THE AGING DECISION MAKER: COGNITIVE AGING AND THE ADAPTIVE SELECTION OF DECISION STRATEGIES

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Motivation Hypothesis
Methods Results
Discussion

OUR ROADMAP

HOW DO COGNITIVE RESOURCES INTERACT WITH TASK DEMANDS?

- Natural ageing will affect the cognitive resources available to a DM
  - Impaired executive functioning
  - Weaker preference for deploying effort
- Different task environments will require different demands of a DM
  - Environment: statistical structure of the relevant set of objects and conditions by which one is surrounded
- Present two 'task environments' to both young and old participants:
  - High cognitive resource requirements
  - Low cognitive resource requirements

HYPOTHESIS 1: OLDER ADULTS CHOOSE SIMPLER STRATEGIES

- Strategy choice will be explained by differences in fluid cognitive abilities

- Lower fluid cognitive abilities will place capacity limits on the quantity and quality of cognitive effort, making more complex strategies infeasible
  - Choose simpler strategies instead

HYPOTHESIS II: OLDER ADULTS ARE MORE ADAPTIVE IN THEIR STRATEGY SELECTION

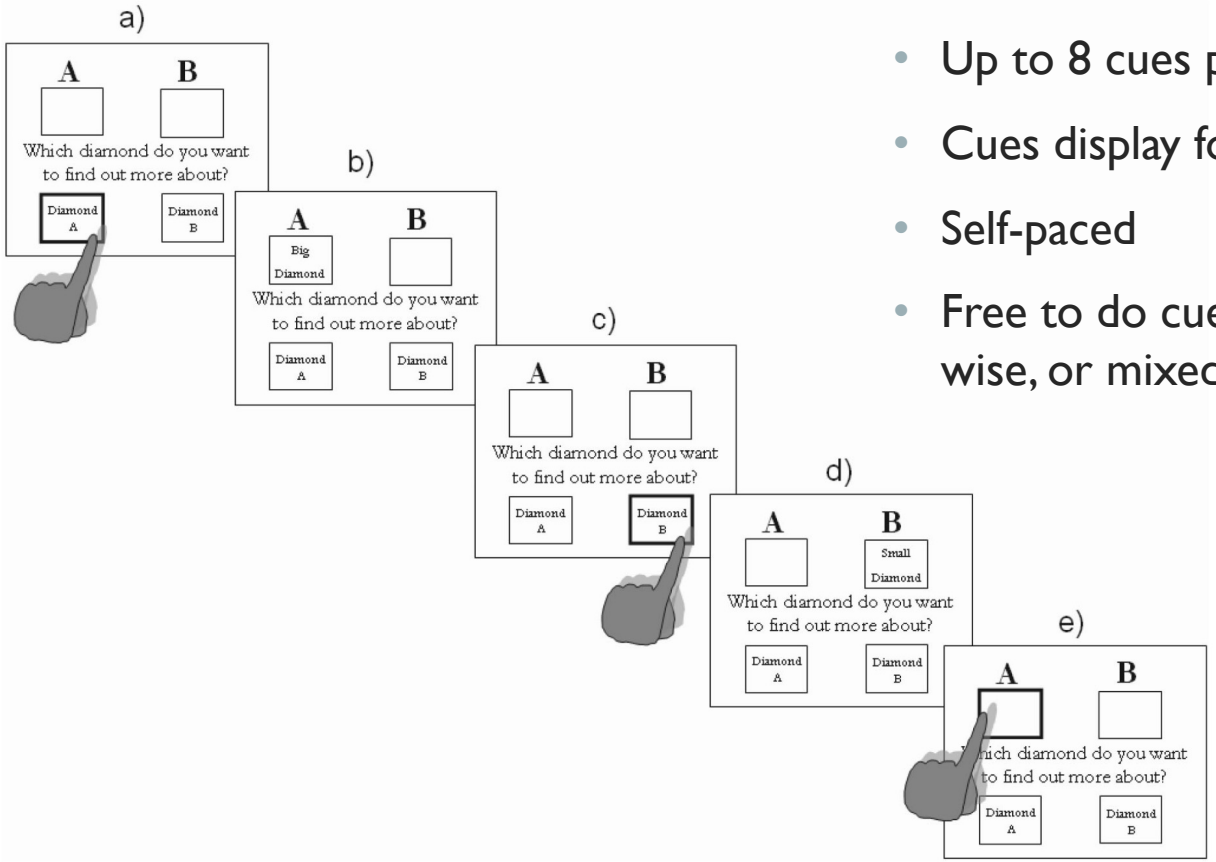
- Adaptive: deploying the right type of strategy to the right type of environment
- Differences in adaptivity will be explained by crystallised cognitive abilities
  - Perhaps subject to a floor in fluid cognitive abilities
- Older adults' experience may make them better at identifying which environment they're in, and then deploying the appropriate strategy

PSYCHOMETRIC TESTS

- Fluid cognitive abilities
  - Processing speed (3 tasks)
  - Reasoning (3 tasks)
  - Working memory (3 tasks)

- Crystallised cognitive abilities
  - Verbal knowledge (2 tasks)

MAIN TASK (INFERENCE)



- Up to 8 cues per diamond
- Cues display for 2s, can't go back
- Self-paced
- Free to do cue-wise, alternative-wise, or mixed search

HIGH- VS LOW-RESOURCE ENVIRONMENT

- **Cue validity:** probability a cue correctly discriminates between the two options
- **High cognitive resource environment:** each cue has an equal validity of 71%
  - Evidence from early cues could be overruled by later cues
  - Favours information-intensive search strategies
- **Low cognitive resource environment:** descending cue validity, first cue is 81% while the last cue is 54%
  - Evidence from early cues unlikely to be overruled by later cues
  - Favours short and simple search strategies
- Participants fully informed as to which environment they assigned to (between subjects)

BENCHMARK STRATEGIES

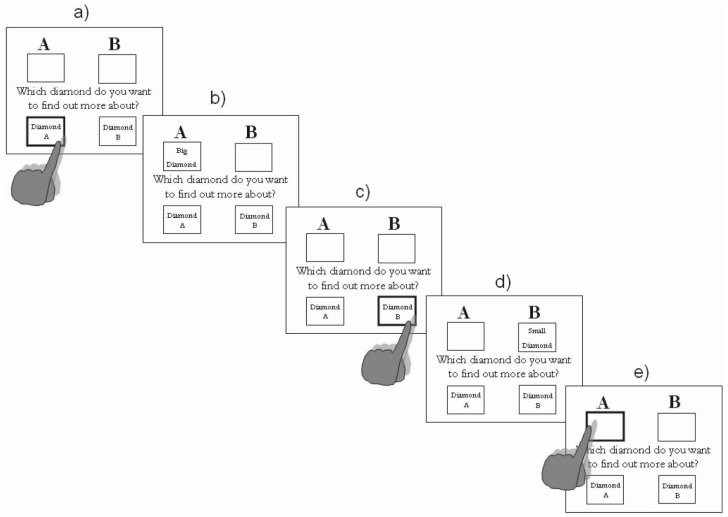
- **Take the Best (TTB):** choose the option that does better on the first cue
- **Take Two:** choose the first option to win on two cues
- **Weighted Additive Rule (WADD):**
  - Code each cue as a 0 or 1 depending on which option it favours
  - Multiply this vector by the vector of cue validities
  - Sum the vector
  - Choose the option with the higher score

MEASURED STRATEGY COMPLEXITY WITH ELEMENTARY INFORMATION PROCESSES

- Elementary Information Processes (EIPs) considered were:
  - Read
  - Compare
  - Add
  - Multiply
  - Guess
  - Decide
- Count total number of EIPs for each given strategy
- **Reference**: Payne, Bettman, and Johnson, 1993

EIP EXAMPLE: TAKE THE BEST

- Take the best:
  - Read cue 1, option 1
  - Read cue 1, option 2
  - Compare cues
  - Decide



- Number of EIPs: 3x + 1, where x is the number of cues needed to find a winner

EIP EXAMPLE: WADD

- WADD:
  - Read every cue for both options (8*2 = 16)
  - Multiply each cue value by cue probability (8)
  - Sum these products (7)
  - Compare sums
  - Decide
  - Guess

- Number of EIPs: 33-34

EIPS SHOW A CLEAR DIFFERENCE IN COMPLEXITY BETWEEN STRATEGIES

Table S.1

Means and Standard Deviations of Elementary Information Processes (EIPs) as a Function of Decision Strategy in our Experiment

EIP	Decision strategy					
	TTB		Take Two		WADD	
	M	*SD*	*M*	*SD*	*M*	*SD*
Read	143	6	349	11	800	0
Compare	72	3	174	6	50	0
Add	—	—	123	2	400	0
Multiply	—	—	—	—	400	0
Decide	50	0	50	0	50	0
Guess	—	—	—	—	2	2
Total	265	8	696	18	1702	2

INSTANCE SAMPLING

- To the extent possible, instances were designed to allow for discrimination between the three benchmark strategies
- Instances in high resource environment were sampled to ensure that:
  - WADD > Take Two > TTB
- Instances in low resource environment were sampled to ensure that:
  - TTB > Take Two > WADD
- Participants did not know how the instances were sampled

MODELLING

- Classified strategy use at the participant level, based on which strategy they used most often
  - Generate predictions for search and choice, for each strategy
  - Count the number of trials on which a given strategy best predicted both search and choice
  - If two strategies are equally predictive, leave the participant unclassified

- Three measures of information search
  - Total cues sampled (ACQ)
  - Time on task (TIME)
  - Custom metric that ranged from -1 (pure cue-wise search) to 1 (pure alternative-wise search) (INDEX)

PROCEDURE

- 83 younger (mean 24, SD 3.3) and 86 older (mean 71, SD 4.9) participants
- In person lab experiment, $10 p/hr + $0.1 per correct answer
  - 2.5 hours for young adults, 3.5 hours for older adults
  - 1 practice trial for young adults, 5 practice trials for older adults
- First complete 50 trials of the inference task (each participant only in one environment)
- Then complete the 11 psychometric tests

HEADLINE RESULTS

- Older adults performed worse, earning ~10% less
- Support for hypothesis I: older adults tended to use simpler strategies, searching for less information and taking more time to process each cue
  - Most of the differences could be explained by reduced reasoning / fluid intelligence
- No support for hypothesis II: both younger and older adults were similarly adaptive, using WADD (TTB) more often in the high (low) resource environment
  - Crystallised intelligence was not related to any of the search measures

OLDER ADULTS SEARCHED FOR LESS INFO AND TOOK MORE TIME TO PROCESS CUES

Table 1
Means and Standard Deviations (SD) for the Search Variables by Age Group and Environment

Search variables	Young adults				Older adults			
	Equal validities		Unequal validities		Equal validities		Unequal validities	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Acquisitions	13.00	2.00	11.00	3.00	11.00	4.00	8.00	4.00
Search index	−.12	.74	−.61	.33	−.16	.75	−.40	.51
Look-up time	610.00	210.00	710.00	250.00	1,350.00	550.00	1,600.00	630.00

Note. Acquisitions represents the number of cue values searched for. Search index characterizes the type of information search: Positive values indicate a more alternative-wise search and negative values indicate a more cue-wise search. Look-up time represents the median time required to process a cue value (in milliseconds).

MORE OLDER ADULTS USED SIMPLER STRATEGIES

Table 2
Strategy Classification by Age Group and Environment

	Young adults				Older adults			
	Equal validities		Unequal validities		Equal validities		Unequal validities	
Strategy	No.	%	No.	%	No.	%	No.	%
TTB	1	2	1	3	3	8	14	33
Take Two	5	12	13	33	10	24	10	24
WADD	35	86	24	61	27	66	17	41
Unclassified	0	0	1	3	1	2	1	2
Total	41	100	39	100	41	100	42	100

Note. TTB = Take The Best; WADD = weighted additive rule.

BOTH GROUPS USED SIMPLER STRATEGIES IN THE LOW COG. RESOURCE SETTING

Table 2
Strategy Classification by Age Group and Environment

	Young adults				Older adults			
	Equal validities		Unequal validities		Equal validities		Unequal validities	
Strategy	No.	%	No.	%	No.	%	No.	%
TTB	1	2	1	3	3	8	14	33
Take Two	5	12	13	33	10	24	10	24
WADD	35	86	24	61	27	66	17	41
Unclassified	0	0	1	3	1	2	1	2
Total	41	100	39	100	41	100	42	100

Note. TTB = Take The Best; WADD = weighted additive rule.

THE SEARCH STRATEGIES WERE DECENT AT PREDICTING BEHAVIOUR

Mean Fit of Strategies

Strategy users	*TTB*	*Take Two*	*WADD*
		Outcome only	
TTB users[a]	.81	.65	.60
Take Two users[b]	.76	.76	.70
WADD users[c]	.68	.74	.79
		Search only	
TTB users[a]	.43	.06	.02
Take Two users[b]	.06	.22	.05
WADD users[c]	.01	.02	.51
		Outcome and search	
TTB users[a]	.40	.04	.01
Take Two users[b]	.05	.19	.03
WADD users[c]	.01	.02	.38

OLDER ADULTS HAD HIGHER CRYSTALLISED, BUT LOWER FLUID INTELLIGENCE SCORES

Table 4
Participants' Characteristics and Individual Difference Measures by Age Group

	Young adults		Older adults		Statistical test	
Measure	*M*	*SD*	*M*	*SD*	*F*	*p*
Knowledge	47.7	9.2	52.2	10.3	56.71	<.01
Speed	58.2	5.5	42.1	6.4	105.83	<.01
Reasoning	56.4	6.7	43.8	8.8	300.52	<.01
Memory	55.2	8.4	45.0	8.9	8.62	<.01

CRYSTALLISED INTELLIGENCE SCORES NOT RELATED TO SEARCH BEHAVIOUR

Table 6
Hierarchical Linear Regressions with Search Measures as the Dependent Variables

	Acquisitions				Look-up time			
Variable	R^2	F	p	B	R^2	F	p	B
Step 1								
Age	0.12	21.61	<.01	−0.35	0.21	40.72	<.01	0.45
Knowledge	0.00	0.01	.92	0.01	0.00	0.57	.45	0.06

Note. In Step 1, B corresponds to the age coefficient or to the cognitive abilities coefficients. In Step 2, R^2 represents the difference between R^2 of the model with age and each capacity as predictors and that of a model with only the cognitive capacity measure as a predictor.

DIFFERENCES IN SPEED AND REASONING FULLY EXPLAIN NUMBER OF CUES SAMPLED

Table 6
Hierarchical Linear Regressions with Search Measures as the Dependent Variables

	Acquisitions			
Variable	R^2	F	p	B
Step 1				
Age	0.12	21.61	<.01	−0.35
Knowledge	0.00	0.01	.92	0.01
Speed	0.13	23.65	<.01	0.36
Reasoning	0.20	39.30	<.01	0.45
Memory	0.09	14.87	<.01	0.29
Step 2				
Knowledge + age	0.13	23.28	<.01	0.10
Speed + age	0.01	1.52	.22	0.23
Reasoning + age	0.01	1.14	.32	0.38
Memory + age	0.05	9.30	<.01	0.15

Note. In Step 1, B corresponds to the age coefficient or to the cognitive abilities coefficients. In Step 2, R^2 represents the difference between R^2 of the model with age and each capacity as predictors and that of a model with only the cognitive capacity measure as a predictor.

DIFFERENCES IN COGNITIVE ABILITIES CAN'T FULLY EXPLAIN TIME ON TASK

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Hierarchical Linear Regressions with Search Measures as the Dependent Variables

Variable	Look-up time			
	R^2	F	p	B
Step 1				
Age	0.21	40.72	<.01	0.45
Knowledge	0.00	0.57	.45	0.06
Speed	0.18	33.54	<.01	−0.42
Reasoning	0.13	24.12	<.01	−0.36
Memory	0.07	12.66	<.01	−0.27
Step 2				
Knowledge + age	0.20	40.36	<.01	−0.05
Speed + age	0.04	7.40	<.01	−0.15
Reasoning + age	0.08	16.20	<.01	−0.12
Memory + age	0.13	26.17	<.01	−0.05

Note. In Step 1, B corresponds to the age coefficient or to the cognitive abilities coefficients. In Step 2, R^2 represents the difference between R^2 of the model with age and each capacity as predictors and that of a model with only the cognitive capacity measure as a predictor.

SUMMARY: OLDER ADULTS ARE ADAPTIVE DM WHO PREFER SIMPLER STRATEGIES

- What I liked
  - Close to our work
    - Explicit modelling of strategy complexity
    - Modulating task environment
  - Thorough psychometric testing

- Changes I would've liked
  - Change in task environment to be within- rather than between-subjects
  - More context-specific measures of crystallised intelligence
    - Does your vocabulary help you identify the statistical structure of your task environment?

Q&A