Structured Barrel Experiment

JB.IC

2024-01-04

Acknowledgments

This design is not going to generalize to every combination possible in the population of all possible combinations. Experiments should be narrow and should not set out to examine everything all at once. When experiments are too large and complex, mistakes can be made and the time and expense of said mistakes should be considered. The proposed experiment here is a bite size experiment that can be controlled with a focus narrowed. Different experiments can be conducted under different designs and conditions.

Factors

Factor 1: structured and unstructured

Factor 2: shooter A and shooter B

Assumptions

The mean group size of a **structured barrel** is estimated to be 0.95” at 100 yards for a string of 30 rounds with a standard deviation (STD) of 0.07071068”.

The hypothetical mean group size of a **unstructured barrel** is estimated to be 1.28” at 100 yards for a string of 30 rounds with an STD of 0.1923538”.

The mean and STD are estimates which are not necessarily perfect. They are only used for simulation which will test if there was no difference between barrel factors and if there was a difference between barrel factors.

Barrel Assumptions:

The barrels are homogeneous in the context that they are from the same manufacture and have similar specifications such as length, rifling type, twist rate, and muzzle attachment. The complexity here is that one will be structured and the other is not.

Shooter Assumption:

There are two shooters, A & B. For this simulation, the shooters are homogeneous which would be highly desirable so that we can rule out the shooter’s influence. However, this factor must be included if there is an emergence of variation between shooters. If the shooters are heterogeneous, then the shooters will need to shoot the different combinations of rifle configurations and barrel type.

Rifle Configuration Assumption:

There will be two rifle configurations if the rifles cannot be matched closely.

A rifle configuration is defined as the configuration of the rifle excluding the barrel. So, the action, stock/chassis, trigger, bipod, etc. Additionally, the type of bipod and rear bag should match closely.

If these can be closely matched, such as two MRADs with the same scope , scope rings, bipod, rear bag and bag rider, then this factor can be eliminated completely. This simulation will assume both rifles are the same. If they are not, then there is added complexity in the design of the experiment which can greatly increase the cost.

Benefits of using a rifle like the MRAD:

1. A rifle can be configured to the shooter’s body such as length of pull and comb height.
2. Users can swap barrels so that each shooter gets to use a structured and unstructured barrel. This will allow us to block out the effects of a shooter since we are wanting to isolate the performance of the barrel.

Environment Assumptions:

The rifles are measured under the same firing conditions to include weather and shooting surfaces. Something like both rifles firing at the same intervals. Otherwise these are factors that need to be included.

Ammunition Assumptions:

Ammunition is the same for both rifles such as factory ammunition. Suppose 500 rounds are needed which would consist of 25 boxes of 20 round ammunition. The boxes will be labeled 1 - 20, 21 - 40, …, 481 – 500. Within an individual box, a ordered numbering will determine the index number of individual rounds. A uniform random number generator will determine order the ammunition is fired which will ultimately select what box and round index number of said box is fired.

Example:

```
##   [1] 335 402 259 144 149  86 418 243  15 447  53 359 366 198 214 307  12 264
##  [19] 284  84   4 206 286 427 403  55 244  98  30 384 223  73 152  25 216 262
##  [37] 401  48  64  68 238 237 146  16  91  99 383 310  42 479 356   3 372  40
##  [55]  45 245 190  24 205 424  52 314 394 249 218  26 428 116 332 312 309   2
##  [73] 192  27 438 421 168 471  49 426 199 362 210 446 340 333 260 107  18 248
##  [91] 128 451 379 433 180  13  36 253  87 247 173 132 353  62   1 371 317 193
## [109] 304 478  35 346 374 195 154  44 449 404 160  31 111 370  46 399  19 235
## [127] 298 324 273  77 303 229 419 141 194 251 230 171 417 215 458 179 167 151
## [145] 166 450 466 443 196 343   8 270 396 301 197 468 239 109 411 296 415 452
## [163] 148 299 351 219 293 271 361  50 390 326 147 131 441 175 302 350 263 357
## [181] 134 189 140 341 124 352 315 177  95  61 242 354 256 420 300 434  66  74
## [199] 156  78  57 241 378 423 367 266  92 122 439 442 457 316 344 437 480 225
## [217] 208 254 183 232 345 114 334  72 329 257 462 381 319 191 280 258 228 436
## [235] 118 224 463 115 472 347 336 275 172 364 123  93 320  94 311 101 236  81
## [253]  85 274 416 408 429  97  71 222 267 375 143 138 135 393 328 425  54 435
## [271] 169 212 161 398 283 178 325  56 477 291 287 153 456 133 130 203 282 181
## [289] 290  60 185   6 470 386 338  76 102  96 233 473 412 227  41 392 276 162
## [307] 461 127 265  90 409 157 397 119 465 272 432  79  58 217 231 295  65 422
## [325] 285 431 360 387 113 278 339 269 380  14 155  43 234 246   5 121 469 358
## [343] 250 448  67 145 322 373 104 200 305 368  70 103 455 186 413 165 294  63
## [361]  47  82 184  34 376 277 159  21  75 110 313 207 170  22 204 292  23 289
## [379] 464 211 136 327 430  83  33 385 261 476 388 176 453 221 395  17 288 365
## [397] 363 240 454 106 475 337 445 467 125 187 202 369  11 330 164 158 306 252
## [415] 349 400 382  28 459 407 220  69 120 342 321  37  89  51 474 226 331  29
## [433] 410 405 150 406 129 255 444 163 460 279   9 355 139  88 268 281  32 142
## [451] 414  20 117 188 126  10 201 318  80 213 105 112 348   7 440 108 209 391
## [469]  59 308  38  39 323 377 174 389 100 182 137 297
```

More on Homogeneity

It is critical for all factors that can be similar to be similar. The goal of controlling such or blocking such out is to prevent poor estimations of effects. Furthermore, we want to be able to prevent any holes in the research.

Simulation

If the above assumptions can be met, then the design of the experiment would be a 2^2 factor design. If there are 30 rounds per group, and say 4 replications at each level, then it would take 480 rounds of ammunition. This is a tentative assumption on ammunition requirements as that will be determined from power analysis.

The methodology is pending and up for debate. But a simple idea would be for each shooter to shoot at the same time at their own target at a specified interval such as 1 shot every 15 seconds. The way the test is administered should simulate some sort of application such as slow fire prone shooting or some other application like fast firing prone shooting. Different shooting disciplines will have different constraints and expectations.

	structured	shooter	test1	test2	test3	test4
8	N	A	1.3549878	0.8700704	1.6538402	1.0698461
3	N	B	1.3907538	0.8865786	1.3907538	0.8865786
5	Y	A	0.8909121	0.8909121	1.1901131	1.0896746
10	Y	B	0.9732997	0.9732997	0.9732997	0.9732997
6	Y	B	1.0628034	1.0628034	1.0628034	1.0628034
12	N	B	0.8539940	0.9593635	0.8539940	0.9593635
4	N	A	1.2212574	0.9630708	1.5220210	1.1635065
16	Y	B	1.0022074	1.0022074	1.0022074	1.0022074
15	N	A	1.2713568	0.9330508	1.5716091	1.1329937
1	Y	A	0.9057030	0.9057030	1.2081077	1.1048111
2	Y	B	0.9629855	0.9629855	0.9629855	0.9629855
14	N	B	1.4963848	1.0000600	1.4963848	1.0000600
13	Y	A	0.9844664	0.9844664	1.2840549	1.1852706
7	N	B	1.5707969	1.0622776	1.5707969	1.0622776
11	Y	A	0.8919841	0.8919841	1.1916849	1.0921175
9	N	A	1.1605020	0.9443253	1.4602125	1.1447027

If there was a significant difference between barrels

This test randomly sampled from the assumed group sizes and STD if there was a difference.

The power is 1 under the assumption that the experimental error is 0.0367 and mean group size difference is 0.284”

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## structured   1 0.4375  0.4375  16.330 0.0014 **
## shooter      1 0.0250  0.0250   0.932 0.3520
## Residuals   13 0.3483  0.0268
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##      alpha a b nreps    Delta  sigma powera powerb
## [1,]  0.05 2 2     4 0.330709 0.0367      1      1
```

If there was not a significant difference between barrels

This test randomly sampled from the assumed group sizes and STD if there was no difference.

The power is 0.86 under the assumption that the experimental error is 0.00326 and mean group size difference is 0.0054”

```
##             Df  Sum Sq  Mean Sq F value Pr(>F)
## structured   1 0.00019 0.000193   0.073 0.7909
## shooter      1 0.01729 0.017292   6.565 0.0236 *
## Residuals   13 0.03424 0.002634
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##      alpha a b nreps       Delta   sigma    powera    powerb
## [1,]  0.05 2 2     4 0.005376687 0.00326 0.8567255 0.8567255
```

If the shooters are not homogeneous but there is significance between barrels

```
##             Df Sum Sq Mean Sq F value Pr(>F)
## structured   1 0.4370  0.4370  16.326 0.0014 **
## shooter      1 0.1955  0.1955   7.302 0.0181 *
## Residuals   13 0.3480  0.0268
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##      alpha a b nreps     Delta  sigma powera powerb
## [1,]  0.05 2 2     4 0.2210522 0.0366      1      1
```

If the shooters are not homogeneous amd there is not significance between barrels

```
##             Df  Sum Sq Mean Sq F value   Pr(>F)
## structured   1 0.00018 0.00018   0.068 0.798059
## shooter      1 0.07200 0.07200  27.106 0.000169 ***
## Residuals   13 0.03453 0.00266
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##      alpha a b nreps     Delta   sigma powera powerb
## [1,]  0.05 2 2     4 0.1341684 0.00326      1      1
```

Conclusion

This experimental design is simple with considerably less time consuming and expernsive. If the assumptions are correct, then the number of rounds needed are 480. The number of rifles needed would be two and the number of shooters is also two. Please note that this is only a simulation to help design the experiment and not final. It can be iteratively updated as it would occur in normal engineering experiments.