (7.4)	64.3 (28.6)	86.8 (30.6)	33.8 (26.7)	90.7 (20.8)
Visual WM	92.2 (15.3)	92.9 (9.9)	60.5 (29.7)	78.5 (15.8)	37.6 (25.6)	72.5 (21.2)
Visual N-back task performance						
Auditory WM	99.5 (1.7)	99.0 (2.3)	78.8 (21.0)	94.4 (6.2)	55.8 (24.2)	88.9 (16.6)
Visual WM	95.0 (8.2)	99.5 (1.7)	68.9 (17.4)	95.5 (6.9)	41.9 (23.5)	93.4 (14.0)

Note. Values are presented as mean (SD). WM = working memory.

For the effect size calculation, data were collapsed across the three levels of difficulty for each test and timepoint. For this purpose unweighted pooled mean and sd formulas were used, see below.

Formula 6 (S8.2.6) Pooled mean – unweighted for 3 conditions

Formula 7 (S8.2.7) Pooled SD – unweighted for 3 conditions

Time	Training	Testing	1-back M	1-back SD	2-back M	2-back SD	3-back M	3-back SD	M pooled	SD pooled
Pre	Auditory	Auditory	94.4	5.4	64.3	28.6	33.8	26.7	64.167	22.804
Post	Auditory	Auditory	95.7	7.4	86.8	30.6	90.7	20.8	91.067	21.785
Pre	Auditory	Visual	99.5	1.7	78.8	21.0	55.8	24.2	78.033	18.525
Post	Auditory	Visual	99.0	2.3	94.4	6.2	88.9	16.6	94.1	10.316
Pre	Visual	Visual	95.0	8.2	68.9	17.4	41.9	23.5	68.6	17.533
Post	Visual	Visual	99.5	1.7	95.5	6.9	93.4	14.0	96.133	9.065
Pre	Visual	Auditory	92.2	15.3	60.5	29.7	37.6	25.6	63.433	24.300
Post	Visual	Auditory	92.9	9.9	78.5	15.8	72.5	21.2	81.3	16.300

S8.6.2 Effect size calculation

Formula 1 (S8.2.1) Effect size (d) – within-group pre-post

Aud training – Aud pre-post: $(91.067 - 64.167) / \sqrt{((22.804^2 + 21.785^2) / 2)} = 1.21$

Aud training – vis pre-post: $(94.1 - 78.033) / \sqrt{((18.525^2 + 10.316^2) / 2)} = 1.07$

Vis training – Vis pre-post: $(96.133 - 68.6) / \sqrt{((17.533^2 + 9.065^2) / 2)} = 1.97$

Vis training – Aud pre-post: $(81.3 - 63.433) / \sqrt{((24.3^2 + 16.3^2) / 2)} = 0.86$

S8.6.3 Significance testing

Aud training – Aud pre-post: *

Aud training – vis pre-post: *

Vis training – Vis pre-post: *

Vis training – Aud pre-post: *

S8.6.4 Note

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

S8.6.5 CM transfer comment

Symmetric CM transfer: aud→vis and vis→aud

S8.6.6 Narrative review

Kimura & Matsuura (2020) compared auditory and visual n-back training in separate groups. Both auditory and visual training improved n-back performance in the trained and untrained modalities, consistent with cross-modality transfer. Effect sizes calculated from the reported descriptive statistics suggested somewhat larger transfer from auditory to visual n-back performance than from visual to auditory performance. However, these estimates should be interpreted cautiously. The analyses in the original study collapsed across multiple load levels, including relatively easy conditions, and post-training accuracy approached ceiling for several conditions, both of which likely inflate pre–post effect sizes. Moreover, the authors did not report a statistically significant difference in gains between training groups. Dual-task outcomes were also assessed but are not discussed here.

S8.7 Olofsson et al. (2020)

S8.7.1 Data extraction

Table 1. Mean demographic, Sniffin' sticks, and questionnaire data for the olfactory and visual training groups at pre- and posttest

	Pre-assessment		Post-assessment	
	Olfactory group	Visual group	Olfactory group	Visual group
Age (±SD)	25.6 (5.0)	27.0 (7.5)	—	—
n (% female)	41 (66)	31 (71)	—	—
Education years (±SD)	14.3 (1.7)	14.6 (2.7)	—	—
Days until posttest (±SD)	—	—	42.7 (5.9)	43.4 (4.1)
Odor threshold (±SD)	11.2 (3.3)	10.8 (2.8)	11.6 (3.3)	10.8 (2.8)
Odor discrimination (±SD)	12.3 (2.1)	12.9 (1.8)	13.9 (1.7)	12.3 (1.7)
Odor identification (±SD)	12.5 (2.0)	12.4 (1.7)	12.9 (2.0)	12.8 (2.3)
Odor naming (±SD)	5.4 (1.9)	6.2 (2.8)	7.1 (2.4)	6.0 (2.4)
OM task (±SD)	38.1 (10.8)	40.1 (10.5)	28.3 (7.3)	38.5 (9.6)
VM task (±SD)	33.8 (10.3)	37.9 (8.8)	26.5 (7.2)	24.4 (6.7)
Self-rated motivation (1–10)	7.5 (1.9)	7.1 (2.3)	5.9 (2.4)	5.9 (2.2)
Self-rated enjoyment of task (1–10)	7.5 (1.8)	7.0 (1.9)	5.1 (2.2)	5.7 (2.5)
Perceived difficulty of task (1–10)	4.7 (2.9)	4.4 (2.4)	4.8 (2.4)	3.5 (1.9)

Time	Training	Testing	M	SD
Pre	Olfactory	Olfactory	38.1	10.8
Post	Olfactory	Olfactory	28.3	7.3
Pre	Olfactory	Visual	33.8	26.5
Post	Olfactory	Visual	10.3	7.2
Pre	Visual	Visual	37.9	8.8
Post	Visual	Visual	24.4	6.7
Pre	Visual	Olfactory	40.1	10.5
Post	Visual	Olfactory	38.5	9.6

S8.7.2 Effect size calculation

Since the outcome measure is “n trials to complete”, where a better score is a lower number, a reversed effect size measure was used for consistency, so that a positive effect size indicates an improvement in performance.

Formula 2 (S8.2.2) Effect size (d) – within-group pre-post (reversed)

Olf training – olf pre-post: $(38.1-28.3)/\text{square}((10.8^2+7.3^2)/2) = 1.06$

Olf training – vis pre-post: $(33.8-26.5)/\text{square}((10.3^2+7.2^2)/2) = 0.82$

Vis training – olf pre-post: $(40.1-38.5)/\text{square}((10.5^2+9.6^2)/2) = 0.16$

Vis training – vis pre-post: $(37.9-24.4)/\text{square}((8.8^2+6.7^2)/2) = 1.73$

S8.7.3 Significance testing

Olfactory training – olfactory pre-post: *

Olfactory training – visual pre-post: *

Visual training – olfactory pre-post:

Visual training – visual pre-post: *

S8.7.4 Note

Effect size direction reversed.

S8.7.5 CM transfer comment

Asymmetric CM transfer: olf→vis., but not vis→olf

S8.7.6 Narrative review

Olofsson et al. (2020) compared olfactory and visual WM training using matched spatial memory tasks. Training with olfactory stimuli produced improvements on both the trained olfactory task and the untrained visual task, indicating cross-modal transfer from olfaction to vision. In contrast, visual training improved only the trained visual task and did not generalize to the olfactory task, demonstrating an absence of transfer in the opposite direction. Overall, the findings show asymmetric cross-modality transfer, with evidence only for olfactory-to-visual transfer.

S8.8 Schneiders et al. (2012)

S8.8.1 Data extraction

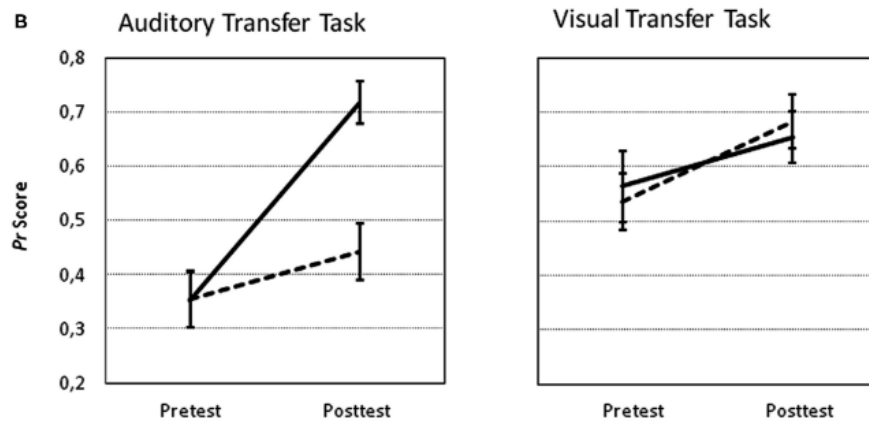


FIGURE 4 | Performance increase in the n-back task for the auditory training group. (A) The mean level of n as an indicator of the participants' performance for each session and corresponding standard errors of the mean

are shown. **(B)** Mean Pr scores and corresponding standard errors of the mean of the auditory transfer task (left panel) and of the visual transfer task (right panel) for both groups during fMRI pretest and posttest.

Values were extracted from the figures using an image measurement tool.

Error bars in the figure are standard errors (SEM) and were converted to SD (S8.2.5 Formula 5: Convert SEM to SD)

Time	Modality	Mean	SEM	SD (converted)	Comment
Pre	Auditory	0.36	0.055	0.22	
Post	Auditory	0.72	0.0425	0.17	
Pre	Visual	0.57	0.065	0.26	
Post	Visual	0.65	0.05	0.20	

S8.8.2 Effect size calculation

Formula 1 (S8.2.1) Effect size (d) – within-group pre-post

Aud training – Aud pre-post: $(0.72 - 0.36) / \sqrt{((0.22^2 + 0.17^2) / 2)} = 1.83$

Aud training – vis pre-post: $(0.65 - 0.57) / \sqrt{((0.26^2 + 0.20^2) / 2)} = 0.34$

S8.8.3 Significance testing

Aud training – Aud pre-post: *

Aud training – vis pre-post:

S8.8.4 Note

Values extracted from figure; SEM converted to SD.

S8.8.5 CM transfer comment

No CM transfer: aud→vis

S8.8.6 Narrative review

Schneiders et al. (2012) trained participants on an adaptive auditory n-back task using tonal sequences. The training group improved during training and showed clear gains on an untrained auditory 2-back task at post-test compared to a no-training control group. Although performance also improved on an analogous visual 2-back task, these gains did not differ from those observed in the control group. Thus, the results indicate modality-specific transfer, with training-related benefits confined to the auditory modality and no statistically reliable cross-modal transfer to visual WM.

S8.9 Zhu et al. (2024)

S8.9.1 Data extraction

Table 1

Pre- and post-test performance and significant changes across different training groups.

Training groups	Tasks	Pre (Mean ± SD)	post (Mean ± SD)	gain	Percentage change	Significant increase
V-VWM training	V-VWM	2.3(0.4)	3.2(0.6)	0.9	39.1 %	Yes
	A-VWM	2.7(0.4)	3.3(0.8)	0.6	22.2 %	Yes
	VA-VWM	2.3(0.6)	3.4(0.6)	1.1	47.8 %	Yes
	operation span	30.1(9.2)	33.5(8.1)	3.4	11.3 %	No
	DSB	5.2(1.6)	5.3(1.8)	0.1	1.9 %	No
	DSF	6.5(1.4)	6.1(1.5)	-0.4	-6.1 %	No
A-VWM training	V-VWM	2.5(0.6)	2.8(0.4)	0.3	12.0 %	No
	A-VWM	2.4(0.7)	3.6(0.5)	1.2	50.0 %	Yes
	VA-VWM	2.5(0.7)	3.1(0.7)	0.6	24.0 %	Yes
	operation span	27.4(7.6)	29.7(8.8)	2.3	8.4 %	No
	DSB	6.0(1.4)	5.7(1.3)	-0.3	-5.0 %	No
	DSF	6.5(1.5)	7.2(1.5)	-0.7	-10.8 %	No
VA-VWM	V-VWM	2.5(0.4)	3.0(0.6)	0.5	20.0 %	Yes
	A-VWM	2.4(0.5)	3.4(0.7)	1.0	41.7 %	Yes
	VA-VWM	2.6(0.5)	3.8(0.5)	1.2	46.2 %	Yes
	operation span	29.6(8.1)	38.4(6.7)	8.8	29.7 %	Yes
	DSB	5.9(1.2)	5.3(1.2)	-0.6	-10.2 %	No
	DSF	5.9(1.4)	6.5(1.3)	-0.4	-6.8 %	No
Control	V-VWM	2.2(0.7)	2.3(0.6)	0.1	4.5 %	No
	A-VWM	2.6(0.6)	2.6(0.6)	-0.01	0 %	No
	VA-VWM	2.7(0.4)	2.9(0.4)	0.2	7.4 %	No
	operation span	29.1(7.6)	29.4(5.8)	0.3	1.0 %	No
	DSB	5.0(1.9)	4.8(1.4)	-0.2	-4.0 %	No
	DSF	6.4(1.8)	6.7(1.7)	0.3	4.7 %	No

Notes: V-VWM refers to visual-verbal working memory; A-VWM refers to Auditory verbal working memory; VA-VWM refers to visual-auditory verbal working memory; DSB refers to digit span backwards; DSF refers to digit span forwards.

Time	Training	Testing	M	SD
Pre	Auditory	Auditory	2.4	0.7
Post	Auditory	Auditory	3.6	0.5
Pre	Auditory	Visual	2.5	0.6
Post	Auditory	Visual	2.8	0.4
Pre	Visual	Visual	2.3	0.4
Post	Visual	Visual	3.2	0.6
Pre	Visual	Auditory	2.7	0.8
Post	Visual	Auditory	3.3	0.4

S8.9.2 Effect size calculation

Formula 1 (S8.2.1) Effect size (d) – within-group pre-post

Aud training – Aud pre-post: $(3.6-2.4)/\sqrt{((0.7^2+0.5^2)/2)} = 1.59$

Aud training – vis pre-post: $(2.8-2.5)/\sqrt{((0.6^2+0.4^2)/2)} = 0.59$

Vis training – Aud pre-post: $(3.3-2.7)/\sqrt{((0.4^2+0.8^2)/2)} = 0.95$

Vis training – vis pre-post: $(3.2-2.3)/\sqrt{((0.4^2+0.6^2)/2)} = 1.77$

S8.9.3 Significance testing

Auditory training – Auditory pre-post: *

Auditory training – visual pre-post:

Visual training – Auditory pre-post: *

Visual training – visual pre-post: *

S8.9.4 Note

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S8.9.5 CM transfer comment

Asymmetric CM transfer: vis→aud., but not aud→vis

S8.9.6 Narrative review

Zhu et al. (2024) compared verbal WM training delivered in visual, auditory, or audiovisual training conditions among older adults. Each training condition improved performance on its respective trained n-back task, measured in adaptive n-back level, but transfer patterns differed. Visual training produced transfer to both auditory and audiovisual n-back, indicating cross-modal transfer. Auditory training showed narrower transfer, with a statistically significant improvement only in the audiovisual condition, but not in the visual condition. Audiovisual training produced the broadest transfer, enhancing performance across all three training and testing conditions and additionally improving verbal operation span. Overall, the results indicate asymmetric transfer across sensory systems, with visual and especially audiovisual training yielding broader benefits than auditory training alone. For comparability across studies, only visual and auditory training conditions and their respective effects on visual and auditory n-back performance are included in Table 3.