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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) + F1xF2(ij) + Slope*T(ijk) + error(ijk), with F1 = 0 (the null hypothesis is true for factor 1, the factor whose levels are compared), F2~N(0, randsd), F1xF2~N(0, interaction), and error~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.

2016Mar03: 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.

2017Jun10: Rerun after fixing multcompareRandom.m function so that it generates P-values for all pairwise comparisons (the previous version had the wrong limit for the for loop that selected pairs to compare).

```
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: 10-Jun-2017

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 family-wise type 1 error rate: 0.0518
Fraction of time all CIs contain true difference: 0.9482
Observed type 1 error rate for ANOVA: 0.0524
Number of completed iterations: 5000
Number of pairwise comparison in sim: 3
```

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 family-wise type 1 error rate: 0.0472
Fraction of time all CIs contain true difference: 0.9528
Observed type 1 error rate for ANOVA: 0.0462
Number of completed iterations: 5000
Number of pairwise comparison in sim: 3
```

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 family-wise type 1 error rate: 0.059048
Fraction of time all CIs contain true difference: 0.94095
Observed type 1 error rate for ANOVA: 0.054228
Number of completed iterations: 4979
Number of pairwise comparison in sim: 3
```

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 family-wise type 1 error rate: 0.0544
Fraction of time all CIs contain true difference: 0.9456
Observed type 1 error rate for ANOVA: 0.0518
Number of completed iterations: 5000
Number of pairwise comparison in sim: 45
```

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 family-wise type 1 error rate: 0.060012
```

```
Fraction of time all CIs contain true difference: 0.93999
Observed type 1 error rate for ANOVA: 0.048495
Number of completed iterations: 4949
Number of pairwise comparison in sim: 45
```

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 family-wise type 1 error rate: 0.059863
Fraction of time all CIs contain true difference: 0.94014
Observed type 1 error rate for ANOVA: 0.05444
Number of completed iterations: 4978
Number of pairwise comparison in sim: 3
```

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 family-wise type 1 error rate: 0.0482
Fraction of time all CIs contain true difference: 0.9518
Observed type 1 error rate for ANOVA: 0.0498
Number of completed iterations: 5000
Number of pairwise comparison in sim: 3
```

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 family-wise type 1 error rate: 0.0594
Fraction of time all CIs contain true difference: 0.9406
Observed type 1 error rate for ANOVA: 0.0576
Number of completed iterations: 5000
Number of pairwise comparison in sim: 3
```

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