MobileMedia Study

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1. Wilcoxon signed ranks analysis

Table 1 presents the summary of steps of the Wilcoxon signed ranks analysis. We refer to Siegel and Castellan Jr. [1] for more details on the procedure.

Table 1. Summary of Wilcoxon signed ranks analysis

Step	Description
W-Step 1	For each matched pair of observations, X_i and Y_i, determine the signed difference $d_i = X_i - Y_i$ between the two variables
W-Step 2	Rank these d_i's without respect to the sign. For tied d_i's, assign the average of the tied ranks
W-Step 3	Affix to each rank the sign (+ or -) of the d which it represents
W-Step 4	Determine *N*, the number of non-zero d_i's
W-Step 5	Determine W^+, the sum of the ranks which have a positive sign.
W-Step 6	Determine whether two samples come from the same population or not, according to the size of *N*.

The first step (*W-Step 1*) of the Wilcoxon test is that for each matched pair of values, it is determined the difference between two variables. In this study, matched pairs are the values for change impact on each release for two implementations. The second and third rows of Table 2 describe the change impact on modules from R2 to R8 on COSMOS*-AO and AO implementations. The fourth row shows the difference (*d*) between the values of the second and third rows. After determining the difference between the matched pairs, it is assigned the rank without respect to the sign for the difference, which is called rank of *d* as shown in the fifth row of Table 2 (*W-Step 2*). Every time *d* equals 0, the value is dropped from the analysis and the sample size is reduced accordingly. For instance, in Table 2, *d* = 0 on R4 and, therefore, the sample size is 6 and not 7. Then, the lowest absolute value is |-3| is assigned the rank 1 and it goes on until the highest absolute value, |14|, is assigned the rank 6. After ranking *d* values, either

the positive (+) or negative (-) sign is affixed to each rank according to the corresponding *d*, that is, if *d* is negative the affixed sign is negative, otherwise is positive (*W-Step 3*). Then, the number of non-zero d_i's is determined (*W-Step 4*) enabling to calculate W^+ by summing the ranks which have a positive sign (*W-Step 5*). In this case, it corresponds to the sum of positive values in fourth row of Table 2, which is 20. The last step (*W-Step 6*) is to check if probability associated with the value W^+ = 20 is less than or equal to the significance level (α = 0.10). Reference to Wilcoxon table for critical values [1] indicates that COSMOS*-AO PLAs are less impacted than AO PLAs, because the tabled probability corresponds to 0.03.

Table 2. Ranked impact for the total change impact on modules comparing AO and COSMOS*-AO techniques

Techniques	R2	R3	R4	R5	R6	R7	R8
AO	18	12	5	14	13	45	25
COSMOS*-AO	6	8	5	17	8	31	14
d	12	4	0	-3	5	14	11
rank of *d*	5	2	-	-1	3	6	4

Table 3 shows the comparison between AO and COSMOS* techniques for change impact on modules. For a $W^+ = 28$ and $N = 7$ the value of p is 0.01.

Table 3. Ranked impact for the total change impact on modules comparing AO and COSMOS*-AO techniques

Techniques	R2	R3	R4	R5	R6	R7	R8
AO	18	12	5	14	13	45	25
COSMOS*	5	5	4	13	12	26	19
d	13	7	1	1	1	19	6
rank of *d*	6	5	2	2	2	7	4

Table 4 shows the comparison between AO and COSMOS* techniques for change impact on modules. For a $W^+ = 21$ and $N = 6$ the value of p is 0.02.

Table 4. Ranked impact for the total change impact on modules comparing AO and COSMOS*-AO techniques

Techniques	R2	R3	R4	R5	R6	R7	R8
OO	14	9	5	13	13	37	29
COSMOS*	5	5	4	13	12	26	19
d	9	4	1	0	1	24	10
rank of *d*	4	3	1.5	-	1.5	6	5

The following tables describe the Wilcoxon signed ranks analysis for change impact on operations. Table 5 shows the comparison between AO and COSMOS* techniques for change impact on operations. For a $W^+ = 25$ and $N = 5$ the value of p is 0.04.

Table 6 shows the comparison between AO and COSMOS* techniques for change impact on operations. For a $W^+ = 26$ and $N = 7$ the value of p is 0.02.

Table 7 shows the comparison between AO and OO techniques for change impact on operations. For a $W^+ = 28$ and $N = 7$ the value of p is 0.01.

Table 5. Ranked impact for the total change impact on operations comparing AO and COSMOS*-AO techniques

Techniques	R2	R3	R4	R5	R6	R7	R8
AO	76	46	11	77	51	250	94
COSMOS*-AO	21	29	14	79	26	127	60
d	55	17	-3	-2	25	123	34
rank of *d*	6	3	-2	-1	4	7	5

Table 6. Ranked impact for the total change impact on operations comparing AO and COSMOS* techniques

Techniques	R2	R3	R4	R5	R6	R7	R8
AO	76	46	11	77	51	250	94
COSMOS*	25	16	0	85	49	158	62
d	51	30	11	-8	2	92	32
rank of *d*	6	4	3	-2	1	7	5

Table 7. Ranked impact for the total change impact on operations comparing AO and COSMOS* techniques

Techniques	R2	R3	R4	R5	R6	R7	R8
AO	76	46	11	77	51	250	94
OO	60	35	10	65	44	203	81
d	16	11	1	12	7	47	13
rank of *d*	6	3	1	4	2	7	5

References

[1] Sidney Siegel and Jr.. N. John Castellan. *Nonparametric statistics for the behavioral sciences*. McGraw-Hill (New York, London), 2nd edition, 1988.