Limited Domain Structure for Conjunction Errors

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osf.io/652wh

PREREGISTERED

Study 1A: osf.io/e95kw
Study 1B: osf.io/5ucaq
**Study 2:** osf.io/65n8q

Question!

Do all conjunction fallacy errors share a common cognitive cause? Or do logically similar errors happen for different reasons in different cases?

Main Items

Physical Conjunction Fallacy (Cannonball & Sphere; C&S):
- Ludwin-Peery, E., Bramley, N., Davis, E., & Gureckis, T.G. (2019). Limits on the Use of Simulation in Physical Reasoning. *Proceedings of the 41st Annual Conference of the Cognitive Science Society*
- Ludwin-Peery, E., Bramley, N., Davis, E., & Gureckis, T.G. (accepted). Broken Physics: A Conjunction Fallacy Effect in Intuitive Physical Reasoning. *Psychological Science*
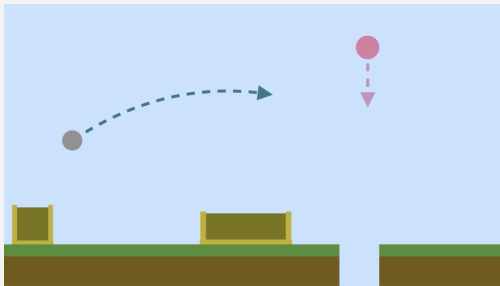
The full list of items is available at
osf.io/652wh/wiki/Comparing%20Conjunction%20Errors%20Reference

Taxes: Please estimate the percent chance of each event below occurring from 0 to 100%.
- A tax cut will be passed by Congress between January 1st and March 31st, 2020.
- A tax cut will be passed by Congress between January 1st and March 31st, 2020 and it will be supported by most Republicans.

Bill: Bill is 34 years old. He is intelligent, but unimaginative, compulsive, and generally lifeless. In school, he was strong in mathematics but weak in social studies and humanities. Please estimate the percent chance of each statement below being true, from 0 to 100%.
- Bill plays jazz for a hobby.
- Bill is an accountant who plays jazz for a hobby.

Peter: Peter is a junior in college who is training to run the mile in a regional meet. In his best race, earlier this season, Peter ran the mile in 4:06 min. Please estimate the percent chance of each event below occurring from 0 to 100%.
- Peter will run the mile in under 4 min.
- Peter will run the second half-mile under 1:55 min, and will complete the mile in under 4 min.

Health: A health survey was conducted in a representative sample of adult males in New York State of all ages and occupations. Mr. F. was included in the sample. He was selected by chance from the list of participants. Please estimate the percent chance of each statement below being true, from 0 to 100%.
- Mr. F. has had one or more heart attacks.
- Mr. F. has had one or more heart attacks and he is over 55 years old.

Dice: Consider a regular six-sided die with four green faces and two red faces. The die will be rolled 20 times and the sequence of greens (G) and reds (R) will be recorded. You are asked to select one sequence, from a set of three, and you will win a bet if the sequence you chose appears on successive rolls of the die. Please estimate the percent chance of each sequence occurring from 0 to 100%.
- RGRRR
- GRGRRR

Study 1A: Conjunction Errors (MTurk)

n = 100

Table 1: Pearson Correlations Among Conjunction Errors in Study 1A

	C&S	Taxes	Bill	Peter	Health	Dice
C&S	–					
Taxes	-0.099	–				
Bill	0.006	-0.153	–			
Peter	-0.057	0.194	-0.023	–		
Health	0.022	0.120	-0.032	0.193	–	
Dice	0.201*	-0.310**	0.202*	-0.064	0.175	–

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

Table 2: Chi-Square Tests of Relation Among Conjunction Errors in Study 1A

	C&S	Taxes	Bill	Peter	Health	Dice
C&S	–					
Taxes	0.007	–				
Bill	0.011	0.988	–			
Peter	0.000	2.459	0.044	–		
Health	1.132	12.971 ***	1.408	1.083	–	
Dice	0.347	0.178	6.253 *	0.096	0.399	–

*, unadjusted $p < .05$
***, unadjusted $p < .001$

Study 1B: Conjunction Errors (Undergraduate)

n = 100

Table 3: Pearson Correlations Among Conjunction Errors in Study 1B

	C&S	Taxes	Bill	Peter	Health	Dice
C&S	–					
Taxes	-0.031	–				
Bill	0.106	0.055	–			
Peter	-0.184	0.202*	-0.122	–		
Health	0.138	-0.096	0.086	-0.051	–	
Dice	-0.014	-0.031	0.154	0.031	0.031	–

*, unadjusted $p < .05$

Table 4: Chi-Square Tests of Relation Among Conjunction Errors in Study 1B

	C&S	Taxes	Bill	Peter	Health	Dice
C&S	–					
Taxes	0.017	–				
Bill	0.079	1.217	–			
Peter	1.145	4.043 *	0.510	–		
Health	0.98	1.411	6.648 *	0.805	–	
Dice	3.428	3.143	1.612	0.409	0.000	–

*, unadjusted $p < .05$

Study 2: Close Comparison

n = 200

❖ **Intentionally similar items**. By comparing very similar problems, we can estimate a baseline of how correlated conjunction errors can be.

❖ Dropped the Peter problem.
❖ For each of the remaining questions, we included **two new questions** that were intended to closely match the original both in content and in structure.
❖ The full list of items is available at osf.io/652wh/wiki/Comparing%20Conjunction%20Errors%20Reference/

Table 5: Pearson Correlations Among Conjunction Errors in Study 2

	C&S	Taxes 1	Taxes 2	Taxes 3	Dice 1	Dice 2	Dice 3	Health 1	Health 2	Health 3	Bill 1	Bill 2	Bill 3
C&S	-												
Taxes 1	-0.049	-											
Taxes 2	-0.116	0.370 †‡	-										
Taxes 3	0.008	0.029	0.169 ‡	-									
Dice 1	-0.011	0.137	0.098	0.155	-								
Dice 2	-0.019	0.118	0.145	0.057	0.207 ‡	-							
Dice 3	-0.056	-0.034	0.092	0.058	0.061	0.242 †‡	-						
Health 1	-0.017	0.244 †‡	0.431 †‡	0.335 †‡	0.251 †‡	0.150	0.113	-					
Health 2	-0.014	0.188 ‡	0.402 †‡	0.328 †‡	0.244 †‡	0.078	0.177 ‡	0.706 †‡	-				
Health 3	-0.182 ‡	0.071	0.224 ‡	0.365 †‡	0.120	0.188 ‡	0.186 ‡	0.445 †‡	0.475 †‡	-			
Bill 1	0.035	0.125	0.167 ‡	0.228 ‡	0.111	0.328 †‡	0.198 ‡	0.237 ‡	0.198 ‡	0.222 ‡	-		
Bill 2	0.089	0.069	0.080	0.111	-0.015	0.134	0.148	0.109	0.077	0.131	0.260 †‡	-	
Bill 3	-0.062	0.109	0.050	0.096	0.132	0.023	0.089	0.035	0.024	0.056	0.226 ‡	0.141	-

†, unadjusted $p < 0.00064$; ‡, significant according to False Discovery Rate threshold

Table 6: Chi-Square Tests of Relation Among Conjunction Errors in Study 2

	C&S	Taxes 1	Taxes 2	Taxes 3	Dice 1	Dice 2	Dice 3	Health 1	Health 2	Health 3	Bill 1	Bill 2	Bill 3
C&S	-												
Taxes 1	0.034	-											
Taxes 2	1.252	21.587 †‡	-										
Taxes 3	1.436	2.446	9.064 ‡	-									
Dice 1	0.017	1.905	5.767 ‡	0.000	-								
Dice 2	0.110	2.987	10.624 ‡	5.832 ‡	29.470 †‡	-							
Dice 3	0.583	0.000	4.746	5.219	18.807 †‡	28.432 †‡	-						
Health 1	0.001	13.055 †‡	32.897 †‡	8.898 ‡	2.249	9.384 ‡	2.712	-					
Health 2	1.722	3.383	23.217 †‡	11.500 ‡	6.477 ‡	7.668 ‡	12.448 †‡	74.647 †‡	-				
Health 3	1.446	9.224 ‡	31.034 †‡	6.764 ‡	0.963	4.567	8.365	53.681 †‡	36.273 †‡	-			
Bill 1	0.485	2.483	11.770 ‡	3.219	1.579	19.316 †‡	7.201 ‡	8.103 ‡	3.365	10.429 ‡	-		
Bill 2	0.000	0.175	0.004	3.328	1.199	0.000	0.004	0.000	0.481	1.615	2.541	-	
Bill 3	0.316	0.000	0.558	0.921	0.000	0.000	0.018	0.223	1.112	0.000	0.946	0.015	-

†, unadjusted $p < 0.00064$; ‡, significant according to False Discovery Rate threshold

Table 7: Factor Analysis of Conjunction Errors in Study 2

	One-Factor Solution	Two-Factor Solution	
	Factor 1		Factor 1	Factor 2
C&S	-	**C&S**	-	-
Taxes 1	0.30	**Taxes 1**	-	-
Taxes 2	0.51	**Taxes 2**	0.48	-
Taxes 3	0.44	**Taxes 3**	0.34	-
Dice 1	0.31	**Dice 1**	-	-
Dice 2	-	**Dice 2**	-	0.50
Dice 3	-	**Dice 3**	-	0.36
Health 1	0.78	**Health 1**	0.87	-
Health 2	0.75	**Health 2**	0.89	-
Health 3	0.58	**Health 3**	0.47	-
Bill 1	0.40	**Bill 1**	-	0.73
Bill 2	-	**Bill 2**	-	0.42
Bill 3	-	**Bill 3**	-	0.32

Rotation Method: Promax
Factor loadings of absolute value less than 0.30 not shown.