PROBLEM SOLVING AND INTELLIGENCE

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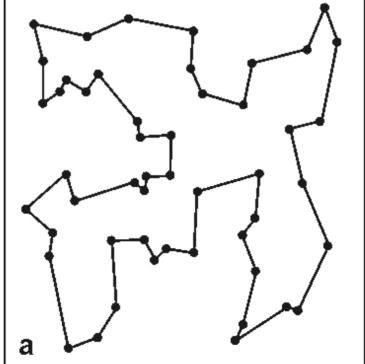
Human Cognition and Applied Decision Making Research Unit

Perceptual optimisation problems:

- Travelling Salesman Problems (TSP)
- Minimum Spanning Tree Problems (MSTP)
- Generalised Steiner Tree Problems (GSTP)

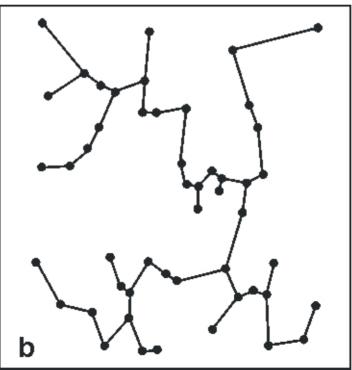
Travelling Salesman Problem:

• a series of *n* cities; devise a route whereby each is visited once and only once, concluding at the city where it began and with the overall distance as short as possible



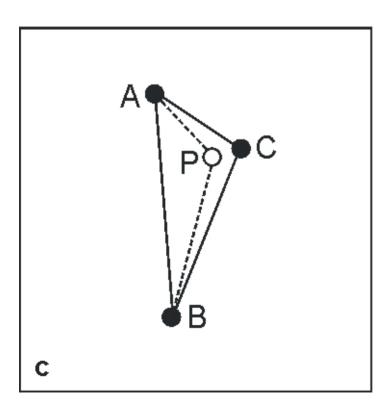
Minimum Spanning Tree Problem:

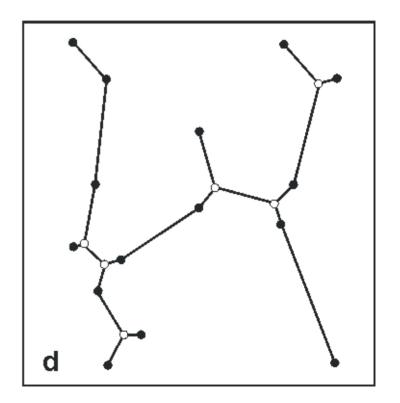
 find the shortest path that directly links all nodes in the array – does not have to be continuous and closed



Generalised Steiner Tree Problem:

• Shortest path connecting three points in a plane - create links from Fermat point





Vickers et al. (2004):

• TSP and Minimum Spanning Tree and Generalised Steiner Tree Problems

- notionally differing degree of use of automatic perceptual vs cognitive processes
- Experiment 1
 - *N* = 69; 50-node TSP (x5); RAPM
- Experiment 2
 - *N* = 48; 50-node TSP, MSTP, 15 node GSTP (all x2); RAPM

Vickers et al. (2004):

Performance quantified as proportion above benchmark

Expt 1: TSP and RAPM: $r_m = -.37$, $CI_{95} = [-.56, -.15]$

Expt 2: TSP and RAPM:r = -.46, $CI_{95} = [-.66, -.20]$ MSTP and RAPM:r = -.44, $CI_{95} = [-.64, -.17]$ GSTP and RAPM:r = -.46, $CI_{95} = [-.66, -.20]$

TSP, MSTP, GSTP: mean r = .67, CI₉₅ = [.47,.80] Mean test-retest reliability r = .7Chronbach's $\alpha = .84$ for five instances of TSP

3G General Intellig	ence						
2F* Fluid Intelligence Level factors: - General sequential reasoning (RG) -Induction (I) - Quantilive reasoning (RQ) -Piagetian reasoning (RP) Speed factors: - Speed of reasoning (RE?)	2C* Crystallized intelligence Level factors: - Language development (LD) - Verbal (printed) language comprehension (V) - Lexical knowledge (VL) - Reading Comprehension (RC) - Reading decoding (RD) - Cloze ability (CZ) - Spelling ability (CZ) - Grammatical sensitivity (MY) - Foreign Language aptitude (LA) - Communication ability (CM) - Listening ability (CM) - Listening ability (CM) - Drai production and fluency (OP) - Writing ability (WA)	2Y General memory and learning Level factor: - Memory span (MS) Rate factors: - Associative memory (MA) - Free recal memory (MA) - Free recal memory (MG) - Meaningful memory (MM) - Visual memory (MV) - Learning ability (LI)	2V Broad visual perception Level factor: - Visualization (VZ) Speed factors: - Spatial relations (SR) - Ciosure speed (CS) - Flexibility of closure (CF) - Serial perceptual integration (PI) - Spatial scanning (SS) - Perceptual speed (P) Miscellaneous: - Imagery (IM) - Length estimation (LE) - perception of illustions (IL) - Perceptual alterations (PN)	2U Broad auditory perception Level factors: - Heaning and speech threshold factors (UA, UT, UU) - Speech sound discrimination (US) - General sound discrimination (US) - Sound-frequency discrimination (US) - Sound-frequency discrimination (US) - Sound-intensity/duration discrimination (UB) - Nusical discrimination and judgement (U1, U9) - Resistance to auditory silimulus distortion (UR) - Tempral tracking (UK) - Tempral tracking (UK) - Maintaining and Judging intythm (UB) - Memory for sound patterns (UM) - Absolute pitch (UP) - Sound localization (UL)	2R Broad retrieval ability Level factor: - Orginality/ creativity (FD) Speed factors: - Ideational fluency (FI) - Naming facility (NA) - Associational fluency (FA) - Expressional fluency (FE) - Word fluency (FW) - Sensitivity to problems (SP) - Figural fluency (FF) - Figural flexibility (FX)	2S Broad cognitive speediness Level factors: - Rate of test taking (R9) - Numerical facility (N) - [Perceptual speed (P) - also listed under 2V}	2T Processing speed (RT decision speed) Level factors: - Simple reaction time (R1) - Choice reaction time (R2) - Semantic processing speed (R4) - Mental companison speed (R7)

Question is whether these correlations with Raven reflect shared perceptual processes, or shared cognitive processes, or both of them

Issue that Raven, while considered a pure measure of $g_{,}$ is a rather narrow measure of cognitive abilities

Perception is even more intelligent than has been generally assumed or cognition is more perceptually based?

Cognitive optimisation problems:

• Secretary Problems (SecP)

• From a sequence of possible choices, accept or reject each in turn; choose the maximum value

- Distribution of numbers is known; number of values to be presented is known
- All incorrect decisions are equally wrong

Secretary Problem:

• From a sequence of possible choices, accept or reject each in turn; choose the maximum value

79.69

[1/5]

Secretary Problem:

• From a sequence of possible choices, accept or reject each in turn; choose the maximum value



[2/5]

Secretary Problem:

• From a sequence of possible choices, accept or reject each in turn; choose the maximum value



[3/5]

Secretary Problem:

• From a sequence of possible choices, accept or reject each in turn; choose the maximum value

95.77

[4/5]

Secretary Problem:

• From a sequence of possible choices, accept or reject each in turn; choose the maximum value

24.26

[5/5]

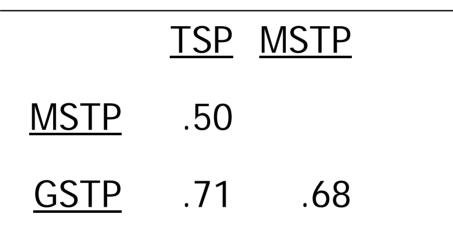
Method:

- *N* = 101; 58 males; mean age 25.3±7.6 yrs
- TSP (30-,60-,90-nodes, 1 of each)
- MSTP (30-,60-,90-nodes, 1 of each)
- GSTP (15-,20-,25-nodes, 1 of each)
- SecP (5-point and 10-point, 40 of each)
- RPM, CCFT (Fluid ability, Gf; Visuo-spatial ability, Gv)
- Picture Swaps (Gf)
- Spatial Relations, Space Relations (Gv)
- Digit Symbol, Visual Matching (Speed of processing, Gs)

Correlations with RPM:

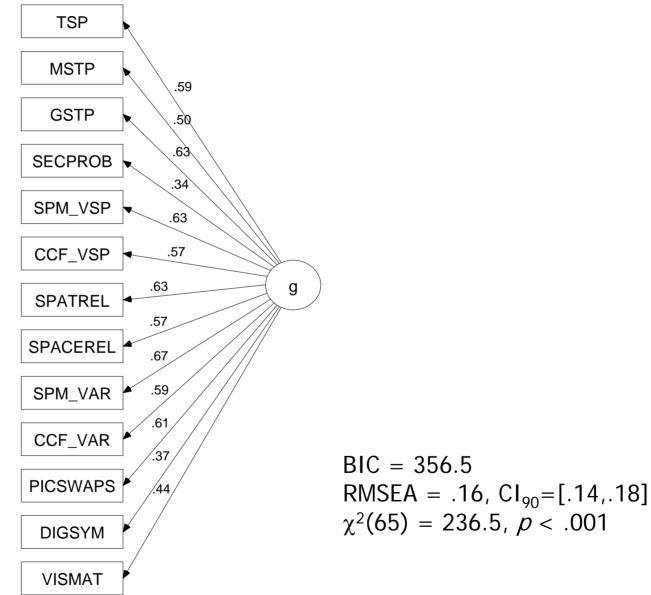
<u> </u>	<u>CI</u> 95	Vickers et al
<u>TSP</u> 35	[51,17]	41
<u>MSTP</u> 25	[43,06]	44
<u>GSTP</u> 46	[60,29]	46

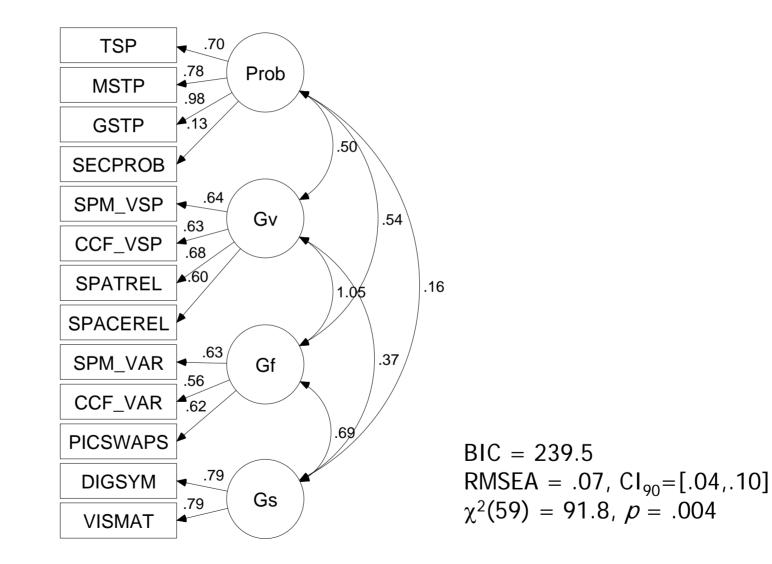
Correlations among problem solving tasks:

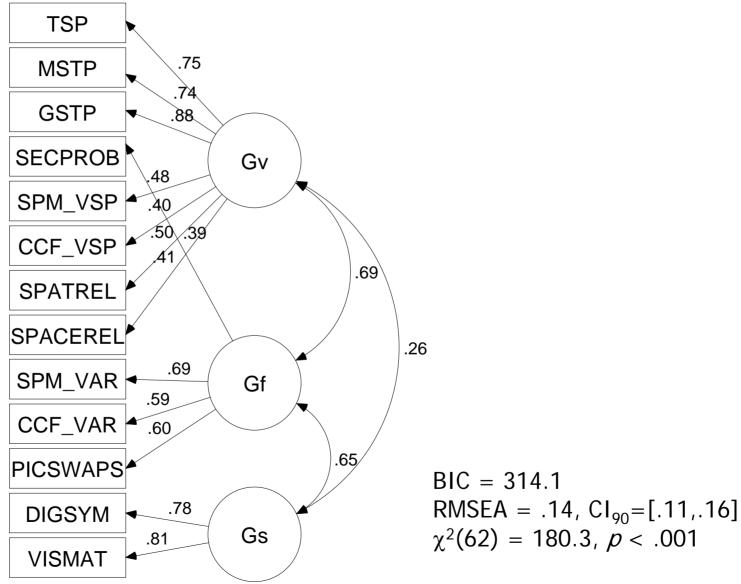


Three initial models to generate observed covariance structure:

- Single general factor (cf Spearman)
- Separate problem solving ability correlated with Gf, Gv, Gs
- Perceptual problem solving tasks load Gv and SecProb loads Gf

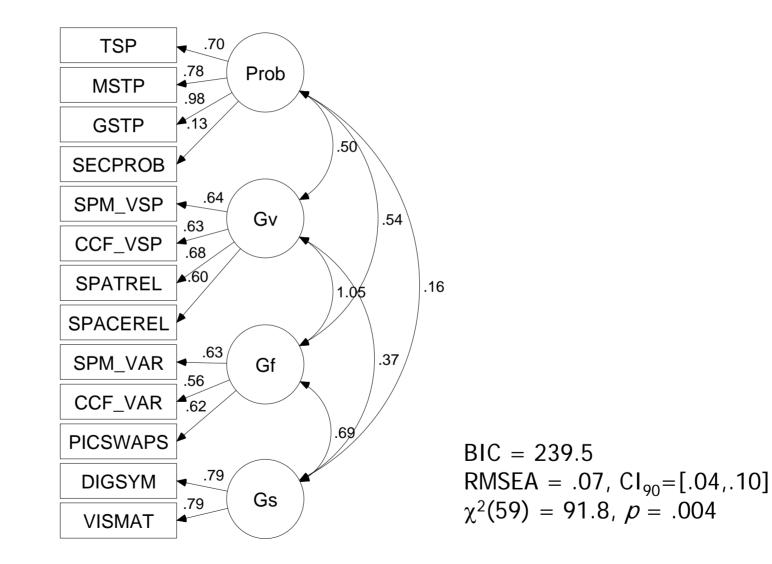


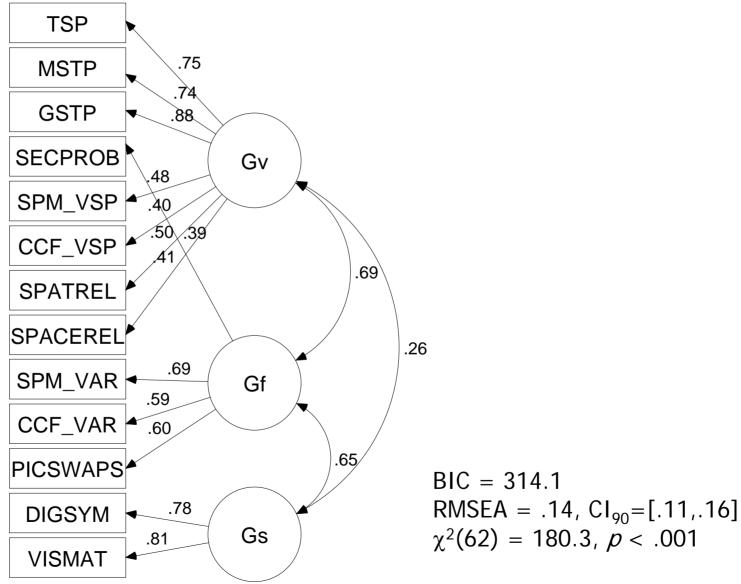


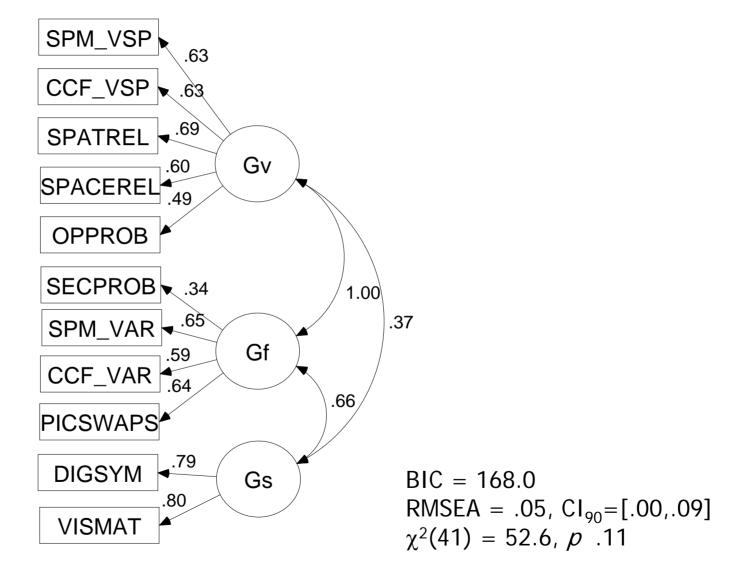


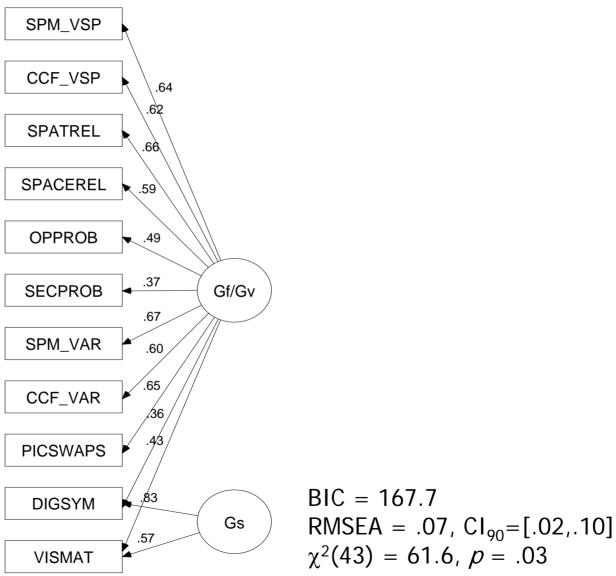
Comparison of models:

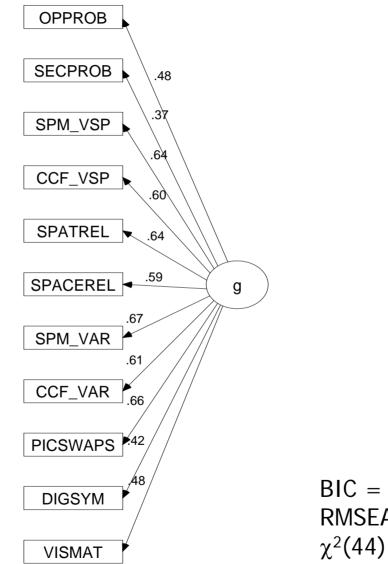
Model	BIC	<u>RMSEA</u>	<u>Chi-sq</u>	<u>df</u>	þ
<u>1</u>	356.5	.16	236.5	65	<.001
<u>2</u>	239.5	.07	91.8	59	.004
<u>3</u>	314.1	.14	180.3	62	<.001
Saturated	420.0	-	0	0	-
<u>Null</u>	596.6	.24	536.6	78	<.001











BIC = 199.6 RMSEA = .11, CI_{90} =[.08,.14] $\chi^{2}(44) = 98.1$, p < .001

Definitions of intelligence invariably make reference to problem solving

Perceptual optimisation problems can be represented by a single measure

Both perceptual and cognitive optimisation problems load a general ability factor (.5 and .4, respectively)

Potential to use optimisation problems as part of assessment batteries

Inform cognitive models of problem solving

Intelligence:

 ability to reason, plan, <u>solve problems</u>, think abstractly, comprehend complex ideas, learn quickly and learn from experience

Difficult optimisation problems:

- can often be stated simply and readily understood
- related to real world problem solving

The End ...