TYPES OF INFERENCES

~~1. IDENTIFYING THE POPULATION MEAN~~

~~2. IDENTIFYING THE POPULATION %~~

~~3. VERIFYING WHETHER THE POPULATION MEAN IS EQUAL TO A CERTAIN VALUE~~

~~4. VERIFYING WHETHER THE POPULATION % IS EQUAL TO A CERTAIN VALUE~~

5. VERIFYING WHETHER 2 POPULATION MEANS ARE DIFFERENT

6. VERIFYING WHETHER 2 POPULATION % ARE DIFFERENT

5. VERIFYING WHETHER 2 POPULATION MEANS ARE DIFFERENT

CASE STUDY: A/B TESTING

MR. Z OWNS A LARGE SOCIAL MEDIA COMPANY

MR. Z OWNS A LARGE SOCIAL MEDIA COMPANY

EVERY WEEK, MR. Z HOLDS A "STRATEGY" MEETING

IN ONE SUCH MEETING..

ONE SIDE THINKS

That's a great idea!

THE OTHER..

UMM.. No...User engagement is really high right now. If it ain't broke don't fix it!


Ok, then. Do an experiment. I want the results in a week!

STEP : 1

SET UP A CONTROLLED EXPERIMENT

AFTER THE MEETING, THE SVP OF WEB PRODUCTS

TOLD THE VP OF WEB PRODUCTS

WHO TOLD THE DIRECTOR OF WEB ANALYTICS

WHO TOLD A SENIOR WEB ANALYST

TO DO THE EXPERIMENT

TO DO THE EXPERIMENT

THE SENIOR WEB ANALYST
IS A PRO AT ALL THIS

HE GETS AN ENGINEER TO
SET UP A MOCK-UP OF THE
NEW WEBSITE

THEN HE TAKES A BUNCH OF USERS

AND RANDOMLY DIVIDES
THEM INTO 2 GROUPS

THE LUCKY DOGS

THE GUINEA PIGS

HEY, LUCKY DOGS!

YOU'RE LUCKY COZ YOUR PROFILE PAGE IS THE SAME, JUST THE WAY YOU LIKE IT

THE LUCKY DOGS

HEY, LUCKY DOGS!

YOU'RE LUCKY COZ YOUR PROFILE PAGE IS THE SAME, JUST THE WAY YOU LIKE IT

THE GUINEA PIGS

POOR GUINEA PIGS,

YOU GET THE NEW MOCK-UP, YOU'RE NOT GOING TO FIND ANYTHING YOU WANT FOR A WHILE

CONTROL GROUP

~~THE LUCKY DOGS~~

HEY, LUCKY DOGS!

YOU'RE LUCKY COZ YOUR PROFILE PAGE IS THE SAME, JUST THE WAY YOU LIKE IT

A

TEST GROUP

~~THE GUINEA PIGS~~

POOR GUINEA PIGS,

YOU GET THE NEW MOCK-UP, YOU'RE NOT GOING TO FIND ANYTHING YOU WANT FOR A WHILE

B

OR WHEN IT'S AN INTERWEB EXPERIMENT

CONTROL GROUP

A

TEST GROUP

B

THE ANALYST RUNS THE A/B TEST FOR 4 DAYS

STEP : 2

COMPUTE SAMPLE MEANS FOR BOTH GROUPS A, B

CONTROL GROUP

A

5 MINS PER VISIT

TEST GROUP

B

3 MINS PER VISIT

THE ANAYLYST COMPARES THE ENGAGEMENT (AVERAGE TIME SPENT ON THE WEBSITE) OF THE 2 GROUPS

CONTROL GROUP

A

5 MINS PER VISIT

TEST GROUP

B

3 MINS PER VISIT

GASP!!

THE NEW WEBSITE WILL DROP ENGAGEMENT BY 40%

CONTROL GROUP

A 5 MINS PER VISIT

TEST GROUP

B 3 MINS PER VISIT

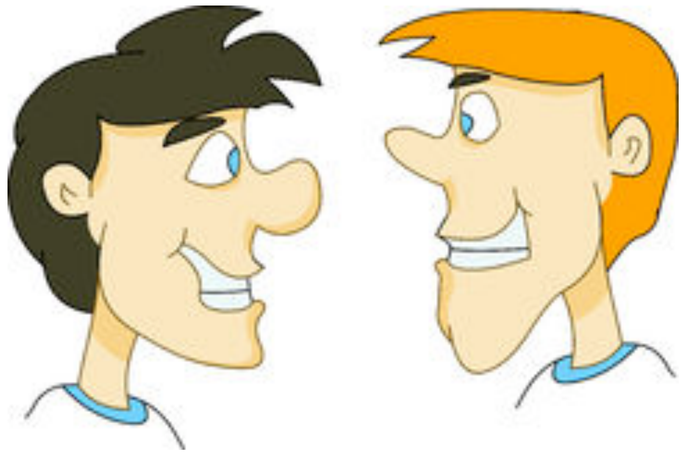
THE STRAT MEETING IS ON MONDAY

ON FRIDAY, THE ANALYST STAYS LATE TO FINISH UP THE DECK WITH THESE RESULTS

THE STRAT MEETING IS ON MONDAY

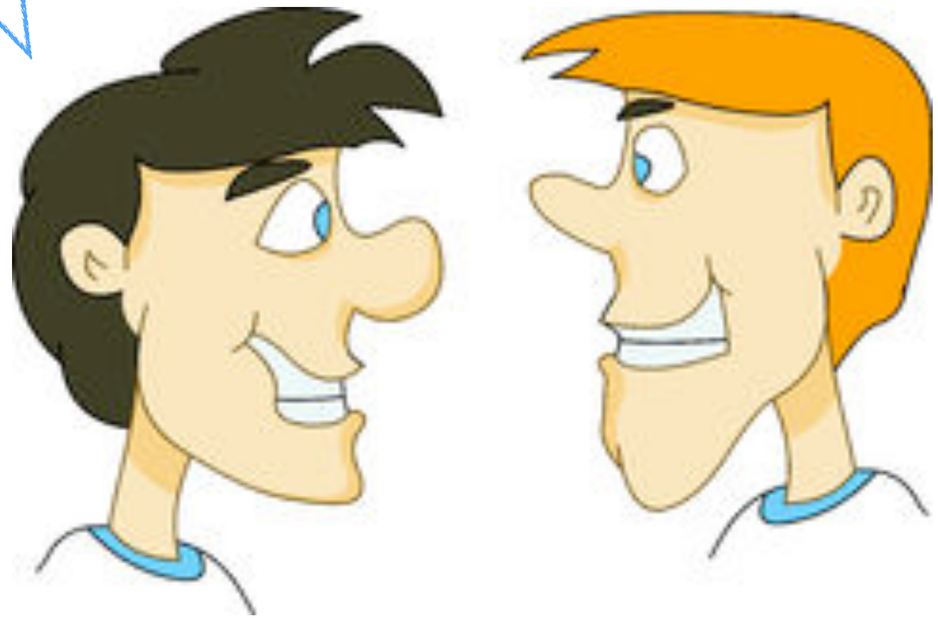
ON FRIDAY, THE ANALYST STAYS LATE TO FINISH UP THE DECK WITH THESE RESULTS

ON SATURDAY, HE RUNS INTO A FRIEND



S***@!#

SO, ARE YOUR RESULTS STATISTICALLY SIGNIFICANT



IT'S SUNDAY, AND THE ANALYST NEEDS TO RUN A TEST OF SIGNIFICANCE

STEP : 3

A TEST OF SIGNIFICANCE COMPARING 2 POPULATION MEANS

NULL HYPOTHESIS

ALL VARIATIONS OBSERVED ARE DUE TO CHANCE I.E. A FLUKE

ALTERNATIVE HYPOTHESIS

THE VARIATIONS OBSERVED CANNOT JUST BE EXPLAINED BY CHANCE

NULL HYPOTHESIS VS ALTERNATIVE HYPOTHESIS

A TEST OF SIGNIFICANCE WILL TELL YOU WHICH OF THESE IS BETTER

A TEST OF SIGNIFICANCE

NULL HYPOTHESIS VS ALTERNATIVE HYPOTHESIS

THIS INVOLVES

1) COMPUTING A TEST STATISTIC

SOME VARIABLE WHOSE PROBABILITY DISTRIBUTION IS KNOWN

A TEST OF SIGNIFICANCE

NULL HYPOTHESIS VS ALTERNATIVE HYPOTHESIS

THIS INVOLVES

1) COMPUTING A TEST STATISTIC

2) COMPUTE THE PROBABILITY IF THE NULL HYPOTHESIS IS TRUE

A TEST OF SIGNIFICANCE

NULL HYPOTHESIS VS ALTERNATIVE HYPOTHESIS

THIS INVOLVES

1) COMPUTING A TEST STATISTIC

2) COMPUTE THE PROBABILITY IF THE NULL HYPOTHESIS IS TRUE

3) IF THE PROBABILITY IS TOO LOW, REJECT THE NULL HYPOTHESIS, ELSE ACCEPT IT

A 5 MINS PER VISIT

B 3 MINS PER VISIT

SAMPLE MEANS ARE DIFFERENT

NULL HYPOTHESIS

THE DIFFERENCE BETWEEN A AND B IS DUE TO CHANCE

ALTERNATIVE HYPOTHESIS

THE DIFFERENCE BETWEEN A AND B IS REAL

STEP : 3 PERFORM A TEST OF SIGNIFICANCE

STEP : 3A

COMPUTE A TEST STATISTIC

WE'LL USE THE Z-STATISTIC

Z-STATISTIC FOR THE NULL HYPOTHESIS

SAMPLE MEAN A

$$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\sigma_{X_1}^2 + \sigma_{X_2}^2}}$$

WE'LL USE THE Z-STATISTIC

Z-STATISTIC FOR THE NULL HYPOTHESIS

$$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\sigma_{X_1}^2 + \sigma_{X_2}^2}}$$

SAMPLE MEAN B

WE'LL USE THE Z-STATISTIC

Z-STATISTIC FOR THE NULL HYPOTHESIS

$$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\sigma^2_{X_1} + \sigma^2_{X_2}}}$$

STANDARD ERROR A

WE'LL USE THE Z-STATISTIC

Z-STATISTIC FOR THE NULL HYPOTHESIS

$$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\sigma_{X_1}^2 + \sigma_{X_2}^2}}$$

STANDARD ERROR B

WE'LL USE THE Z-STATISTIC

Z-STATISTIC FOR THE NULL HYPOTHESIS

$$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\sigma_{X_1}^2 + \sigma_{X_2}^2}}$$

THIS IS WHY IT'S IMPORTANT TO CALCULATE STANDARD ERROR TOO - NOT JUST THE MEANS

A 5 MINS PER VISIT STANDARD ERROR : 0.5

B 3 MINS PER VISIT STANDARD ERROR : 0.4

5 3

$$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\sigma_{X_1}^2 + \sigma_{X_2}^2}}$$

0.5 0.4

= 3.12

COMPUTE THE VALUE FOR THE NULL HYPOTHESIS

STEP : 3 PERFORM A TEST OF SIGNIFICANCE

STEP : 3B

COMPUTE THE PROBABILITY IF
THE NULL HYPOTHESIS IS TRUE

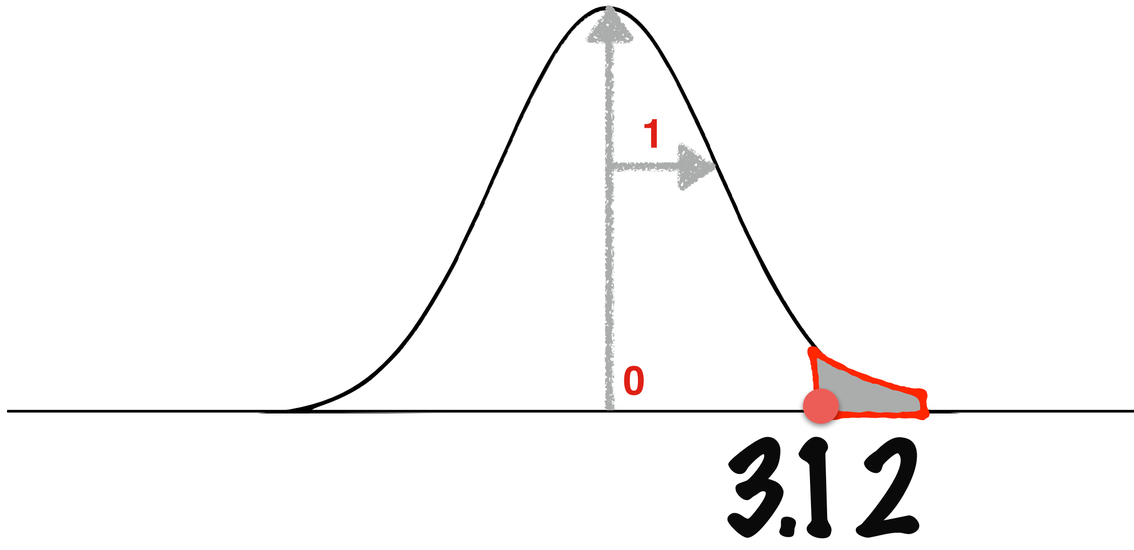
Z-STATISTIC FOR THE NULL HYPOTHESIS =3.12

P-VALUE

P(Z > 3.12)

= (AREA UNDER THE CURVE ABOVE 3.1)

= ?

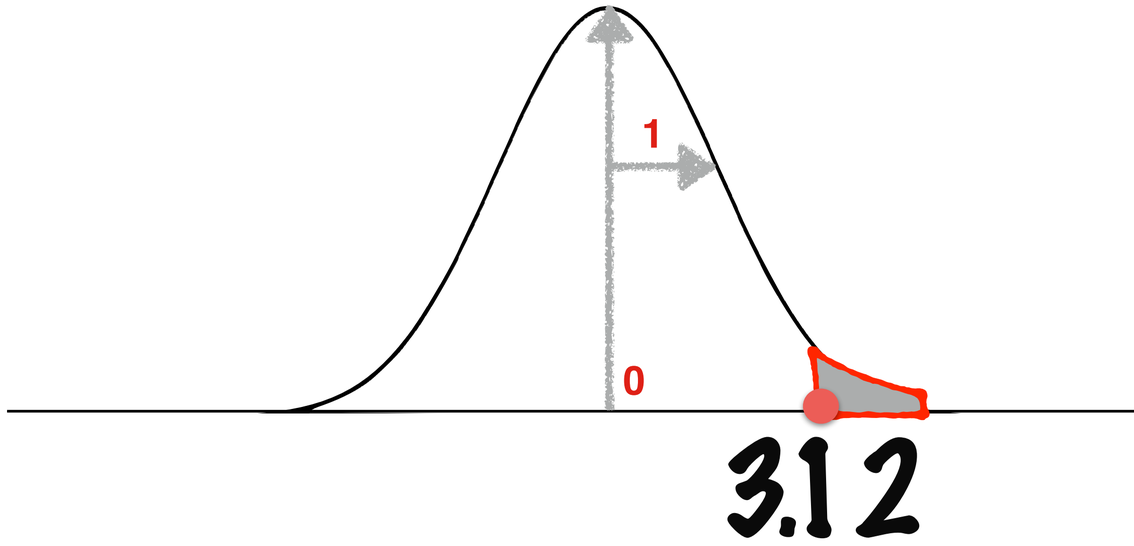


1 SIDED TEST (SINCE WE ARE CHECKING A>B NOT JUST INEQUALITY)

Z-STATISTIC FOR THE NULL HYPOTHESIS =3.12

P-VALUE

P(Z > 3.12)



In R the value can be calculated in 2 ways

```
> 1-(pnorm(3.12))
[1] 0.0009042552
```

```
> pnorm(-3.12)
[1] 0.0009042552
```

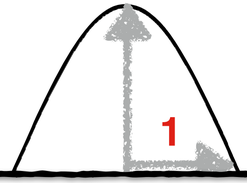
Z-STATISTIC FOR THE NULL HYPOTHESIS =3.12

P-VALUE

$P(Z > 3.12)$

$=0.0009$

We can even calculate the same using a Normal distribution table



STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

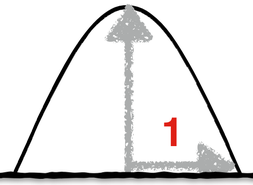
Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-3.9	.00005	.00005	.00004	.00004	.00004	.00004	.00004	.00004	.00003	.00003
-3.8	.00007	.00007	.00007	.00006	.00006	.00006	.00006	.00005	.00005	.00005
-3.7	.00011	.00010	.00010	.00010	.00009	.00009	.00008	.00008	.00008	.00008
-3.6	.00016	.00015	.00015	.00014	.00014	.00013	.00013	.00012	.00012	.00011
-3.5	.00023	.00022	.00022	.00021	.00020	.00019	.00019	.00018	.00017	.00017
-3.4	.00034	.00032	.00031	.00030	.00029	.00028	.00027	.00026	.00025	.00024
-3.3	.00048	.00047	.00045	.00043	.00042	.00040	.00039	.00038	.00036	.00035
-3.2	.00069	.00066	.00064	.00062	.00060	.00058	.00056	.00054	.00052	.00050
-3.1	.00097	.00094	.00090	.00087	.00084	.00082	.00079	.00076	.00074	.00071
-3.0	.00135	.00131	.00126	.00122	.00118	.00114	.00111	.00107	.00104	.00100
-2.9	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139
-2.8	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
-2.7	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
-2.6	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
-2.5	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
-2.4	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639
-2.3	.01072	.01044	.01017	.00990	.00964	.00939	.00914	.00889	.00866	.00842
-2.2	.01390	.01355	.01321	.01287	.01255	.01222	.01191	.01160	.01130	.01101
-2.1	.01786	.01743	.01700	.01659	.01618	.01578	.01539	.01500	.01463	.01426
-2.0	.02275	.02222	.02169	.02118	.02068	.02018	.01970	.01923	.01876	.01831
-1.9	.02872	.02807	.02743	.02680	.02619	.02559	.02500	.02442	.02385	.02330
-1.8	.03593	.03515	.03438	.03362	.03288	.03216	.03144	.03074	.03005	.02938
-1.7	.04457	.04363	.04272	.04182	.04093	.04006	.03920	.03836	.03754	.03673
-1.6	.05480	.05370	.05262	.05155	.05050	.04947	.04846	.04746	.04648	.04551
-1.5	.06681	.06552	.06426	.06301	.06178	.06057	.05938	.05821	.05705	.05592
-1.4	.08076	.07927	.07780	.07636	.07493	.07353	.07215	.07078	.06944	.06811
-1.3	.09680	.09510	.09342	.09176	.09012	.08851	.08691	.08534	.08379	.08226
-1.2	.11507	.11314	.11123	.10935	.10749	.10565	.10383	.10204	.10027	.09853
-1.1	.13567	.13350	.13136	.12924	.12714	.12507	.12302	.12100	.11900	.11702
-1.0	.15866	.15625	.15386	.15151	.14917	.14686	.14457	.14231	.14007	.13786

Z-STATISTIC FOR THE NULL HYPOTHESIS =3.12

P-VALUE

P(Z > 3.12)

=0.0009



STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

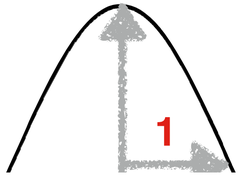
Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-3.9	.00005	.00005	.00004	.00004	.00004	.00004	.00004	.00004	.00003	.00003
-3.8	.00007	.00007	.00007	.00006	.00006	.00006	.00006	.00005	.00005	.00005
-3.7	.00011	.00010	.00010	.00010	.00009	.00009	.00008	.00008	.00008	.00008
-3.6	.00016	.00015	.00015	.00014	.00014	.00013	.00013	.00012	.00012	.00011
-3.5	.00023	.00022	.00022	.00021	.00020	.00019	.00019	.00018	.00017	.00017
-3.4	.00034	.00032	.00031	.00030	.00029	.00028	.00027	.00026	.00025	.00024
-3.3	.00048	.00047	.00045	.00043	.00042	.00040	.00039	.00038	.00036	.00035
-3.2	.00069	.00066	.00064	.00062	.00060	.00058	.00056	.00054	.00052	.00050
-3.1	.00097	.00094	.00090	.00087	.00084	.00082	.00079	.00076	.00074	.00071
-3.0	.00135	.00131	.00126	.00122	.00118	.00114	.00111	.00107	.00104	.00100
-2.9	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139
-2.8	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
-2.7	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
-2.6	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
-2.5	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
-2.4	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639

Z-STATISTIC FOR THE NULL HYPOTHESIS =3.12

P-VALUE

$P(Z > 3.12)$

$=0.0009$



STANDARD NORMAL DISTRIBUTION: Table Values Represent AREA to the LEFT of the Z score.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-3.9	.00005	.00005	.00004	.00004	.00004	.00004	.00004	.00004	.00003	.00003
-3.8	.00007	.00007	.00007	.00006	.00006	.00006	.00006	.00005	.00005	.00005
-3.7	.00011	.00010	.00010	.00010	.00009	.00009	.00008	.00008	.00008	.00008
-3.6	.00016	.00015	.00015	.00014	.00014	.00013	.00013	.00012	.00012	.00011
-3.5	.00023	.00022	.00022	.00021	.00020	.00019	.00019	.00018	.00017	.00017
-3.4	.00034	.00032	.00031	.00030	.00029	.00028	.00027	.00026	.00025	.00024
-3.3	.00048	.00047	.00045	.00043	.00042	.00040	.00039	.00038	.00036	.00035
-3.2	.00069	.00066	.00064	.00062	.00060	.00058	.00056	.00054	.00052	.00050
-3.1	.00097	.00094	.00090	.00087	.00084	.00082	.00079	.00076	.00074	.00071
-3.0	.00135	.00131	.00126	.00122	.00118	.00114	.00111	.00107	.00104	.00100
-2.9	.00187	.00181	.00175	.00169	.00164	.00159	.00154	.00149	.00144	.00139
-2.8	.00256	.00248	.00240	.00233	.00226	.00219	.00212	.00205	.00199	.00193
-2.7	.00347	.00336	.00326	.00317	.00307	.00298	.00289	.00280	.00272	.00264
-2.6	.00466	.00453	.00440	.00427	.00415	.00402	.00391	.00379	.00368	.00357
-2.5	.00621	.00604	.00587	.00570	.00554	.00539	.00523	.00508	.00494	.00480
-2.4	.00820	.00798	.00776	.00755	.00734	.00714	.00695	.00676	.00657	.00639
-2.3	.01072	.01044	.01017	.00990	.00964	.00939	.00914	.00889	.00866	.00842
-2.2	.01390	.01355	.01321	.01287	.01255	.01222	.01191	.01160	.01130	.01101
-2.1	.01786	.01743	.01700	.01659	.01618	.01578	.01539	.01500	.01463	.01426
-2.0	.02275	.02222	.02169	.02118	.02068	.02018	.01970	.01923	.01876	.01831
-1.9	.02872	.02807	.02743	.02680	.02619	.02559	.02500	.02442	.02385	.02330
-1.8	.03593	.03515	.03438	.03362	.03288	.03216	.03144	.03074	.03005	.02938
-1.7	.04457	.04363	.04272	.04182	.04093	.04006	.03920	.03836	.03754	.03673
-1.6	.05480	.05370	.05262	.05155	.05050	.04947	.04846	.04746	.04648	.04551
-1.5	.06681	.06552	.06426	.06301	.06178	.06057	.05938	.05821	.05705	.05592
-1.4	.08076	.07927	.07780	.07636	.07493	.07353	.07215	.07078	.06944	.06811
-1.3	.09680	.09510	.09342	.09176	.09012	.08851	.08691	.08534	.08379	.08226
-1.2	.11507	.11314	.11123	.10935	.10749	.10565	.10383	.10204	.10027	.09853
-1.1	.13567	.13350	.13136	.12924	.12714	.12507	.12302	.12100	.11900	.11702
-1.0	.15866	.15625	.15386	.15151	.14917	.14686	.14457	.14231	.14007	.13786

Values in this table represent the area to the left of the Z statistic

STEP : 3 PERFORM A TEST OF SIGNIFICANCE

STEP : 3C

IF THE PROBABILITY IS TOO LOW, REJECT THE NULL HYPOTHESIS, ELSE ACCEPT IT

Z-STATISTIC FOR THE NULL HYPOTHESIS =3.12

P-VALUE = 0.0009

PHEW!

SINCE THE P-VALUE IS TOO LOW

THE NULL HYPOTHESIS IS REJECTED

So, the experiment showed that the new website brings down engagement, and this result is statistically significant with 99% confidence