Journal Review

Motor expertise and performance in spatial tasks: A meta-analysis

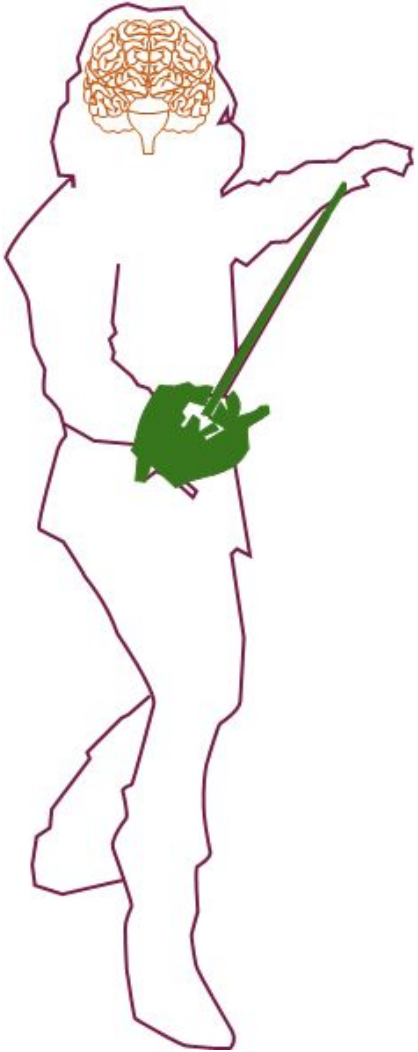
Daniel Voyer and Petra Jansen (2017) in *Human Movement Science, 54* 110-124. DOI: 10.1016/j.humov.2017.04.004

Presented by Brandon Brockshus
For ISU Neurophysiology Lab Meeting, March 4, 2021

Embodied Cognition

Cognition: the act and process of acquiring, storing, and using knowledge; in a word, thinking

perception, attention, memory, learning, problem-solving, decision-making are all cognitive processes



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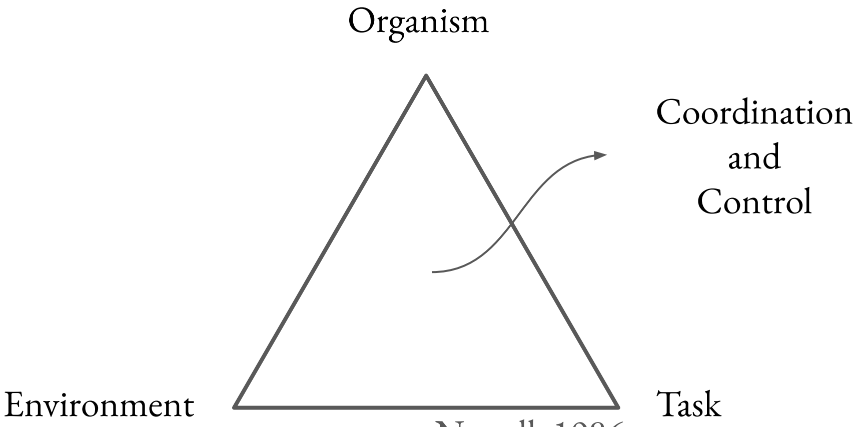
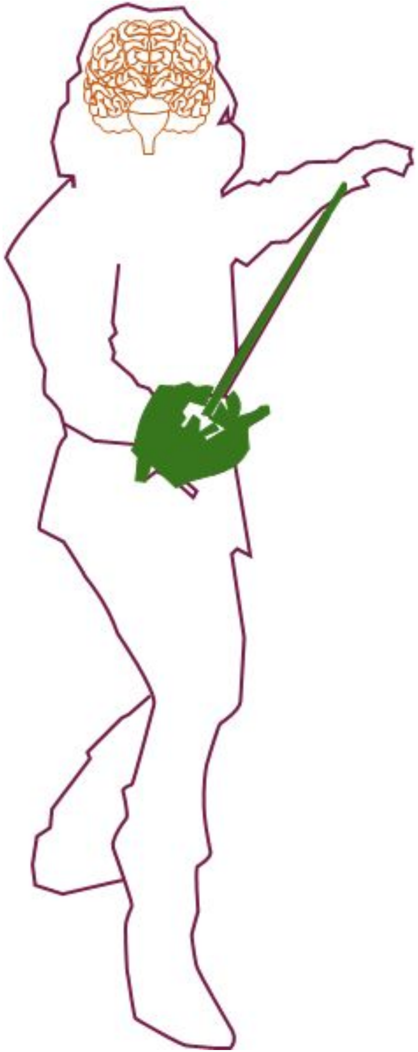
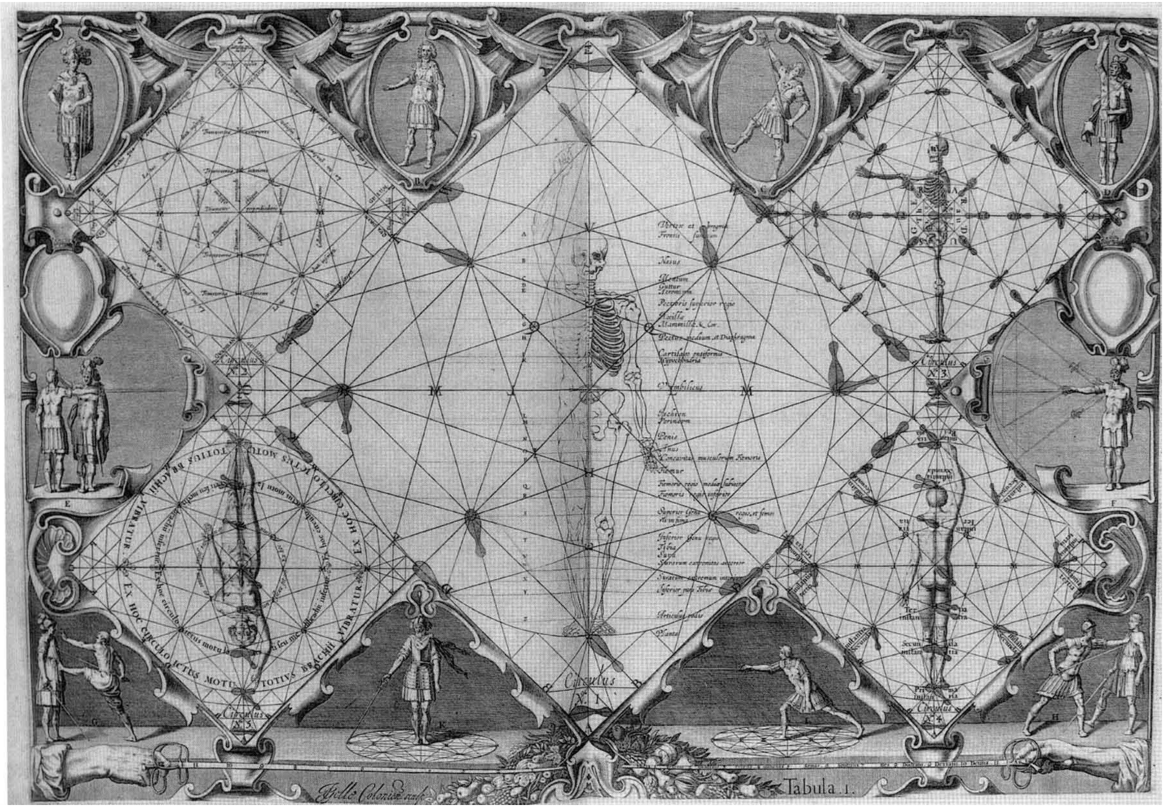


Newell, 1986

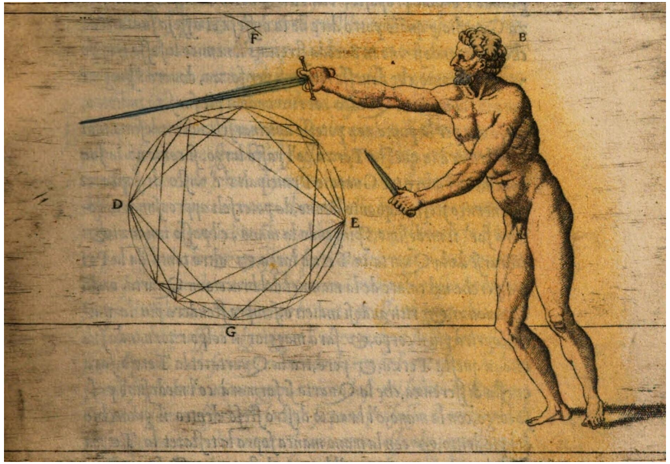


Spatial Ability



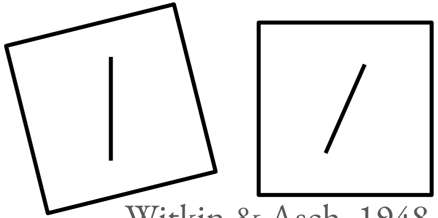
Thibault, 1630

Capo Ferro, 1629



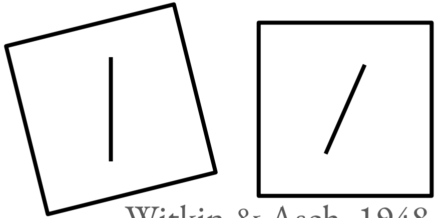
Agrippa, 1553

Spatial Tasks



Witkin & Asch, 1948

Spatial Tasks



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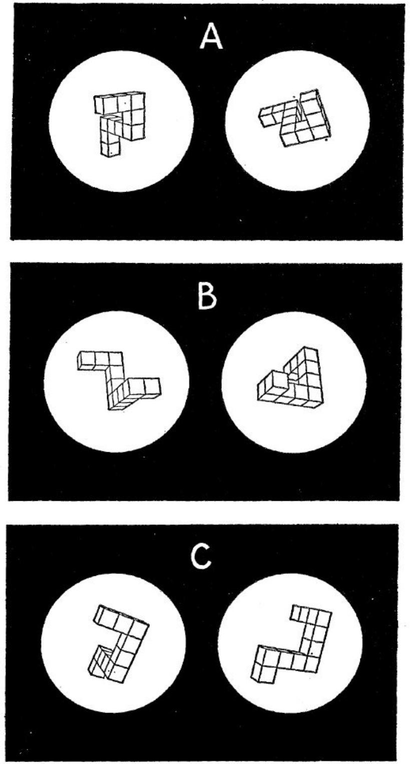
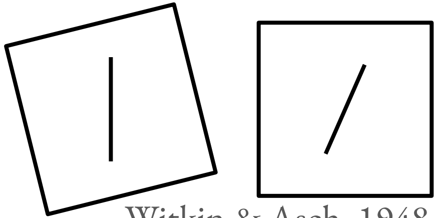


Fig. 1. Examples of pairs of perspective line drawings presented to the subjects. (A) A "same" pair, which differs by an 80° rotation in the picture plane; (B) a "same" pair, which differs by an 80° rotation in depth; and (C) a "different" pair, which cannot be brought into congruence by *any* rotation.

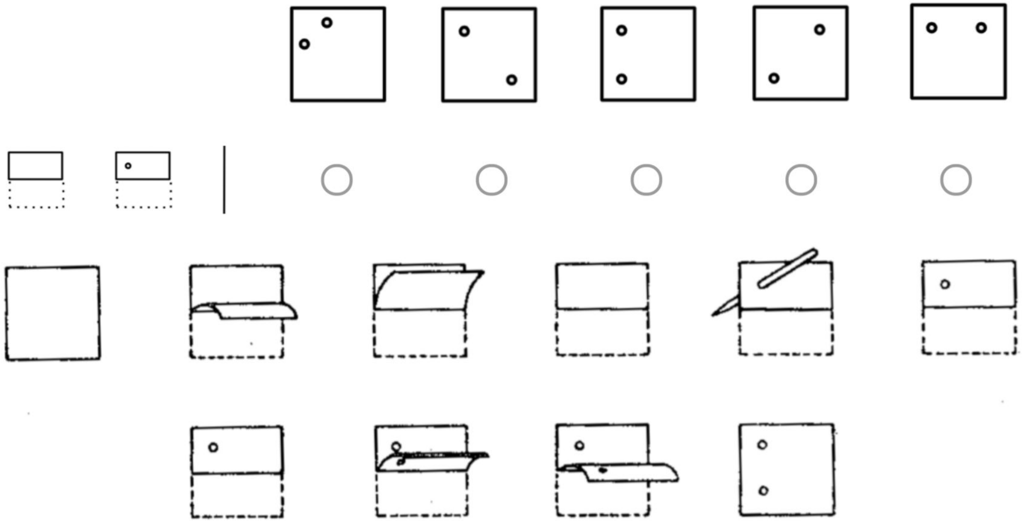
Shepard & Metzler, 1971

Spatial Tasks

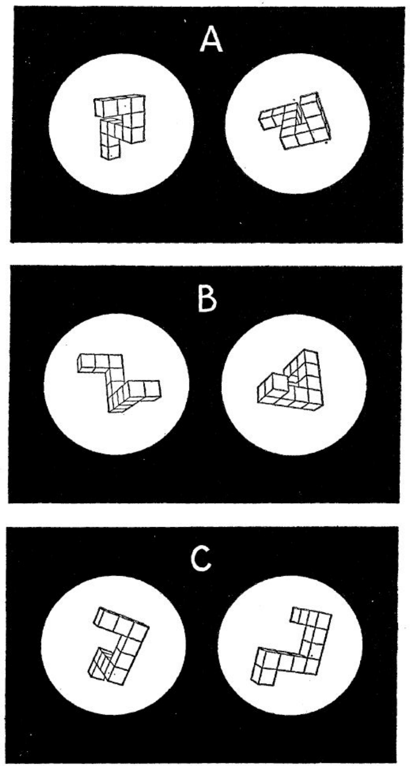


Witkin & Asch, 1948

Which shows the paper unfolded?



Ekstrom, French, Harman, & Dermen, 1976



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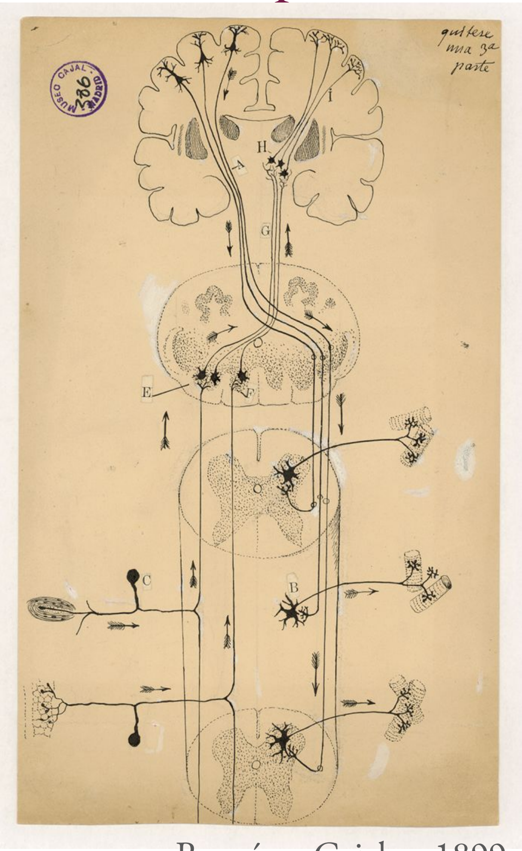
Shepard & Metzler, 1971

Motor Expertise



Ramón e Cajal, c. 1899

Motor Skill: activity or task that requires voluntary control over movements of the joints and body segments to achieve a goal

Motor Control: how our neuromuscular system functions to activate and coordinate the muscles and limbs involved in the performance of a motor skill

Motor Learning: the acquisition, the performance enhancement, or the reacquisition of motor skills

Motor Development: human development from infancy to old age with specific interest in issues related to either motor learning or motor control

Magill & Anderson, 2019

Motor Competence: the ability to learn and perform motor skills; associated with physical fitness (Catuzzo et al., 2014)

Motor Expertise: high degree of motor learning; this paper required minimum 10 years experience to attain expertise

Motor Expertise⟷Embodied Cognition⟷Spatial Ability

Do ‘individuals who practice activities requiring a strong representation of motor actions also show gains in cognition, particularly spatial tasks’?

Study Selection

Terms

spatial or mental rotation

with motor learning
- motor effects
- motor training
- motor expertise
- motor performance
- motor impairment
- motor behavior
- motor process
- motor practice
- motor experience
- gesture
- action control

elite athlete, musician, or wrestler

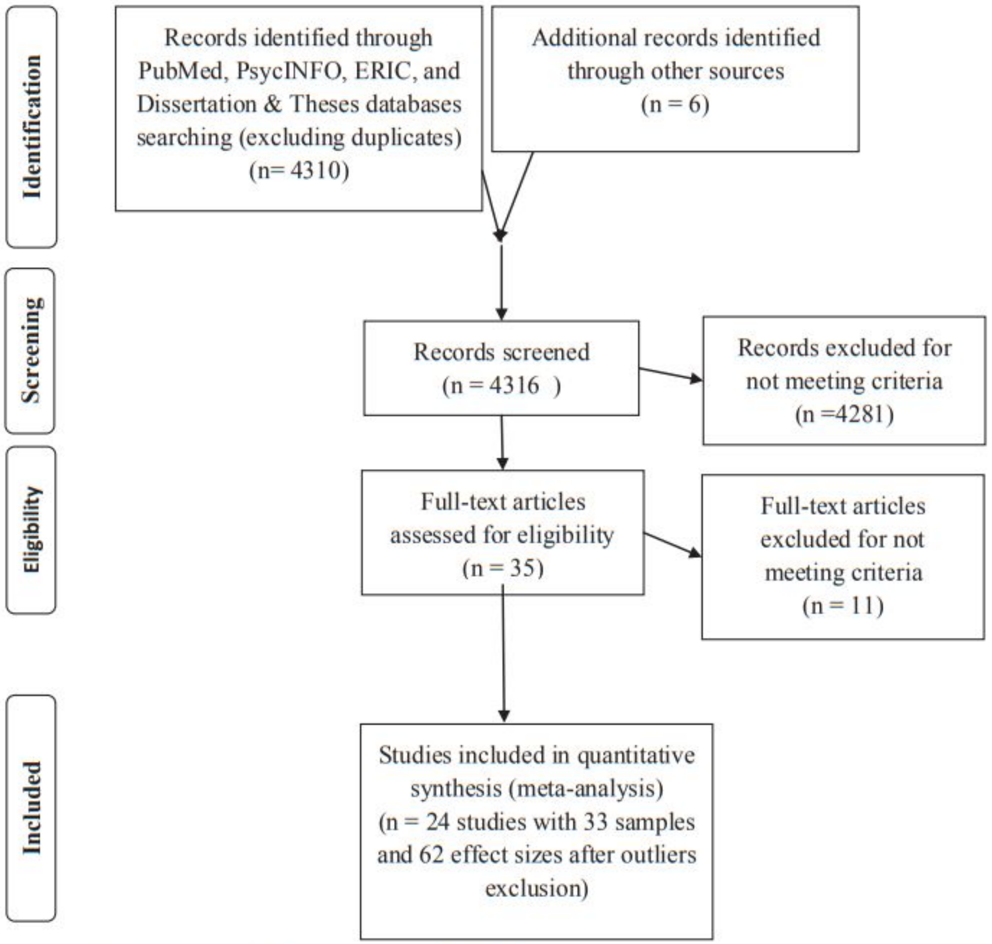


Fig. 1. Flow chart summarizing the data search and inclusion process. Modified from: Moher, Liberati, Tetzlaff, Altman, and The PRISMA Group (2009).

Population

athletes	*k* = 10
ball sports/open sports	*k* = 19
combat sports	*k* = 4
runners/cyclists	*k* = 8
gymnasts/dancers	*k* = 18
musicians	*k* = 5
	---------
	64 effect sizes

Spatial Tasks

spatial visualization	*k* = 13
disembedding tasks, paper folding tests	
mental rotation	*k* = 46
spatial perception	*k* = 5
rod-and-frame test	
	---------
	64 effect sizes

Table 2
Classification Details for the Type of Expert Moderator.

Final classification	Expertise named in original paper
Athlete	Athletes, without elaborations in the original paper; motor skills training
Open skills/ ball sports	All ball sports: only handball, soccer, and squash identified in papers included in the meta-analysis
Combat sports	Wrestling; fencing; judo
Runners/cyclists	Running; cyclism
Gymnasts/dancers	Gymnastics; dancing
Musicians	Musicians

Forest Plot

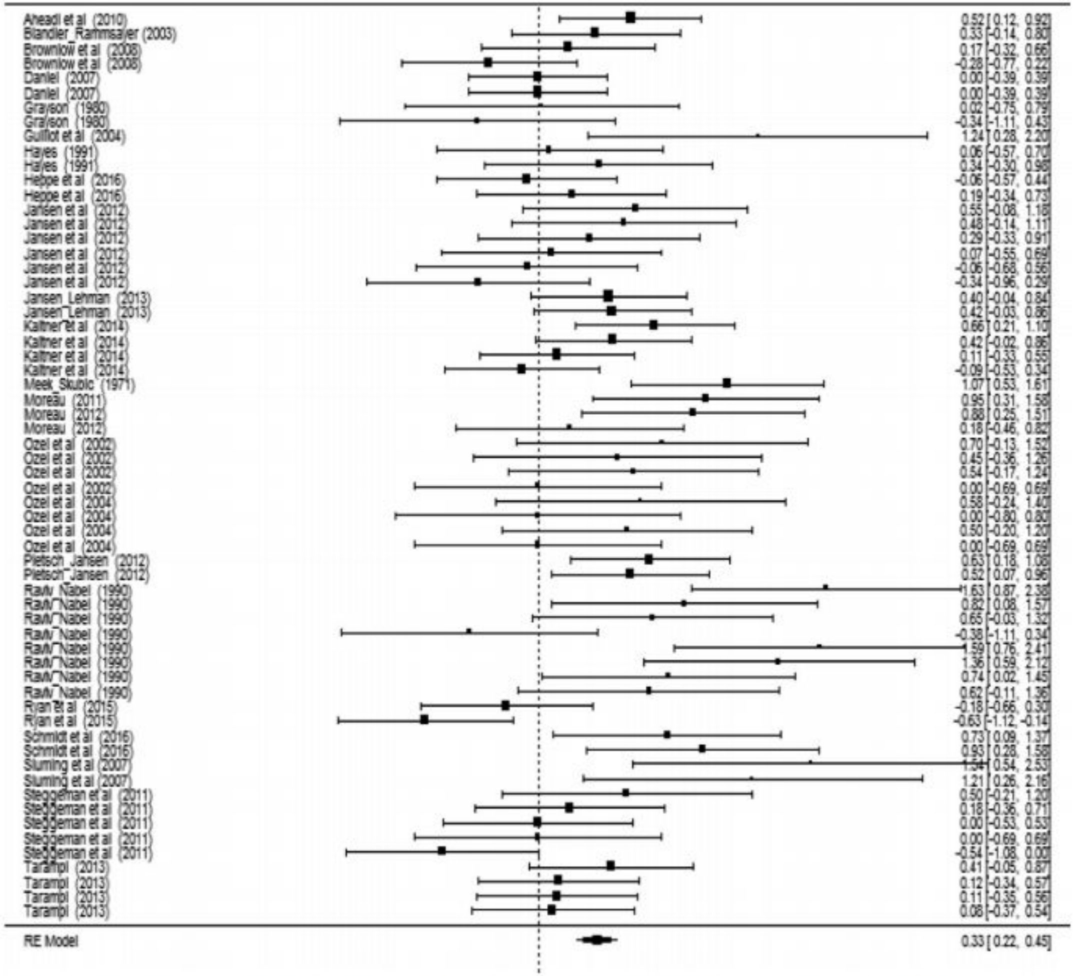
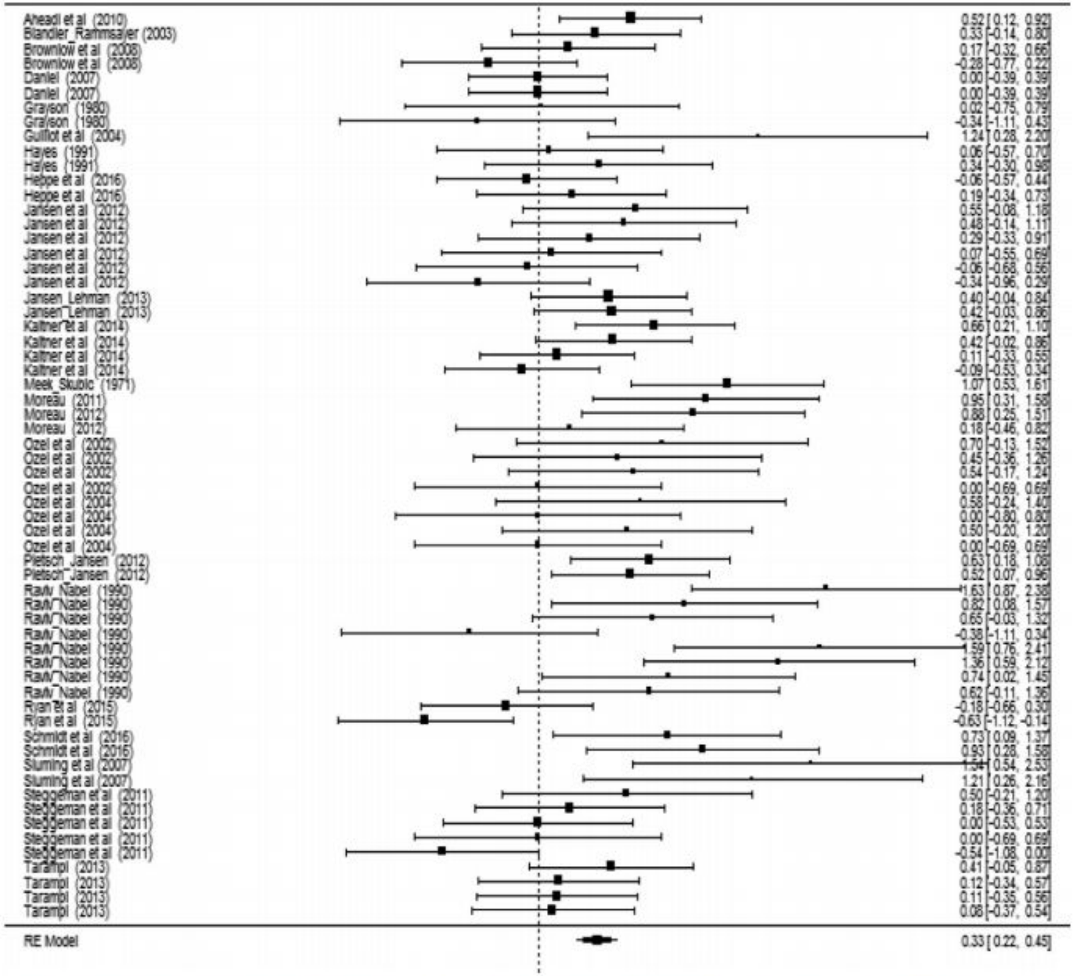


Fig. 2. Forest plot of effect sizes as a function of authors and year of publication for the studies entered in the present analysis. The square for each study represents the Cohen's *d* and the size of the square reflects its precision. The error bars represents the 95% confidence interval. Although not appropriate to this multilevel model, the random effect model estimate is presented at the bottom of the plot for information purpose.

Forest Plot

$$d = \frac{m_A - m_B}{\sigma}$$

Cohen, 1988



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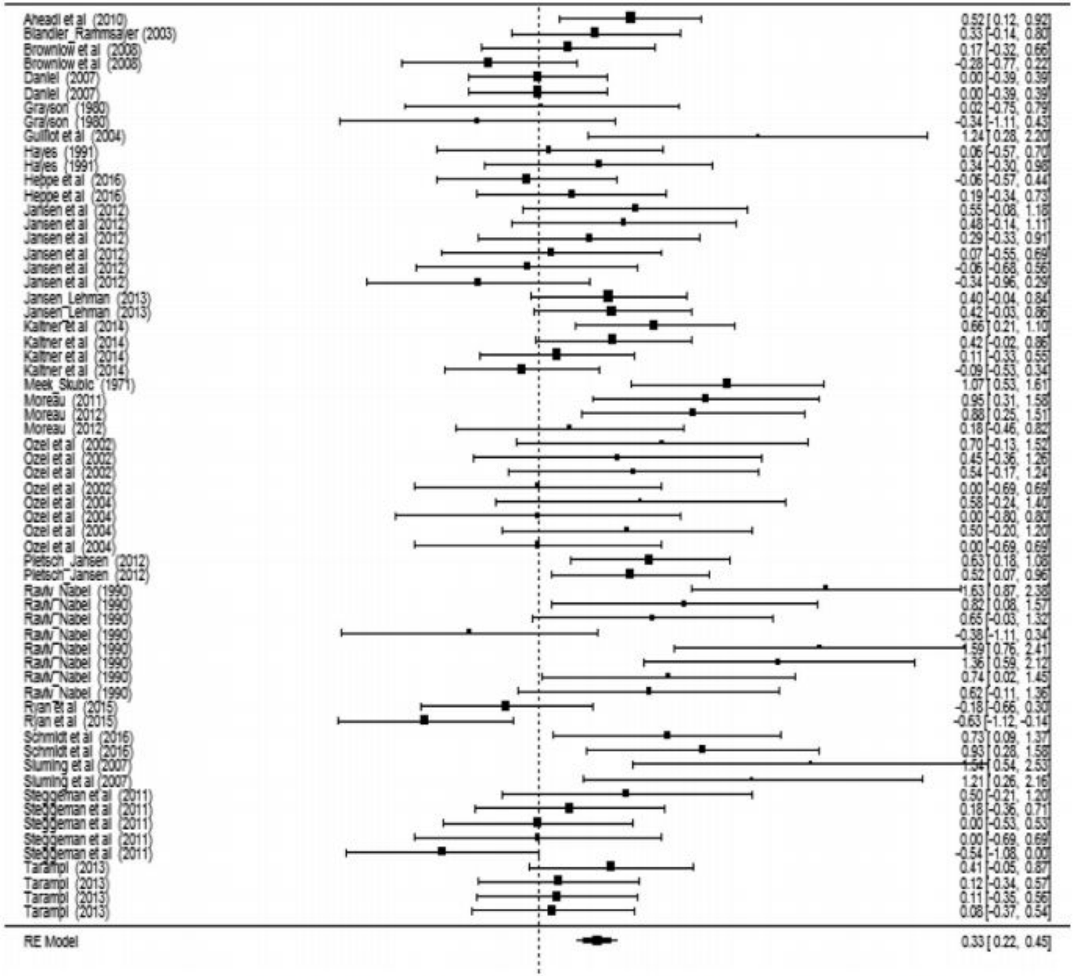
ES: 0.382 (95% CI = 0.240, 0.523)



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Moderator Variables

Table 3
Results for Significant Moderators in the Multilevel Meta-Analysis.

Moderator	Sample size	Estimated mean *d*	95% CI
Expert type			
Athlete	10	0.321	−0.047, 0.689
Open skills/ ball sports	19	0.197	−0.278, 0.672
Combat sports	2	0.911	0.543, 1.279
Runners/cyclists	8	0.297	−0.118, 0.712
Gymnasts/dancers	18	0.462	−0.025, 0.950
Musicians	5	0.570	0.395, 0.745
Test categories			
Mental rotation	44	0.329	0.176, 0.481
Spatial perception	5	1.085	0.661, 1.510
Spatial visualization	13	0.295	.099, 0.689
Specific test			
MRT	13	0.390	0.239, 0.542
GMR	31	0.228	−0.045, 0.501
Other	8	0.189	−0.098, 0.281
Disembedding	5	0.663	0.054, 1.380
RFT	5	1.072	0.741, 1.403

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Funnel Plot

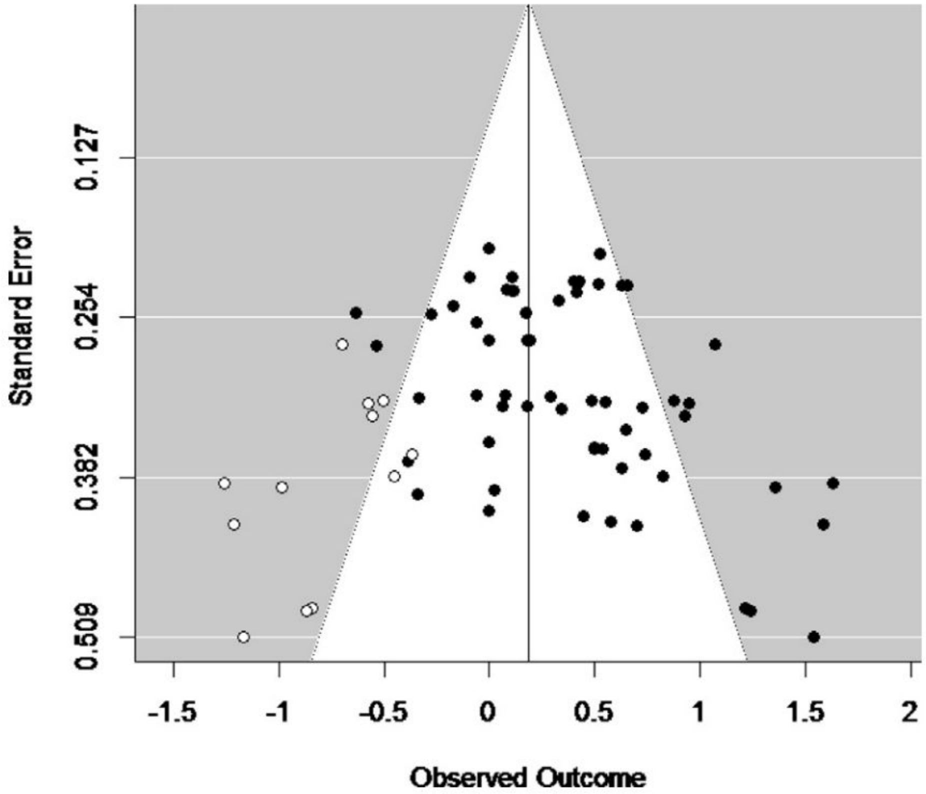

Fig. 3. Funnel plot of standard error over *d* (observed outcome) for the overall sample. Empty circles represent imputed trim and fill points.

Conclusions

‘overall advantage of motor experts compared to non-motor experts in spatial tasks’

‘expert type, stimulus type, and test type were significant moderators’

‘evidence for a publication bias in the sample of studies included in the analysis’

‘there is little support for an excess of significant findings in the present data set’

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The presence of a publication biases raises the possibility that we observed significant effects from a disproportionate number of studies with low power, as can be determined from the sample sizes reported in Table 1. To examine this possibility, we conducted a further analysis with the test of excess significant findings proposed by Ioannidis and Trikalinos (2007). In brief, these authors suggested a statistical test that compares observed significance for individual findings to the expected significance based on the statistical power available from the sample. This test produces a statistic distributed like χ^2 that compares observed and expected significant findings. To improve its power, Ioannidis and Trikalinos proposed a significance level of .10. A significant test therefore reflects an excess of significant results. Accordingly, implementation of this test with our data showed an observed number of significant findings of 26 and an expected number of 20.05. This difference failed to achieve significance, $\chi^2(1) = 2.61$, $p = .1065$, although close. It would therefore appear that there is little support for an excess of significant findings in the present data set.

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Resources

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Do actor-combatants' motor function, cognitive performance, and general well-being differ from those of martial artists and theatre actors?

Recording Starts (begins at Demographic and History Survey)

1. Informed Consent — 20 minutes
2. Demographic and History Survey — 30-40 minutes
3. Physical Warm-Up — 5 minutes
4. 2-Minute Push-Up Test — 5 minutes

5 Minute Break

5. Reaction Time Tasks — 15 minutes
6. Movement-Related Memory Tasks — 25 minutes
7. Language-Related Memory Tasks — 10 minutes
8. Spatial Ability Tests — 20 minutes
9. Well-Being Survey — 20-30 minutes