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Multiple Object Tracking Ability, Working Memory Capacity and Other Individual Predictors of Complex Task Performance

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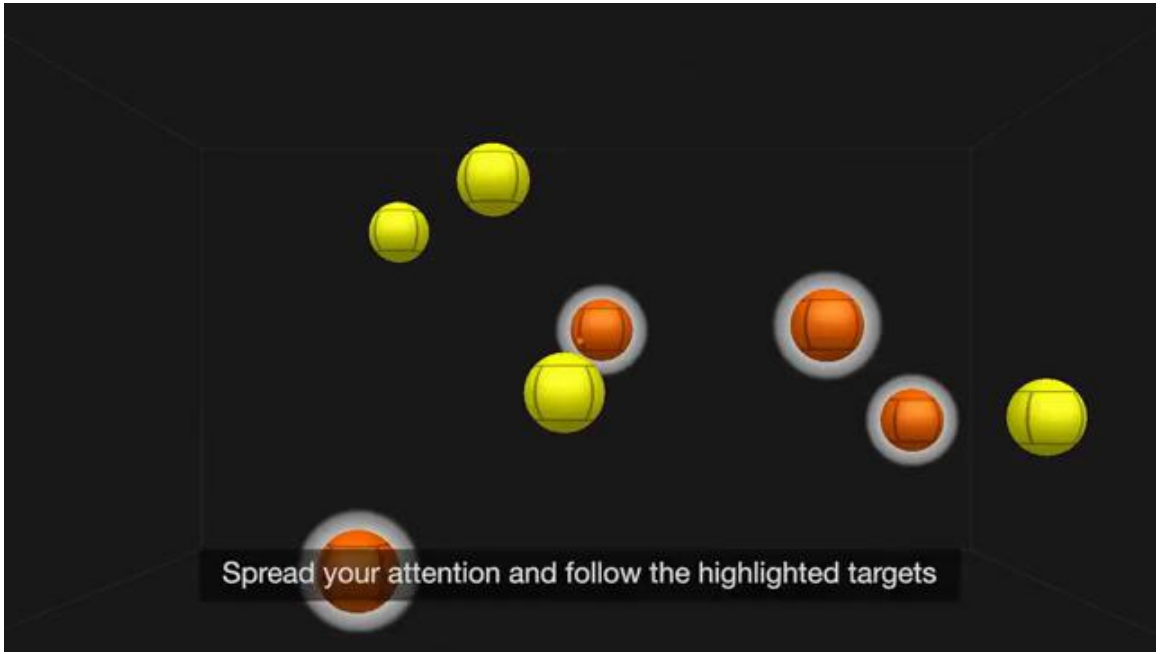
Multiple Object Tracking (MOT)

- The ability to track multiple objects is important in everyday activities and many high-risk occupations
- MOT tasks are proposed to measure:
  - Information processing speed
  - Working memory
  - Sustained, selective, and divided attention
- Age and action video game experience have been suggested to influence MOT performance

NeuroTracker

- Commercially available MOT task developed by Cognisens



NeuroTracker (continued)

- Research suggests it may be predictive of performance on:
  - Simulated surgical task (Harenberg et al, 2016)
  - Driving simulation task (Woods-Fry et al, 2016)
  - Professional basketball performance (Mangine et al, 2014)
- However, studies are small and not all have found associations
- No studies have examined whether NeuroTracker can predict performance on defence-relevant tasks (e.g. air traffic control)

Air Traffic Control (ATC)

- Requires multiple moving objects to be tracked simultaneously
- Is complex and cognitively demanding
- Cognitive abilities linked to performance on simulated ATC tasks:
  - Selective and sustained attention
  - Working memory
  - Spatial ability
  - Information processing speed

The Current Study

- **Primary Aim:** Examine the utility of NeuroTracker (MOT) as a predictor of complex task performance using a simulated ATC task
  - Compared to two working memory tasks linked to ATC task performance (Bender et al, 2018); Corsi block-tapping task and Operation span (OSPAN) task

- **Hypotheses:**
  - H1: MOT positively associated with ATC task performance
  - H2: MOT better predictor of ATC task performance than either working memory test

The Current Study

- **Secondary Aim:** Examine the influence of action video game experience and age on MOT and ATC task performance

- **Hypotheses:** MOT ability and ATC task performance will be:
  - H3: Positively associated with AVG experience (Green & Bavelier, 2006)
  - H4: Negatively associated with age (Dreary et al., 2009).

Methodology

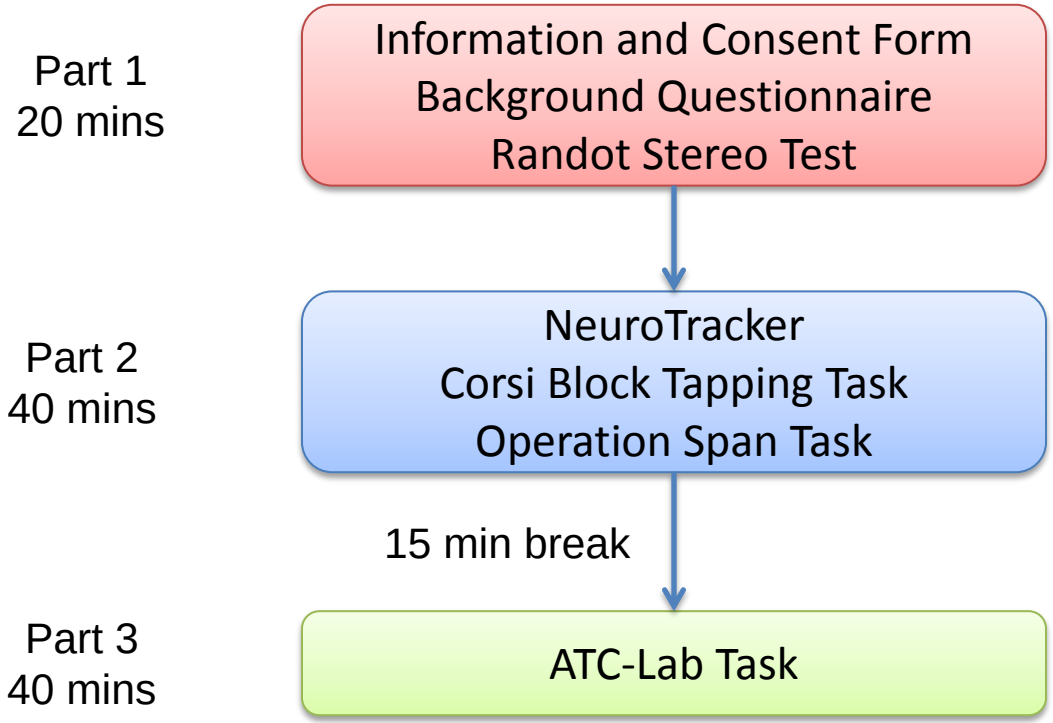
Participants

- 46 healthy adults with normal vision (37 males)
- Age range = 20 to 55 years (*M* = 28.7, *SD* = 9.1)

Study Design

- Within-subjects design with convenience sample
- G*Power used to estimate required sample size

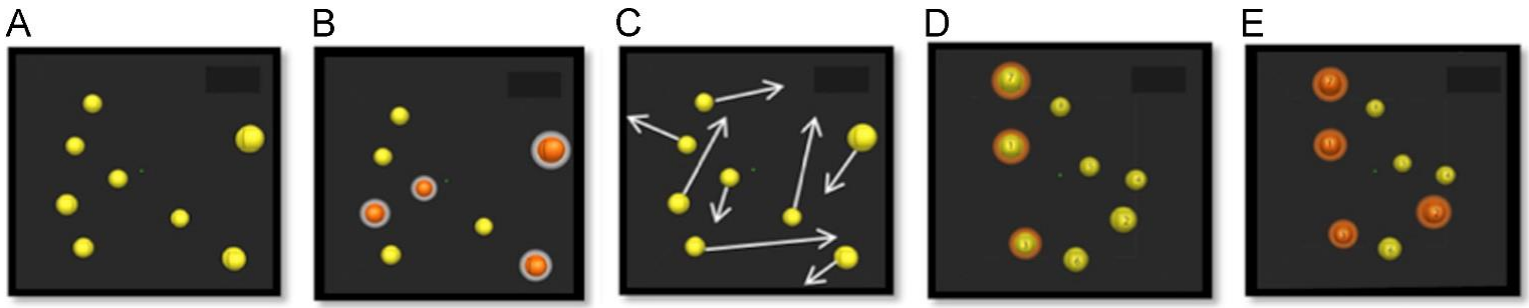
Methodology: Procedure



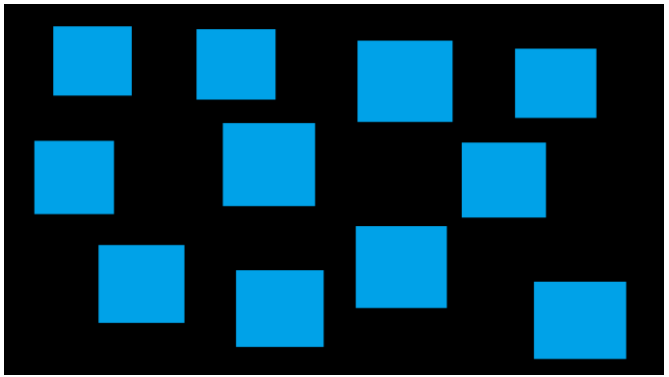
Methodology: Tasks and Measures

MOT Task (NeuroTracker)

- **Task**: Track four target balls while ignoring four identical distractor balls
- **Measure**: Average visual tracking speed over 60 trials



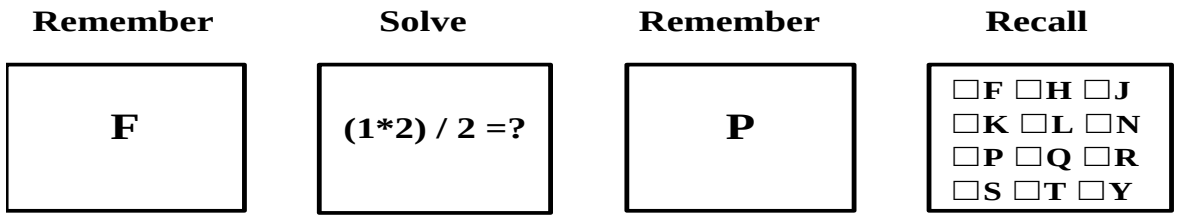
Corsi Block Tapping Task (Corsi, 1972)



- **Task**: Remember a sequence of 2 to 9 blocks
- **Measure**: Length of last correctly recalled sequence

Automated OSPAN Task (Redick et al, 2012)

- **Task**: Remember a series of letters while simultaneously solving simple math problems
- **Measure**: Total number of letters correctly recalled in the correct sequence



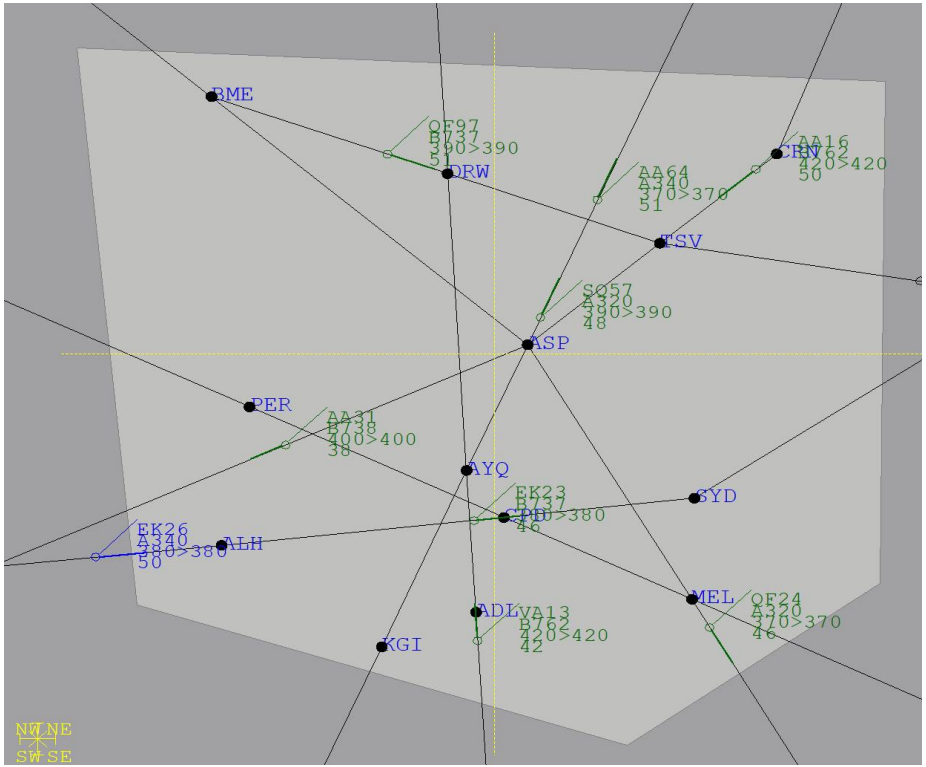
Air Traffic Control-Lab Task (Fothergill, Loft & Neal, 2009)

Tasks

- Accept all aircraft entering sector
- Handoff all aircraft leaving sector
- Correct conflicts between aircraft

Measures

- Accept and handoff response time
- Accept and handoff accuracy
- Conflict response time
- Conflict accuracy
- Conflict false alarms



Method: Analyses

- Descriptive statistics and correlations calculated for all variables
- A series of hierarchical multiple regressions run in 3 steps:
  - Step 1: Action video game (AVG) experience and age
  - Step 2: AVG, age and NeuroTracker
  - Step 3: AVG, age, Corsi, OSPAN and NeuroTracker

Results

H1: MOT will be associated with better ATC performance

- NeuroTracker was correlated with 2/5 ATC measures:
  - Accept and handoff response time: r =- 0.36, p =.017
  - Conflict false alarms: r =-0.39, p =.010

Results (continued)

H2: MOT will be a better predictor of ATC performance than either WM test

Task	Accept and Handoff Response Time	Accept and Handoff Accuracy	Conflict Response Time	Conflict Accuracy	Conflict False Alarms
NeuroTracker					
Corsi					
OSPAN					

Results (continued)

H3: AVG experience will be positively associated with MOT and ATC task performance

- AVG experience correlated with accept and handoff response time: $r = 0.53$, $p < .001$
- No significant correlation with MOT performance $r = -0.12$, $p > .050$

H4: Age will be negatively associated with MOT ability and ATC task performance

- No significant correlations found

Strengths and Limitations

Strengths

- Use of standardised protocol for test administration
- Use of well validated tests (ATC-Lab, Corsi, OSPAN)
- Sufficiently powered sample size

Limitations

- Use of convenience sample
- Non-randomisation of test order
- Large percentage of ATC task performance variance unexplained

Future Research

- Replicate study with a more representative sample
- Increase ATC task complexity and realism
- Compare NeuroTracker's predictive utility with a greater battery of cognitive tests
- Investigate influence of other personal characteristics on complex task performance

Conclusion

- NeuroTracker potentially more predictive of ATC performance than either working memory test
- Findings generally consistent with previous studies that have used NeuroTracker as a predictor variable
- Results suggest further research into the predictive utility of NeuroTracker for complex task performance is warranted
- Potential utility as screening tool requires further research

Acknowledgements

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- Associate Professor Shayne Loft for providing access to ATC-Lab
- Dr Angela Bender for assistance with setting up ATC-Lab task
- Dr Sasha Quayum for assistance with data collection
- All participants for their time and contribution

Scale	1	2	3	4	5	6	7	8	9	10
1. NeuroTracker										
2. Corsi	.41**									
3. OSPAN	.50**	.26								
4. Response time	-.36*	-.25	-.18							
5. Response accuracy	.28	.39**	.09	-.49**						
6. Conflict time	-.16	-.44**	-.22	.41**	-.47**					
7. Conflict accuracy	.27	.38*	.16	-.56**	.54**	.67**				
8. Conflict false alarms	-.39*	-.02	-.16	.23	-.07	-.38*	-.01			
9. Age	.08	-.03	.15	.05	.02	.10	.01	-.18		
10. Gender	-.10	-.12	.04	.14	.05	.22	-.08	-.05	.18	
11. Action video games	-.12	-.11	.05	.53**	.03	.17	-.06	-.00	.31*	.33*

Note. * $p < .05$, * *$p < .01$

Response Time

Variable	β	t	p	sr^2	R^2	ΔR^2
					.23	.23
Response time						
Step 1						
Constant	16.87	3.85	<.001			
Age	.02	.13	.894	.00		
AVG	8.53	3.05	.004	.18		
Step 2					.34	.11
Constant	26.41	4.82	<.001			
Age	.03	.24	.810	.00		
AVG	7.67	2.90	.006	.17		
NeuroTracker	-7.40	-2.62	.012	.15		
Step 3					.35	.01
Constant	30.63	2.86	.007			
Age	-.00	-.00	.998	.00		
AVG	7.76	2.86	.007	.18		
NeuroTracker	-7.09	-1.94	.060	.09		
Corsi	-1.11	-.73	.472	.01		
OSPAN	.06	.48	.637	.01		

Response Accuracy

Variable	X^2 (df)	Log Likelihood	Nagelkerke R^2	Coefficient Estimates	Standard Error	Odds Ratio
Response accuracy	2.37(2)	-38.65	.06			
Model 1						
Intercept				7.51	1.41	1861.77
AVG				-.94	.74	.39
Age				-.04	.03	.96
Model 2	20.93**(3)	-29.37	.45			
Intercept				5.37	2.00	215.18
AVG				-1.77	1.03	.17
Age				-.08	.04	.93
NeuroTracker				3.86*	1.16	47.41
Model 3	26.77**(5)	-26.45	.54			
Intercept				.42	3.40	1.52
AVG				-2.03	1.31	.13
Age				-.05	.05	.96
NeuroTracker				3.27*	1.28	26.26
Corsi				1.17*	.52	3.23
OSPAN				-.04	.03	.96

Note. * $p < .050$, ** $p < .001$

Conflict Accuracy

Variable	X^2 (df)	Log Likelihood	Nagelkerke R^2	Coefficient Estimates	Standard Error	Odds Ratio
Conflict accuracy	3.37(2)	-106.73	.08			
Model 1						
Intercept				2.71	.62	15.00
AVG				-.27	.32	.76
Age				-.03	.02	.97
Model 2	34.31**(3)	-91.26	.55			
Intercept				.82	.76	2.28
AVG				-.52	.36	.59
Age				-.04*	.02	.96
NeuroTracker				2.18**	.44	8.83
Model 3	46.82**(5)	-85.00	.67			
Intercept				-3.57	1.66	.03
AVG				-.39	.38	.68
Age				-.01	.02	.99
NeuroTracker				1.83**	.49	6.23
Corsi				.78*	.23	2.18
OSPAN				-.02	.01	.98

Note. * $p < .050$, ** $p < .001$

Conflict False Alarms

Variable	X^2 (df)	Log Likelihood	Nagelkerke R^2	Coefficient Estimates	Standard Error	Odds Ratio
Conflict False Alarms	1.67(2)	-112.58	.04			
Model 1						
Intercept				2.37	.69	10.70
AVG				-.20	.37	.82
Age				-.03	.02	.98
Model 2	8.87*(3)	-108.99	.19			
Intercept				3.52	.82	33.82
AVG				-.02	.38	.98
Age				-.02	.02	.98
NeuroTracker				-1.29*	.48	.28
Model 3	9.37(5)	-108.73	.20			
Intercept				2.55	1.78	12.80
AVG				-.01	.38	.99
Age				-.02	.02	.98
NeuroTracker				-1.54*	.60	.22
Corsi				.09	.23	1.09
OSPAN				.01	.02	1.01

Note. * $p < .050$, ** $p < .001$