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## Simulations run to test multiple comparison approach.

These simulations were run to test whether Zar's approach to multiple comparisons (using Tukey's HSD) has been correctly implemented (in `multcompareRandom()`), and gives results close to the desired alpha level (or CIs close to the desired nominal confidence interval) under various circumstances.

Ideally, the observed alpha should match the nominal alpha, and the fraction of time all CIs contain the 'true' difference should be  $1-\alpha$  (the familywise error rate should be  $\alpha$ ).

The data generator for the simulations assumes the following model:  $Y(ijk) = F1(i) + F2(j) + F1 \times F2(ij) + \text{Slope} \times T(ijk) + \text{error}(ijk)$ , with  $F1 = 0$  (the null hypothesis is true for factor 1, the factor whose levels are compared),  $F2 \sim N(0, \text{randsd})$ ,  $F1 \times F2 \sim N(0, \text{interaction})$ , and  $\text{error} \sim N(0, 1)$ . Setting `randsd = 1` or `interaction = 1` means the variance components associated with these terms is 1; setting `slope = 1` makes maximum the difference among subgroup members due to  $T$  reach 1.

2016Mat03: Added 2 simulations for more than 3 treatment levels (many more comparisons) because some multiple comparisons procedures work well for a few comparisons, but not for many comparisons.

```
clear all; close all hidden
disp(['Date run: ', date]);

%Initial values
nreps = 5000; % Number of repetitions of simulation
npergrp = 5; % Maximum sample size per subgroup (factor1xfactor2)
ntris = 4; % Number of levels of random factor (factor2)
nlvls = 3; % Number of levels of fixed factor (factor1), whose levels are
% compared by multcompareRandom (factor 1 follows null hypothesis of no
% effect in simulated data).
randsd = 0; % SD of means of factor 2: (variance component)^0.5
interaction = 0; % SD of means of factor1xfactor2 interaction:
% (variance component)^0.5
slope = 0; % Magnitude of effect of linear covariate term (slope = 1 would
% give a difference of 1 between 1st and last member of each subgroup)
missing = 0; % Probability of eliminating each member of subgroup (on
% average, max n per subgroup will be npergrp, min n per subgroup set
% to 1, average n per subgroup will be about (1-missing)*npergrp
alpha = 0.05; % Alpha level for comparisons (CI's set to 1-alpha).
nway = 3; % Number of
```

*Date run: 03-May-2016*

---

## Balanced 3 way ANOVA; no factors have effect.

no factors have effect.

```
testmultcompare('nreps', nreps, 'npergrp', npergrp, 'ntris', ntris, ...  
  'nlvls', nlvls, 'randsd', randsd, 'interaction', interaction, ...  
  'slope', slope, 'missing', missing, 'alpha', alpha, 'nway', nway);
```

```
ANOVA MODEL  
  'Source'      'Type'  
  'X1'          'fixed'  
  'X2'          'random'  
  'X1*X2'       'random'  
  'X3'          'fixed'  
  'Error'       'random'  
  'Total'       []  
  
  'Continuous variable:'  'X3'
```

```
median min subgroup n: 5  
median median subgroup n: 5  
median max subgroup n: 5
```

Nominal type 1 error rate (alpha): 0.05

```
Simulation results:  
Observed type 1 error rate: 0.047  
Fraction of time all CIs contain true difference: 0.953  
Observed type 1 error rate for ANOVA: 0.0472  
Number of completed iterations: 5000
```

## Balanced 3 way ANOVA; all other factors have effects.

Factor2, factor1xfactor2 interaction, and linear covariate all have effects (factor 1 always has no effect).

```
testmultcompare('nreps', nreps, 'npergrp', npergrp, 'ntris', ntris, ...  
  'nlvls', nlvls, 'randsd', 1, 'interaction', 1, ...  
  'slope', 1, 'missing', missing, 'alpha', alpha, 'nway', nway);
```

```
ANOVA MODEL  
  'Source'      'Type'  
  'X1'          'fixed'  
  'X2'          'random'  
  'X1*X2'       'random'  
  'X3'          'fixed'  
  'Error'       'random'  
  'Total'       []  
  
  'Continuous variable:'  'X3'
```

```
median min subgroup n: 5  
median median subgroup n: 5
```

---

median max subgroup n: 5

Nominal type 1 error rate (alpha): 0.05

Simulation results:

Observed type 1 error rate: 0.0478

Fraction of time all CIs contain true difference: 0.9522

Observed type 1 error rate for ANOVA: 0.0488

Number of completed iterations: 5000

## Unbalanced 3 way ANOVA; all other factors have effects

Factor2, factor1xfactor2 interaction, and linear covariate all have effects (factor 1 always has no effect).

```
testmultcompare('nreps', nreps, 'npergrp', npergrp, 'ntris', ntris, ...  
                'nlvls', nlvls, 'randsd', 1, 'interaction', 1, ...  
                'slope', 1, 'missing', 0.2, 'alpha', alpha, 'nway', nway);
```

ANOVA MODEL

'Source'	'Type'
'X1'	'fixed'
'X2'	'random'
'X1*X2'	'random'
'X3'	'fixed'
'Error'	'random'
'Total'	[']

'Continuous variable:' 'X3'

median min subgroup n: 2

median median subgroup n: 4

median max subgroup n: 5

Nominal type 1 error rate (alpha): 0.05

Simulation results:

Observed type 1 error rate: 0.054027

Fraction of time all CIs contain true difference: 0.94597

Observed type 1 error rate for ANOVA: 0.051818

Number of completed iterations: 4979

## Balanced 3 way ANOVA; no factors have effect; many comparisons

no factors have effect; nlvs set to 10 (90 comparisons).

```
testmultcompare('nreps', nreps, 'npergrp', npergrp, 'ntris', ntris, ...  
                'nlvls', 10, 'randsd', randsd, 'interaction', interaction, ...  
                'slope', slope, 'missing', missing, 'alpha', alpha, 'nway', nway);
```

ANOVA MODEL

---

```

'Source'      'Type'
'X1'          'fixed'
'X2'          'random'
'X1*X2'       'random'
'X3'          'fixed'
'Error'       'random'
'Total'       []

'Continuous variable:'      'X3'

median min subgroup n: 5
median median subgroup n: 5
median max subgroup n: 5

Nominal type 1 error rate (alpha): 0.05

Simulation results:
Observed type 1 error rate: 0.0178
Fraction of time all CIs contain true difference: 0.9446
Observed type 1 error rate for ANOVA: 0.0582
Number of completed iterations: 5000

```

## Unbalanced 3 way ANOVA; all other factors have effects, many comparisons

Factor2, factor1xfactor2 interaction, and linear covariate all have effects (factor 1 always has no effect); nlvs set to 10 (90 comparisons).

```

testmultcompare('nreps', nreps, 'npergrp', npergrp, 'ntris', ntris, ...
    'nlvls', 10, 'randsd', 1, 'interaction', 1, ...
    'slope', 1, 'missing', 0.2, 'alpha', alpha, 'nway', nway);

```

```

ANOVA MODEL
'Source'      'Type'
'X1'          'fixed'
'X2'          'random'
'X1*X2'       'random'
'X3'          'fixed'
'Error'       'random'
'Total'       []

'Continuous variable:'      'X3'

median min subgroup n: 2
median median subgroup n: 4
median max subgroup n: 5

Nominal type 1 error rate (alpha): 0.05

Simulation results:
Observed type 1 error rate: 0.017868
Fraction of time all CIs contain true difference: 0.93949
Observed type 1 error rate for ANOVA: 0.051777
Number of completed iterations: 4925

```

---

## Unbalanced 2 way ANOVA; all other factors have effects.

Factor2 & factor1xfactor2 have effects (factor 1 always has no effect); covariate has no effect.

```
testmultcompare('nreps', nreps, 'npergrp', npergrp, 'ntris', ntris, ...  
    'nlvls', nlvls, 'randsd', 1, 'interaction', 1, ...  
    'slope', 0, 'missing', 0.2, 'alpha', alpha, 'nway', 2);
```

```
ANOVA MODEL  
  'Source'      'Type'  
  'X1'          'fixed'  
  'X2'          'random'  
  'X1*X2'       'random'  
  'Error'       'random'  
  'Total'              []  
  
  'Continuous variable:'
```

```
median min subgroup n: 2  
median median subgroup n: 4  
median max subgroup n: 5
```

```
Nominal type 1 error rate (alpha): 0.05
```

```
Simulation results:  
Observed type 1 error rate: 0.054852  
Fraction of time all CIs contain true difference: 0.94515  
Observed type 1 error rate for ANOVA: 0.050633  
Number of completed iterations: 4977
```

## Balanced complete block without replication (2 way ANOVA).

Factor2 & factor1xfactor2 have effects (although interaction is included in error term in ANOVA analysis (factor 1 always has no effect); covariate has no effect.

```
testmultcompare('nreps', nreps, 'npergrp', 1, 'ntris', ntris, ...  
    'nlvls', nlvls, 'randsd', 1, 'interaction', 1, ...  
    'slope', 0, 'missing', 0, 'alpha', alpha, 'nway', 2);
```

```
ANOVA MODEL  
  'Source'      'Type'  
  'X1'          'fixed'  
  'X2'          'random'  
  'X1*X2'       'random'  
  'Error'       'random'  
  'Total'              []  
  
  'Continuous variable:'
```

```
median min subgroup n: 1  
median median subgroup n: 1  
median max subgroup n: 1
```

---

Nominal type 1 error rate ( $\alpha$ ): 0.05

Simulation results:

Observed type 1 error rate: 0.0504

Fraction of time all CIs contain true difference: 0.9496

Observed type 1 error rate for ANOVA: 0.0508

Number of completed iterations: 5000

## One way ANOVA. All effects set to zero.

```
testmultcompare('nreps', nreps, 'npergrp', 10, 'ntris', 1, ...  
    'nlvls', nlvls, 'randsd', 0, 'interaction', 0, ...  
    'slope', 0, 'missing', 0, 'alpha', alpha, 'nway', 1);
```

```
ANOVA MODEL  
    'Source'  
    'X1'  
    'Error'  
    'Total'
```

```
median min subgroup n: 10
```

```
median median subgroup n: 10
```

```
median max subgroup n: 10
```

Nominal type 1 error rate ( $\alpha$ ): 0.05

Simulation results:

Observed type 1 error rate: 0.054

Fraction of time all CIs contain true difference: 0.946

Observed type 1 error rate for ANOVA: 0.0532

Number of completed iterations: 5000

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