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**Level 3 GCE**

**Psychology**

**Advanced Subsidiary**

**Paper 2: Biological Psychology**  
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**Formulae and Statistical**  
**Tables**

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## Standard deviation (sample estimate)

$$\sqrt{\left(\frac{\sum (x - \bar{x})^2}{n - 1}\right)}$$

## Spearman's rank correlation coefficient

$$1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

Level of significance for a one-tailed test					
	0.05	0.025	0.01	0.005	0.0025
Level of significance for a two-tailed test					
N	0.10	0.05	0.025	0.01	0.005
5	0.900	1.000	1.000	1.000	1.000
6	0.829	0.886	0.943	1.000	1.000
7	0.714	0.786	0.893	0.929	0.964
8	0.643	0.738	0.833	0.881	0.905
9	0.600	0.700	0.783	0.833	0.867
10	0.564	0.648	0.745	0.794	0.830

Level of significance for a one-tailed test				
0·05	0·025	0·01	0·005	0·0025
Level of significance for a two-tailed test				
N	0·10	0·05	0·025	0·01
11	0·536	0·618	0·709	0·755
12	0·503	0·587	0·678	0·727
13	0·484	0·560	0·648	0·703
14	0·464	0·538	0·626	0·679
15	0·446	0·521	0·604	0·654
16	0·429	0·503	0·582	0·635
				0·679

Level of significance for a one-tailed test				
0·05	0·025	0·01	0·005	0·0025
Level of significance for a two-tailed test				
N	0·10	0·05	0·025	0·01
17	0·414	0·485	0·566	0·615
18	0·401	0·472	0·550	0·600
19	0·391	0·460	0·535	0·584
20	0·380	0·447	0·520	0·570
21	0·370	0·435	0·508	0·556
22	0·361	0·425	0·496	0·544
				0·586

Level of significance for a one-tailed test				
	0·05	0·025	0·01	0·005
				0·0025
Level of significance for a two-tailed test				
N	0·10	0·05	0·025	0·01
23	0·353	0·415	0·486	0·532
24	0·344	0·406	0·476	0·521
25	0·337	0·398	0·466	0·511
26	0·331	0·390	0·457	0·501
27	0·324	0·382	0·448	0·491
28	0·317	0·375	0·440	0·483
				0·573
				0·562
				0·551
				0·541
				0·531
				0·522



Level of significance for a one-tailed test				
0·05		0·025	0·01	0·005
Level of significance for a two-tailed test				
N	0·10	0·05	0·025	0·01
29	0·312	0·368	0·433	0·475
30	0·306	0·362	0·425	0·467

The calculated value must be equal to or exceed the critical value in this table for significance to be shown.

# Chi-squared distribution formula

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

$$df = (r - 1)(c - 1)$$

Level of significance for a one-tailed test					
	0·10	0·05	0·025	0·01	0·0005
Level of significance for a two-tailed test					
df	0·20	0·10	0·05	0·025	0·01
1	1·64	2·71	3·84	5·02	6·64
2	3·22	4·61	5·99	7·38	9·21
3	4·64	6·25	7·82	9·35	11·35
4	5·99	7·78	9·49	11·14	13·28
5	7·29	9·24	11·07	12·83	15·09
					16·27
					18·47
					20·52

Level of significance for a one-tailed test					
	0·10	0·05	0·025	0·01	0·0005
Level of significance for a two-tailed test					
df	0·20	0·10	0·05	0·025	0·01
6	8·56	10·65	12·59	14·45	16·81
7	9·80	12·02	14·07	16·01	18·48
8	11·03	13·36	15·51	17·54	20·09
9	12·24	14·68	16·92	19·02	21·67
10	13·44	15·99	18·31	20·48	23·21
					24·32
					26·12
					27·88
					29·59

Level of significance for a one-tailed test					
	0·10	0·05	0·025	0·01	0·005
					0·0005
Level of significance for a two-tailed test					
df	0·20	0·10	0·05	0·025	0·01
11	14·63	17·28	19·68	21·92	24·73
12	15·81	18·55	21·03	23·34	26·22
13	16·99	19·81	22·36	24·74	27·69
14	18·15	21·06	23·69	26·12	29·14
15	19·31	22·31	25·00	27·49	30·58
					31·26
					32·91
					34·53
					36·12
					37·70

Level of significance for a one-tailed test					
0·10		0·05	0·025	0·01	0·0005
Level of significance for a two-tailed test					
df	0·20	0·10	0·05	0·025	0·01
16	20·47	23·54	26·30	28·85	32·00
17	21·62	24·77	27·59	30·19	33·41
18	22·76	25·99	28·87	31·53	34·81
19	23·90	27·20	30·14	32·85	36·19
20	25·04	28·41	31·41	34·17	37·57
					40·79
					42·31
					43·82
					45·32

Level of significance for a one-tailed test						
0·10		0·05	0·025	0·01	0·005	0·0005
Level of significance for a two-tailed test						
df	0·20	0·10	0·05	0·025	0·01	0·001
21	26·17	29·62	32·67	35·48	38·93	46·80
22	27·30	30·81	33·92	36·78	40·29	48·27
23	28·43	32·01	35·17	38·08	41·64	49·73
24	29·55	33·20	36·42	39·36	42·98	51·18
25	30·68	34·38	37·65	40·65	44·31	52·62

Level of significance for a one-tailed test					
0·10		0·05	0·025	0·01	0·0005
Level of significance for a two-tailed test					
df	0·20	0·10	0·05	0·025	0·01
26	31·80	35·56	38·89	41·92	45·64
27	32·91	36·74	40·11	43·20	46·96
28	34·03	37·92	41·34	44·46	48·28
29	35·14	39·09	42·56	45·72	49·59
30	36·25	40·26	43·77	46·98	50·89
					54·05
					55·48
					56·89
					58·30
					59·70



Level of significance for a one-tailed test						
0·10		0·05	0·025	0·01	0·005	0·0005
Level of signficance for a two-tailed test						
df	0·20	0·10	0·05	0·025	0·01	0·001
40	47·27	51·81	55·76	59·34	63·69	73·40
50	58·16	63·17	67·51	71·42	76·15	86·66
60	68·97	74·40	79·08	83·30	88·38	99·61
70	79·72	85·53	90·53	95·02	100·43	112·32

The calculated value must be equal to or exceed the critical value in this table for significance to be shown.

## Mann–Whitney U test formulae

$$U_a = n_a n_b + \frac{n_a(n_a + 1)}{2} - \sum R_a$$

$$U_b = n_a n_b + \frac{n_b(n_b + 1)}{2} - \sum R_b$$

(U is the smaller of  $U_a$  and  $U_b$ )

$p \leq 0.05$  (one-tailed),  $p \leq 0.10$  (two-tailed)

N <sub>b</sub>									
5	6	7	8	9	10	11	12		

N <sub>a</sub>	4	5	6	8	9	11	12	13	
5									
6	5	7	8	10	12	14	16	17	
7	6	8	11	13	15	17	19	21	
8	8	10	13	15	18	20	23	26	
9	9	12	15	18	21	24	27	30	
10	11	14	17	20	24	27	31	34	

$p \leq 0.05$  (one-tailed),  $p \leq 0.10$  (two-tailed) continued.

N <sub>b</sub>									
5	6	7	8	9	10	11	12		

N <sub>a</sub>										
	11	12	16	19	23	27	31	34	38	
	12	13	17	21	26	30	34	38	42	
	13	15	19	24	28	33	37	42	47	
	14	16	21	26	31	36	41	46	51	
	15	18	23	28	33	39	44	50	55	
16	19	25	30	36	42	48	54	60		

$p \leq 0.05$  (one-tailed),  $p \leq 0.10$  (two-tailed) continued.

$N_b$

5	6	7	8	9	10	11	12
---	---	---	---	---	----	----	----

$N_a$

17	20	26	33	39	45	51	57	64
18	22	28	35	41	48	55	61	68
19	23	30	37	44	51	58	65	72
20	25	32	39	47	54	62	69	77

$p \leq 0.05$  (one-tailed),  $p \leq 0.10$  (two-tailed) continued.

$N_b$

13	14	15	16	17	18	19	20
----	----	----	----	----	----	----	----

$N_a$

5	15	16	18	19	20	22	23	25
6	19	21	23	25	26	28	30	32
7	24	26	28	30	33	35	37	39
8	28	31	33	36	39	41	44	47
9	33	36	39	42	45	48	51	54
10	37	41	44	48	51	55	58	62

$p \leq 0.05$  (one-tailed),  $p \leq 0.10$  (two-tailed) continued.

$N_b$

13	14	15	16	17	18	19	20
----	----	----	----	----	----	----	----

$N_a$

11	42	46	50	54	57	61	65	69
12	47	51	55	60	64	68	72	77
13	51	56	61	65	70	75	80	84
14	56	61	66	71	77	82	87	92
15	61	66	72	77	83	88	94	100
16	65	71	77	83	89	95	101	107

$p \leq 0.05$  (one-tailed),  $p \leq 0.10$  (two-tailed) continued.

$N_b$

13	14	15	16	17	18	19	20
----	----	----	----	----	----	----	----

$N_a$

17	70	77	83	89	96	102	109	115
18	75	82	88	95	102	109	116	123
19	80	87	94	101	109	116	123	130
20	84	92	100	107	115	123	130	138



$p \leq 0.01$  (one-tailed),  $p \leq 0.02$  (two-tailed)

$N_b$

5	6	7	8	9	10	11	12
---	---	---	---	---	----	----	----

$N_a$

5	1	2	3	4	5	6	7	8
6	2	3	4	6	7	8	9	11
7	3	4	6	7	9	11	12	14
8	4	6	7	9	11	13	15	17
9	5	7	9	11	14	16	18	21
10	6	8	11	13	16	19	22	24

$p \leq 0.01$  (one-tailed),  $p \leq 0.02$  (two-tailed) continued.

$N_b$

5	6	7	8	9	10	11	12
---	---	---	---	---	----	----	----

$N_a$

11	7	9	12	15	18	22	25	28
12	8	11	14	17	21	24	28	31
13	9	12	16	20	23	27	31	35
14	10	13	17	22	26	30	34	38
15	11	15	19	24	28	33	37	42
16	12	16	21	26	31	36	41	46

$p \leq 0.01$  (one-tailed),  $p \leq 0.02$  (two-tailed) continued.

$N_b$

5	6	7	8	9	10	11	12
---	---	---	---	---	----	----	----

$N_a$

17	13	18	23	28	33	38	44	49
18	14	19	24	30	36	41	47	53
19	15	20	26	32	38	44	50	56
20	16	22	28	34	40	47	53	60

$p \leq 0.01$  (one-tailed),  $p \leq 0.02$  (two-tailed) continued.

$N_b$

13	14	15	16	17	18	19	20
----	----	----	----	----	----	----	----

$N_a$

5	9	10	11	12	13	14	15	16
6	12	13	15	16	18	19	20	22
7	16	17	19	21	23	24	26	28
8	20	22	24	26	28	30	32	34
9	23	26	28	31	33	36	38	40
10	27	30	33	36	38	41	44	47

$p \leq 0.01$  (one-tailed),  $p \leq 0.02$  (two-tailed) continued.

N <sub>b</sub>							
13	14	15	16	17	18	19	20

N <sub>a</sub>									
	11	31	34	37	41	44	47	50	53
	12	35	38	42	46	49	53	56	60
	13	39	43	47	51	55	59	63	67
	14	43	47	51	56	60	65	69	73
	15	47	51	56	61	66	70	75	80
16	51	56	61	66	71	76	82	87	

$p \leq 0.01$  (one-tailed),  $p \leq 0.02$  (two-tailed) continued.

N <sub>b</sub>							
13	14	15	16	17	18	19	20

N <sub>a</sub>	17	55	60	66	71	77	82	88	93
18	59	65	70	76	82	88	94	100	
19	63	69	75	82	88	94	101	107	
20	67	73	80	87	93	100	107	114	

$N_b$

5	6	7	8	9	10	11	12
---	---	---	---	---	----	----	----

$N_a$

5	2	3	5	6	7	8	9	11
6	3	5	6	8	10	11	13	14
7	5	6	8	10	12	14	16	18
8	6	8	10	13	15	17	19	22
9	7	10	12	15	17	20	23	26
10	8	11	14	17	20	23	26	29

$p \leq 0.025$  (one-tailed),  $p \leq 0.05$  (two-tailed) continued.

$N_b$

5	6	7	8	9	10	11	12
---	---	---	---	---	----	----	----

$N_a$

11	9	13	16	19	23	26	30	33
12	11	14	18	22	26	29	33	37
13	12	16	20	24	28	33	37	41
14	13	17	22	26	31	36	40	45
15	14	19	24	29	34	39	44	49
16	15	21	26	31	37	42	47	53





$p \leq 0.025$  (one-tailed),  $p \leq 0.05$  (two-tailed) continued.

$N_b$

13	14	15	16	17	18	19	20
----	----	----	----	----	----	----	----

$N_a$

5	12	13	14	15	17	18	19	20
6	16	17	19	21	22	24	25	27
7	20	22	24	26	28	30	32	34
8	24	26	29	31	34	36	38	41
9	28	31	34	37	39	42	45	48
10	33	36	39	42	45	48	52	55

N <sub>b</sub>							
13	14	15	16	17	18	19	20

N <sub>a</sub>	11	12	13	14	15	16	17	18	19	20
11	37	40	44	47	51	55	58	62		
12	41	45	49	53	57	61	65	69		
13	45	50	54	59	63	67	72	76		
14	50	55	59	64	67	74	78	83		
15	54	59	64	70	75	80	85	90		
16	59	64	70	75	81	86	92	98		

$p \leq 0.025$  (one-tailed),  $p \leq 0.05$  (two-tailed) continued.

$N_b$							
13	14	15	16	17	18	19	20

N <sub>a</sub>	17	63	67	75	81	87	93	99	105
	18	67	74	80	86	93	99	106	112
	19	72	78	85	92	99	106	113	119
	20	76	83	90	98	105	112	119	127

N <sub>b</sub>							
5	6	7	8	9	10	11	12

N <sup>a</sup>									
	5	0	1	1	2	3	4	5	6
	6	1	2	3	4	5	6	7	9
	7	1	3	4	6	7	9	10	12
	8	2	4	6	7	9	11	13	15
	9	3	5	7	9	11	13	16	18
	10	4	6	9	11	13	16	18	21

$p \leq 0.005$  (one-tailed),  $p \leq 0.01$  (two-tailed) continued.

$N_b$

5	6	7	8	9	10	11	12
---	---	---	---	---	----	----	----

$N_a$

11	5	7	10	13	16	18	21	24
12	6	9	12	15	18	21	24	27
13	7	10	13	17	20	24	27	31
14	7	11	15	18	22	26	30	34
15	8	12	16	20	24	29	33	37
16	9	13	18	22	27	31	36	41

$p \leq 0.005$  (one-tailed),  $p \leq 0.01$  (two-tailed) continued.

N <sub>b</sub>							
5	6	7	8	9	10	11	12

N <sub>a</sub>									
	17	10	15	19	24	29	34	39	44
	18	11	16	21	26	31	37	42	47
	19	12	17	22	28	33	39	45	51
	20	13	18	24	30	36	42	48	54

$p \leq 0.005$  (one-tailed),  $p \leq 0.01$  (two-tailed) continued.

N <sub>b</sub>								
13	14	15	16	17	18	19	20	

N <sub>a</sub>									
	5	7	7	8	9	10	11	12	13
	6	10	11	12	13	15	16	17	18
	7	13	15	16	18	19	21	22	24
	8	17	18	20	22	24	26	28	30
	9	20	22	24	27	29	31	33	36
10	24	26	29	29	31	34	37	39	42



$p \leq 0.005$  (one-tailed),  $p \leq 0.01$  (two-tailed) continued.

N <sub>b</sub>							
13	14	15	16	17	18	19	20

N <sub>a</sub>									
	11	27	30	33	36	39	42	45	48
	12	31	34	37	41	44	47	51	54
	13	34	38	42	45	49	53	56	60
	14	38	42	46	50	54	58	63	67
	15	42	46	51	55	60	64	69	73
	16	45	50	55	60	65	70	74	79

$p \leq 0.005$  (one-tailed),  $p \leq 0.01$  (two-tailed) continued.

N <sub>b</sub>							
13	14	15	16	17	18	19	20

N <sub>a</sub>	17	49	54	60	65	70	75	81	86
	18	53	58	64	70	75	81	87	92
	19	56	63	69	74	81	87	93	99
	20	60	67	73	79	86	92	99	105

The calculated value must be equal to or less than the critical value in this table for significance to be shown.

# Wilcoxon Signed Ranks test process

- Calculate the difference between two scores by taking one from the other
- Rank the differences giving the smallest difference Rank 1

**Note:** do not rank any differences of 0 and when adding the number of scores, do not count those with a difference of 0, and ignore the signs when calculating the difference

- Add up the ranks for positive differences
- Add up the ranks for negative differences
- **T** is the figure that is the smallest when the ranks are totalled (may be positive or negative)
- **N** is the number of scores left, ignore those with 0 difference

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Critical values for the Wilcoxon Signed Ranks test

Level of significance for a one-tailed test

0.05	0.025	0.01
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Level of significance for a two-tailed test

n	0.1	0.05	0.02
N = 5	0	–	–
6	2	0	–
7	3	2	0
8	5	3	1
9	8	5	3

Level of significance for a one-tailed test		
0.05	0.025	0.01

Level of significance for a two-tailed test

n	0.1	0.05	0.02
N = 10	11	8	5
11	13	10	7
12	17	13	9

The calculated value must be equal to or less than the critical value in this table for significance to be shown.