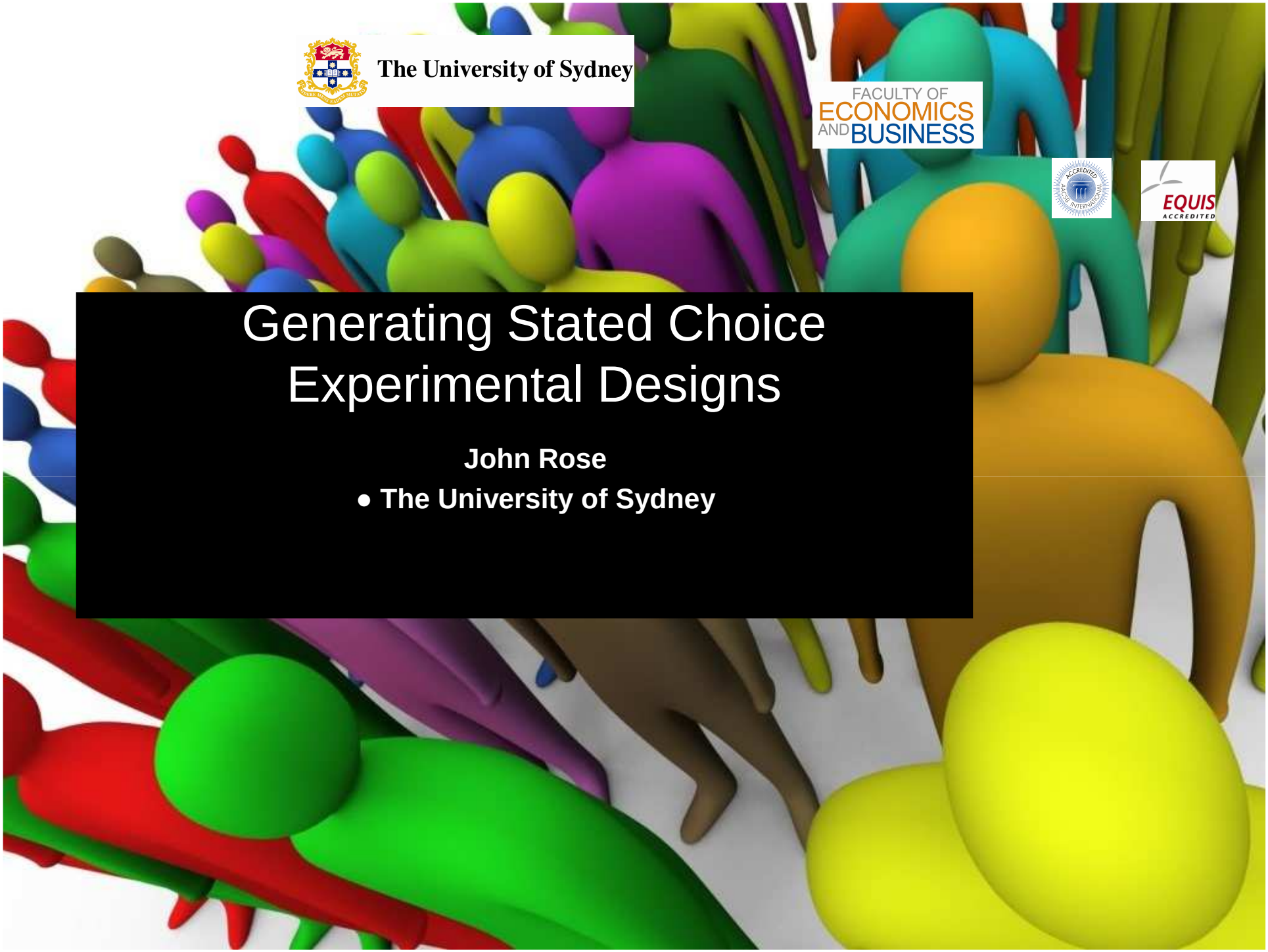

Generating Stated Choice Experimental Designs

John Rose

- **The University of Sydney**

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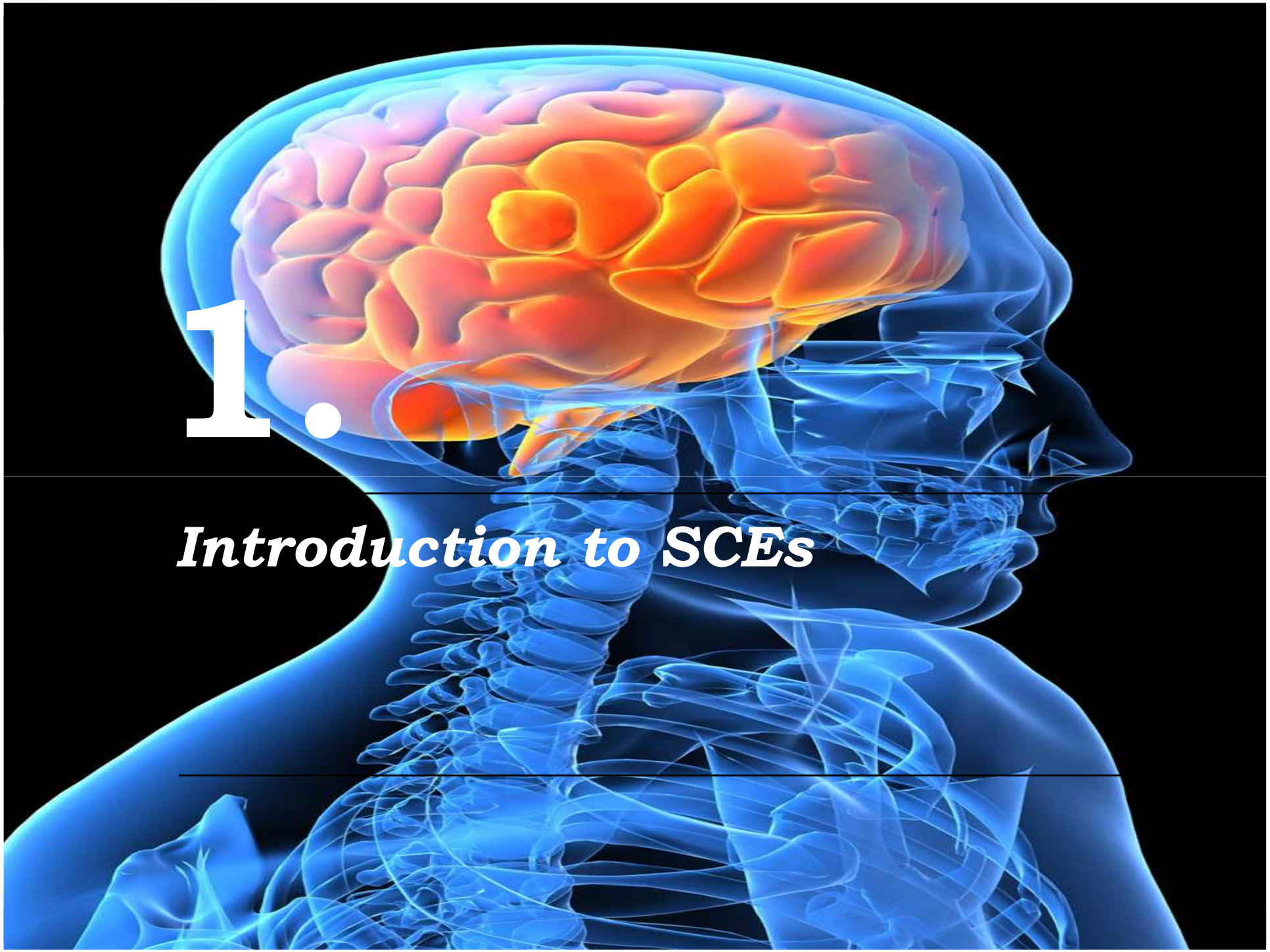
Workshop Structure

1. Introduction to SCEs
2. Generation of SCEs
3. Case example
4. Creating designs using Excel: Constructing the choice probabilities
5. Creating designs using Excel: Constructing the AVC matrix
6. Creating designs using Excel: Calculating the D-error
7. Creating designs using Excel: Generating the design



1.

Introduction to SCEs

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Introduction to SCEs

	car	train
Travel time (mins)	20	30
Fuel costs / fare ($)	5	4
Which alternative do you prefer?	○	◉

next ...

Introduction to SCEs

	car	train
Travel time (mins)	20	30
Fuel costs / fare ($)	5	4

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Introduction to SCEs

choice task

	car	train
Travel time (mins)	20	30
Fuel costs / fare ($)	5	4

alternative

attribute

attribute level

	car	train
Travel time (mins)	25	25
Fuel costs / fare ($)	6	5

	car	train
Travel time (mins)	25	30
Fuel costs / fare ($)	5	3

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Introduction to SCEs

Questionnaire

	car	train
Travel time (mins)	20	30
Fuel costs / fare ($)	5	4

	car	train
Travel time (mins)	25	25
Fuel costs / fare ($)	6	5

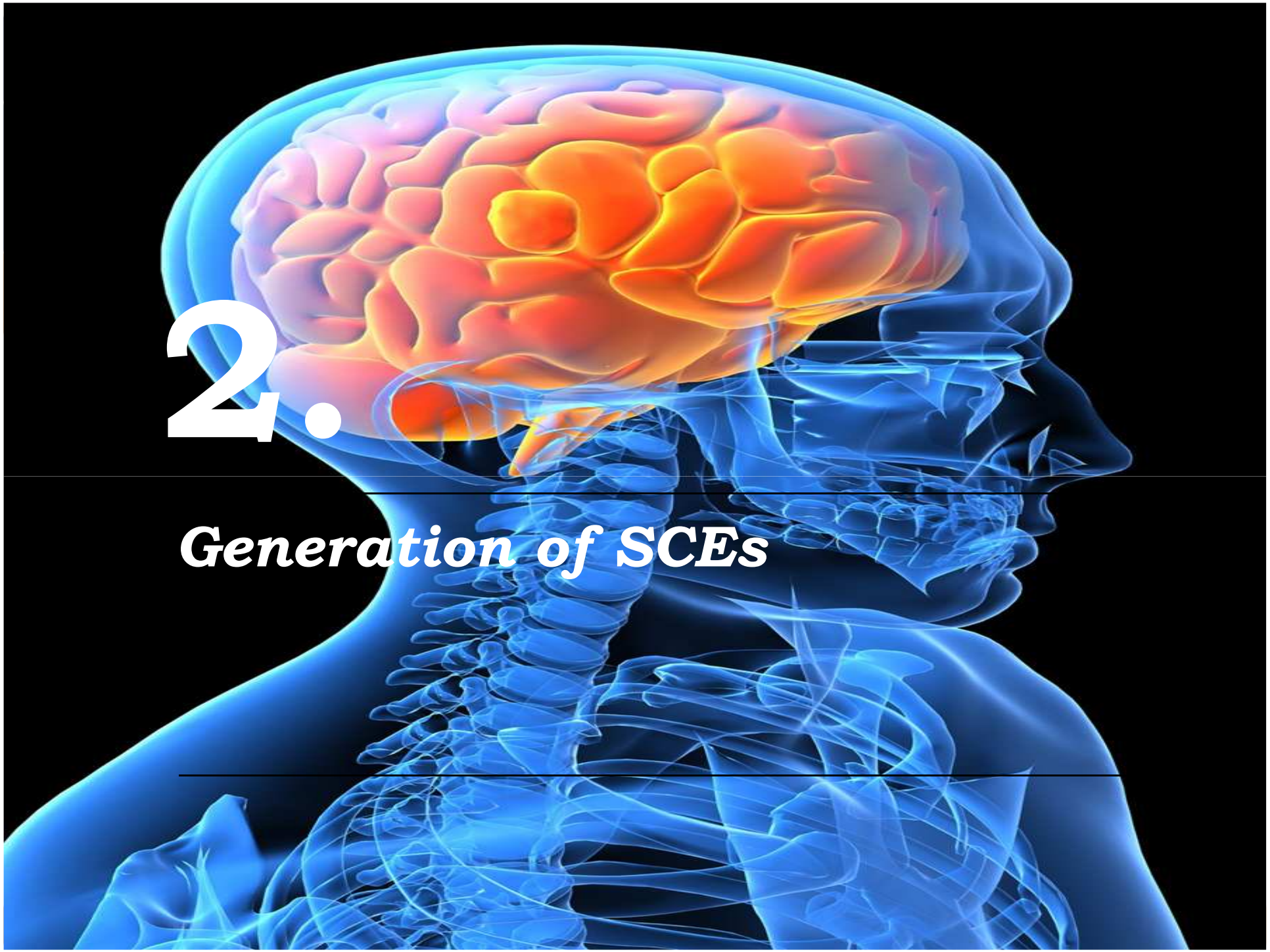
	car	train
Travel time (mins)	25	30
Fuel costs / fare ($)	5	3

Experimental design

$X =$

car		train	
Time	Cost	Time	Cost
...	...	...	...
...	...	...	...
...	...	...	...

Each column represents an attribute.
Each row represents a choice task.



2.

Generation of SCEs

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Generating SCEs

Choice Study

Utility specification

$$V_1 = \sum_{k=1}^{K} \beta_{1k} x_{1k}$$

$$V_2 = \sum_{k=1}^{K} \beta_{2k} x_{2k}$$

$$\vdots$$

$$V_j = \sum_{k=1}^{K} \beta_{jk} x_{jk}$$

Model specification

$$\beta_k = \bar{\beta}_k$$

$$\vdots$$

$$\beta_k \sim N(\mu_k, \sigma_k^2)$$

1	30	3	15	4
2	30	1	35	4
3	30	1	20	4
4	20	1	25	4
5	25	5	30	2
6	20	3	35	2
7	20	1	20	4
8	25	3	40	2
9	25	5	25	2
10	20	5	15	2
11	30	5	30	2
12	25	3	40	4

Experimental design

Respondents

0 0 1 0
0 1 0 0
0 1 0 0
0 0 0 1
1 0 0 0
0 1 0 0
1 0 0 0

Data

Estimation

$\hat{\beta}$

$se(\hat{\beta})$

Results

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Generating SCEs

Choice Study

Utility specification

$$V_1 = \sum_{k=1}^{K} \beta_{1k} x_{1k}$$

$$V_2 = \sum_{k=1}^{K} \beta_{2k} x_{2k}$$

$$\vdots$$

$$V_j = \sum_{k=1}^{K} \beta_{jk} x_{jk}$$

$\longrightarrow$

$$\begin{cases} \beta_k = \bar{\beta}_k \\ \vdots \\ \beta_k \sim N(\mu_k, \sigma_k^2) \end{cases}$$

Model specification

- **model specification influences parameter estimates**
  - **MNL? Random parameters? Nonlinearities? Generic parameters?**

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Generating SCEs

Choice Study

- **experimental design influences parameter estimates**

  Orthogonal? Efficient? Attribute level range? Number of choice situations?

1	30	3	15	4
2	30	1	35	4
3	30	1	20	4
4	20	1	25	4
5	25	5	30	2
6	20	3	35	2
7	20	1	20	4
8	25	3	40	2
9	25	5	25	2
10	20	5	15	2
11	30	5	30	2
12	25	3	40	4

Experimental design

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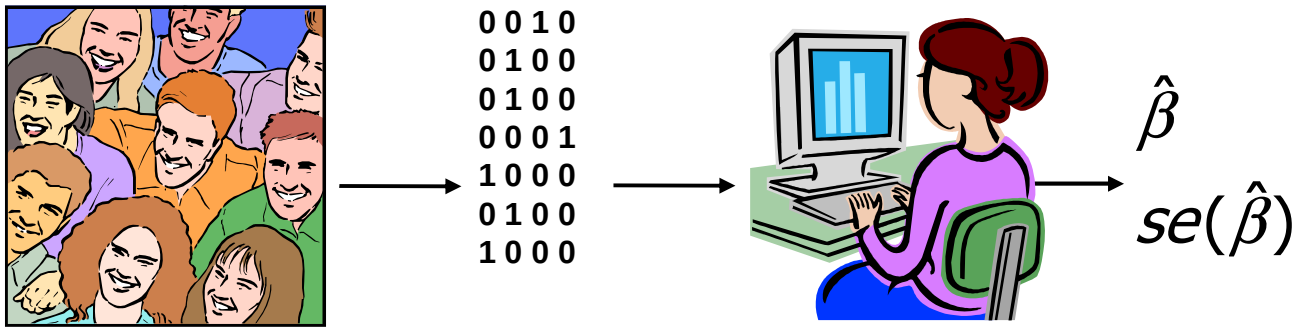
Generating SCEs

Choice Study

- **number of respondents influences parameter estimates**

  What sample size is required for accurate and reliable parameter estimates?



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Generating SCEs

ED generation process

Utility specification

$$V_1 = \sum_{k=1}^{K} \beta_{1k} x_{1k}$$

$$V_2 = \sum_{k=1}^{K} \beta_{2k} x_{2k}$$

$$\vdots$$

$$V_j = \sum_{k=1}^{K} \beta_{jk} x_{jk}$$

Model specification

$$\beta_k = \bar{\beta}_k$$

$$\vdots$$

$$\beta_k \sim N(\mu_k, \sigma_k^2)$$

1	30	3	15	4
2	30	1	35	4
3	30	1	20	4
4	20	1	25	4
5	25	5	30	2
6	20	3	35	2
7	20	1	20	4
8	25	3	40	2
9	25	5	25	2
10	20	5	15	2
11	30	5	30	2
12	25	3	40	4

Experimental design

Respondents

0 0 1 0
0 1 0 0
0 1 0 0
0 0 0 1
1 0 0 0
0 1 0 0
1 0 0 0

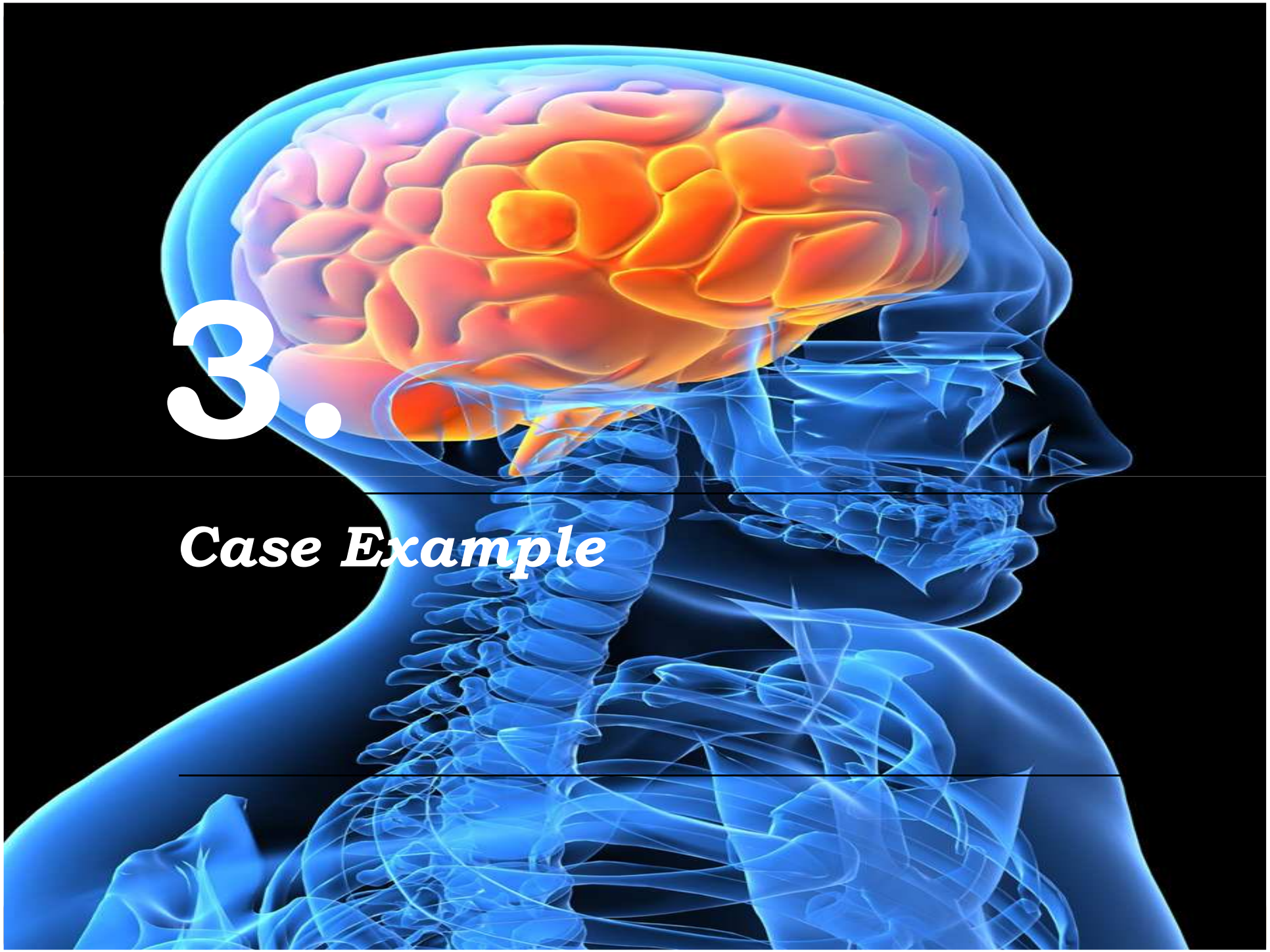
Data

Estimation

$\hat{\beta}$

$se(\hat{\beta})$

Results



3.

Case Example

Step 1: Define the Design Characteristics

- Assume utility specification for the design:

$$U_1 = \beta_{10} + \beta_1 x_{11} + \beta_2 x_{12} + \beta_{13} x_{13}$$
$$U_2 = \beta_{20} + \beta_1 x_{21} + \beta_2 x_{22} + \beta_{23} x_{23}$$
$$U_3 = \beta_1 x_{31} + \beta_{33} x_{33}$$

S	A1	B1	C1	A2	B2	C2	A3	C3
1	10	8	0	8	8	1	6	1
2	12	4	1	6	8	0	6	1
3	8	4	1	8	8	0	10	0
4	6	8	1	6	4	1	12	1
5	10	8	0	10	4	1	8	0
6	6	4	0	12	4	0	8	0
7	12	4	1	12	8	0	12	0
8	8	8	0	10	4	1	10	1

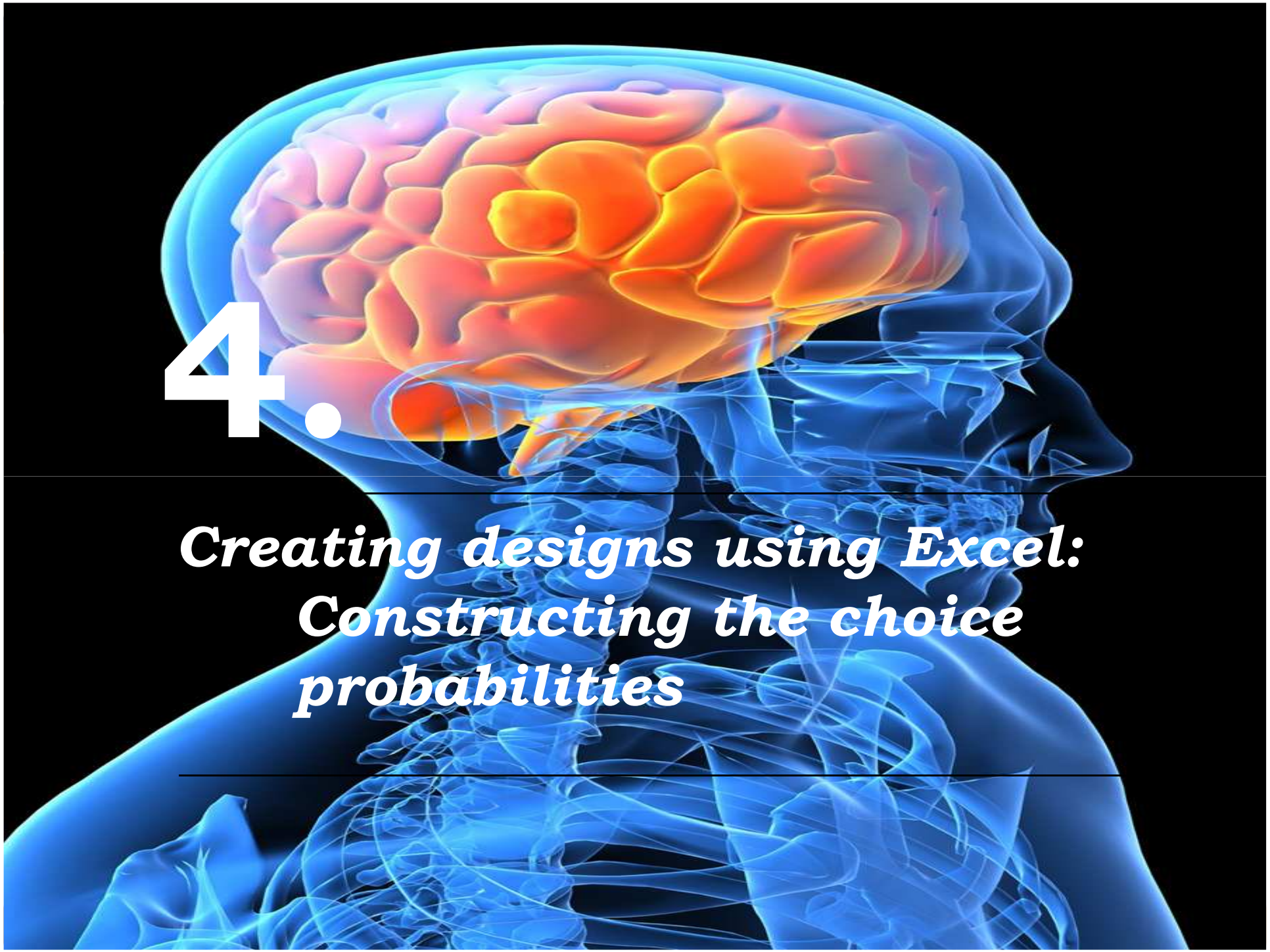
- Let $x_{11}, x_{21}, x_{31} \in \{6,8,10,12\}$,
  $x_{12}, x_{22} \in \{4,8\}$, and
  $x_{13}, x_{23}, x_{33} \in \{0,1\}$.
- Assume 8 choice situations

Step 2: Decide on the Prior Parameters

- Priors:

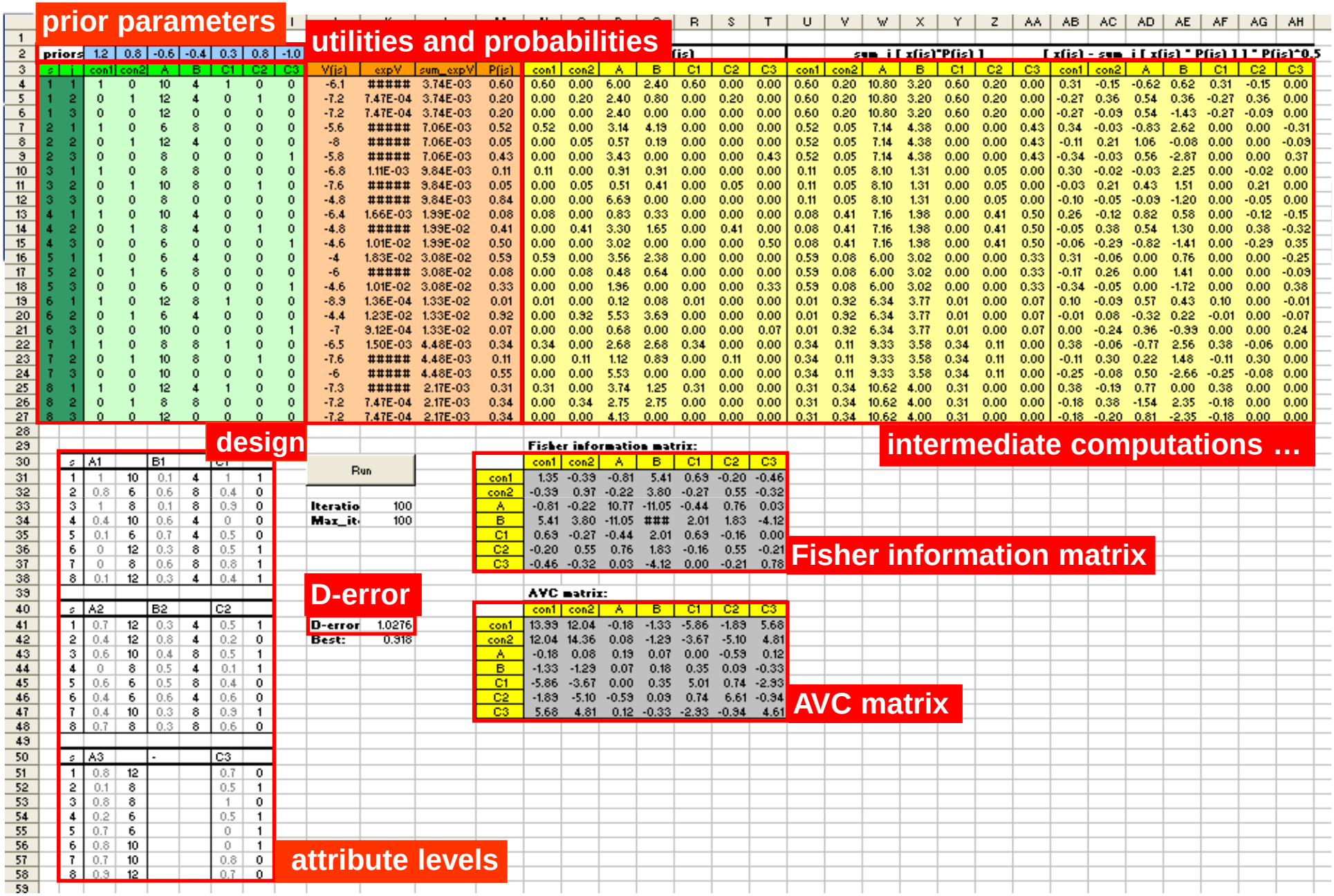
$$U_1 = 1.2 - 0.6x_{11} - 0.4x_{12} + 0.3x_{13}$$
$$U_2 = 0.8 - 0.6x_{21} - 0.4x_{22} + 0.8x_{23}$$
$$U_3 = - 0.6x_{31} - 1.0x_{33}$$

S	A1	B1	C1	A2	B2	C2	A3	C3
1	10	8	0	8	8	1	6	1
2	12	4	1	6	8	0	6	1
3	8	4	1	8	8	0	10	0
4	6	8	1	6	4	1	12	1
5	10	8	0	10	4	1	8	0
6	6	4	0	12	4	0	8	0
7	12	4	1	12	8	0	12	0
8	8	8	0	10	4	1	10	1



4.

Creating designs using Excel: Constructing the choice probabilities


prior parameters
utilities and probabilities
design
intermediate computations …
Run
Iteratio 100
Max_it 100
D-error
D-error 1.0276
Best: 0.918
Fisher information matrix:
Fisher information matrix
AVC matrix:
AVC matrix
attribute levels

Overview

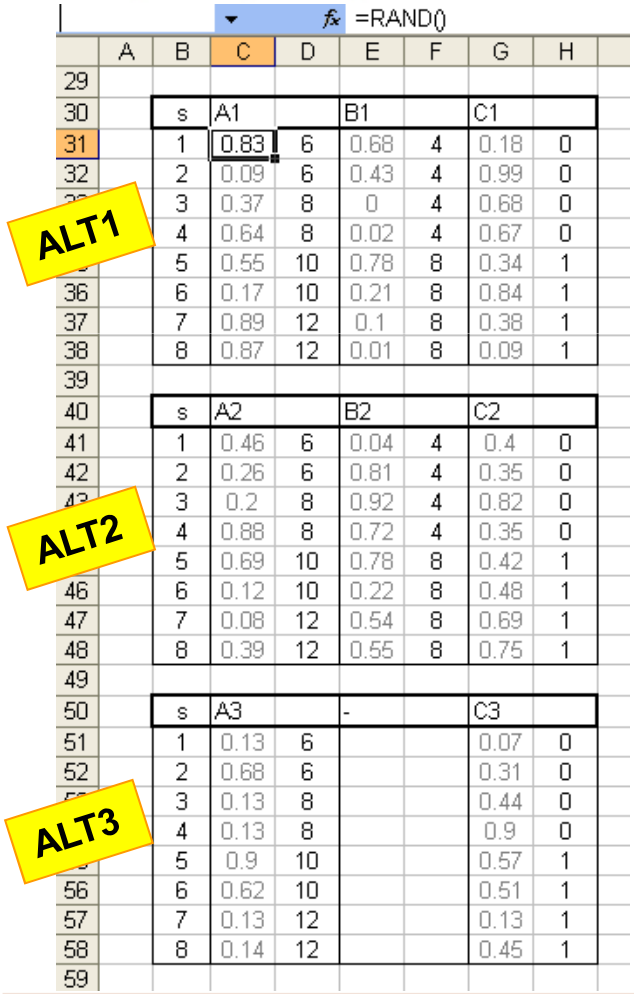
Step 3: Construct the Design Grid

	A	B	C	D	E	F	G	H	I
1									
2									
3	s	j	con1	con2	A	B	C1	C2	C3
4	1	1							
5	1	2							
6	1	3							
7	2	1							
8	2	2							
9	2	3							
10	3	1							
11	3	2							
12	3	3							
13	4	1							
14	4	2							
15	4	3							
16	5	1							
17	5	2							
18	5	3							
19	6	1							
20	6	2							
21	6	3							
22	7	1							
23	7	2							
24	7	3							
25	8	1							
26	8	2							
27	8	3							
28									

- Let *s* = choice situation
- Let *j* = alternative
- Let each row represent an alternative *j* within choice situation *s*
- Let each column represent an attribute (or constant) within the design (# columns = # parameters)

$$U_1 = \beta_{10} + \beta_1 x_{11} + \beta_2 x_{12} + \beta_{13} x_{13}$$
$$U_2 = \beta_{20} + \beta_1 x_{21} + \beta_2 x_{22} + \beta_{23} x_{23}$$
$$U_3 = \beta_1 x_{31} + \beta_{33} x_{33}$$

Step 4: Create Attribute Matrices



=RAND()

	A	B	C	D	E	F	G	H
29								
30		s	A1		B1		C1	
31		1	0.83	6	0.68	4	0.18	0
32		2	0.09	6	0.43	4	0.99	0
		3	0.37	8	0	4	0.68	0
		4	0.64	8	0.02	4	0.67	0
		5	0.55	10	0.78	8	0.34	1
36		6	0.17	10	0.21	8	0.84	1
37		7	0.89	12	0.1	8	0.38	1
38		8	0.87	12	0.01	8	0.09	1
39								
40		s	A2		B2		C2	
41		1	0.46	6	0.04	4	0.4	0
42		2	0.26	6	0.81	4	0.35	0
		3	0.2	8	0.92	4	0.82	0
		4	0.88	8	0.72	4	0.35	0
		5	0.69	10	0.78	8	0.42	1
46		6	0.12	10	0.22	8	0.48	1
47		7	0.08	12	0.54	8	0.69	1
48		8	0.39	12	0.55	8	0.75	1
49								
50		s	A3		-		C3	
51		1	0.13	6			0.07	0
52		2	0.68	6			0.31	0
		3	0.13	8			0.44	0
		4	0.13	8			0.9	0
		5	0.9	10			0.57	1
56		6	0.62	10			0.51	1
57		7	0.13	12			0.13	1
58		8	0.14	12			0.45	1
59								

ALT1

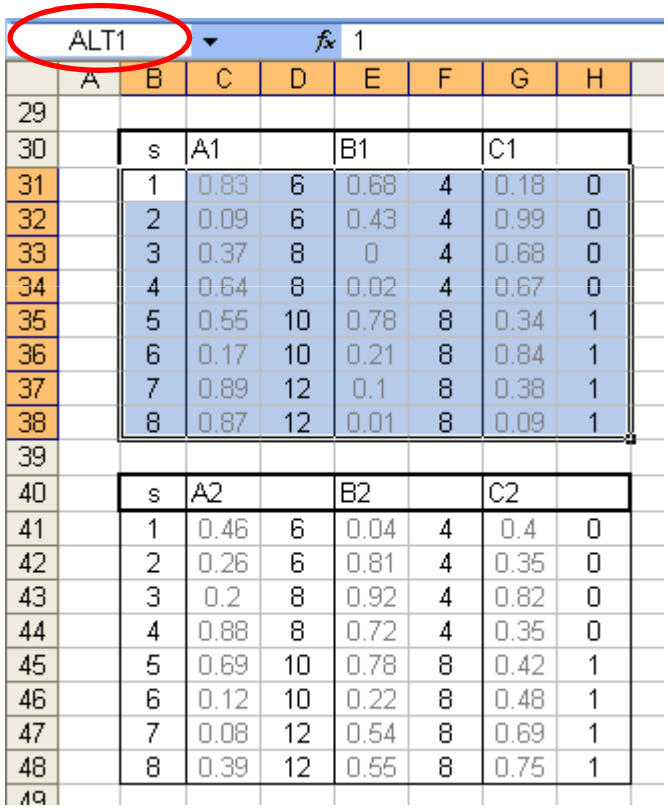
ALT2

ALT3

- For each alternative and each attribute, create two columns
  - Column 1: =RAND()
  - Column 2: place the relevant attribute levels
- The number of rows for each is equal to the number of choice situations, *S*
- Don't do this for constants
- Place attributes in alternative groups

$$U_1 = \beta_{10} + \beta_1 x_{11} + \beta_2 x_{12} + \beta_{13} x_{13}$$
$$U_2 = \beta_{20} + \beta_1 x_{21} + \beta_2 x_{22} + \beta_{23} x_{23}$$
$$U_3 = \beta_1 x_{31} + \beta_{33} x_{33}$$

Step 4: Create Attribute Matrices (cont'd)



ALT1 | fx 1

	A	B	C	D	E	F	G	H
29								
30		s	A1		B1		C1	
31		1	0.83	6	0.68	4	0.18	0
32		2	0.09	6	0.43	4	0.99	0
33		3	0.37	8	0	4	0.68	0
34		4	0.64	8	0.02	4	0.67	0
35		5	0.55	10	0.78	8	0.34	1
36		6	0.17	10	0.21	8	0.84	1
37		7	0.89	12	0.1	8	0.38	1
38		8	0.87	12	0.01	8	0.09	1
39								
40		s	A2		B2		C2	
41		1	0.46	6	0.04	4	0.4	0
42		2	0.26	6	0.81	4	0.35	0
43		3	0.2	8	0.92	4	0.82	0
44		4	0.88	8	0.72	4	0.35	0
45		5	0.69	10	0.78	8	0.42	1
46		6	0.12	10	0.22	8	0.48	1
47		7	0.08	12	0.54	8	0.69	1
48		8	0.39	12	0.55	8	0.75	1

For each alternative, name the attribute matrix

- Select the matrix
- Name the matrix (e.g., ALT1, ALT2, ALT3) for each alternative in the box in the upper left corner

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Step 5: Create the Constant Terms

	A	B	C	D	E	F	G	H	I
1									
2									
3	s	j	con1	con2	A	B	C1	C2	C3
4	1	1	1	0					
5	1	2	0	1					
6	1	3	0	0					
7	2	1	1	0					
8	2	2	0	1					
9	2	3	0	0					
10	3	1	1	0					
11	3	2	0	1					
12	3	3	0	0					
13	4	1	1	0					
14	4	2	0	1					
15	4	3	0	0					
16	5	1	1	0					
17	5	2	0	1					
18	5	3	0	0					
19	6	1	1	0					
20	6	2	0	1					
21	6	3	0	0					
22	7	1	1	0					
23	7	2	0	1					
24	7	3	0	0					
25	8	1	1	0					
26	8	2	0	1					
27	8	3	0	0					
28									

- For each constant, place a 1 in the column and row for the relevant alternative (and 0 otherwise)

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Step 6: Allocate Attribute Levels to Design

	A	B	C	D	E	F	G	H	I
1									
2									
3	s	j	con1	con2	A	B	C1	C2	C3
4	1	1	1	0	=VLOOKUP(A4,ALT1,3)	=VLOOKUP(A4,ALT1,5)	=VLOOKUP(A4,ALT1,7)	0	0
5	1	2	0	1	=VLOOKUP(A5,ALT2,3)	=VLOOKUP(A5,ALT2,5)	0	=VLOOKUP(A5,ALT2,7)	0
6	1	3	0	0	=VLOOKUP(A6,ALT3,3)	0	0	0	=VLOOKUP(A6,ALT3,7)
7	2	1	1	0					
8	2	2	0	1					
9	2	3	0	0					
10	3	1	1	0					
11	3	2	0	1					
12	3	3	0	0					

- For design attributes, link the attribute to the attribute levels created in Step 4 (matrices ALT1, ALT2, ALT3)
- For alternative-specific parameters, the attribute is zero if not appropriate

=VLOOKUP(“value to lookup” , “table to look in” , “return value from this column”)

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Step 6: Allocate Attribute Levels to Design

	A	B	C	D	E	F	G	H	I
1									
2									
3	s	j	con1	con2	A	B	C1	C2	C3
4	1	1	1	0	=VLOOKUP(A4,ALT1,3)	=VLOOKUP(A4,ALT1,5)	=VLOOKUP(A4,ALT1,7)	0	0
5	1	2	0	1	=VLOOKUP(A5,ALT2,3)	=VLOOKUP(A5,ALT2,5)	0	=VLOOKUP(A5,ALT2,7)	0
6	1	3	0	0	=VLOOKUP(A6,ALT3,3)	0	0	0	=VLOOKUP(A6,ALT3,7)
7	2	1	1	0					
8	2	2	0	1					
9	2	3	0	0					
10	3	1	1	0					
11	3	2	0	1					
12	3	3	0	0					

	A	B	C	D	E	F	G	H
29								
30		s	A1		B1		C1	
31		1	0.22	6	0.65	4	0.2	0
32		2	0.04	6	0.68	4	0.68	0
33		3	0.84	8	0.52	4	0.77	0
34		4	0.77	8	0.09	4	0.09	0
35		5	0.69	10	0.69	8	0.14	1
36		6	0.05	10	0.11	8	0.24	1
37		7	0.53	12	0.33	8	0.88	1
38		8	0.34	12	0.85	8	0.15	1
39								

=VLOOKUP(“value to lookup” , “table to look in” , “return value from this column”)

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Step 7: Set Prior Parameters

	A	B	C	D	E	F	G	H	I
1									
2	priors:		1.2	0.8	-0.6	-0.4	0.3	0.8	-1.0
3	s	j	con1	con2	A	B	C1	C2	C3
4	1	1	1	0	6	4	0	0	0
5	1	2	0	1	6	4	0	0	0
6	1	3	0	0	6	0	0	0	0
7	2	1	1	0	6	4	0	0	0
8	2	2	0	1	6	4	0	0	0
9	2	3	0	0	6	0	0	0	0
10	3	1	1	0	8	4	0	0	0
11	3	2	0	1	8	4	0	0	0
12	3	3	0	0	8	0	0	0	0
13	4	1	1	0	8	4	0	0	0
14	4	2	0	1	8	4	0	0	0
15	4	3	0	0	8	0	0	0	0
16	5	1	1	0	10	8	1	0	0
17	5	2	0	1	10	8	0	1	0
18	5	3	0	0	10	0	0	0	1
19	6	1	1	0	10	8	1	0	0
20	6	2	0	1	10	8	0	1	0
21	6	3	0	0	10	0	0	0	1
22	7	1	1	0	12	8	1	0	0
23	7	2	0	1	12	8	0	1	0
24	7	3	0	0	12	0	0	0	1
25	8	1	1	0	12	8	1	0	0
26	8	2	0	1	12	8	0	1	0
27	8	3	0	0	12	0	0	0	1
28									

$$U_1 = 1.2 - 0.6x_{11} - 0.4x_{12} + 0.3x_{13}$$

$$U_2 = 0.8 - 0.6x_{21} - 0.4x_{22} + 0.8x_{23}$$

$$U_3 = -0.6x_{31} - 1.0x_{33}$$

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Step 8: Calculate Utilities

	A	B	C	D	E	F	G	H	I	J
1										
2	priors:		1.2	0.8	-0.6	-0.4	0.3	0.8	-1.0	
3	s	j	con1	con2	A	B	C1	C2	C3	V(js)
4	1	1	1	0	6	4	0	0	0	=SUMPRODUCT($C$2:$I$2,C4:I4)
5	1	2	0	1	6	4	0	0	0	-4.4
6	1	3	0	0	6	0	0	0	0	-3.6
7	2	1	1	0	6	4	0	0	0	-4
8	2	2	0	1	6	4	0	0	0	-4.4
9	2	3	0	0	6	0	0	0	0	-3.6
10	3	1	1	0	8	4	0	0	0	-5.2
11	3	2	0	1	8	4	0	0	0	-5.6
12	3	3	0	0	8	0	0	0	0	-4.8
13	4	1	1	0	8	4	0	0	0	-5.2
14	4	2	0	1	8	4	0	0	0	-5.6
15	4	3	0	0	8	0	0	0	0	-4.8
16	5	1	1	0	10	8	1	0	0	-7.7
17	5	2	0	1	10	8	0	1	0	-7.6
18	5	3	0	0	10	0	0	0	1	-7
19	6	1	1	0	10	8	1	0	0	-7.7
20	6	2	0	1	10	8	0	1	0	-7.6
21	6	3	0	0	10	0	0	0	1	-7
22	7	1	1	0	12	8	1	0	0	-8.9
23	7	2	0	1	12	8	0	1	0	-8.8
24	7	3	0	0	12	0	0	0	1	-8.2
25	8	1	1	0	12	8	1	0	0	-8.9
26	8	2	0	1	12	8	0	1	0	-8.8
27	8	3	0	0	12	0	0	0	1	-8.2
28										

$$V_{js} = \sum_{k=1}^{K_j} \beta_{jk} x_{jks}$$

=SUMPRODUCT(“priors”,“levels”)

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Step 9: Calculate the Choice Probabilities

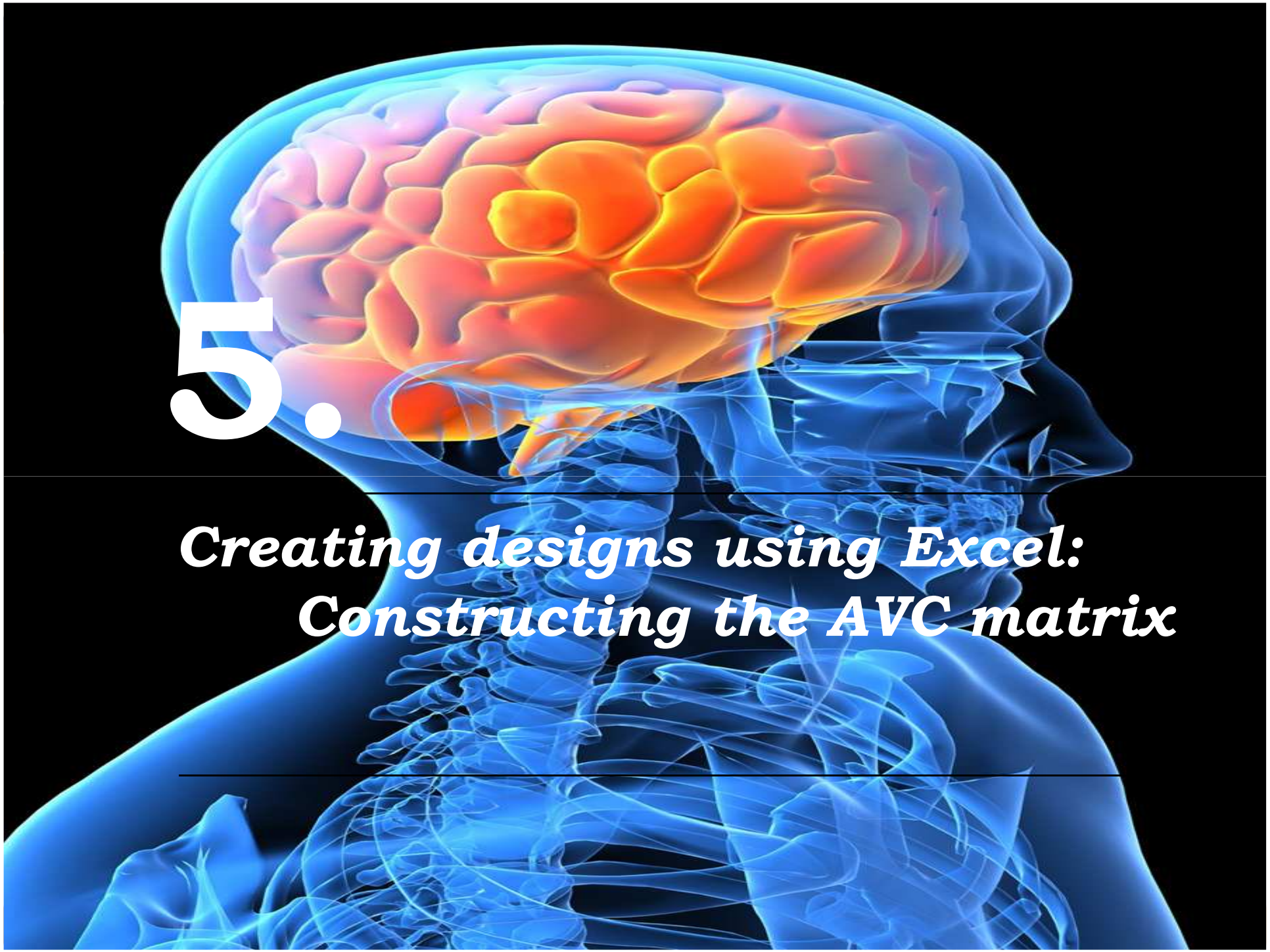
	A	B	C	D	E	F	G	H	I	J	K	L	M
1													
2	**priors:**		1.2	0.8	-0.6	-0.4	0.3	0.8	-1.0				
3	s	j	con1	con2	A	B	C1	C2	C3	V(js)	expV	sum expV	P(js)
4	1	1	1	0	6	4	0	0	0	-4	=EXP(J4)	=K4+K5+K6	=K4/L4
5	1	2	0	1	6	4	0	0	0	-4.4	=EXP(J5)	=L4	=K5/L5
6	1	3	0	0	6	0	0	0	0	-3.6	=EXP(J6)	=L4	=K6/L6
7	2	1	1	0	6	4	0	0	0	-4	1.83E-02	5.79E-02	0.32
8	2	2	0	1	6	4	0	0	0	-4.4	1.23E-02	5.79E-02	0.21
9	2	3	0	0	6	0	0	0	0	-3.6	2.73E-02	5.79E-02	0.47
10	3	1	1	0	8	4	0	0	0	-5.2	5.52E-03	1.74E-02	0.32
11	3	2	0	1	8	4	0	0	0	-5.6	3.70E-03	1.74E-02	0.21
12	3	3	0	0	8	0	0	0	0	-4.8	8.23E-03	1.74E-02	0.47
13	4	1	1	0	8	4	0	0	0	-5.2	5.52E-03	1.74E-02	0.32
14	4	2	0	1	8	4	0	0	0	-5.6	3.70E-03	1.74E-02	0.21
15	4	3	0	0	8	0	0	0	0	-4.8	8.23E-03	1.74E-02	0.47
16	5	1	1	0	10	8	1	0	0	-7.7	4.53E-04	1.87E-03	0.24
17	5	2	0	1	10	8	0	1	0	-7.6	5.00E-04	1.87E-03	0.27
18	5	3	0	0	10	0	0	0	1	-7	9.12E-04	1.87E-03	0.49
19	6	1	1	0	10	8	1	0	0	-7.7	4.53E-04	1.87E-03	0.24
20	6	2	0	1	10	8	0	1	0	-7.6	5.00E-04	1.87E-03	0.27
21	6	3	0	0	10	0	0	0	1	-7	9.12E-04	1.87E-03	0.49
22	7	1	1	0	12	8	1	0	0	-8.9	1.36E-04	5.62E-04	0.24
23	7	2	0	1	12	8	0	1	0	-8.8	1.51E-04	5.62E-04	0.27
24	7	3	0	0	12	0	0	0	1	-8.2	2.75E-04	5.62E-04	0.49
25	8	1	1	0	12	8	1	0	0	-8.9	1.36E-04	5.62E-04	0.24
26	8	2	0	1	12	8	0	1	0	-8.8	1.51E-04	5.62E-04	0.27
27	8	3	0	0	12	0	0	0	1	-8.2	2.75E-04	5.62E-04	0.49
28													

$$P_{js} = \frac{\exp\left(V_{js}\right)}{\sum_{i=1}^{J} \exp\left(V_{is}\right)}$$

1. Calculate the exponentials

   =EXP("value")

2. Within each choice set, sum the exponentials
3. Compute probabilities



5.

Creating designs using Excel: Constructing the AVC matrix

Overview Part 2

$$MAT_{jks} = \left(x_{jks} - \sum_{i=1}^{J} x_{iks} P_{is} \right) \sqrt{P_{js}}$$

$$FISHER = MAT^{T} \cdot MAT$$

$$AVC = FISHER^{-1}$$

$$D\text{-error} = DET(AVC)^{1/K}$$

- Calculate matrix MAT
- Compute the Fisher information matrix, using MAT
- Compute AVC matrix, using the Fisher information matrix
- Compute the *D*-error as the determinant of the AVC matrix (scaled to the number of parameters)

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$$MAT_{jks} = \left(x_{jks} - \sum_{i=1}^{J} x_{iks} P_{is} \right) \sqrt{P_{js}}$$

Step 10: Compute Matrix $x_{jks}P_{js}$

	A	B	C	D	E	F	G	H	I
1									
2	**priors:**		1.2	0.8	-0.6	-0.4	0.3	0.8	-1.0
3	s	j	con1	con2	A	B	C1	C2	C3
4	1	1	1	0	6	4	0	0	0
5	1	2	0	1	6	4	0	0	0
6	1	3	0	0	6	0	0	0	0
7	2	1	1	0	6	4	0	0	0
8	2	2	0	1	6	4	0	0	0
9	2	3	0	0	6	0	0	0	0
10	3	1	1	0	8	4	0	0	0
11	3	2	0	1	8	4	0	0	0
12	3	3	0	0	8	0	0	0	0
13	4	1	1	0	8		0	0	0
14	4	2	0	1	8		0	0	0
15	4	3	0	0	8		0	0	0
16	5	1	1	0	10		1	0	0
17	5	2	0	1	10	8	0	1	0
18	5	3	0	0	10	0	0	0	1
19	6	1	1	0	10	8	1	0	0
20	6	2	0	1	10	8	0	1	0
21	6	3	0	0	10	0	0	0	1
22	7	1	1	0	12	8	1	0	0
23	7	2	0	1	12	8	0	1	0
24	7	3	0	0	12	0	0	0	1
25	8	1	1	0	12	8	1	0	0
26	8	2	0	1	12	8	0	1	0
27	8	3	0	0	12	0	0	0	1

x_{jks}

	M	N	O	P	Q	R	S	T
					x(js) * P(js)			
	P(js)	con1	con2	A	B	C1	C2	C3
	0.32	=C4*$M4	0.00	1.90	1.26	0.00	0.00	0.00
	0.21	0.00	0.21	1.27	0.85	0.00	0.00	0.00
	0.47	0.00	0.00	2.83	0.00	0.00	0.00	0.00
	0.32	0.32	0.00	1.90	1.26	0.00	0.00	0.00
	0.21	0.00	0.21	1.27	0.85	0.00	0.00	0.00
	0.47	0.00	0.00	2.83	0.00	0.00	0.00	0.00
	0.32	0.32	0.00	2.53	1.26	0.00	0.00	0.00
	0.21	0.00	0.21	1.70	0.85	0.00	0.00	0.00
	0.47	0.00	0.00	3.77	0.00	0.00	0.00	0.00
		0.32	0.00				0.00	0.00
		0.00	0.21				0.00	0.00
		0.00	0.00				0.00	0.00
	0.24	0.00					0.00	0.00
	0.27	0.00	0.27	2.68	2.15	0.00	0.27	0.00
	0.49	0.00	0.00	4.89	0.00	0.00	0.00	0.49
	0.24	0.24	0.00	2.43	1.94	0.24	0.00	0.00
	0.27	0.00	0.27	2.68	2.15	0.00	0.27	0.00
	0.49	0.00	0.00	4.89	0.00	0.00	0.00	0.49
	0.24	0.24	0.00	2.91	1.94	0.24	0.00	0.00
	0.27	0.00	0.27	3.22	2.15	0.00	0.27	0.00
	0.49	0.00	0.00	5.87	0.00	0.00	0.00	0.49
	0.24	0.24	0.00	2.91	1.94	0.24	0.00	0.00
	0.27	0.00	0.27	3.22	2.15	0.00	0.27	0.00
	0.49	0.00	0.00	5.87	0.00	0.00	0.00	0.49

P_{js}

$x_{jks}P_{js}$

- Compute $x_{jks}P_{js}$

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$$MAT_{jks} = \left(x_{jks} - \sum_{i=1}^{J} x_{iks} P_{is} \right) \sqrt{P_{js}}$$

Step 11: Compute Matrix $\Sigma x_{iks} P_{is}$

	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA
1														
2			x(js) * P(js)							sum_i [x(is)*P(is)]				
3	con1	con2	A	B	C1	C2	C3	con1	con2	A	B	C1	C2	C3
4	0.32	0.00	1.90	1.26	0.00	0.00	0.00	=N4+N5+N6	0.21	6.00	2.11	0.00	0.00	0.00
5	0.00	0.21	1.27	0.85	0.00	0.00	0.00	=U4	0.21	6.00	2.11	0.00	0.00	0.00
6	0.00	0.00	2.83	0.00	0.00	0.00	0.00	=U4	0.21	6.00	2.11	0.00	0.00	0.00
7	0.32	0.00	1.90	1.26	0.00	0.00	0.00	=N7+N8+N9	0.21	6.00	2.11	0.00	0.00	0.00
8	0.00	0.21	1.27	0.85	0.00	0.00	0.00	=U7	0.21	6.00	2.11	0.00	0.00	0.00
9	0.00	0.00	2.83	0.00	0.00	0.00	0.00	=U7	0.21	6.00	2.11	0.00	0.00	0.00
10	0.32	0.00	2.53	1.26	0.00	0.00	0.00	0.32	0.21	8.00	2.11	0.00	0.00	0.00
11	0.00	0.21	1.70	0.85	0.00	0.00	0.00	0.32	0.21	8.00	2.11	0.00	0.00	0.00
12	0.00	0.00	3.77	0.00	0.00	0.00	0.00	0.32	0.21	8.00	2.11	0.00	0.00	0.00
13	0.32	0.00	2.53	1.26	0.00	0.00	0.00	0.32	0.21				0.00	0.00
14	0.00	0.21			0.00	0.00	0.00	0.32	0.21				0.00	0.00
15	0.00	0.00			0.00	0.00	0.00	0.32	0.21				0.00	0.00
16	0.24	0.00			0.24	0.00	0.00	0.24	0.27				0.27	0.49
17	0.00	0.27			0.00	0.27	0.00	0.24	0.27				0.27	0.49
18	0.00	0.00	4.89	0.00	0.00	0.00	0.49	0.24	0.27				0.27	0.49
19	0.24	0.00	2.43	1.94	0.24	0.00	0.00	0.24	0.27	10.00	4.09	0.24	0.27	0.49
20	0.00	0.27	2.68	2.15	0.00	0.27	0.00	0.24	0.27	10.00	4.09	0.24	0.27	0.49
21	0.00	0.00	4.89	0.00	0.00	0.00	0.49	0.24	0.27	10.00	4.09	0.24	0.27	0.49
22	0.24	0.00	2.91	1.94	0.24	0.00	0.00	0.24	0.27	12.00	4.09	0.24	0.27	0.49
23	0.00	0.27	3.22	2.15	0.00	0.27	0.00	0.24	0.27	12.00	4.09	0.24	0.27	0.49
24	0.00	0.00	5.87	0.00	0.00	0.00	0.49	0.24	0.27	12.00	4.09	0.24	0.27	0.49
25	0.24	0.00	2.91	1.94	0.24	0.00	0.00	0.24	0.27	12.00	4.09	0.24	0.27	0.49
26	0.00	0.27	3.22	2.15	0.00	0.27	0.00	0.24	0.27	12.00	4.09	0.24	0.27	0.49
27	0.00	0.00	5.87	0.00	0.00	0.00	0.49	0.24	0.27	12.00	4.09	0.24	0.27	0.49
28														

$$x_{jks} P_{js}$$

$$\sum_{i=1}^{J} x_{iks} P_{is}$$

- Compute $\sum_{i=1}^{J} x_{iks} P_{is}$

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$$MAT_{jks} = \left(x_{jks} - \sum_{i=1}^{J} x_{iks} P_{is} \right) \sqrt{P_{js}}$$

Step 12: Compute Matrix $(x_{jks}-\Sigma x_{iks}P_{is})\sqrt{P_{js}}$

	A	B	C	D	E	F	G	H	I	M
1										
2	priors:		1.2	0.8	-0.6	-0.4	0.3	0.8	-1.0	
3	s	j	con1	con2	A	B	C1	C2	C3	P(js)
4	1	1	1	0	6	4	0	0	0	0.32
5	1	2	0	1	6	4	0	0	0	0.21
6	1	3	0	0	6	0	0	0	0	0.47
7	2	1	1	0	6	4	0	0	0	0.32
8	2	2	0	1	6	4	0	0	0	0.21
9	2	3	0	0	6	0	0	0	0	0.47
10	3	1	1	0	8	4	0	0	0	0.32
11	3	2	0	1	8	4	0	0	0	0.21
12	3	3	0	0	8	0	0	0	0	0.47
13	4	1	1	0	8	4	0	0	0	0.32
14	4	2	0	1	8			0	0	
15	4	3	0	0	8			0	0	
16	5	1	1	0	10			0	0	
17	5	2	0	1	10			1	0	
18	5	3	0	0	10	0	0	0	1	0.49
19	6	1	1	0	10	8	1	0	0	0.24
20	6	2	0	1	10	8	0	1	0	0.27
21	6	3	0	0	10	0	0	0	1	0.49
22	7	1	1	0	12	8	1	0	0	0.24
23	7	2	0	1	12	8	0	1	0	0.27
24	7	3	0	0	12	0	0	0	1	0.49
25	8	1	1	0	12	8	1	0	0	0.24
26	8	2	0	1	12	8	0	1	0	0.27
27	8	3	0	0	12	0	0	0	1	0.49

x_{jks}

P_{js}

	U	V	W	X	Y	Z	AA
1							
2			sum_i [x(is)*P(is)]				
3	con1	con2	A	B	C1	C2	C3
4	0.32	0.21	6.00	2.11	0.00	0.00	0.00
5	0.32	0.21	6.00	2.11	0.00	0.00	0.00
6	0.32	0.21	6.00	2.11	0.00	0.00	0.00
7	0.32	0.21	6.00	2.11	0.00	0.00	0.00
8	0.32	0.21	6.00	2.11	0.00	0.00	0.00
9	0.32	0.21	6.00	2.11	0.00	0.00	0.00
10	0.32	0.21	8.00	2.11	0.00	0.00	0.00
11	0.32	0.21	8.00	2.11	0.00	0.00	0.00
12	0.32	0.21	8.00	2.11	0.00	0.00	0.00
13	0.32	0.2				0.00	0.00
14	0.32	0.2				0.00	0.00
15	0.32	0.2				0.00	0.00
16	0.24	0.2				0.27	0.49
17	0.24	0.2				0.27	0.49
18	0.24	0.2				0.27	0.49
19	0.24	0.27				0.27	0.49
20	0.24	0.27	10.00	4.09	0.24	0.27	0.49
21	0.24	0.27	10.00	4.09	0.24	0.27	0.49
22	0.24	0.27	12.00	4.09	0.24	0.27	0.49
23	0.24	0.27	12.00	4.09	0.24	0.27	0.49
24	0.24	0.27	12.00	4.09	0.24	0.27	0.49
25	0.24	0.27	12.00	4.09	0.24	0.27	0.49
26	0.24	0.27	12.00	4.09	0.24	0.27	0.49
27	0.24	0.27	12.00	4.09	0.24	0.27	0.49

$$\sum_{i=1}^{J} x_{iks} P_{is}$$

	AB	AC	AD	AE	AF	AG	AH
1							
2	[x(js) - sum_i [x(is) * P(is)]] * P(js)^0.5						
3	con1	con2	A	B	C1	C2	C3
4	=(C4-U4)*$M4^(0.5)	-0.12	0.00	1.06	0.00	0.00	0.00
5	-0.15	0.36	0.00	0.87	0.00	0.00	0.00
6	-0.22	-0.15	0.00	-1.45	0.00	0.00	0.00
7	0.38	-0.12	0.00	1.06	0.00	0.00	0.00
8	-0.15	0.36	0.00	0.87	0.00	0.00	0.00
9	-0.22	-0.15	0.00	-1.45	0.00	0.00	0.00
10	0.38	-0.12	0.00	1.06	0.00	0.00	0.00
11	-0.15	0.36	0.00	0.87	0.00	0.00	0.00
12							
13							
14							
15							
16							
17							
18							
19							
20	-0.13	0.38	0.00	2.03	-0.13	0.38	-0.25
21	-0.17	-0.19	0.00	-2.86	-0.17	-0.19	0.36
22	0.37	-0.13	0.00	1.93	0.37	-0.13	-0.24
23	-0.13	0.38	0.00	2.03	-0.13	0.38	-0.25
24	-0.17	-0.19	0.00	-2.86	-0.17	-0.19	0.36
25	0.37	-0.13	0.00	1.93	0.37	-0.13	-0.24
26	-0.13	0.38	0.00	2.03	-0.13	0.38	-0.25
27	-0.17	-0.19	0.00	-2.86	-0.17	-0.19	0.36

$$\left(x_{jks} - \sum_{i=1}^{J} x_{iks} P_{is} \right) \sqrt{P_{js}}$$

- Compute $\left(x_{jks} - \sum_{i=1}^{J} x_{iks} P_{is} \right) \sqrt{P_{js}}$

$\sqrt{x}$ **=SQRT(*x*) or =*x*^0.5**

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$$MAT_{jks} = \left(x_{jks} - \sum_{i=1}^{J} x_{iks} P_{is} \right) \sqrt{P_{js}}$$

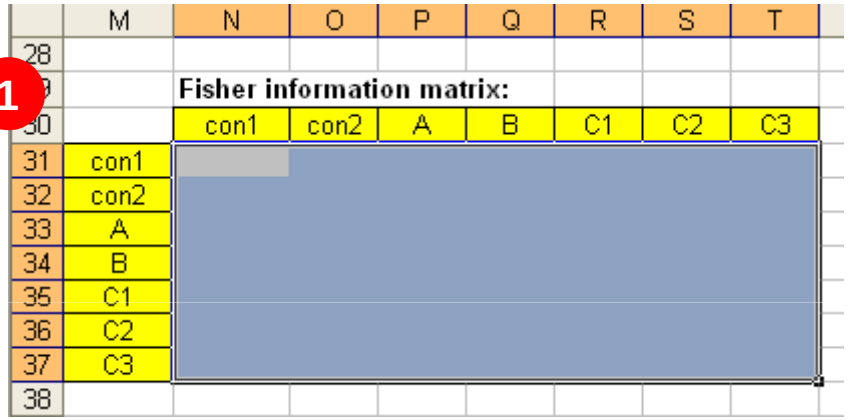
Step 13: Name MAT Matrix

MAT =(C4-U4)*$M4^(0.5)

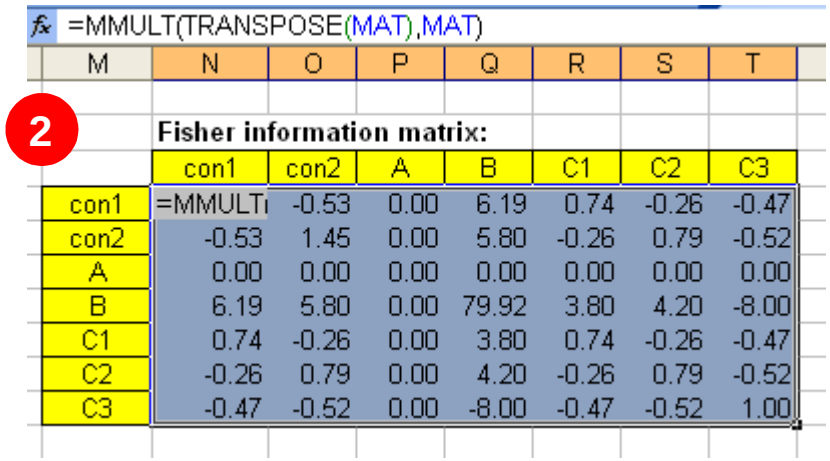
	AB	AC	AD	AE	AF	AG	AH
1							
2	[x(js) - sum_i [x(is) * P(is)]] * P(js)^0.5						
3	con1	con2	A	B	C1	C2	C3
4	0.38	-0.12	0.00	1.06	0.00	0.00	0.00
5	-0.15	0.36	0.00	0.87	0.00	0.00	0.00
6	-0.22	-0.15	0.00	-1.45	0.00	0.00	0.00
7	0.38	-0.12	0.00	1.06	0.00	0.00	0.00
8	-0.15	0.36	0.00	0.87	0.00	0.00	0.00
9	-0.22	-0.15	0.00	-1.45	0.00	0.00	0.00
10	0.38	-0.12	0.00	1.06	0.00	0.00	0.00
11	-0.15	0.36	0.00	0.87	0.00	0.00	0.00
12	-0.22	-0.15	0.00	-1.45	0.00	0.00	0.00
13	0.38	-0.12	0.00	1.06	0.00	0.00	0.00
14	-0.15	0.36	0.00	0.87	0.00	0.00	0.00
15	-0.22	-0.15	0.00	-1.45	0.00	0.00	0.00
16	0.37	-0.13	0.00	1.93	0.37	-0.13	-0.24
17	-0.13	0.38	0.00	2.03	-0.13	0.38	-0.25
18	-0.17	-0.19	0.00	-2.86	-0.17	-0.19	0.36
19	0.37	-0.13	0.00	1.93	0.37	-0.13	-0.24
20	-0.13	0.38	0.00	2.03	-0.13	0.38	-0.25
21	-0.17	-0.19	0.00	-2.86	-0.17	-0.19	0.36
22	0.37	-0.13	0.00	1.93	0.37	-0.13	-0.24
23	-0.13	0.38	0.00	2.03	-0.13	0.38	-0.25
24	-0.17	-0.19	0.00	-2.86	-0.17	-0.19	0.36
25	0.37	-0.13	0.00	1.93	0.37	-0.13	-0.24
26	-0.13	0.38	0.00	2.03	-0.13	0.38	-0.25
27	-0.17	-0.19	0.00	-2.86	-0.17	-0.19	0.36
28							

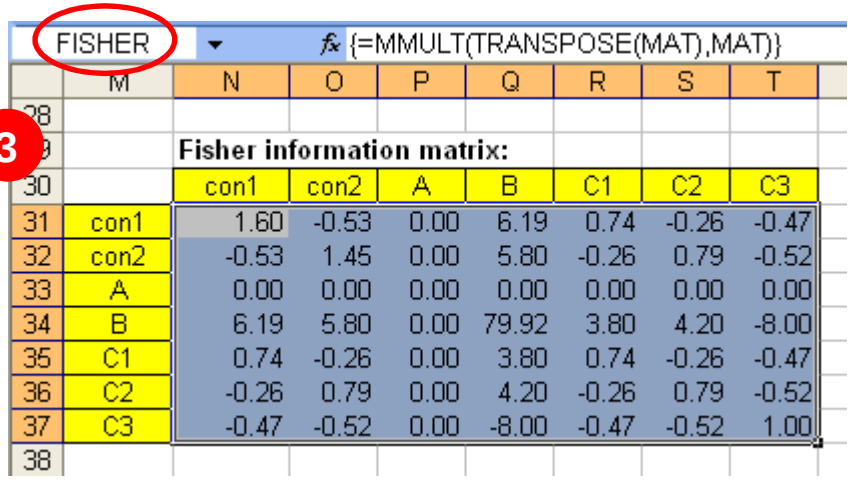
- Select the matrix and name it MAT

Step 14: Compute Fisher Information Matrix

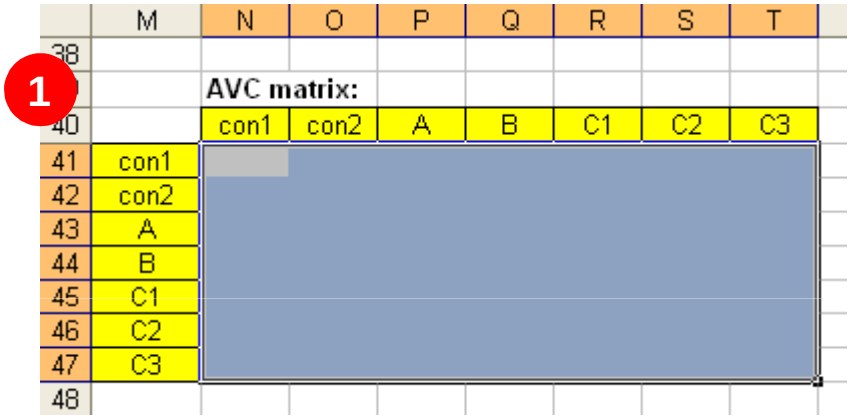


- Compute $FISHER = MAT^T \cdot MAT$
  1. Select an area of size *K* x *K*
  2. Type =MMULT(TRANSPOSE(MAT),MAT) and press <ctrl>+<shift>+<enter>
  3. Select the matrix and name it FISHER



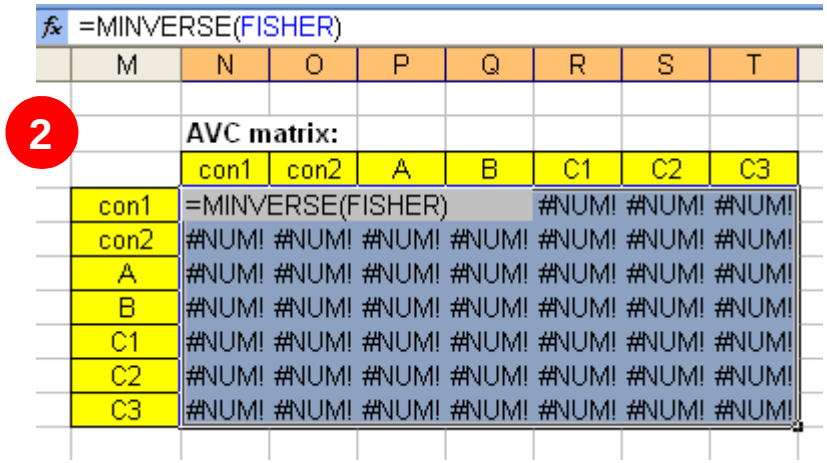


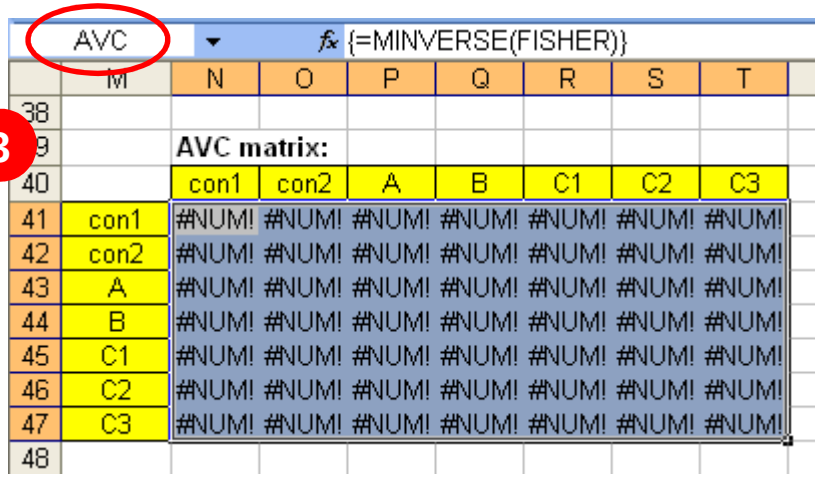
Step 15: Compute AVC Matrix

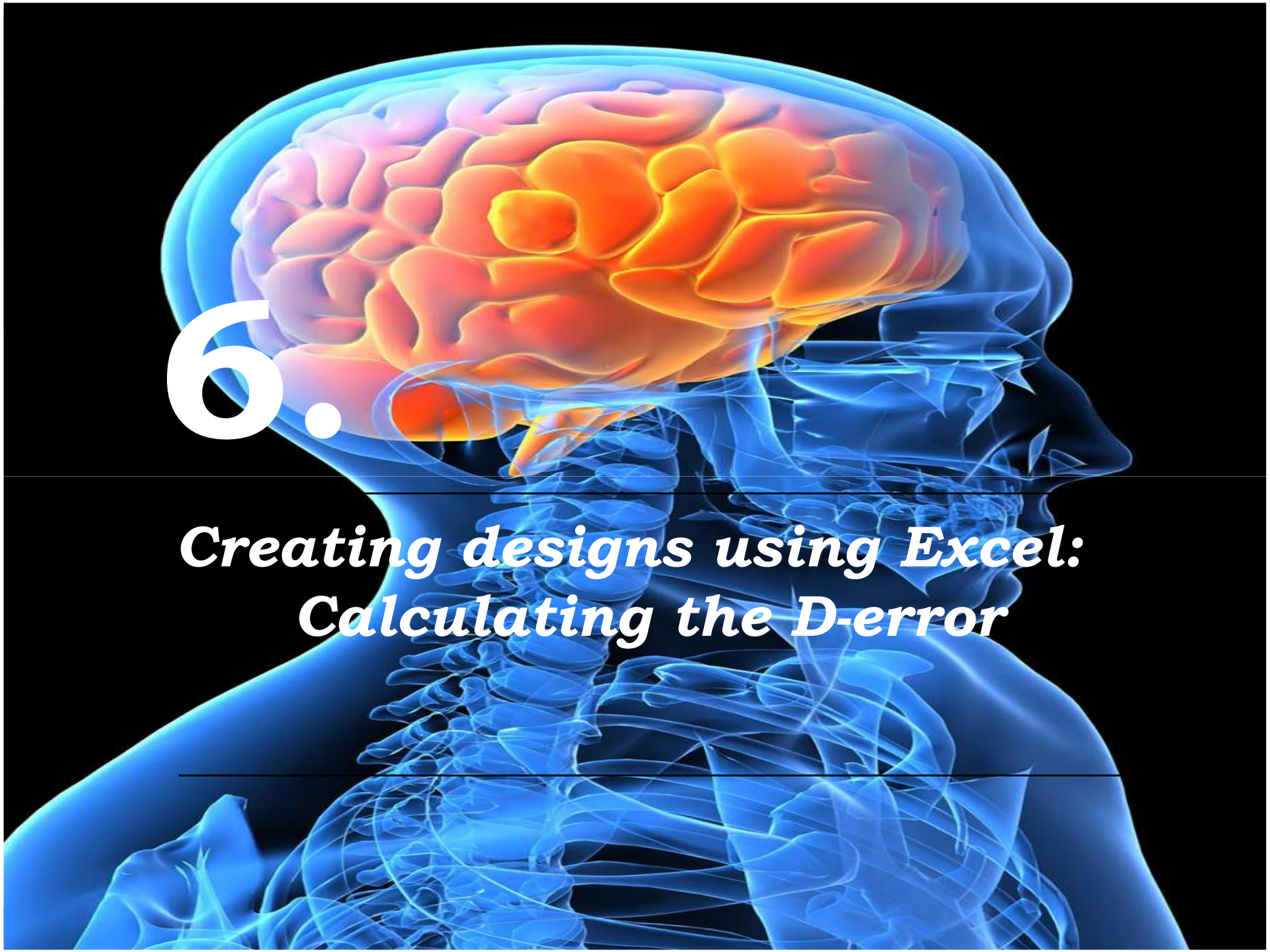


- Compute $AVC = FISHER^{-1}$
  1. Select an area of size *K* x *K*
  2. Type =MINVERSE(FISHER) and press <ctrl>+<shift>+<enter>
  3. Select the matrix and name it AVC

  (Note: Do not worry if cells state #NUM! at this stage)







6.

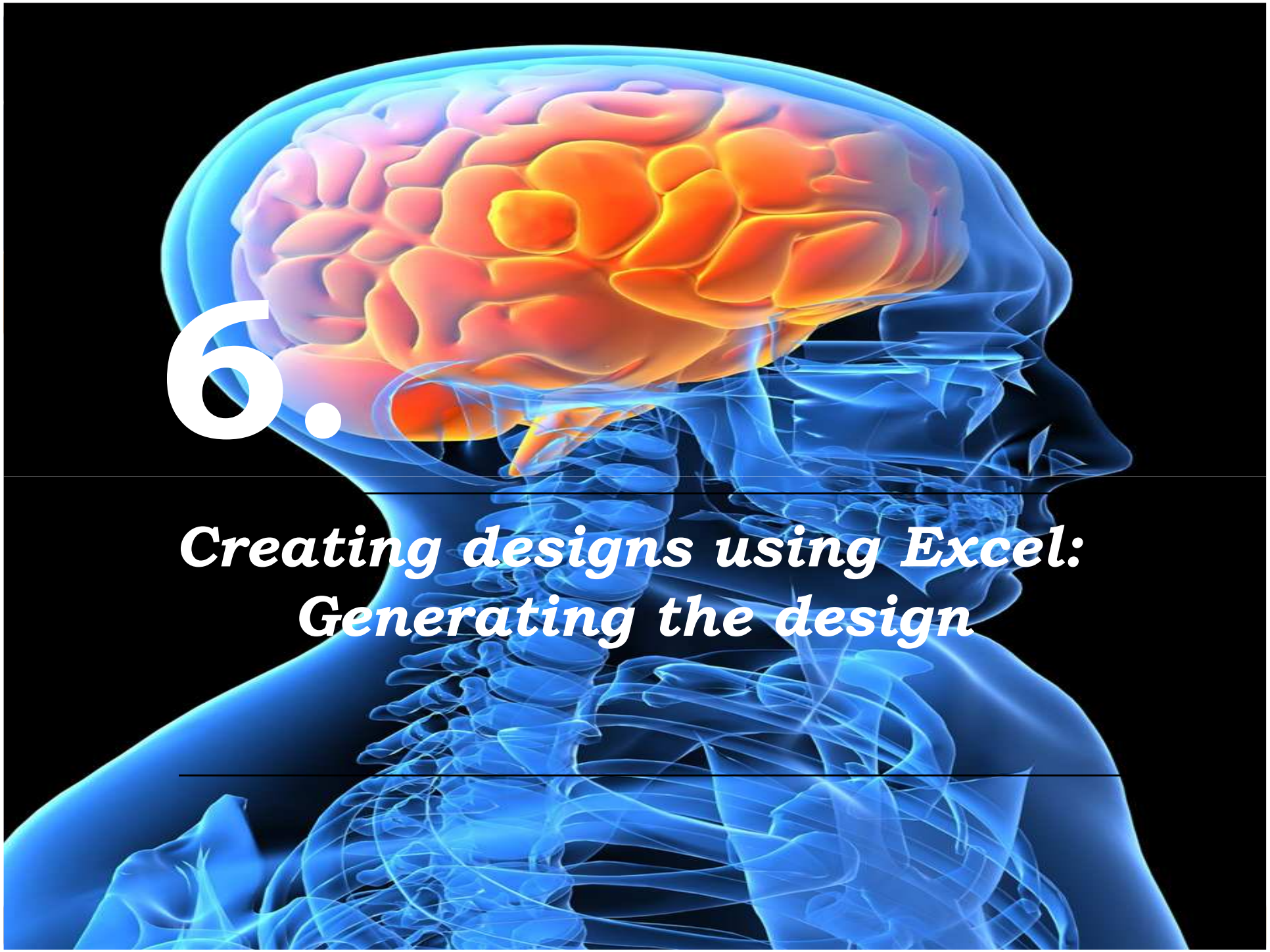
Creating designs using Excel: Calculating the D-error

Step 16: Calculate the D-error

	J	K	L	M	N	O	P	Q	R	S	T
38											
39					**AVC matrix:**						
40					con1	con2	A	B	C1	C2	C3
41	**D-error:**	=MDETERM(AVC)^(1/7)		con1	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
42				con2	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
43				A	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
44				B	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
45				C1	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
46				C2	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
47				C3	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
48											

- Calculate the determinant of the AVC matrix

  =MDETERM(AVC)
- Scale the determinant to the power 1/*K* where *K* is the number of parameters



6.

Creating designs using Excel: Generating the design

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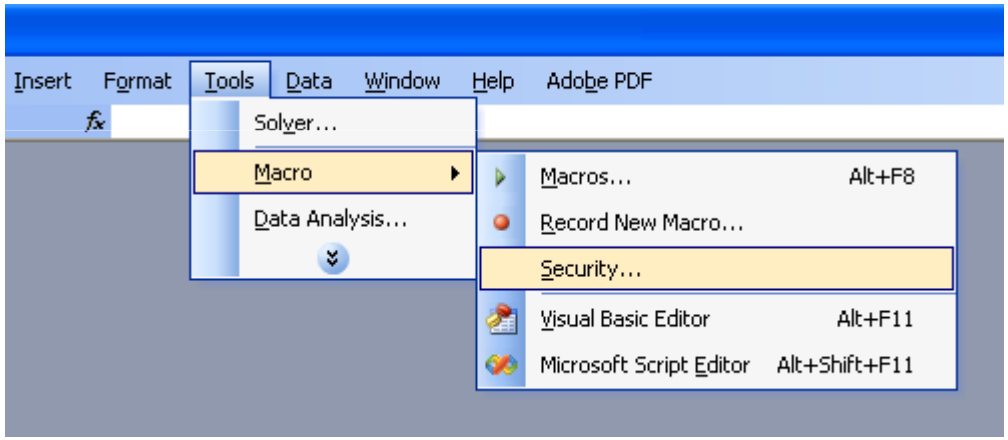
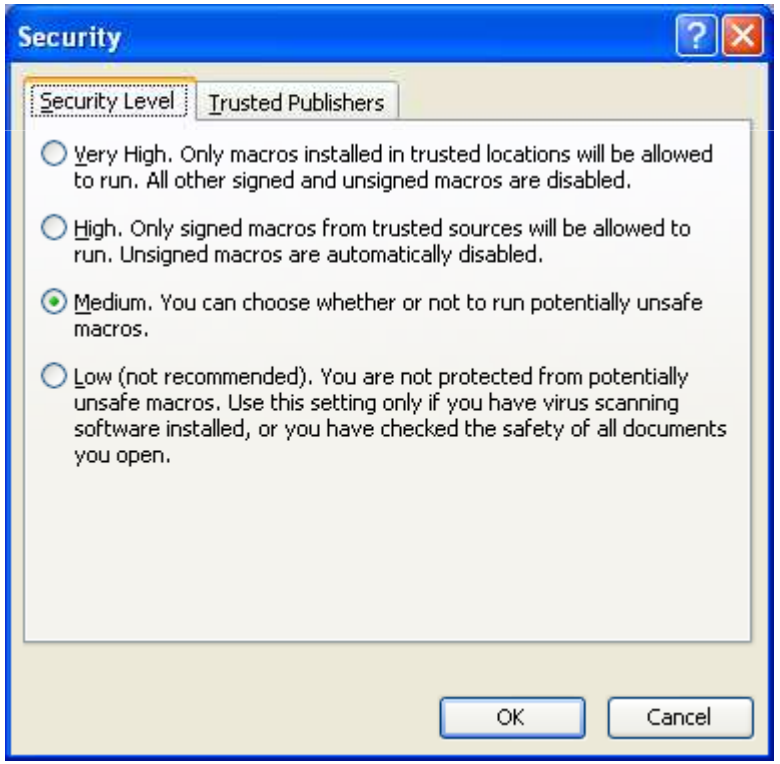
Macro Security Settings

- You may need to change the Macro security settings





Macros

- Macros can be created in two ways:
  - Recording macros through performed
  - Write macros yourself (in Visual Basic script)

  We will use both ways of creating macros
- You can then use the macro to repeat the same task over and over again

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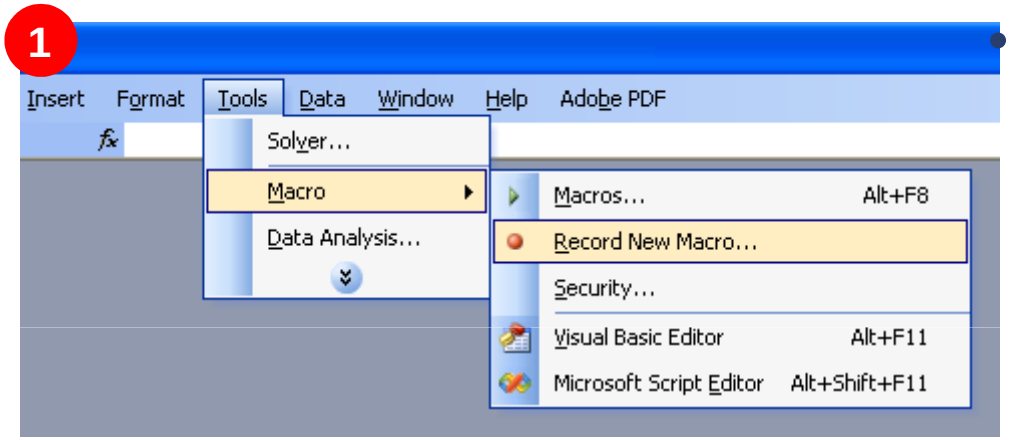
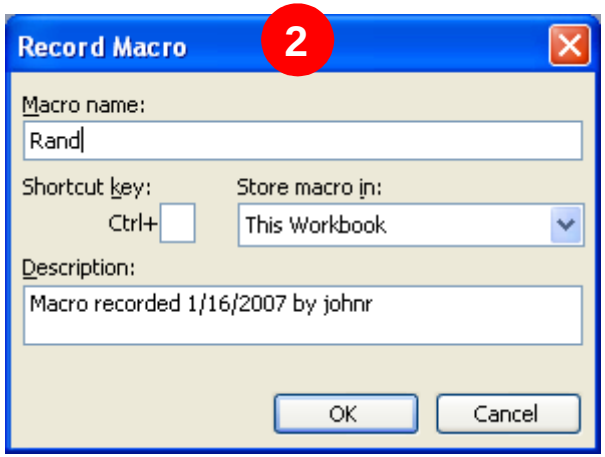
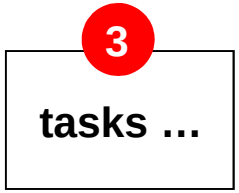
Recording macros

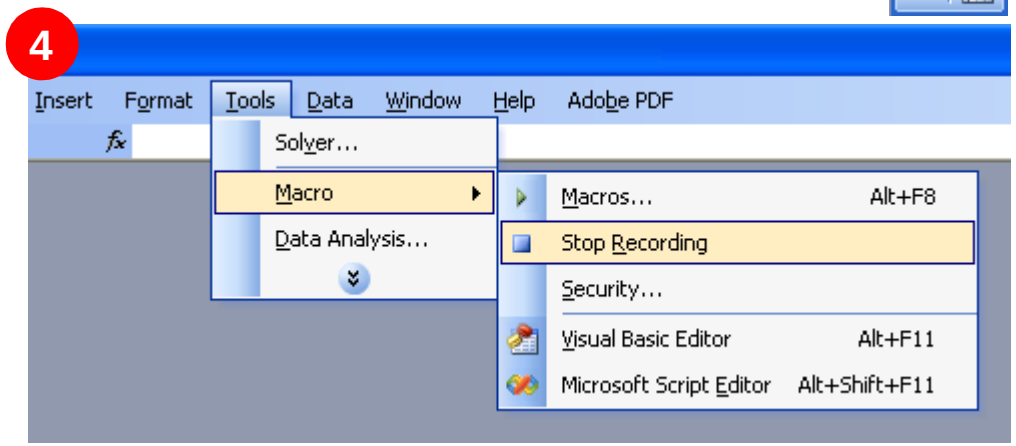


Recording macros:

1. Start recording new macro
2. Give macro a name
3. Perform tasks in Excel
4. Stop recording macro







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Step 17: Randomising the Design

	A	B	C	D	E	F	G	H
29								
30		s	A1		B1		C1	
31		1	0.65	6	0.66	4	0.54	0
32		2	0.61	6	0.33	4	0.89	0
33		3	0.18	8	0.72	4	0.76	0
34		4	0.89	8	0.13	4	0.04	0
35		5	0.02	10	0.66	8	0.17	1
36		6	0.63	10	0.59	8	0.11	1
37		7	0.84	12	0.09	8	0.78	1
38		8	0.02	12	0.99	8	0.12	1
39								
40		s	A2		B2		C2	
41		1	0.13	6	0.96	4	0.86	0
42		2	0.43	6	0.4	4	0.76	0
43		3	0.3	8	0.5	4	0.2	0
44		4	0.08	8	0.53	4	0.26	0
45		5	0.56	10	0.74	8	0.31	1
46		6	0.93	10	0.39	8	0.97	1
47		7	0.61	12	0.39	8	0.56	1
48		8	0.59	12	0	8	0.18	1
49								
50		s	A3		-		C3	
51		1	0.24	6			0.63	0
52		2	0.36	6			0.43	0
53		3	0.62	8			0.37	0
54		4	0.68	8			0.49	0
55		5	0.43	10			0.91	1
56		6	0.98	10			0.06	1
57		7	0.83	12			0.4	1
58		8	0.6	12			0.19	1

sort

	A	B	C	D	E	F	G	H
29								
30		s	A1		B1		C1	
31		1	0.02	10	0.09	8	0.04	0
32		2	0.02	12	0.13	4	0.11	1
33		3	0.18	8	0.33	4	0.12	1
34		4	0.61	6	0.59	8	0.17	1
35		5	0.63	10	0.66	8	0.54	0
36		6	0.65	6	0.66	4	0.76	0
37		7	0.84	12	0.72	4	0.78	1
38		8	0.89	8	0.99	8	0.89	0
39								
40		s	A2		B2		C2	
41		1	0.08	8	0	8	0.18	1
42		2	0.13	6	0.39	8	0.2	0
43		3	0.3	8	0.39	8	0.26	0
44		4	0.43	6	0.4	4	0.31	1
45		5	0.56	10	0.5	4	0.56	1
46		6	0.59	12	0.53	4	0.76	0
47		7	0.61	12	0.74	8	0.86	0
48		8	0.93	10	0.96	4	0.97	1
49								
50		s	A3		-		C3	
51		1	0.24	6			0.06	1
52		2	0.36	6			0.19	1
53		3	0.43	10			0.37	0
54		4	0.6	12			0.4	1
55		5	0.62	8			0.43	0
56		6	0.68	8			0.49	0
57		7	0.83	12			0.63	0
58		8	0.98	10			0.91	1

	A	B	C	D	E	F	G	H	I
3	s	j	con1	con2	A	B	C1	C2	C3
4	1	1	1	0	10	8	0	0	0
5	1	2	0	1	8	8	0	1	0
6	1	3	0	0	6	0	0	0	1
7	2	1	1	0	12	4	1	0	0
8	2	2	0	1	6	8	0	0	0
9	2	3	0	0	6	0	0	0	1
10	3	1	1	0	8	4	1	0	0
11	3	2	0	1	8	8	0	0	0
12	3	3	0	0	10	0	0	0	0
13	4	1	1	0	6	8	1	0	0
14	4	2	0	1	6	4	0	1	0
15	4	3	0	0	12	0	0	0	1
16	5	1	1	0	10	8	0	0	0
17	5	2	0	1	10	4	0	1	0
18	5	3	0	0	8	0	0	0	0
19	6	1	1	0	6	4	0	0	0
20	6	2	0	1	12	4	0	0	0
21	6	3	0	0	8	0	0	0	0
22	7	1	1	0	12	4	1	0	0
23	7	2	0	1	12	8	0	0	0
24	7	3	0	0	12	0	0	0	0
25	8	1	1	0	8	8	0	0	0
26	8	2	0	1	10	4	0	1	0
27	8	3	0	0	10	0	0	0	1

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Step 17: Randomising the Design (cont'd)

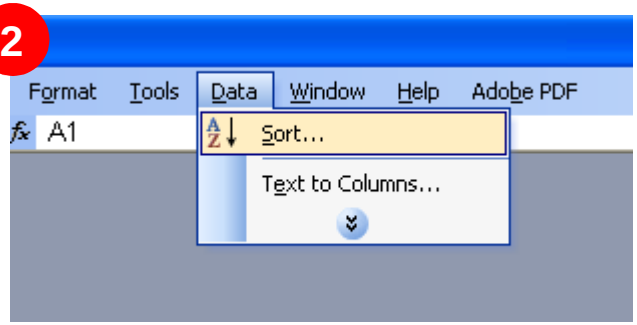
1

	A	B	C	D	E	F	G	H
29								
30		s	A1		B1		C1	
31		1	0.65	6	0.66	4	0.54	0
32		2	0.61	6	0.33	4	0.89	0
33		3	0.18	8	0.72	4	0.76	0
34		4	0.89	8	0.13	4	0.04	0
35		5	0.02	10	0.66	8	0.17	1
36		6	0.63	10	0.59	8	0.11	1
37		7	0.84	12	0.09	8	0.78	1
38		8	0.02	12	0.99	8	0.12	1
39								

- Randomise design (store in macro "Rand")
  1. Select attribute level columns (including header)
  2. Select Sort from the Data menu
  3. In the Sort window, select OK
  4. The first column is sorted, changing the attribute levels

  … Repeat for all attribute level columns

2



3

4

	A	B	C	D	E	F	G	H
29								
30		s	A1		B1		C1	
31		1	0.02	10	0.66	4	0.54	0
32		2	0.02	12	0.33	4	0.89	0
33		3	0.18	8	0.72	4	0.76	0
34		4	0.61	6	0.13	4	0.04	0
35		5	0.63	10	0.66	8	0.17	1
36		6	0.65	6	0.59	8	0.11	1
37		7	0.84	12	0.09	8	0.78	1
38		8	0.89	8	0.99	8	0.12	1
39								

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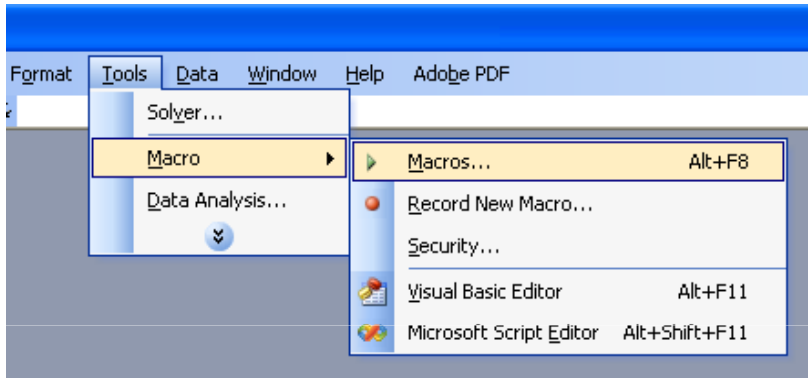
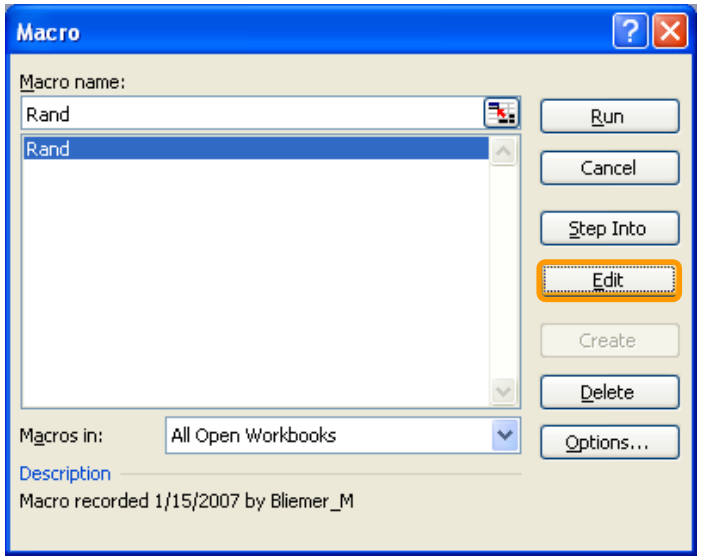
To View the Macro






```
Sub Rand()

    Range("C30:D38").Select
    Selection.Sort Key1:=Range("C31"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal

    Range("E30:F38").Select
    Selection.Sort Key1:=Range("E31"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal

    Range("G30:H38").Select
    Selection.Sort Key1:=Range("G31"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal

    Range("C40:D48").Select
    Selection.Sort Key1:=Range("C41"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal

    Range("E40:F48").Select
    Selection.Sort Key1:=Range("E41"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal

    Range("G40:H48").Select
    Selection.Sort Key1:=Range("G41"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal

    Range("C50:D58").Select
    Selection.Sort Key1:=Range("C51"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal

    Range("G50:H58").Select
    Selection.Sort Key1:=Range("G51"), Order1:=xlAscending, Header:=xlGuess, _
        OrderCustom:=1, MatchCase:=False, Orientation:=xlTopToBottom, _
        DataOption1:=xlSortNormal

End Sub
```

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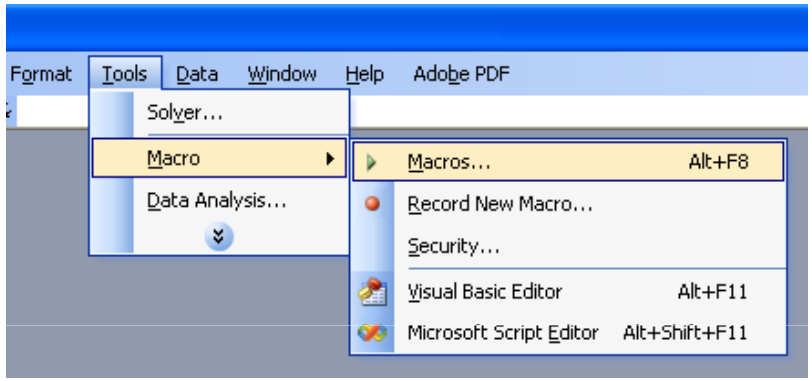
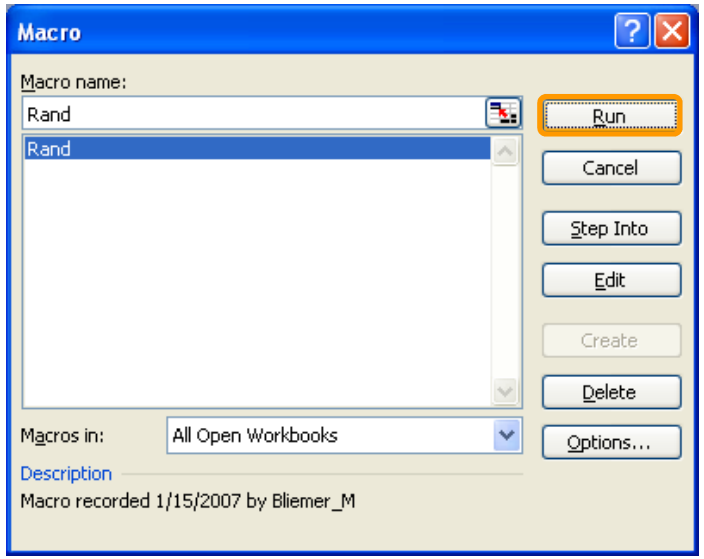
To Run the Macro





The macro changes the design, a new AVC matrix is calculated, and a new *D*-error is reported

	I	J	K	L	M	N	O	P	Q	R	S	T
38												
39						AVC matrix:						
40						con1	con2	A	B	C1	C2	C3
41		D-error:	1.076263		con1	15.98	12.52	-1.33	-2.22	2.63	4.62	5.30
42					con2	12.52	13.73	-1.25	-1.90	4.68	0.44	5.21
43					A	-1.33	-1.25	0.22	0.22	-0.56	-0.20	-0.46
44					B	-2.22	-1.90	0.22	0.36	-0.65	-0.67	-0.63
45					C1	2.63	4.68	-0.56	-0.65	5.53	-0.53	2.18
46					C2	4.62	0.44	-0.20	-0.67	-0.53	6.38	0.48
47					C3	5.30	5.21	-0.46	-0.63	2.18	0.48	4.80
48												

Step 18: Design Search

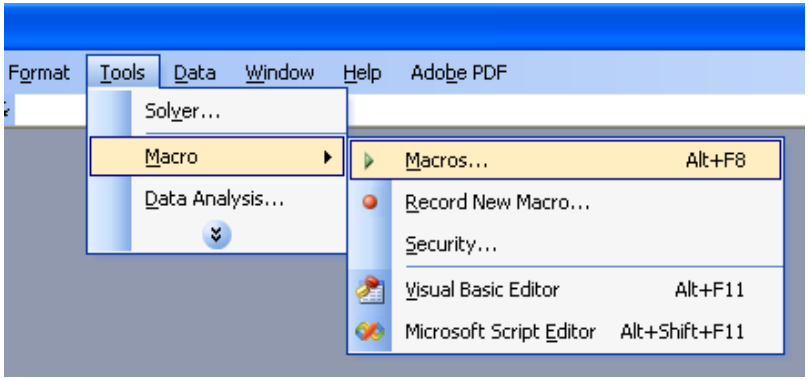
- Determine how many random designs (iterations) you wish to search

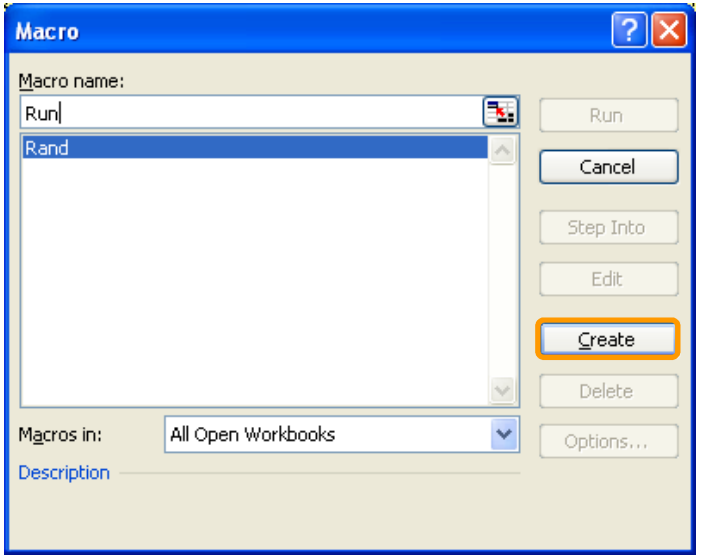
- Create two values (and note the cells you place them in):
  - Current iteration
  - Maximum iteration

	I	J	K
32			
33		**Iteration:**	1
34		**Max_iter:**	500
35			

Step 18: Design Search (cont'd)

- Create a new macro (call it "Run") to randomise the current design from iteration 1 to the maximum iteration number.
- Each Macro routine begins with the command **Sub (followed by the name you give the routine)** and ends with the command **End Sub**






```
Sub Run()

End Sub
```

Step 18: Design Search (cont'd)

- Reading the maximum number of iterations from Excel:

  Maxit = Range("K34").Value

- Writing the iteration number to Excel:

  Range("K33").Value = 1

	I	J	K	
32				
33		**Iteration:**	1	
34		**Max_iter:**	500	
35				

Step 18: Design Search (cont'd)

- The following macro creates iteratively new random designs (by calling the earlier created macro "Rand"):

```
Sub Run()

    Maxit = Range("K34").Value

    For it = 1 To Maxit

        Range("K33").Value = it
        Rand

    Next it

End Sub
```

Step 18: Design Search (cont'd)

```
Sub Run()

    Maxit = Range("K34").Value

    For it = 1 To Maxit

        Range("K33").Value = it
        Rand

        D_error = Range("K41").Value
        Best = Range("K42").Value

        If Not (IsError(D_error)) And D_error > 0 Then

            If D_error < Best Then

                Best = D_error
                Range("K42").Value = Best

            End If

        End If

    Next it

End Sub
```

- Read D-error of current design
- Read D-error of best design so far

- Some checking to avoid runtime errors

- If current design has lower D-error than best design so far, store the new D-error

	I	J	K
32			
33		**Iteration:**	1
34		**Max_iter:**	100
35			
36			
37			
38			
39			
40			
41		**D-error:**	1.109927
42		**Best:**	9999999
43			

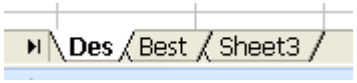
← (start with a large number)

Step 19: Store the Best Design

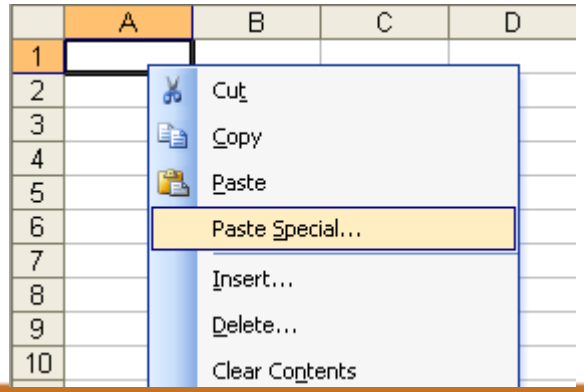
- Save the best design found to date
  - If the *D*-error of a new design is better than all other designs before it, then we want to keep it
  - To do this, we can record a macro to copy the design to a new worksheet if it has a lower *D*-error than the previous best design

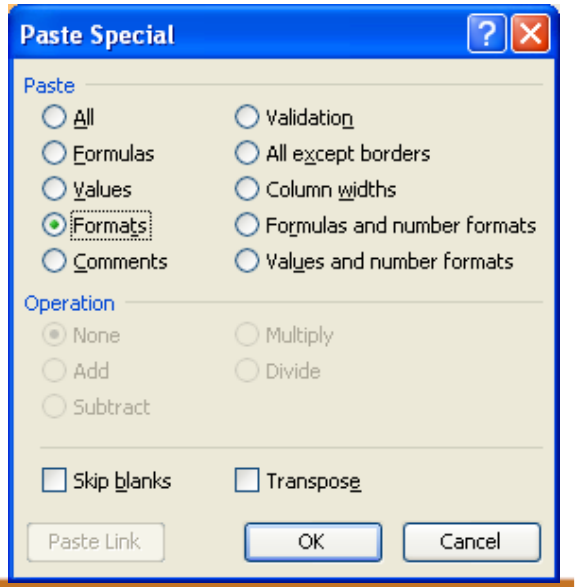
Step 19: Store the Best Design (cont'd)

- First some preparations:
  - Begin by giving the worksheets appropriate names



  - Copy the formatting from the worksheet **Des** to worksheet **Best**
    - Copy all (e.g., <ctrl>+A and then <ctrl>+C) from worksheet **Des**
    - Select worksheet **Best**
    - Select cell A1 and right-mouse click
    - Choose Paste Special, and select Formats





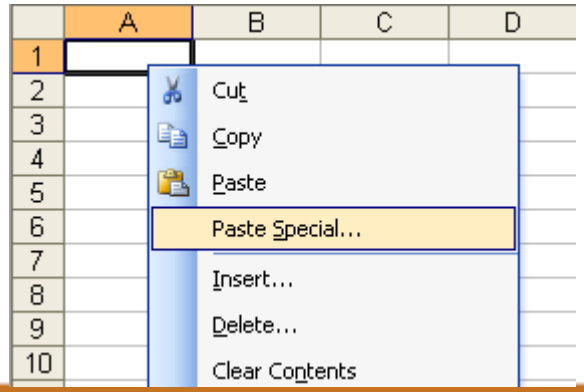
Step 19: Store the Best Design (cont'd)

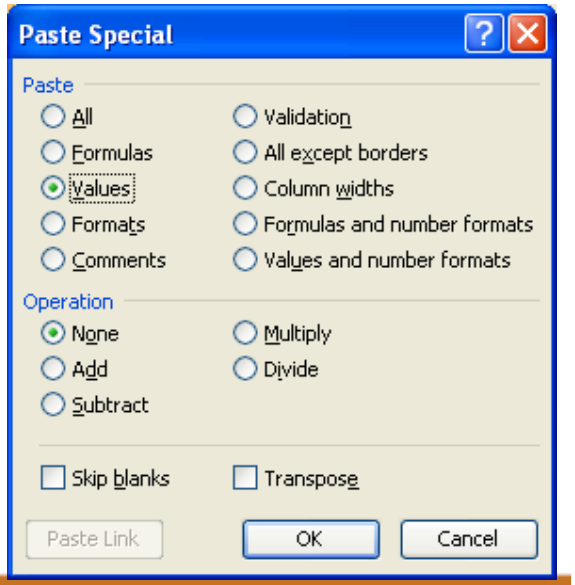
- Record a new macro (call it "Paste") that copies the design in worksheet **Des** into the best design worksheet **Best**

  (start recording macro)

  – Copy all (e.g, <ctrl>+A and then <ctrl>+C) from worksheet **Des**
  – Select worksheet **Best**
  – Select cell A1 and right-mouse click
  – Choose Paste Special, and select Values
  – Select worksheet **Des**

  (stop recording macro)





Step 19: Store the Best Design (cont'd)

```
Sub Run()

    Maxit = Range("K34").Value

    For it = 1 To Maxit

        Range("K33").Value = it
        Rand

        D_error = Range("K41").Value
        Best = Range("K42").Value

        If Not (IsError(D_error)) And D_error > 0 Then

            If D_error < Best Then

                Best = D_error
                Range("K42").Value = Best
                Paste

            End If

        End If

    Next it

End Sub
```

- **Edit macro "Run"**

- Paste the new best design if D-error is smaller than current best design

Tip

To make the macro run faster, include:

```
Application.ScreenUpdating = False
```

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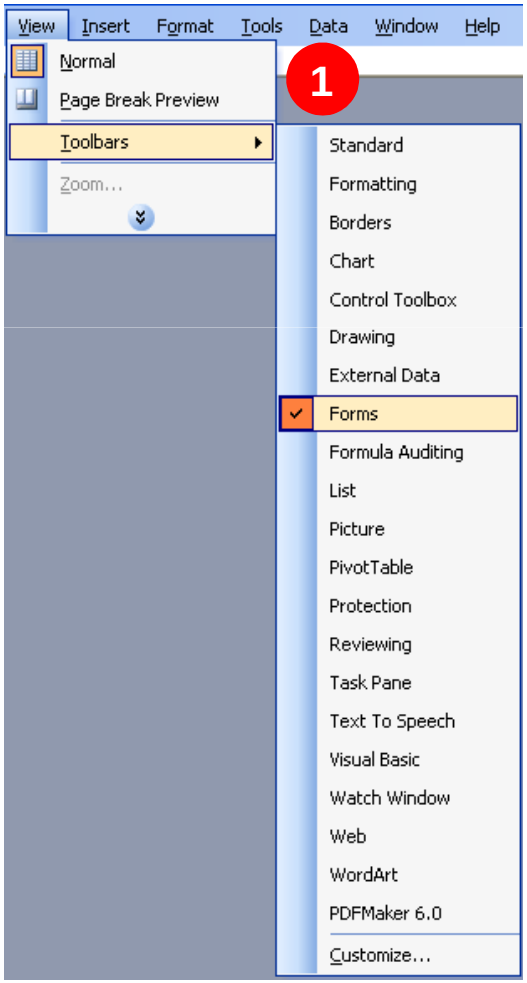
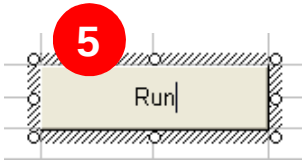
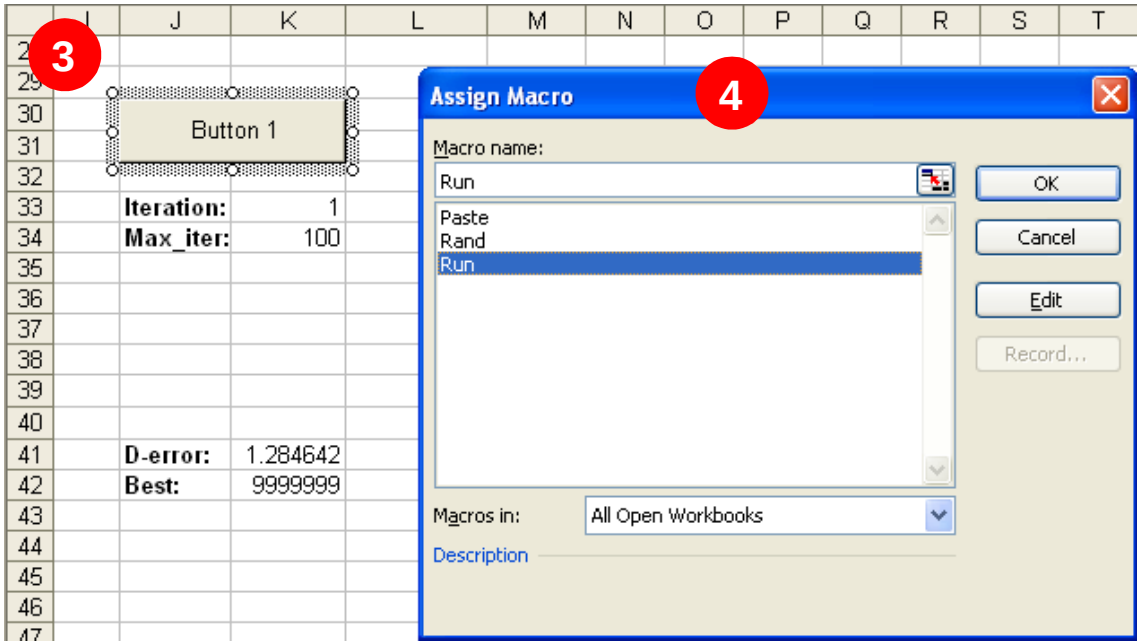
Step 20: Create Run Button



1. Make the Forms toolbar visible
2. From the Forms toolbar, select Button
3. Click, drag, and release to create a button
4. Assign the macro “Run” to the button
5. Change the button name to “Run”





Step 21: Press the Run Button