FEAT 2 Practical FEAT 2 实操

This tutorial leads you through examples of higher-level group analysis in FEAT.

本教程将引导您完成 FEAT 中更高级的组分析示例。

Contents:

- **Paired t-test**

  Perform a group-level analysis of a repeated measure experiment, using the paired t-test.

- **Group analysis with multiple sessions for each subject**

  Perform second and third level analyses for an experiment with multiple sessions per subject.

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- 配对 t 检验

  使用配对 t 检验对重复测量实验进行组分析。

- 每个被试有多个 session 的组分析

  对每个被试有多个 session 的实验进行第二级和第三级分析。

Paired t-test

We have a group of six subjects, each scanned twice: once doing motor tasks with their left hand, and once with their right hand. This is a stroke study, and hence comparing left and right motor function is particularly interesting in this case. Within each run, subjects completed different blocks of index finger movement, sequential finger movement and random finger movement.

配对 t 检验

我们有六位被试，每为被试扫描两次：一次用左手做运动任务，一次用右手。这是一项中风研究，因此在这种情况下比较左右手运动功能特别有趣。在每次运行中，被试完成了不同组块的食指运动，顺序手指运动和随机手指运动。

Research question: Is there a significant left vs right hand finger movement paired-difference, generalisable to the population from which the subjects are drawn?

To address this, we want the *left* − *right* paired mean difference within a mixed effects model, taking into account the within-subject fixed effects variances and the between-subject random effect variance. This is done as a two-level analysis with the following structure:

- **Level 1: Single-session analyses** There are 6 subjects × 2 sessions = 12 first-level FEAT analyses. These have already been done for you.
- **Level 2: Between-subject analysis** We do a separate second-level analysis for each of the first-level contrasts, and estimate the mean (paired) difference for each.

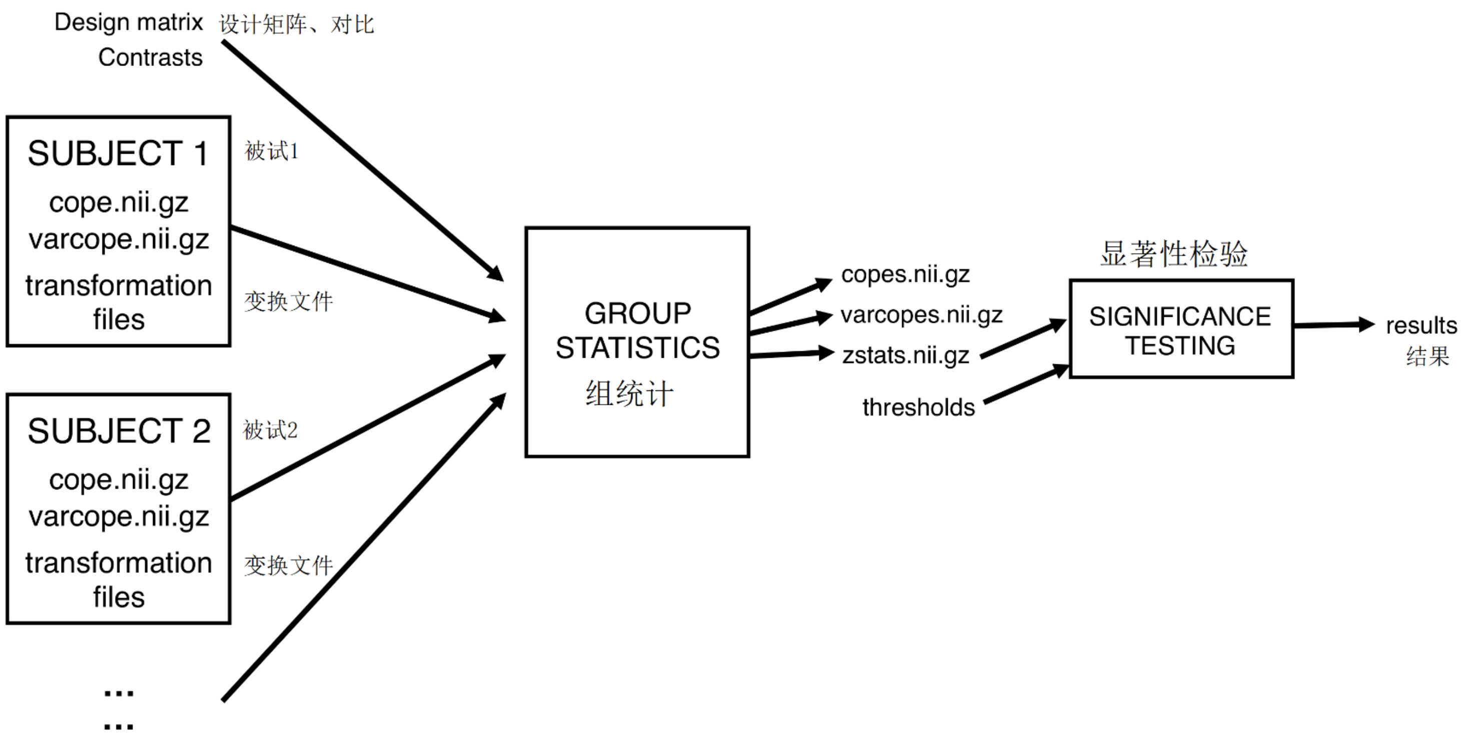
In FSL terminology, each contrast is represented by a COPE (contrast of parameter estimate), and it is these which we pass up to any higher-level analysis. Note that as well as the COPEs, FEAT passes the variance of these COPEs (VARCOPEs), and even the uncertainty in the variance of these COPEs (DOFs; degrees-of-freedom), between the different levels.

研究问题：是否存在显著的左右手指运动配对差异，从而可推广到抽取的被试人群？

为了解决这个问题，我们希望在混合效应模型中考察左-右配对差异，同时考虑被试内固定效应方差和被试间随机效应方差的影响。我们采用以下结构的两级分析来完成：

- **第一级：单 session 分析** 共有 6 个被试×2 个 session=12 个第一级 FEAT 分析。这些已经为您完成。
- **第二级：被试间分析** 我们对每个第一级对比进行单独的第二级分析，并估计每个对比的均值（配对）差异。

在 FSL 术语中，每个对比都由 COPE（参数估计的对比）表示，我们使用这些对比可以进行任何更高级别的分析。请注意，与 COPE 一样，FEAT 在不同级别之间传递了这些 COPE（VARCOPE）的方差，甚至是这些 COPE（自由度）方差的不确定性。



What do the values in a COPE image obtained from the single-session analysis represent?

- The parameter estimates for a certain EV
- The parameter estimates for a certain contrast

  Correct! COPE (contrast of parameter estimates) images are calculated by performing simple algebra on the EV parameter estimates. For example, for the contrasts 1 -1, the contrast parameter estimate is calculated by subtracting the parameter estimate for EV 2 from the parameter estimate for EV1. The COPE image will show regions in the brain in which this difference is large.
- The uncertainty of the parameter estimates for a certain contrast

从单阶段分析中获得的 COPE 图像中的值代表什么？

- 某 EV 的参数估计
- 某对比的参数估计

  正确！通过对 EV 参数估算值执行简单的代数运算来计算 COPE（参数估算值的对比度）图像。 例如，对于对比 1 -1，通过从 EV1 的参数估计中减去 EV 2 的参数估计来计算对比参数估计。COPE 图像将显示大脑中差异较大的区域。
- 某对比的不确定参数估计

First-level analyses

Each first-level analysis contains 6 contrasts, each related to the different types of finger tapping performed in the scanner (e.g. mean response over the different conditions, index finger only, etc.). Thus there are 6 COPEs in the stats subdirectory of each first-level .feat directory. A higher-level FEAT analysis entails an independent analysis on each of these contrasts (i.e. a second-level analysis of all subjects' first-level *mean* contrasts, a separate second-level analysis of all first-level *index* contrasts, etc.). Each of these second-level analyses is performed simultaneously and will form a separate cope?.fea directory inside a newly-created .gfeat directory.

第一级分析

每个第一级分析包含 6 个对比，每个对比都与扫描仪中执行的不同类型的手指敲击有关（例如，在不同条件下的平均响应，仅食指的平均响应等）。因此，每个第一级.feat 目录的 stats 子目录中有 6 个 COPE。更高级别的 FEAT 分析需要对这些对比的每一个进行独立分析（即，对所有被试的第一级平均对比进行第二级分析，对所有第一级食指对比进行单独的第二级分析等）。这些第二级分析中的每一个都同时执行，并将在新创建的.gfeat 目录中形成一个单独的 cope？.feat 目录。

```
cd ~/fsl_course_data/fmri2/paired_ttest
```

The first-level analyses are held in 6 different directories within ~/fsl_course_data/fmri2/paired_ttest, one for each subject. The subject directories are ac at cm df dn eg. There are two first-level FEAT directories within each of these, and these have already been run for you. Have a quick look at one of the lower-level reports if you want to familiarise yourself with the study design and data.

第一级分析保存在～/ fsl_course_data / fmri2 / paired_ttest 中的 6 个不同目录中，每个目录对应一个被试。被试目录为 ac at cm df dn eg。其中每个都有两个第一级 FEAT 目录，并且这些目录已经为您运行。如果您想熟悉研究设计和数据，请快速查看其中一份较低级别的报告。

FEAT set-up

Open FEAT (`Feat &` or [`Feat_gui &` on a mac]) and follow the instructions below to set up the higher-level analysis.

First, change **First-level analysis** to **Higher-level analysis** in the drop down box at the top.

Data

Here we are going to set up the input data for our higher level analysis. First, change the **Number of inputs** to 12 (i.e. 6 subjects × 2 sessions).

Press **Select FEAT directories**. At this stage, you need to decide on a sensible order for the first-level analyses. You could choose to group the analyses by subject (i.e. ac/ac_left.feat, ac/ac_right.feat, at/at_left.feat, etc.), or you could group by condition (i.e. ac/ac_left.feat, at/at_left.feat, …, ac/ac_right.feat, etc.). We recommend the latter option, because this matches the example paired t-test in the FEAT manual, and also matches the way the paired t-test is set up for you if you use the **Model setup wizard** (explained below).

FEAT 设置

打开 FEAT（Feat & 或 [Mac 上为 Feat &]），然后按照以下说明进行高级分析。

首先，在顶部的下拉框中将 First-level analysis 更改为 Higher-level analysis。

数据

在这里，我们将为高级分析设置输入数据。首先，将 Number of inputs 更改为 12（即 6 个被试×2 个 session）。

点击 Select FEAT directories。在此阶段，您需要为第一级分析确定合理的顺序。您可以选择按被试将分析分组（即 ac/ac_left.feat, ac/ac_right.feat, at/at_left.feat 等），也可以按条件分组（即 ac/ac_left.feat, at/at_left.feat, …, ac/ac_right.feat 等）。我们建议使用后一种方式，因为它与 FEAT 手册中的示例配对 t 检验匹配，且也与配对 t 检验为你设置的方式匹配，如果您使用 Model setup wizard（如下所述）。

You can often avoid having to tediously hand-select each of these first-level FEAT directories separately, using the **Paste** button. If you press this, a new free-text window comes up, within which you can paste text (in this case the list of first-level FEAT directories) which you can copy, e.g. from a list in a terminal. Press **Clear** to clear the text window. Then in your terminal, making sure you are inside the paired_ttest directory, type:

您通常可以使用 Paste 按钮避免分别繁琐地手动选择每个一级 FEAT 目录。如果点击了该按钮，则会出现一个新的自由文本窗口，您可以在其中粘贴可复制的文本（在这种情况下，一级 FEAT 目录的列表），例如你可从终端列表中复制文本然后黏贴在这里。点击 Clear 以清空文本窗口。然后在终端中，确保您位于 paired_ttest 目录中，键入：

```
ls -d1 "$PWD"/??/??_left.feat ; ls -d1 "$PWD"/??/??_right.feat
```

ls -1d lists a set of files or directories. The -1 flag prints each result on a separate line, and -d means that only directory names, rather than their contents, are shown. The "$PWD" part fills out the full pathname of the current directory. The ? characters are expanded by the shell to fit any single character, in alphabetical order. The command is repeated so that the _left FEAT directories are listed first, and then all the _right.

ls -1d 列出了一组文件或目录。-1 标志将每个结果打印在单独的行上，而-d 表示仅显示目录名称，而不显示其内容。“$PWD”部分填写当前目录的完整路径名。 ? 外壳会扩展字符以按字母顺序适合任何单个字符。该命令会重复运行，以便首先列出_left FEAT 目录，然后列出所有_right。

This should give you a complete listing of the full pathnames of the FEAT directories in the right order. You can now highlight this list with the mouse, and paste it into the FEAT paste window with the middle mouse button, or by clicking in the paste window and pressing control-y.

这应该给您以正确的顺序完整列出 FEAT 目录的完整路径名。现在，您可以用鼠标选中列表内容，然后使用鼠标中键将其粘贴到 FEAT 粘贴窗口中，或者在粘贴窗口中单击并按 Ctrl-y。

To save time, we will only pass the mean contrast up to the top level. Make sure that **ONLY** contrast 1 is selected in the **Use lower-level copes** boxes.

When this is done, set the **Output directory** to paired_ttest_ols (the full path will end up as /home/fslcourse/fsl_course_data/fmri2/paired_ttest/paired_ttest_ols.gfeat).

Stats

Select the **Mixed Effects: Simple OLS** option from the top drop down box. Also, make sure that the **Use automatic outlier de-weighting** button is **NOT** turned on. It is important that these two settings are chosen, otherwise the analysis will not be quick enough to be of use to you in the time that we have available for the practical. Normally, we recommend that the more accurate "Mixed Effects: FLAME 1" option is used in combination with outlier de-weighting, for the reasons outlined in the lectures. However, in the interest of speed, in this practical we choose the faster OLS option without outlier de-weighting.

为了节省时间，我们只会将平均对比度传递到高级别。 确保在 Use lower-level copes 框中**只选择了对比 1**。

完成此操作后，将 Output directory 设置为 paired_ttest_ols（完整路径是 /home/fslcourse/fsl_course_data/fmri2/paired_ttest/paired_ttest_ols.gfeat）。

统计

从顶部下拉框中选择 Mixed Effects: Simple OLS 选项。另外，请确保**未打开** Use automatic outlier de-weighting 按钮。进行这两个设置很重要，否则在我们实操时，分析将不够迅速。通常，像我们在课堂中解释的那样，我们建议结合使用更准确的"Mixed Effects: FLAME 1"选项，并结合离群值去加权。但是，出于速度的考虑，在本次实操中，我们选择了更快的 OLS 选项，而没有进行离群值去加权。

With this design you can use the **Model setup wizard**, which provides an easy way of setting up a few simple designs. Select **two groups, paired** and press **Process**. You will now see the design matrix that has been created for you.

通过这种设计，您可以使用Model setup wizard，它提供了一种简单的方法来设置一些简单的设计。选择 two groups, paired 并点击 Process。 现在，您将看到为您创建的设计矩阵。

To understand how this is controlled in detail, click on **Full model setup**.

要了解如何对其进行详细控制，请单击 Full model setup。

- The inputs (*Input 1* to *Input 12*) correspond to the order you entered the first-level FEAT directories—it is essential that your design matches the order you entered the lower level directories under the **Data** tab! Note also that the first column, labelled *Group*, corresponds to groupings of inputs that will share the same random effects (RE) variance in this level of the model. Here, we let all subjects have the same RE variance (i.e. the *Group* column should be left as all 1s).

- 输入（Input 1 到 Input 12）与您输入一级 FEAT 目录的顺序相对应-设计必须与您在 Data 选项卡下输入的低级目录顺序相匹配！还要注意的是，标记为 group 的第一列，对应于在此模型级别上共享相同随机效应（RE）方差的输入分组。在这里，我们让所有被试的 RE 方差都相同（即 group 列应保留为全 1）。

- There are 7 EVs: EV 1 models the left − right paired difference, and EVs 2-7 are confounds which model out each subject's mean (this is what makes the design a paired t-test).

- 共有 7 个 EV：EV 1 为左-右配对差异建模，而 EV 2-7 为每个模型的均值混淆变量建模（就是它使设计成为配对 t 检验）。

- Click on the **Contrasts & F-tests** tab. There are two contrasts set up for you by the wizard. EVs 2-7 are confounds of no interest and so do not appear in the contrasts. Hence, the contrasts only involve EV1. Change the **Titles** boxes to read *left > right* and *right > left*.

- Press **Done**.

Post-stats

Because we only use a small number of subjects in order to make it possible to run the analysis in the practical session, we will reduce the cluster threshold slightly. This will allow us to see some more results, but is **NOT** recommended for your own analyses. In the **Thresholding** box change the **Z threshold** to 2.3.

Go!

Press **Go**! The web browser that appears monitors the overall progress. This second-level analysis should take about 5 minutes. While you're waiting, either make a cup of tea (but do NOT add milk while the bag is still in the water) or familiarise yourself with the introduction to the next major section of the practical on group analyses with multiple sessions per subject.

- 单击 Contrasts & F-tests 选项卡。已为您设置了两种对比。 EV 2-7 是我们不感兴趣的混淆，所以不会出现在对比中。 因此，对比仅涉及 EV1。 更改 Titles 框，以读取 left > right 和 right > left。

- 点击 Done。

后统计

因为我们仅使用少量被试，以便可以在实操中运行分析，所以我们将稍微降低聚类阈值。这将使我们看到更多结果，但**不建议**您在自己的分析中也这样做。在 Thresholding 框中，将 Z threshold 更改为 2.3。

Go!

按下 Go！弹出的 Web 浏览器将监控总体进度。此第二级分析大约需要 5 分钟。在等待时，您可以喝杯茶，也可以熟悉下一节有关每位被试多 session 的组分析的实操介绍。

Results

Higher-level FEAT runs produce .gfeat directories. Once the analysis has finished, explore the web report. This top-level report provides links to the previous level reports, a registration summary page and links to the separate higher-level reports.

LOOK AT YOUR DATA! In particular it is always important to check the registration summary report page very carefully, to ensure that all lower-level registrations succeeded. If any of the lower-level FEATs look like the registration has failed badly, you need to fix this before re-running the higher-level FEAT analysis. Note that field maps were not acquired with this data—you should be able to spot this on the registration page!

结果

高级别的 FEAT 运行会生成.gfeat 目录。分析完成后，浏览 Web 报告。该高级报告提供到上一级报告的链接，配准摘要页面以及到单独的更高级别报告的链接。

查看您的数据!特别是，非常仔细地检查配准摘要报告页面，以确保所有较低级别的配准都成功。如果任何较低级别的 FEAT 看起来严重失败，则需要在重新运行较高级别的 FEAT 分析之前解决此问题。请注意，此数据并未采集场图-您应该能够在配准页面上发现这一点!

In the results page you get a link to the group results from running the group-level analysis on each first-level contrast. Within each contrast you get a group-level results page showing the standard post-stats output. However, note that the time course outputs in these higher-level results no longer refer to time (despite the heading). They refer to subject (or session) number. In this case that is the 12 sessions (6 subjects × 2 conditions) in the study, and it is effect size shown on the vertical axis, rather than normalised MRI signal. Have a look at this and the other parts of the results webpage and make sure you understand what is being shown.

在结果页面中，您可以通过在每个第一级对比上运行组分析获得指向组结果的链接。在每个对比中，您将获得一个组级别的结果页面，其中显示了标准的 post-stats 输出。但是，请注意，这些高级结果中的时程输出不再指的是时间。它们指的是被试（或 session）数量。在这种情况下，即研究中的 12 个 session（6 个被试×2 个条件），它是在垂直轴上显示的效果大小，而不是标准化的 MRI 信号。查看该部分和结果网页的其他部分，并确保您了解所显示的内容。

Pre-baked analyses

We have run a full analysis for you on this data (i.e. on all the contrasts, using FLAME for statistics, and with the recommended Z-thresholds). Take a quick look at this report as well.

Pre-baked 分析

我们已为你对数据进行了完整分析（即，对所有对比使用 FLAME 进行统计分析，并使用推荐的 Z 阈值）。也请快速浏览此报告。

```
firefox examples/flame.gfeat/report.html &
```

Can you spot any major differences between the two analyses?

您能发现这两个分析之间的主要区别吗？

Group analysis with multiple sessions for each subject

It is common to split a task up into multiple short scans instead of having one long scan. This can often help to reduce subject movement in the scans, and also to keep the attention of your participant. As a result, we need to combine data across multiple scanning sessions using a three-level FEAT analysis.

The data consists of a set of subjects, each scanned twice several months apart. For simplicity's sake, we will look for a simple mean effect across subjects and sessions. Hopefully this will help you understand how this analysis can be extended to more complex questions.

We want the mean group effect, within a mixed effects model, taking into account the within-subject fixed effects variances and the between-subject random effect variance. This is done in THREE levels:

- **Level 1: Within-session analysis.** There are 5 subjects × 2 sessions = 10 of these first level FEAT analyses, which have already been done for you.

每位被试有多个 session 的组分析

我们通常会将一个任务分成多个短扫描而不是进行一个长扫描。这可以帮助减少扫描时被试的运动，也可以保持你对参与注意力。因此，我们需要使用三级 FEAT 分析来组合多个扫描 session 中的数据。

数据包括一组被试，每个被试进行了两次扫描，期间间隔了数月。简单起见，我们将在被试和 session 之间寻找简单的平均效应。希望这将帮助您了解如何将这种分析扩展到更复杂的问题。

我们希望在混合效应模型中考察平均组效应，并考虑被试内固定效应方差和被试间随机效应方差的影响。这通过以下的三级分析完成：

- **第一级：session 内分析。**共有 5 个被试 × 2 个 session=10 个一级 FEAT 分析，在此处已为你完成。

- **Level 2: Between-session analysis.** Here, we input the data from Level 1, and estimate each subject's mean response.

- **Level 3: Between-subject analysis.** We input the data corresponding to the subject means from Level 2, model the between-subject variances and estimate the group mean response.

Because each subject will typically only have a handful of sessions, we do not run a mixed effects second-level analysis to get an estimation of each subject's mean response. The reason for this is that we would not be able to get a good estimation of the within-subject session-to-session variance with a limited number of sessions. Hence we choose to ignore the session-to-session variance by using a fixed effects analysis at this second level.

- **第二级：session 间分析。**在这里，我们输入来自第一级数据，并估算每个被试的平均响应。

- **第三级：被试分析。**我们输入与第二级被试均值相对应的数据，对被试间的差异进行建模，并估计组平均响应。

由于每个被试通常只有少数几个 session，因此我们不会进行混合效应第二级分析来估计每个被试的平均响应。这样做的原因是，在 session 数有限的情况下，我们无法很好地估算出被试内 session 间的差异。因此，我们在第二级分析中通过使用固定效应分析来忽略 session 间差异。

If you are carrying out a mid-level analysis (e.g., cross-session) that will be fed into an even higher-level analysis (e.g., cross-subject), then it could be argued that a mixed-effects analysis should be done at the mid-level. A mixed-effects analysis would assume that the sessions are randomly sampled from a population of sessions that that subject could produce. This includes estimation of each subject's session-to-session variance. However, it is common for only a small number of sessions to be collected for each subject, making estimation of each subject's session-to-session variance impractical. One solution to this is to assume a common session-to-session variance for all subjects, thereby providing enough data for the session-to-session variance to be estimated. However, this has a downside in that you lose information about which subjects are good (i.e. low variance) and which subjects are bad (i.e. high variance). Hence, when only a small number of sessions have been collected for each subject (say, less than 10), it is recommended that you use a fixed effects analysis at the mid-level. This in effect treats the multiple first-level sessions (for each subject) as if they were one long session, and estimates the simple average across the sessions. Although this does ignore the session-to-session variability at this level, it is arguable that this is not of interest anyway (this is a somewhat philosophical debate). However, the combined session and subject variability will still affect (and be estimated at) the next level.

如果您正在进行中级分析（例如，跨 session），并将其纳入至更高级别的分析（例如，跨被试）中，则可能会认为应该在中级分析进行混合效果分析。混合效果分析将假定这些 session 是从该被试可能产生的一系列 session 中随机抽取的。这包括对每个被试 session 间差异的估计。但是，通常只为每个被试收集少量 session，这使得对每个被试的 session 间差异进行估算是不切实际的。一种解决方案是假设所有被试的 session 间均存在共同差异，从而为估算 session 之间的差异提供足够的数据。但是，这样做的缺点是您会丢失有关哪些被试好（即低方差）和哪些被试不好（即高方差）的信息。因此，当为每个被试收集的 session 数量很少（例如少于 10 个）时，建议您在中级分析阶段使用固定效应分析。实际上，这将多个（每个被试的）第一级 session 视为一个较长的 session，并估计了各个 session 的简单平均值。尽管这确实忽略了此级别的 session 间，但可以争论的是无论如何这都不是我们感兴趣的部分（这在哲学上是有争议的）。但是，合并的 session 和被试差异仍将影响下一级别的分析，并会在那时被估计。

In short, fixed effects is favoured as it avoids practical problems associated with estimating the session-to-session variance (when there are not many sessions per subject), at the same time as maintaining information about which subjects are good and bad (i.e. low or high variance).

简而言之，固定效应分析是受青睐的，因为它避免了与估计 session 间差异相关的实际问题（当每个被试没有多少 session 时），同时保留了有关被试的优劣（即高低方差）的信息。

In addition to this, the analysis cannot be combined into a single second-level analysis. This is tempting as a design matrix can easily be formed containing each subject's mean (across sessions) as a separate EV, and then contrasts can be formed to test the mean across all subjects. The problem with this model is that there are two separate sources of variability (session-to-session and subject-to-subject) but, within FSL, a single level cannot model more than one separate sources of variance.

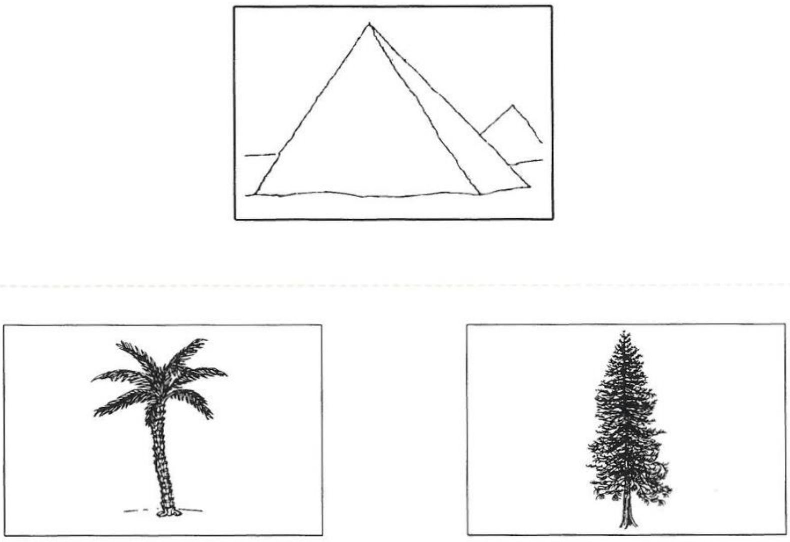
除此之外，该分析不能合并为单个第二级分析。我们知道这一想法很诱人，因为可以轻松地形成包含以每个被试平均值（session 间）作为单独 EV 的设计矩阵，然后可以形成对比来测试所有被试的平均值。但这种模型的问题在于，有两个单独的差异源（session 间和被试间），但是在 FSL 中，单个级别的分析不能为多个独立的差异源建模。

First-level analyses

In both sessions, subjects performed the "Pyramids & Palm Trees" task (PPTT). Participants are presented with a target image, and are asked to select the image they most associate with the target from a pair of additional images. The canonical example is below:

第一级分析

在两个 session 中，被试均执行 "Pyramids & Palm Trees" task (PPTT)。 向被试展示目标图像，并要求他们从一对其他图像中选择与目标最相关的图像。示例如下：



This is meant to be a test of semantic memory, as the task requires reasoning about the links between objects. There is also a control condition, where participants have to match abstract line drawings. We are primarily interested in the semantic > lines responses. To begin with, familiarise yourself with the first-level design and typical responses in one of the session-specific FEAT analyses we have run for you:

这是一个语义记忆的测试，因为该任务需要对对象之间的关系进行推理。任务还包括一个控制条件，被试要匹配抽象线条图。我们主要对 semantic > lines 的响应感兴趣。 首先，熟悉一下我们为您运行的特定 session FEAT 分析中的第一级设计和典型响应：

```
cd ~/fsl_course_data/fmri2/3_levels
```

Take a quick look at one of the web reports within the run directories of the level_1/ directory.

快速浏览一下 level_1 /目录里下的 run 目录中的一个 Web 报告。

Second-level analysis

We will now set up the second-level (i.e. within-subject) analysis. Open FEAT (Feat & [or Feat_gui & if on a mac]) and follow the instructions below:

- Change **First-level analysis** to **Higher-level analysis**.

- Change the **Number of inputs** to 10 (5 subjects × 2 sessions).

- Press **Select FEAT directories**. Again, you need to specify the first-level FEAT directories in a sensible order: subject 1, sessions 1, 2; then subject 2, sessions 1, 2; etc. There are lots of ways we can enter these into the GUI: we can enter them individually into the GUI by hand, but this can be laborious for large studies; we can type out the names in a file and use the **Paste** window; or we could do some simple ls commands and then reorder the outputs as necesary in a text editor. Finally, if we have chosen a sensible naming convention we may be able to script the whole process.

第二级分析

现在，我们将进行第二级（即被试内）分析。 打开 FEAT（Feat & [Mac 上为 Feat_gui &]）并按照以下说明进行操作：

- 将 First-level analysis 更改为 Higher-level analysis。

- 将 Number of inputs 更改为 10（5 个科目×2 个会话）。

- 点击 Select FEAT directories。同样，您需要以合理的顺序指定一级 FEAT 目录：被试 1，session 1，2； 然后是被试 2，session 1、2 等。我们有很多方法可以将它们输入到 GUI 中：我们可以手动将它们单独输入到 GUI 中，但这对于大型研究可能很费力；我们也可以在文件中键入名称，然后使用 Paste 窗口； 或者我们可以执行一些简单的 ls 命令，然后在文本编辑器中根据需要对输出进行重新排序。最后，如果我们选择了明智的命名约定，则可能可以编写整个过程的脚本。

To save time, we have done this for you here. Copy and paste the following into the **Paste** window (ctrl-y). and then press **OK** to close the data input windows.

为了节省时间，我们在这里为您完成了此操作。将以下内容复制并粘贴到 Paste 窗口（ctrl-y）中。 然后点击 OK 关闭数据输入窗口。

```
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_1/CON_417/CON_417_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_2/CON_417_2/CON_424_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_1/CON_425/CON_425_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_2/CON_425_2/CON_442_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_1/CON_428/CON_428_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_2/CON_428_2/CON_447_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_1/CON_429/CON_429_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_2/CON_429_2/CON_457_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_1/CON_430/CON_430_PPTT.feat
/home/fslcourse/fsl_course_data/fmri2/3_levels/level_1/run_2/CON_430_2/CON_444_PPTT.feat
```

Note that the above will not work if you are running the practicals on your own computers. To generate the list in that instance, use the command:

请注意，如果您在自己的计算机上进行实操，则以上操作将无效。在这种情况下要生成该列表，请使用以下命令：

```
for sub in CON_417 CON_425 CON_428 CON_429 CON_430 ; do
   ls -1d $PWD/level_1/run_1/$sub/*.feat ;
   ls -1d $PWD/level_1/run_2/${sub}_2/*.feat ;
done
```

Note how this command is more complicated than the ones we have used to generate file lists before. This is because of the naming convention we have chosen! Setting up a sensible naming convention from the start will make subsequent analyses immeasurably easier.

请注意，此命令比我们之前用来生成文件列表的命令要复杂得多。这是因为我们选择了命名约定！从一开始就建立合理的命名约定将使后续分析变得异常容易。

- To save time, we will only pass the *semantic > lines* and *semantic < lines* contrasts up to the higher levels. Make sure that **ONLY** contrasts 1 & 2 are selected in the **Use lower-level copes** boxes.

- Set the **Output directory** to /home/fslcourse/fsl_course_data/fmri2/3_levels/level_2.gfeat

- Go to the **Stats** tab and select the **Fixed-effects** option.

- Press **Full model setup**. Remember that the *Inputs* (1-10) correspond to the order you entered the first-level FEAT directories. As this is a fixed effects analysis the *Group* column is ignored so leave all these entries as 1 (if we had lots of sessions and did a mixed effects analysis instead then we would use a unique number in this column for each subject (i.e. within each subject we would estimate a separate variance).

为了节省时间，我们只传递 semantic > lines 和 semantic < lines contrasts 对比到高级分析。确保在 Use lower-level copes 框中只选择了对比 1 和 2。

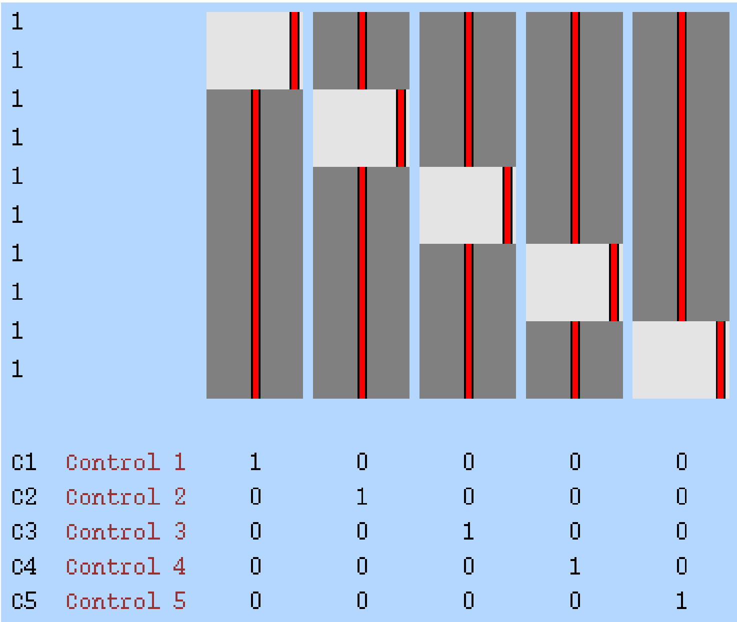
- 将 Output directory 设置为 /home/fslcourse/fsl_course_data/fmri2/3_levels/level_2.gfeat

- 转到 Stats 选项卡，然后选择 Fixed-effects 选项。

- 点击 Full model setup。请记住，输入（1-10）对应于您输入的第一级 FEAT 目录的顺序。由于这是固定效应分析，因此忽略了 Group 列，所以将所有这些条目保留为 1（如果我们有多个 session 并进行了混合效应分析，那么我们将在此列中为每个被试使用唯一编号（即，对每个被试，我们将估计一个单独的方差）。

- We need 5 EVs: one for each subject mean. Change the 0s to 1s appropriately, in such a way that each EV models a different subject mean. We then need to pass the 5 parameter estimates (PEs) corresponding to the 5 subject means through to the third level as COPEs. To enable this, we need to have a contrast for each subject mean that just selects that parameter. Set the contrasts appropriately. Your design matrix should now match this complete design matrix.

- 我们需要 5 个 EV：每个被试均值一个。适当地将 0 更改为 1，以使每个 EV 为不同的被试均值建模。然后，我们需要将与 5 个被试均值对应的 5 个参数估计值（PE）作为 COPE 传递到第三级分析。为了实现这一点，我们需要对每个被试设置对比，以便仅选择该参数。适当设置对比。现在，您的设计矩阵应与此完整的设计矩阵匹配。



- Press **Done**. The default **Post-stats** are fine (in fact, the post-stats don't affect what gets passed up to third-level). You are now ready to run the second-level analysis so press **Go!**

- 点击 Done。保留默认的 Post-stats 设计即可（实际上，Post-stats 不影响传递到第三级的内容）。现在您可以运行第二级分析了，所以按 Go！

This analysis should only take a couple of minutes to run. Wait for the result web pages and then view them *carefully*. Check that the registrations are accurate, and then take a look at the results.

*Aside: If something has gone wrong with your analysis, or it is taking too long to run, there is a pre-baked version available: examples/level_2.gfeat. You can use this as the input to the third level analysis too if necessary.

Third-level analysis

We are now ready to set up the third-level (i.e. between-subject) analysis. This will be valid for one of the contrasts we passed up to the second level (but it easy to repeat the analysis for the others). We will use the *semantic > lines* results, which corresponds to contrast 1. Reopen FEAT (Feat &) and follow the instructions below:

- Change **First-level analysis** to **Higher-level analysis**.

- Change **Inputs are lower-level FEAT directories** to **Inputs are 3D cope images from FEAT directories**. The inputs will be the 5 COPE images, one for each subject mean, from the second-level analysis.

此分析只需几分钟即可运行完成。等待结果网页出现，然后仔细查看它们。检查配准是否正确，然后查看结果。

*此外：如果您的分析出现问题，或者运行时间太长，则可以使用 pre-baked 版本：examples / level_2.gfeat。如有必要，您也可以将其用作第三级分析的输入。

第三级分析

现在，我们准备进行第三级（即被试间）分析。这对于我们传递到第二级的对比之一是有效的（但对于其他对比也很容易重复该分析）。我们将使用 semantic > lines 结果，该结果对应于对比 1。重新打开 FEAT (Feat &)，并按照以下说明进行操作：

- 将 First-level analysis 更改为 Higher-level analysis。

- 将 Inputs are lower-level FEAT directories 更改为 Inputs are 3D cope images from FEAT directories。输入将是来自第二级分析的 5 张 COPE 图像，每张代表一个被试均值。

- Change the **Number of inputs** to 5 (each corresponding to a subject mean).

- 将 Number of inputs 更改为 5（每个对应于一个被试均值）。

- Press **Select cope images** and enter the COPEs from the second level. These will be inside the cope1.feat/stats directory which is inside the second-level level_2.gfeat directory that you just created. The relevant command for pasting is:

- 点击 Select cope images，然后输入来自第二级的 COPE。 它们位于 cope1.feat / stats 目录中，该目录则位于您刚刚创建的第二级目录 level_2.gfeat 中。相关的粘贴命令是：

```
ls -1d "$PWD"/level_2.gfeat/cope1.feat/stats/cope?.nii.gz
```

What does the `cope1.feat/stats/cope5.nii.gz` represent?

- The mean for subject 1 for the fifth contrast that was entered at the first-level analysis
- The mean for subject 5 for the first contrast that was entered at the first-level analysis

  Correct! The `cope1.feat` directory contains the results for the first contrast at the subject level, which in this case is *semantic > lines*. Within that directory, the individual `cope5.nii.gz` files represent the second-level contrasts, which in our case correspond to individual subjects.
- The third group-level statistical result for the first contrast that was entered at the first-level analysis

cope1.feat / stats / cope5.nii.gz 代表什么？

- 在第一级分析中输入的第 5 个对比的被试 1 均值
- 在第一级分析中输入的第 1 个对比的被试 5 均值

  正确！cope1.feat 目录包含被试水平的第一个对比的结果，在本例中为 semantic > lines。在该目录中，单独的 cope5.nii.gz 文件表示第二级对比，在我们的情况下，该对比对应于单独被试。
- 在第一级分析中输入的第 1 对比的第三组级统计结果

- Set the output directory to level_3.gfeat

- Go to the **Stats** tab and change to **Fixed effects**. Note that this is **NOT** recommended for group-level analyses, but we use it here to save time and because we are only analysing five subjects. Normally, mixed effects would be used.

- Use the **Model setup wizard** to generate a single group average design.

- Press **Go!**

*Aside: You can look at examples/level_3.gfeat if necessary.

Again, this analysis should only take a couple of minutes to run. Wait for the result web pages and look at the results. Do they look plausible?

- 将输出目录设置为 level_3.gfeat

- 转到 Stats 标签，然后更改为 Fixed effects。请注意，**不建议**在组级分析中使用此方法，但是我们在这里使用以节省时间，并且因为我们仅分析五个被试。通常，这里将将使用 mixed effects。

- 使用 Model setup wizard 来生成单个组平均设计。

- 按下 **Go！**

*此外：如有必要，您可以查看 examples / level_3.gfeat。

同样，此分析只需几分钟即可运行完成。等待结果网页弹出并查看结果。它们看起来合理吗？

—— THE END ——