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PSYCHOLOGY
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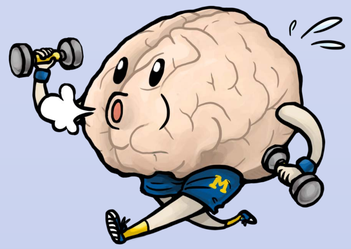
Working Memory Training and Transfer to Gf: Evidence for Domain Specificity?



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Presented at the 52nd Annual Meeting of the Psychonomic Society, Seattle, WA 2011

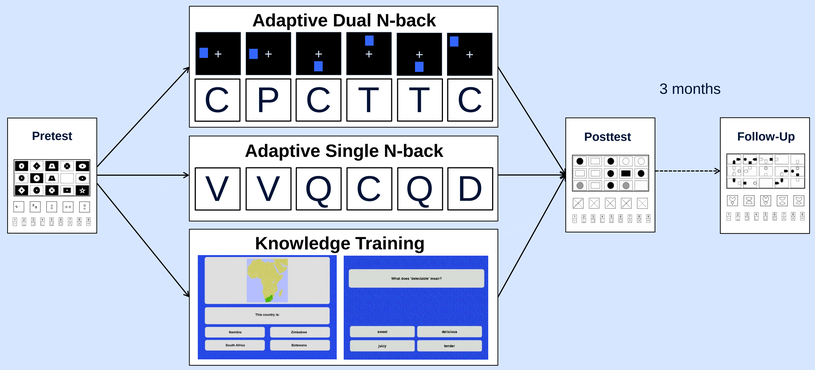
Introduction

We were recently able to show that a 4-week long training intervention with an adaptive n-back task leads to improvements in reasoning performance in healthy young adults (Jaeggi et al., 2008, 2010). In the current study, one group of participants trained on a dual n-back task (visuospatial and verbal material), whereas another group trained on a single n-back task (verbal material only). We investigated the extent of transfer in that we used multiple fluid intelligence (Gf) measures tasks which we combined into latent variables in order to investigate whether the effects we found previously are restricted to one specific test, or whether they can be regarded as more general. We compared the two experimental groups' gain in Gf with the gain of an active control group who trained on an intervention focusing on improving skills related to crystallized intelligence. We further assessed individual differences variables such as need for cognition and beliefs in intelligence to test whether those factors might mediate training or transfer.

Method

Participants: We had 209 participants signing up for the study. 175 of those volunteered for participation in a "Brain Training Study" and did not receive any payment or course credit. 37 participants (21%) withdrew from participation after having completed one or two pre-test sessions (i.e., they never trained). 60 participants (34%) dropped out at some point during training, after having trained for 8.43 sessions on average (SD: 6.27; range: 1-20). The final group of participants which completed pre- and post-testing, as well as a minimum amount of 15 training sessions consisted of 78 participants (mean age: 25.21, SD: 6.46; range: 18-45; 36 women). Finally, 34 participants (mean age: 22.79; SD; 6.11; range: 18-44; 17 women) were recruited to take part in two paid baseline measurement sessions.

Procedure



Questionnaires: Beliefs in Intelligence, Need for Cognition, Cognitive Failure Questionnaire

Transfer Measures:

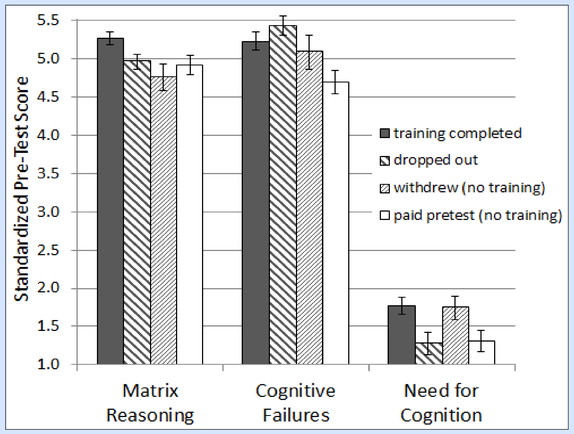
Matrices Tasks (untimed):	Visual Tasks (timed):	Verbal Tasks (timed):	Speed (timed):
- Raven's APM - BOMAT - Cattell's CFT	- Surface Development - Form Board - Space Relations	- Inferences - Reading Comprehension - Verbal Analogies	- Digit Symbol Test

Factor 1 (30% explained variance)	Factor 2 (30% explained variance)
• APM • BOMAT • Surface Development • Space Relations • Form Board	• CFT • Inferences • Reading Comprehension • Verbal Analogies
⇨ Visuospatial Factor	⇨ Verbal Factor

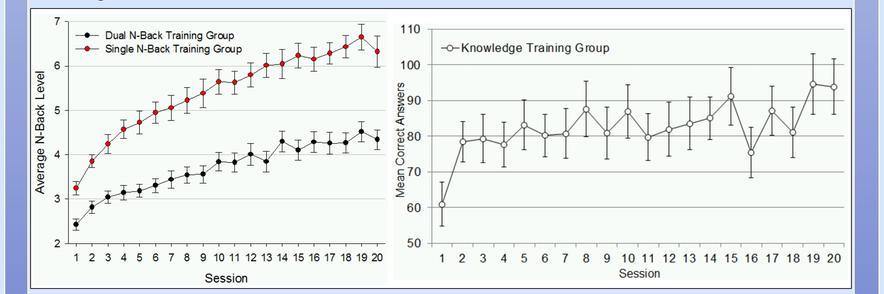
Note: DST did not load on either factor.

Results

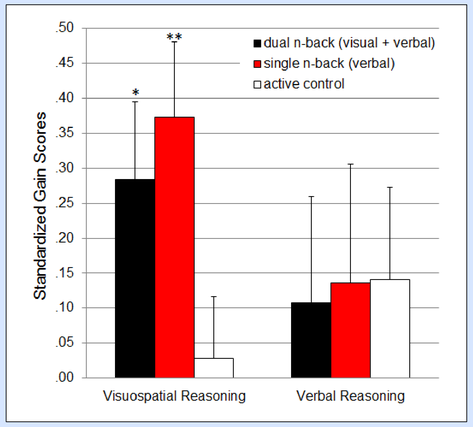
Pre-Existing Individual Differences - Who signs up for training and sticks to it?



Training Performance



Transfer – Latent Variables



References

Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Perrig, W. J. (2008). Improving Fluid Intelligence With Training on Working Memory. *Proceedings of the National Academy of Sciences of the United States of America, 105*(19), 6829-6833.

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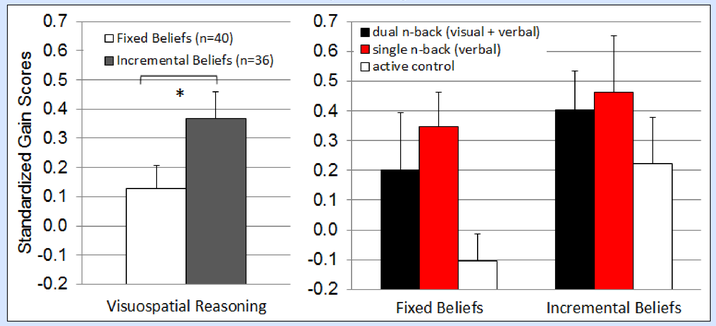
Transfer - Individual Measures Including Follow-Up Data

Table 1. Descriptive data for the transfer measures as a function of group and test session.

	Pre-Test			Post-Test			Follow-Up			Pre vs. Post			Pre vs. FU			Post vs. FU		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	p	r	ES	p	r	ES	p	r	ES
Dual N-back Training																		
Visuospatial Reasoning Factor	*25*	*3.84*	*.77*	*25*	*4.14*	*.84*				**	*.81*	*.60*						
APM	25	15.32	2.63	25	14.96	2.70					.64	-.16						
BOMAT	25	18.24	3.26	25	18.48	3.90	17	18.76	4.98		.70	.08		.66	.28		.60	.11
Surface Development	25	19.96	8.50	25	22.88	8.10				**	.80	.55						
Space Relations	25	12.40	4.17	25	13.36	4.08					.55	.25						
Form Board	25	61.92	26.20	25	75.68	25.20				***	.74	.74						
Verbal Reasoning Factor	*24*	*5.14*	*.87*	*25*	*5.63*	*.67*				**	*.38*	*.56*						
CFT	25	19.84	3.95	25	20.56	3.25	17	21.35	3.10		.20	.16	*	.59	.57		.55	.21
Inferences	25	7.16	1.91	25	7.68	1.68					.26	.24						
Reading Comprehension	25	7.52	2.02	25	7.60	2.57					.63	.04						
Verbal Analogies	24	.74	.10	25	.75	.08					.16	.09						
Speed																		
DST	24	67.88	13.26	25	70.36	12.77	17	73.18	15.04		.86	.36	***	.88	1.25	***	.94	1.01
Single N-back Training																		
Visuospatial Reasoning Factor	*26*	*3.84*	*.71*	*26*	*4.25*	*.76*				***	*.81*	*.90*						
APM	26	14.88	2.30	26	15.23	2.44					.51	.15						
BOMAT	26	17.31	3.03	26	18.96	2.84	14	18.14	4.05	*	.43	.53		.73	.28		.64	-.34
Surface Development	26	19.96	8.34	26	21.85	8.30				*	.85	.41						
Space Relations	26	12.54	3.97	26	14.27	3.24				**	.69	.59						
Form Board	26	73.19	28.37	26	80.54	24.79					.57	.30						
Verbal Reasoning Factor	*26*	*5.12*	*.73*	*26*	*5.65*	*.77*				*	*.10*	*.53*						
CFT	26	19.50	3.37	26	20.15	2.51	14	21.29	3.24		-.20	.17		.39	.24		.31	.29
Inferences	26	8.00	1.79	26	8.04	1.59					.00	.02						
Reading Comprehension	26	6.88	2.47	26	7.69	2.69					.36	.28						
Verbal Analogies	26	.74	.09	26	.74	.10					.13	.00						
Speed																		
DST	25	72.80	12.15	26	75.88	11.09	14	79.29	8.82	**	.90	.58	***	.86	1.09	0.06	.78	.55
Knowledge Training																		
Visuospatial Reasoning Factor	*27*	*3.92*	*.78*	*27*	*4.02*	*.75*					*.86*	*.25*						
APM	27	14.81	2.79	27	14.74	2.80					.56	-.03						
BOMAT	27	18.00	4.10	27	17.63	3.78	23	17.78	4.36		.69	-.12		.82	.02		.76	.23
Surface Development	27	21.41	8.23	27	22.56	7.65					.82	.24						
Space Relations	27	13.48	3.13	27	13.81	3.11					.13	.13						
Form Board	27	67.41	27.26	27	66.63	24.49					.70	-.04						
Verbal Reasoning Factor	*27*	*4.89*	*.76*	*27*	*5.46*	*.73*				**	*.32*	*.66*						
CFT	27	19.63	3.12	27	19.63	3.12	23	20.13	2.75		-.07	.00		.47	.28		.03	.13
Inferences	27	7.22	1.91	27	7.96	1.89				*	.61	.44						
Reading Comprehension	27	6.04	2.77	27	5.85	2.78					.74	-.09						
Verbal Analogies	27	.72	.10	27	.75	.09					.09	.23						
Speed																		
DST	27	68.67	11.26	27	71.85	11.41	23	73.39	12.76	*	.77	.41	***	.89	.76		.76	.18

Note: r=re-test reliability (Pearson Correlation); ES= Effect size (Cohen's d). *p<.05; **p<.01; ***p<.001; Values are given as standardized scores for the factors (in color and italics), and as raw scores for the individual measures.

Individual Differences in Beliefs About the Malleability of Intelligence and Transfer



Conclusion

The current study is promising in that we observed transfer in a latent variable of Gf, providing evidence for broader generalization effects than we have demonstrated in our previous studies. Interestingly, the processes underlying n-back training seem to be domain free in that training on a verbal n-back task results in transfer on measures of visuospatial reasoning. On the other hand, the transfer effects seem to be restricted to the visuospatial domain, however, reliability issues in the verbal tasks might have prevented any transfer to occur. Finally, there seem to be important boundary conditions, one of which is related to intrinsic motivation to sign up for such a study, but also to stick with the intervention, and further, individual differences such as pre-existing ability, need for cognition, and beliefs in intelligence; all of which need to be considered in order get to a better understanding of why it is that some studies result in transfer to Gf, whereas others do not.

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Support: This work is funded by the ONR (N00014-09-022).