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Executing prescriptive psychological heuristics: *Compatibility effects in decision support applications*

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Decision Support

Compatibility effects in the prescriptive application of psychological heuristics: Inhibition, Integration and Selection

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Highlights

- Experimental investigation on the use of "fast and frugal" decision-aids in decision-analysis.
- Difference in compensatory/non-compensatory methods is a function of task-features.
- A more compensatory decision-making style improves performance in both modes.
- Inhibitory control is implicated in the execution of non-compensatory strategies.
- Alignment between individual, model and task features enhances task-performance.

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The contingency framework

- DMs use a range of different heuristics of varying degrees of sophistication (Beach & Mitchell, 1978; Payne, Bettman & Johnson, 1993)

- Effort and accuracy are negatively correlated.

- Strategy selection is based on task-complexity and cognitive-ability.

> Complexity => *Compensatory* to *Non-compensatory*.

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Stylised facts from the behavioural literature

1. Decision strategies depend on the structure of task environments.

2. Decision makers are parsimonious in their expenditure of scarce cognitive resources.

3. Decisions are often based on relative salience (of attributes/criteria) rather than an integration of information (across attributes/criteria).

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The ecological framework

- Gigerenzer, Todd, & The ABC Research Group (1999) – *Simple heuristics that make us smart.*

- Effort and accuracy are not necessarily enemies in the wild – strategies are optimized for an uncertain world (i.e., 'ecologically rational').

- **Can be prescriptively useful** in many circumstances.
  - Information acquisition costs are high (Bröder, 2000).
  - Time pressures and psychological stress (Payne et al., 1993; Rieskamp & Hoffrage, 1999; Keller & Katsikopoulos, 2016).
  - Criterion information is obfuscated/retrieved from memory (Bröder & Schiffer, 2006).

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From descriptive to prescriptive ‘fast and frugal’ heuristics

1. Decision strategies *should* depend on the structure of task environments.

2. Decision makers *should be* parsimonious in their expenditure of scarce cognitive resources if…

3. Decisions *should be* based on relative salience rather than an integration of information if…

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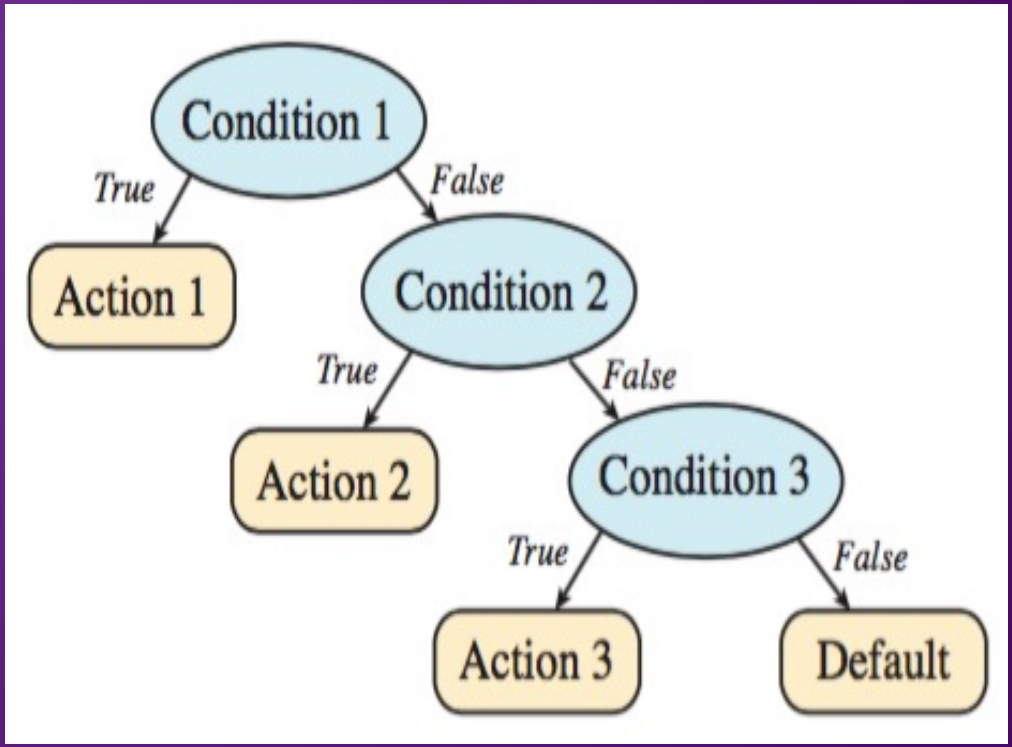
Open questions for B-OR Research

- Costless to execute?
- More transparent?
- Easy to use?
- Easy to understand?
- Easy to explain?



A fast and frugal decision-tree

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Consider Wally (aka Waldo)

- Martin Handford's famous artworks and an impressive study in information-search behaviour.
- The objective of the game – Where's Wally?
- Highly discriminatory criteria:
  - **Red** and **White** stripes.
  - **Black** glasses.
- Search in this context is highly non-compensatory but…costless?

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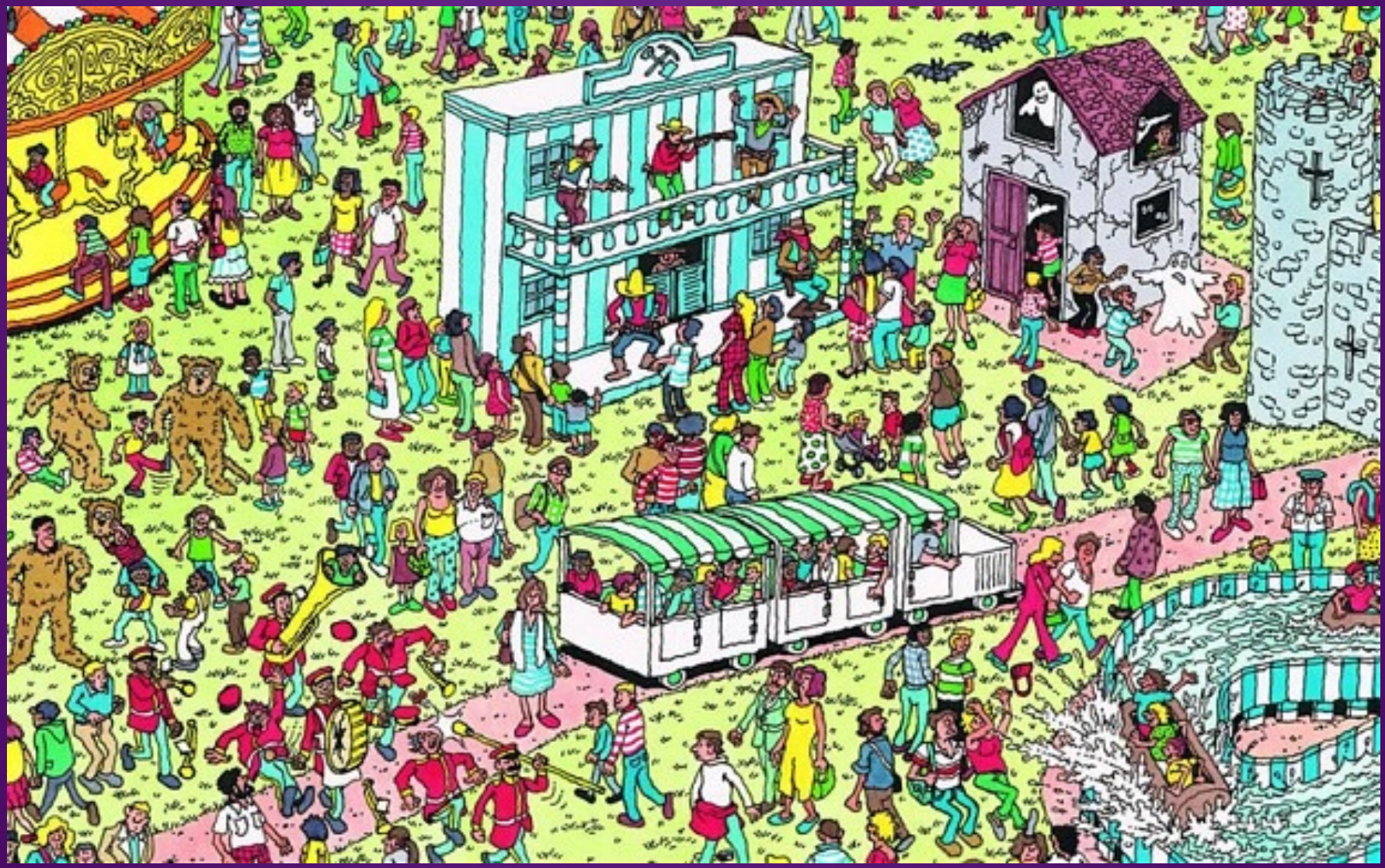
Where's Wally?



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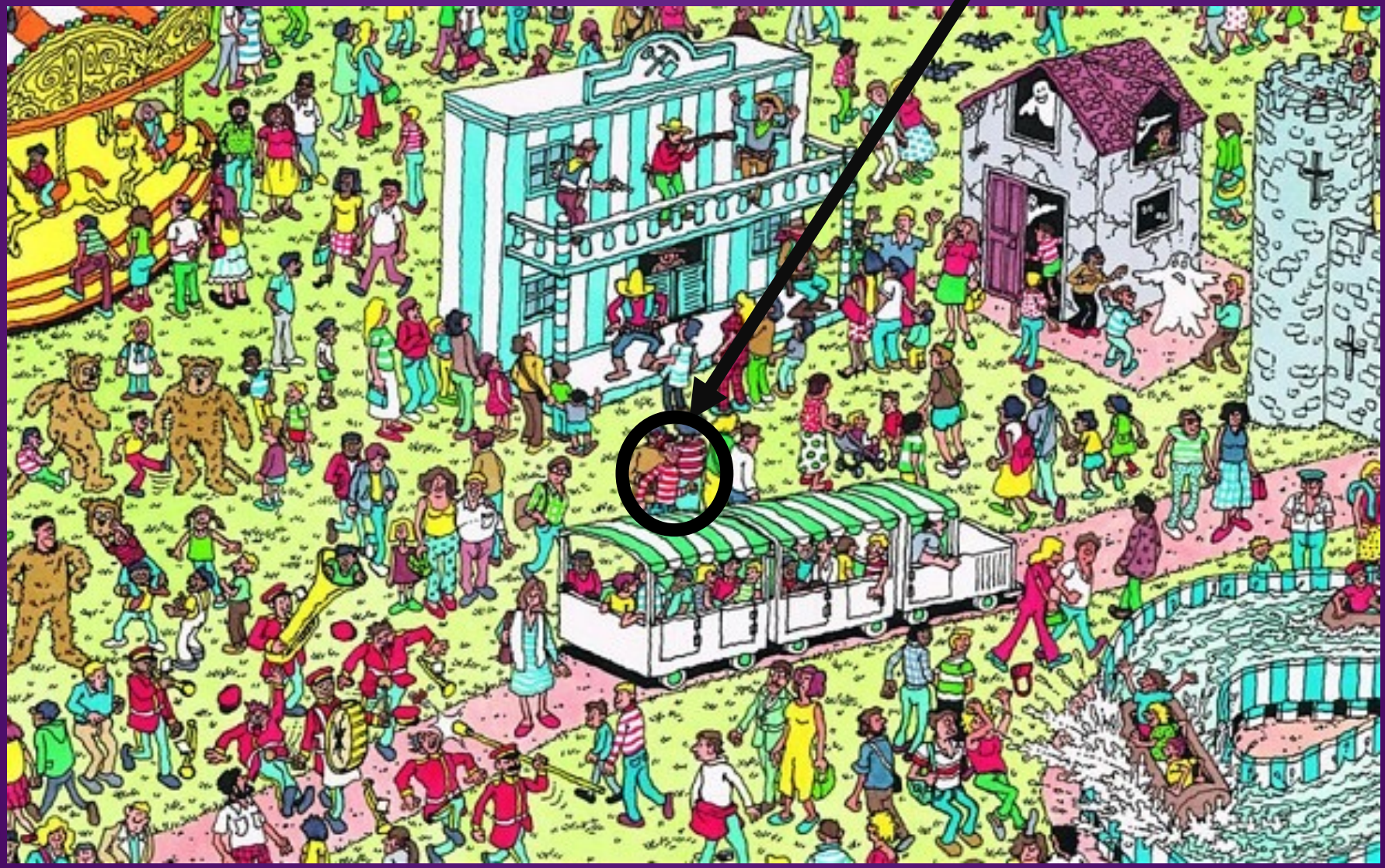
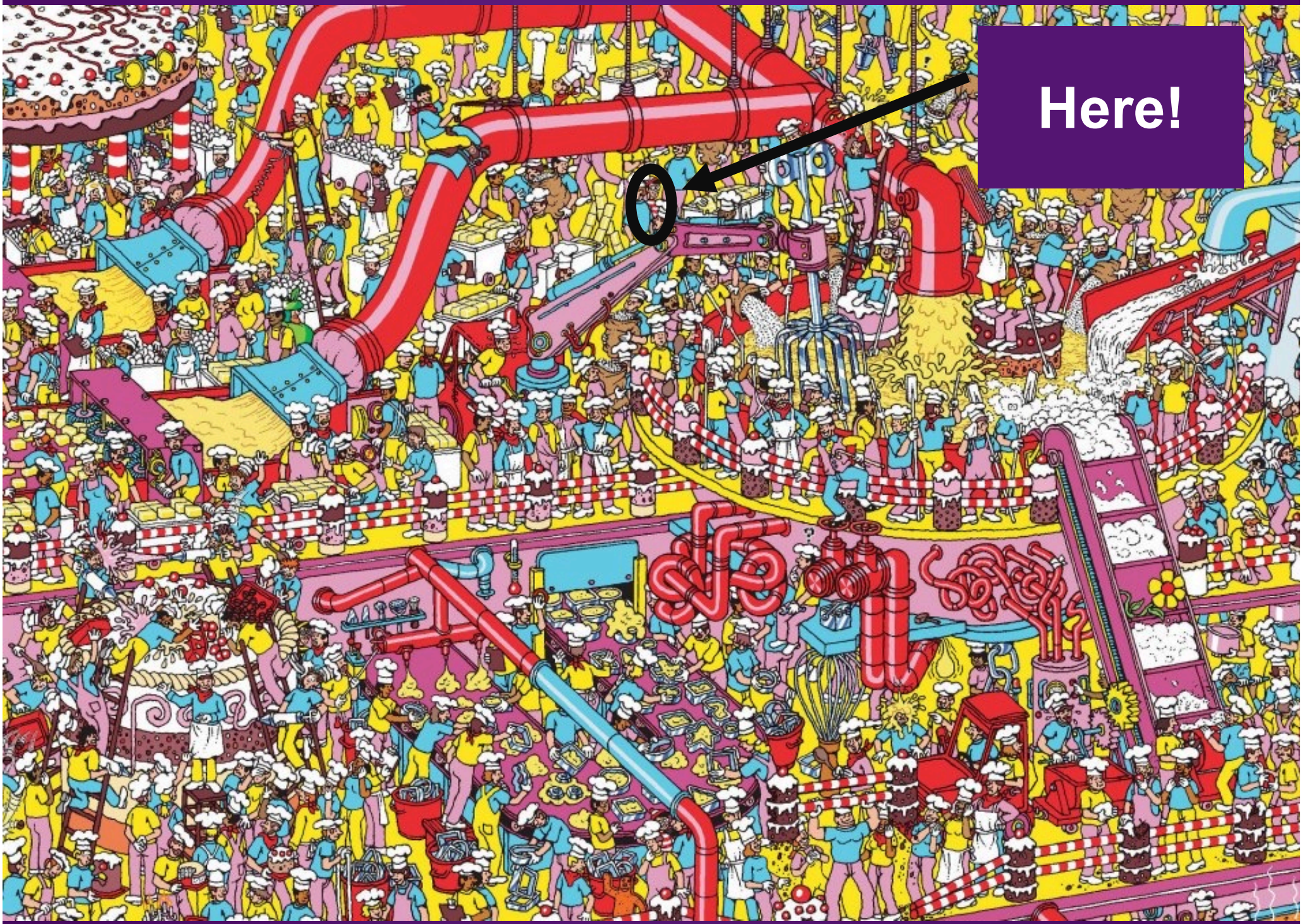
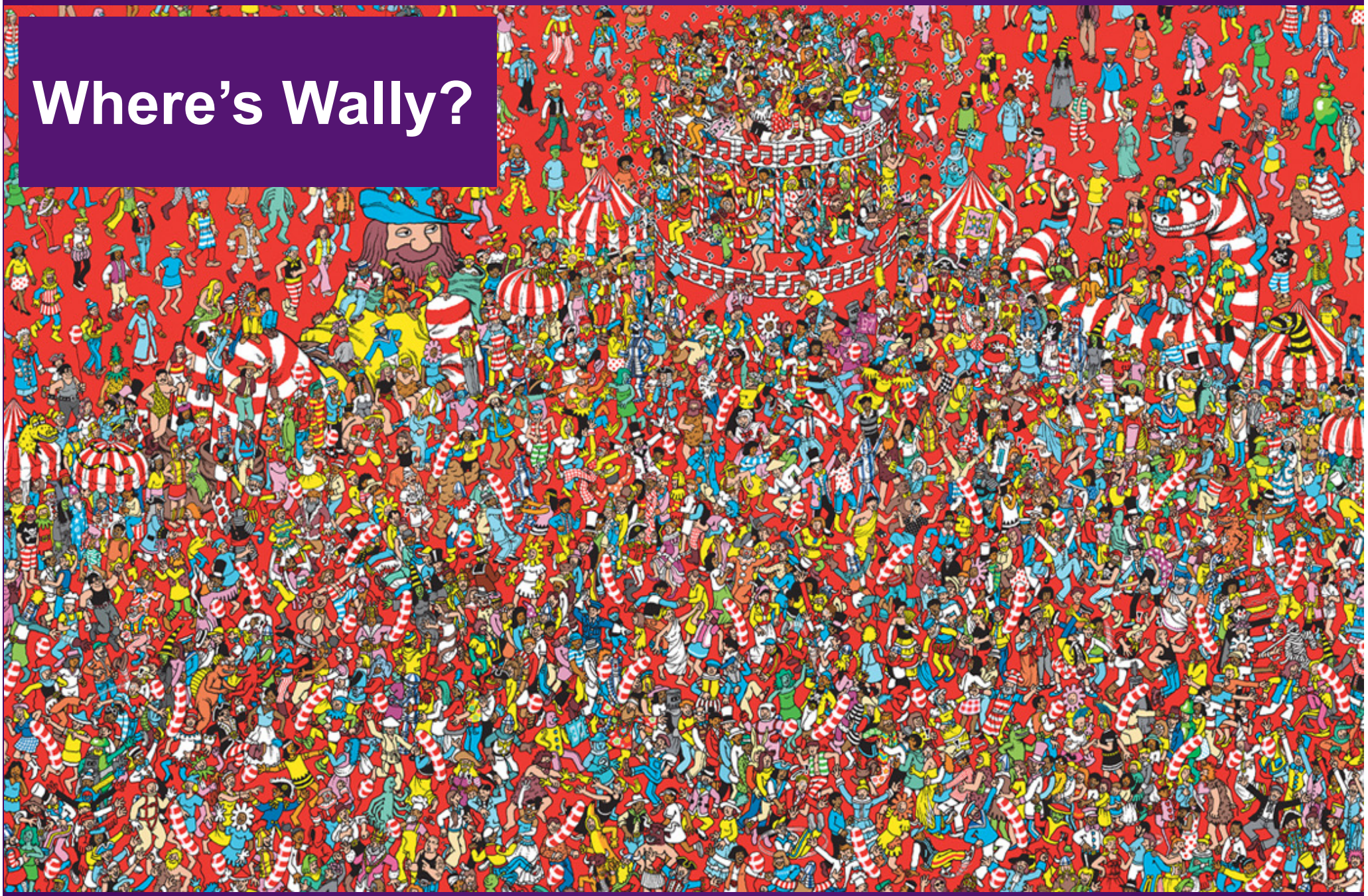



Where's Wally?


Here!

Where's Wally?



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What factors might impact strategy execution?

- Complexity (Information handling – PBJ, 1993, ABC group, 1999)
  - Information load (no. of alternatives, no. of attributes)
- Cognitive Ability (Inhibitory Control – Efficient allocation of attention)
  - "…if information is abundant the resource that becomes scarce is…the attention of its recipients" (Simon, 1971)
- Tendency (Compensatory style – Basic disposition)
  - Do decision makers generally prefer confronting trade-offs?

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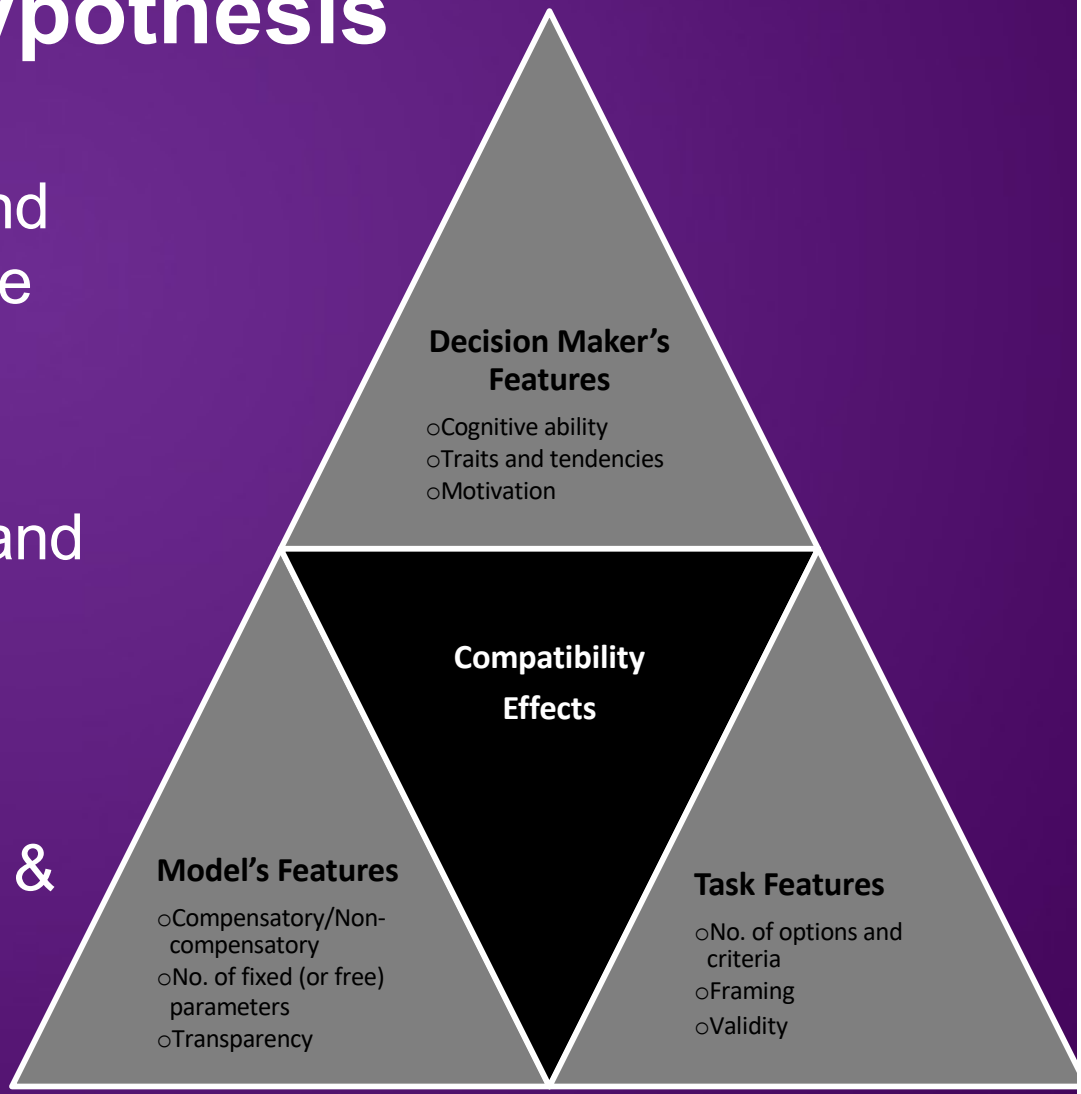
The compatibility hypothesis

- Fit between mind, model and environment should improve performance.
- Alignment between inputs and outputs within a decision context is facilitative.
- Simon (1955, 1990); Griffin & Tversky (1990); Endsley (2015)



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The Experiment

- 768 task-outcomes across 48 participants recruited from the MTurk panel.
- Prescriptive application of simple psychological heuristics (EQW, FRQ, DEBA and SAT).
- Contrast between compensatory (integrative) and non-compensatory (selective) heuristics.
  - EQW: Equal Weights Across Attributes (compensatory, Einhorn & Hogarth, 1975)
  - FRQ: Tallying across attribute-cues against options (compensatory, Alba & Marmorstein, 1987)
  - DEBA: Deterministic eliminations by aspects (non-compensatory, Tversky, 1972)
  - SAT: Satisficing at an assigned threshold (non-compensatory, Simon, 1955).

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Measures

- 2 x 2 x 2 mixed-factorial design.

- Within subjects:
  - No. of alternatives => 3 or 5
  - No. of attributes => 5 or 9
  - Prescribed strategy => Compensatory or Non-compensatory

- Between-subject measures for inhibitory control (ability) and compensatory style (tendency/trait):
  - *Ability to inhibit noise* => Eriksen Flanker Task
  - *Tendency for compensatory decision making* => Compensatory style questionnaire

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Compensatory style questionnaire

- Zakay (1990)
- Bi-polar and self-reported construct measuring tendency (stated preference) for a more compensatory style
- 40-items
- *“When making a decision I always try to treat the advantages and disadvantages of different alternatives as counterbalancing each other.”*

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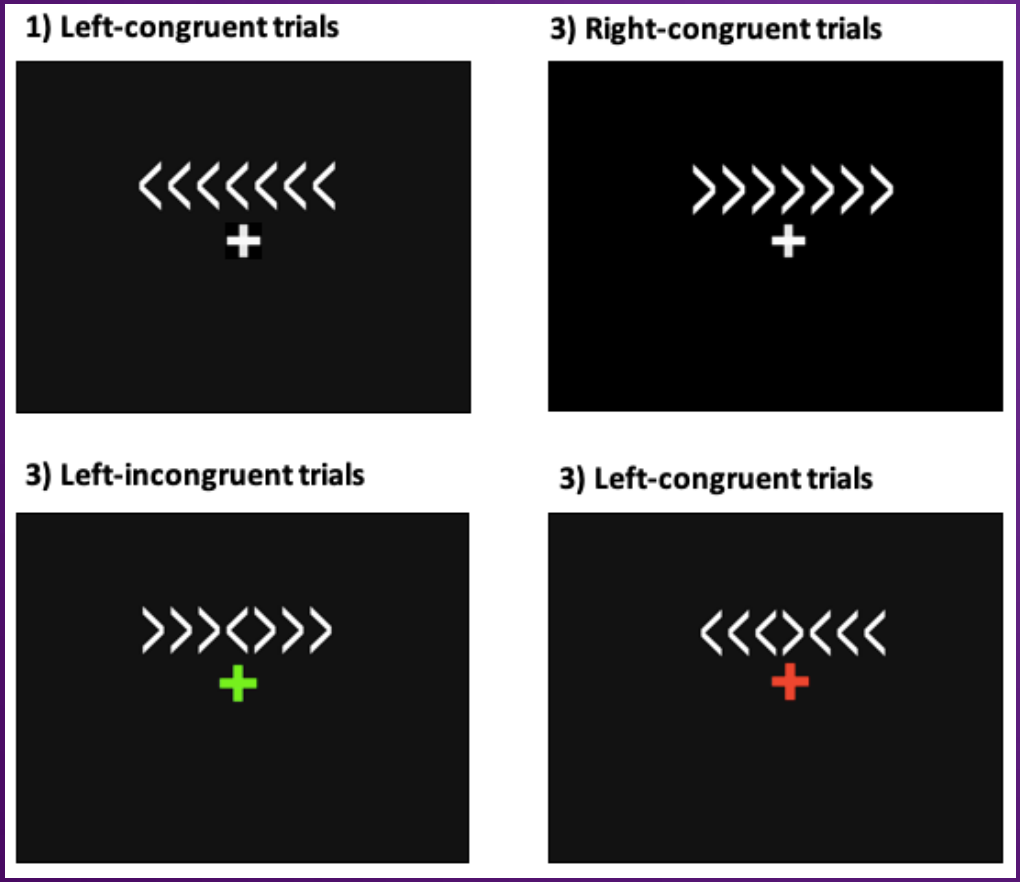
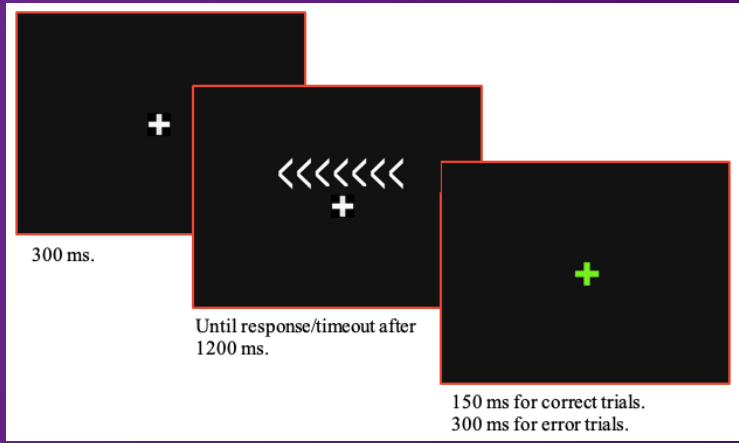
Eriksen (1974) 'flanker' task – Inhibitory Attentional Control





- Relative difference in response times (420-trials) in the congruent and incongruent conditions across subjects.

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Choice Problems

- Loosely adapted from A-DMC subscale measuring strategy execution (Bruine de Bruin et al., 2007).
  - 3x5, 3x9, 5x5, 5x9 alternatives by attributes.
  - Absence of strict dominance.
  - Balanced number of compensatory (8) and non-compensatory (8) choice problems.

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Choice Problems

Non-Compensatory

		Features				
		Picture Quality	Sound Quality	Programming Options	Reliability of Brand	Ease of Use
DVD	A	5	4	5	1	5
	B	**5**	**5**	**3**	**3**	**5**
	C	4	5	2	5	2
	D	4	5	3	3	2
	E	5	3	3	3	5

Jimmy first selects the DVD players with the best Ease of Use. From the selected DVD players, he then selects the best on Picture Quality. Then, if there is still more than one left to choose from, he selects the one best on Sound Quality. Which **one** of the presented DVD players will Jimmy choose?

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Choice Problems

Compensatory

		Features				
		Picture Quality	Sound Quality	Programming Options	Reliability of Brand	Ease of Use
DVD	A	5	4	2	1	1
	B	5	5	1	3	3
	C	**4**	**5**	**2**	**5**	**3**
	D	4	5	3	3	2
	E	5	3	3	4	3

Julia wants a DVD player with the highest average rating across all features. Which **one** of the presented DVD players will Julia choose?

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Results

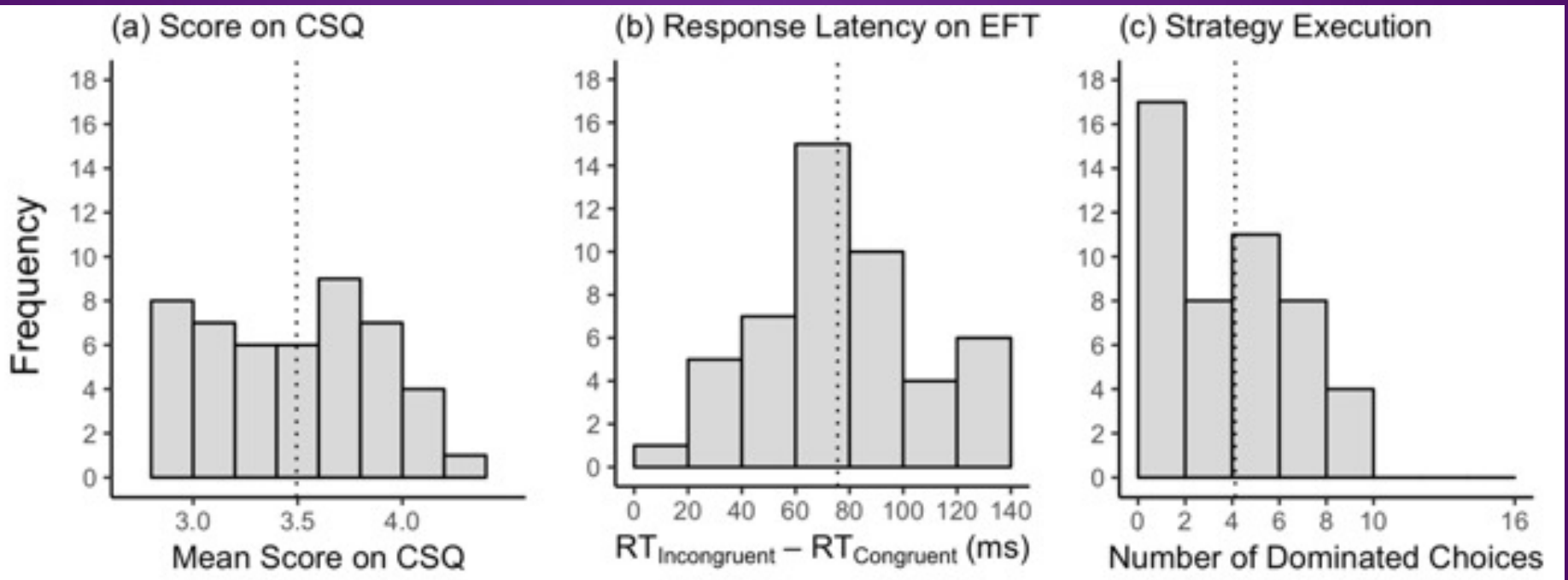

Figure A.1: Histograms for experimental variables. The dotted line represents the mean.

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Results

- No difference between strategies after accounting for other dependencies.

- Complexity
  - No. of alternatives (ALT)
  - No. of attributes (ATT)
- Tendency
  - Compensatory style (CSQ)
- Ability
  - Inhibitory Control (EFT)

Table 2. Results from multilevel logistic regression predicting the odds of selecting a dominated outcome.

	Estimates		Odds-Ratios	
Level and Variable	B (SE)	z-value	OR	95% CI for OR
(Intercept)	-2.23 (.35)	-7.08***	-	-
Task Level (n = 768)				
STRAT (ref = Compensatory)	.50 (.36)	1.38	1.65	[.81, 3.37]
ALT (ref = 3)	1.23 (.34)	3.63***	**3.42**	**[1.76, 6.63]**
ATT (ref = 5)	.87 (.34)	2.56*	**2.39**	**[1.23, 4.64]**
ALT x ATT	.09 (.38)	.24	1.10	[.52, 2.30]
ALT x STRAT	-.67 (.38)	-1.74†	.51	[.24, 1.09]
ATT x STRAT	-1.52 (.38)	-4.03***	**.22**	**[.10, .46]**
Subject Level (N = 48)				
EFT	-.09 (.14)	-.65	.91	[.70, 1.19]
CSQ	-.89 (.15)	-5.96***	**.41**	**[.30, .55]**
Cross-Level				
EFT x STRAT	.56 (.19)	2.94**	**1.75**	**[1.21, 2.55]**
CSQ x STRAT	.08 (.21)	.38	1.08	[.72, 1.63]
Variance Component				
σ_j^2		3.29		
μ_α		.11		
Fit Statistics				
Log-Likelihood		-383.6		
Marginal R^2 (Conditional R^2)		.29 (.31)		

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Results – Complexity

- Alternatives and attributes exert distinct influence.
  - ➢ Increasing alternatives degraded choice quality in both compensatory and non-compensatory environments.
  - ➢ However, increasing non-instrumental attributes *improved* choice quality in non-compensatory environments.
  - ➢ Using non-compensatory strategies in attribute-rich environments with a few highly discriminative aspects seems to improve performance.

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Results – Complexity

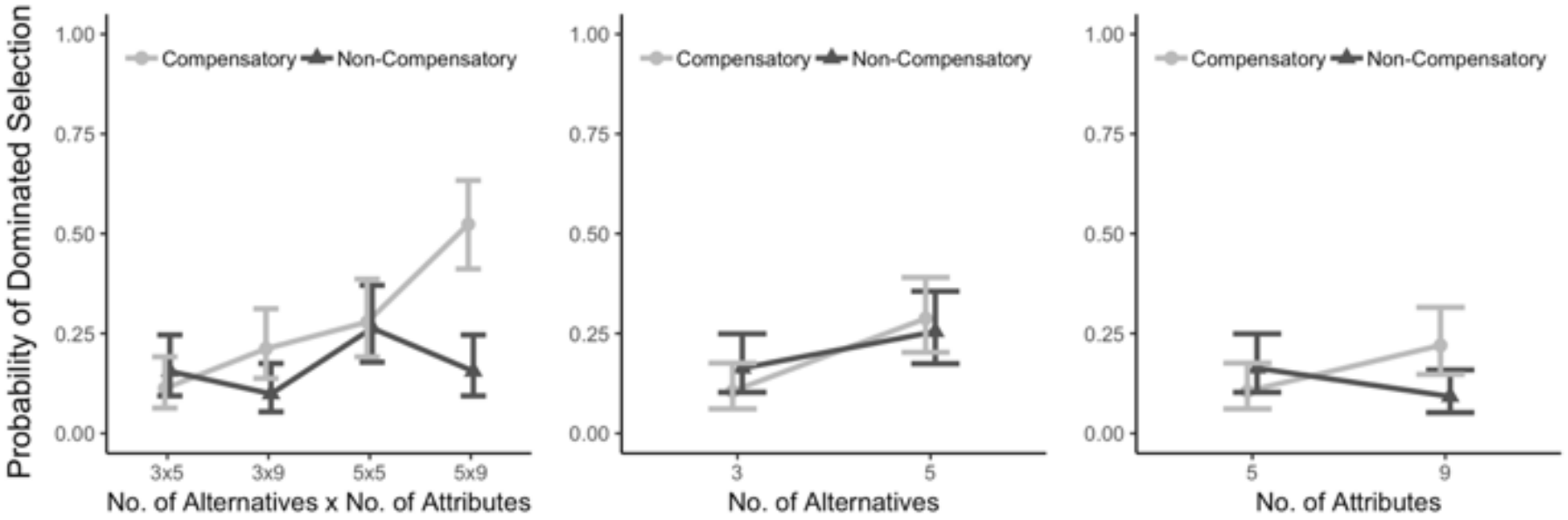

Figure 1. The effect of the number of alternatives and attributes on strategy execution in the compensatory (light-grey) and non-compensatory (dark-grey) conditions. The vertical bars represent the 95% confidence interval.

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Results – Tendency

- Most subjects reported a higher tendency for compensatory decision making.
  - A relatively more compensatory style was associated with improved task performance in general but…
  - Does not provide discriminatory information about different strategies.
  - May be associated with greater flexibility or general decision-making ability.

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Results – Ability

- Relatively better performance on the flaker task predicts improved performance in non-compensatory environments.
  - ➢ Lower inhibitory control can mean that non-compensatory strategies are applied poorly.
  - ➢ Inhibitory control might allow individuals to screen criterion information more effectively.

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Results – Ability

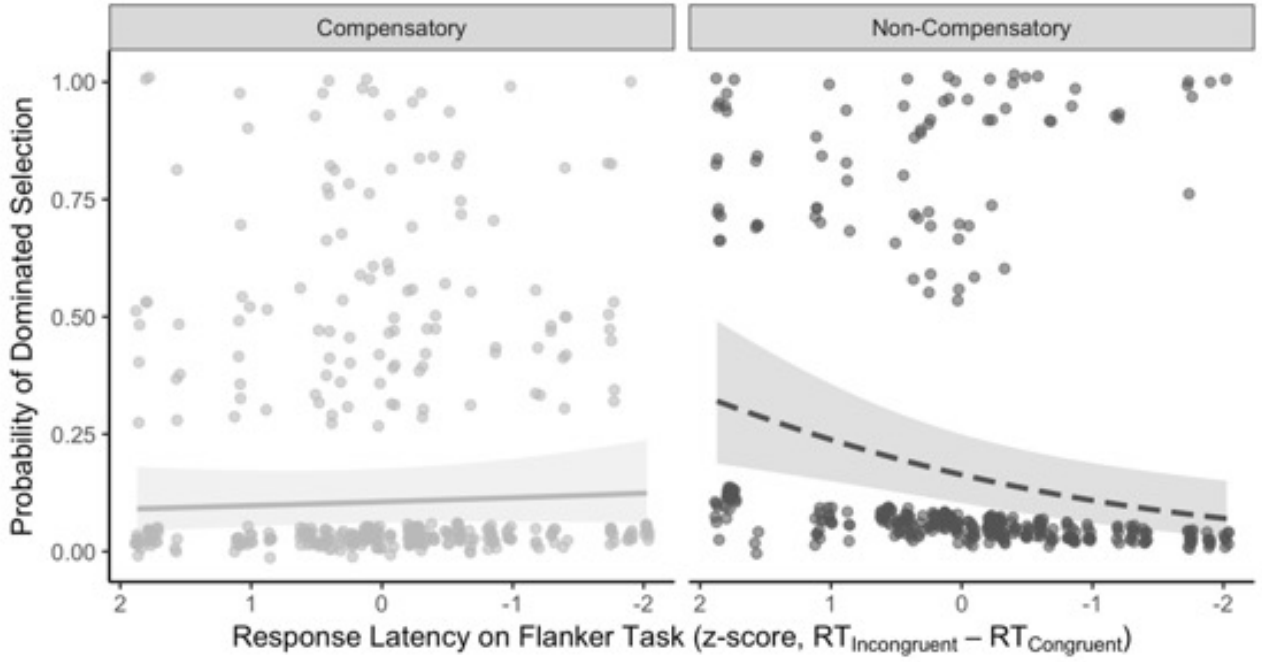

Figure 2. The effect of inhibitory control on strategy execution in the compensatory (light-grey) and non-compensatory (dark-grey) conditions. The translucent polygons represent the 95% confidence interval. The point estimates represent residual variance after accounting for the presence of other independent variables in the model. The x-axis is reversed and represents increasing inhibitory control. RTs are represented as z-scores for convenience (range = 129.85 to 16.94 *ms*).

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Implications for B-OR

- Simon's scissors:
  - Strategies should be assessed by their compatibility with both environmental and decision-maker features.
  - Mind and Environment both matter!

- Intuition from psychological studies may not hold in prescriptive settings.
  - Stable decision-maker traits do not discriminate across prescriptive applications of heuristics.

- Non-compensatory strategies are not necessarily cost-less and require effective attentional control.
  - Training inhibition and automatizing selective processing?

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