Clinical Guide to fNIRS Research

Prepared by: Andrew Lapointe

EXPERIMENTAL NEUROIMAGING CENTRE
UNIVERSITY OF CALGARY

Contents

Chapter 1

Documentation for Author

The `_output.yml` contains the header arguments. I would but them here so its cleaner and easier to read the code. **To/Do**

To render the book used the following code

```
bookdown::render_book("index.Rmd", "bookdown::gitbook")
bookdown::render_book("index.Rmd", "bookdown::pdf_book")
bookdown::render_book("index.Rmd", "bookdown::epub_book")
```

- Is there a way I can have matlab code syntax highlighted properly? Maybe here
- Get Camera to take nice pictures
- Get example dataset that I can run through
- Can I export this to github.io? The GitHub Repository for this guidebook can be found here
- Add highlight arg to `_output.yml`
- Upload the MATLAB packages required to GitHub directory
- [x] Finish my changes
- [ ] Push my commits to GitHub
- [ ] Open a pull request

```
% This is a comment in MATLAB
function y = average(x)
if ~isvector(x)
   error('Input must be a vector')
end
y = sum(x)/length(x);
end
```

This also seems like a nice format to export to https://cran.r-project.org/web//packages/tint/vignettes/tintHTML.html

https://cran.r-project.org/web/packages/prettydoc/vignettes/architect.html

```
#This is MATLAB code
```

Chapter 2

Preface

Copy from the preface in the Anesthesiology book

Chapter 3

Background Information

What is fNIRS?

Functional near-infrared spectroscopy (fNIRS)

fNIRS measures the brain tissue concentration changes in oxyhemoglobin (HbO_2) and deoxyhemoglobin (HbR) associated with an increased metabolic demand of the brain during neuronal activity, and an increased tissue perfusion.

What is fNIRS?

Types of boxes laser vs LED (Tekker vs NIRx)

```
% This is a comment in MATLAB
function y = average(x)
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   error('Input must be a vector')
end
y = sum(x)/length(x);
end
```

3.1 Hemoglobin

Each Red Blood Cell contains about 250 million molecules of hemoglobin, each cc of blood contains 5 billion Red Blood cells, you have approximately 5,000 cc's of blood in your vascular system. The reason we have so much hemoglobin is because oxygen does not easily dissolve in water (about 3% of all our oxygen is in the serum - the rest is bound to hemoglobin), so we have developed this unique system of oxygen transportation to meet our needs.

Hemoglobin is assumed to be the main chromophore in biological tissue that absorbs light in this near infrared region.

When oxygen is bound to hemoglobin, it is called oxyhemoglobin.

3.1.1 What is Oxyhemoglobin (HbO_2)?

Oxyhemoglobin is the oxygenated form of hemoglobin.

Insert the YouTube video here (https://www.youtube.com/watch?reload=9&v=Fs7eJElU3m8)

3.1.2 Deoxygenated hemoglobin

Deoxygenated version of hemoglobin.

3.2 So how does this relate back to NIRS?

Deoxygenated hemoglobin is the form of hemoglobin without the bound oxygen. The absorption spectra of oxyhemoglobin and deoxyhemoglobin differ. The oxyhemoglobin has significantly lower absorption of the 660 nm wavelength than deoxyhemoglobin, while at 940 nm its absorption is slightly higher. This difference is used for the measurement of the amount of oxygen in a patient's blood by an instrument called a pulse oximeter.

3.2.1 How do we gather hemoglobin related measures?

Insert figure with optodes here. Example in this publication

It might be best to just photoshop something yourself.

3.2.2 What does Hemoglobin/fNIRS tell us about brain function?

Here write what we can infer from fNIRS/hemoglobin. Is it related to neurotransmitter release? extra synaptic potentials?

3.3 Some Math

The science If the absorption is known, the Lambert-Beer law can be used to calculate the chromophore's absorption. The Lambert-Beer law is given by:

Taken from here

OD is a dimensionless factor known as the optical density of the medium, I0 is the incident light, I the transmitted light, the chromophore's extinction coefficient (in µM-1 • cm-1), c is the concentration (in µM) of the chromophore, L the distance (in cm) between light entry and exit points and is the wavelength used (in nm).

```
% This is a comment in MATLAB
function y = average(x)
if ~isvector(x)
   error('Input must be a vector')
end
y = sum(x)/length(x);
end
```

This could also work for Latex only –> https://tex.stackexchange.com/questions/35193/how-to-sweave-matlab-or-mathemat

```
% This is a comment in MATLAB
function y = average(x)
if ~isvector(x)
   error('Input must be a vector')
end
y = sum(x)/length(x);
end
```

So could this https://amber.rbind.io/blog/2017/11/15/syntax-highlighting/

Chapter 4

Who is Homer?

4.1 Types of boxes

laser vs LED (Tekker vs NIRx)

Chapter 5

Common Findings with fNIRS

This list is by no means exhaustive but provides a slight overview of the more common findings using fNIRS.

Insert Table with most common findings here Might be able to rip this off a meta-paper

Chapter 6

Setup

Example text here

Chapter 7

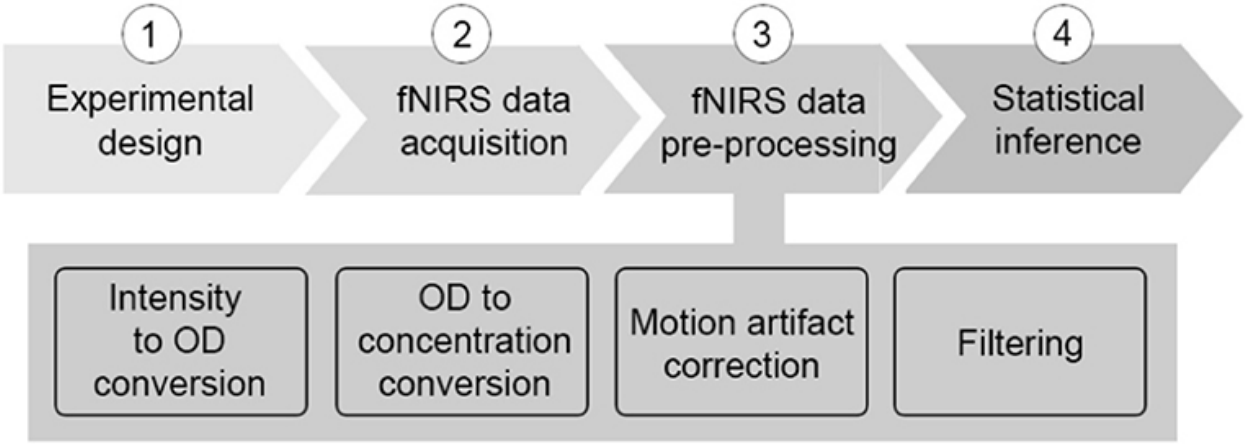
Collecting Data

Example text here

7.1 Getting Good Quality Data

Gel used in ultrasound can help with the recordings. They do not have a "reference" electrode like we do with EEG but I did brainstorm some ideas for this.

- Using a laser on the forehead which could be used as a reference. # Analyzing Your Data



A statement paper was released by some of the heavy hitters in fNIRS which is a good read Required MATLAB packages.

We would recommend ggplotly. It is a great tool for visualizing several waveforms at once.

7.2 In MATLAB

The pre-processing steps are as follows

- Load mat file
- Convert raw to optical density (DoD)
- Convert DoD to dConcentration (Hb Concentrations)
- Assess signal quality and discard if necessary

- Motion correction with MARA
- Signal Cleaning - Detrend, Bandpass Filter (0.001Hz - 2Hz), and Downsample (5Hz)

```
% load the .nirs file into MATLAB
load('G:\My Drive\Projects\fNIRS_guide\data\VS101_1.nirs', '-mat')
```

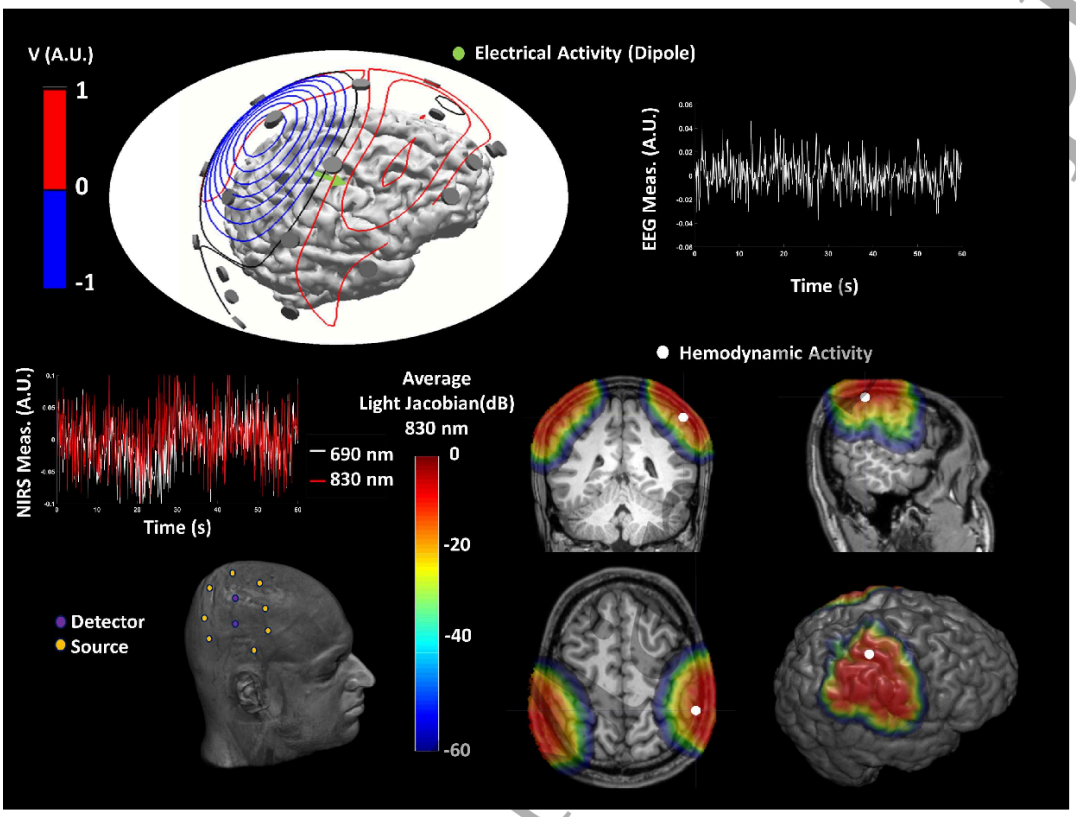
7.3 Types of variables you will obtain

7.3.1 Formats

Time frequency data

- Show an example of a typical dataframe

7.4 Types of Figure you can Produce



another image

another image

This is a great looking image http://www.bic.mni.mcgill.ca/ResearchLabsMFIL/Research

Another Example

Another Image

7.5 Types of Analysis

- Linear Discriminant Analysis

Chapter 8

Appendix

8.1 Plotly in MATLAB

Here is example code

```
% Download the MATLAB plotly package and add it to your directory.
plotlysetup('alapo', 'FlY6wuJdDgUL5FclfJ8D') % Required to run

plot(1:100); %create any plot
response = fig2plotly(gcf, 'filename', 'title of my figure');
plotly_url = response.url;  % This will cause a webpage to open up with your graph.
```

8.2 fNIRS Books

Book #1

Book #2

Book #3

8.3 Setting up your work environment

8.3.1 Folder Organization

Check a few of the websites I have bookmarked on this subject

8.4 Experimental Designs

8.5 Setting up your work environment

I have serveral sites on this (look at my bookmarks)

8.5.1 Folder Organization

Check a few of the websites I have bookmarked on this subject

8.6 Experimental Designs

8.7 Top 10 fNIRS Articles to Read

Paper #1 # Misc code/data

```
gitbook(fig_caption = TRUE, number_sections = TRUE, self_contained = FALSE,
   lib_dir = "libs", pandoc_args = NULL, ..., template = "default",
   split_by = c("chapter", "chapter+number", "section", "section+number",
       "rmd", "none"), split_bib = TRUE, config = list(), table_css = TRUE)
```

Chapter 9

fNIRS/EEG Papers

Paper #1

Paper #2

Paper #3

Paper #4

Paper #5

Chapter 10

Introduction

You can label chapter and section titles using `{#label}` after them, e.g., we can reference Chapter **??**. If you do not manually label them, there will be automatic labels anyway, e.g., Chapter **??**.

Figures and tables with captions will be placed in `figure` and `table` environments, respectively.

```
par(mar = c(4, 4, .1, .1))
plot(pressure, type = 'b', pch = 19)
```

Reference a figure by its code chunk label with the `fig:` prefix, e.g., see Figure **??**. Similarly, you can reference tables generated from `knitr::kable()`, e.g., see Table **??**.

```
knitr::kable(
  head(iris, 20), caption = 'Here is a nice table!',
  booktabs = TRUE
)
```

You can write citations, too. For example, we are using the **bookdown** package (**?**) in this sample book, which was built on top of R Markdown and **knitr** (**?**).

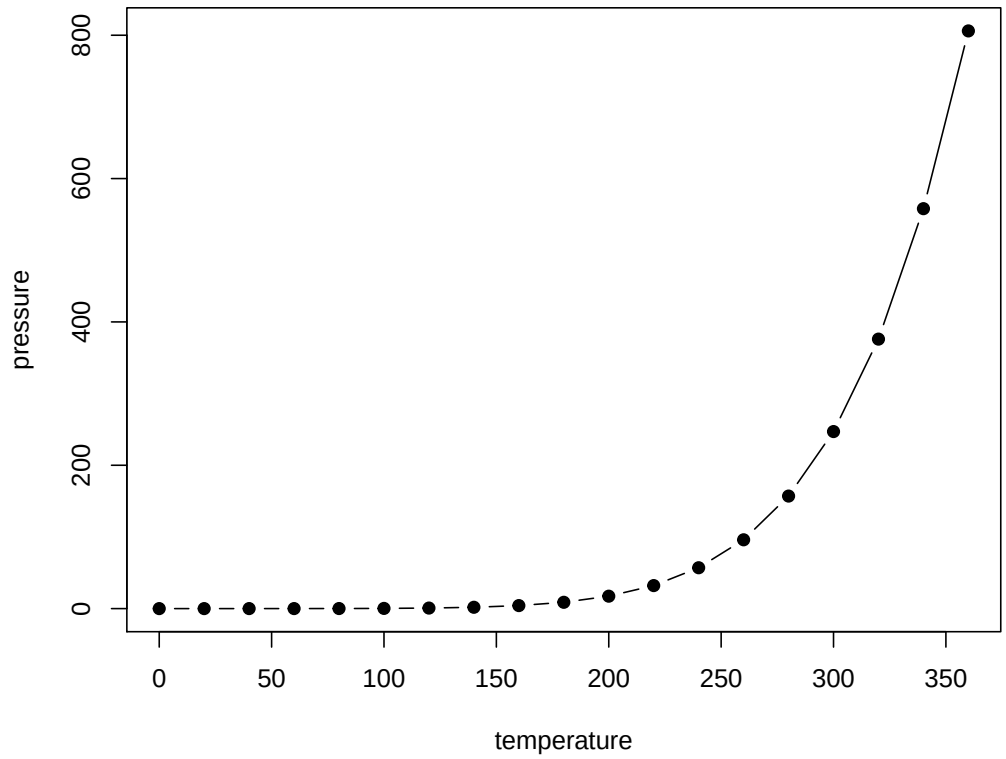


Figure 10.1: Here is a nice figure!

Table 10.1: Here is a nice table!

Sepal.Length	Sepal.Width	Petal.Length	Petal.Width	Species
5.1	3.5	1.4	0.2	setosa
4.9	3.0	1.4	0.2	setosa
4.7	3.2	1.3	0.2	setosa
4.6	3.1	1.5	0.2	setosa
5.0	3.6	1.4	0.2	setosa
5.4	3.9	1.7	0.4	setosa
4.6	3.4	1.4	0.3	setosa
5.0	3.4	1.5	0.2	setosa
4.4	2.9	1.4	0.2	setosa
4.9	3.1	1.5	0.1	setosa
5.4	3.7	1.5	0.2	setosa
4.8	3.4	1.6	0.2	setosa
4.8	3.0	1.4	0.1	setosa
4.3	3.0	1.1	0.1	setosa
5.8	4.0	1.2	0.2	setosa
5.7	4.4	1.5	0.4	setosa
5.4	3.9	1.3	0.4	setosa
5.1	3.5	1.4	0.3	setosa
5.7	3.8	1.7	0.3	setosa
5.1	3.8	1.5	0.3	setosa

Chapter 11

Literature

Here is a review of existing methods. There have been extensive reviews on the use of fNIRS.

Here is an example of a PRISMA2009 Figure from a previous project (HBEHED 682)

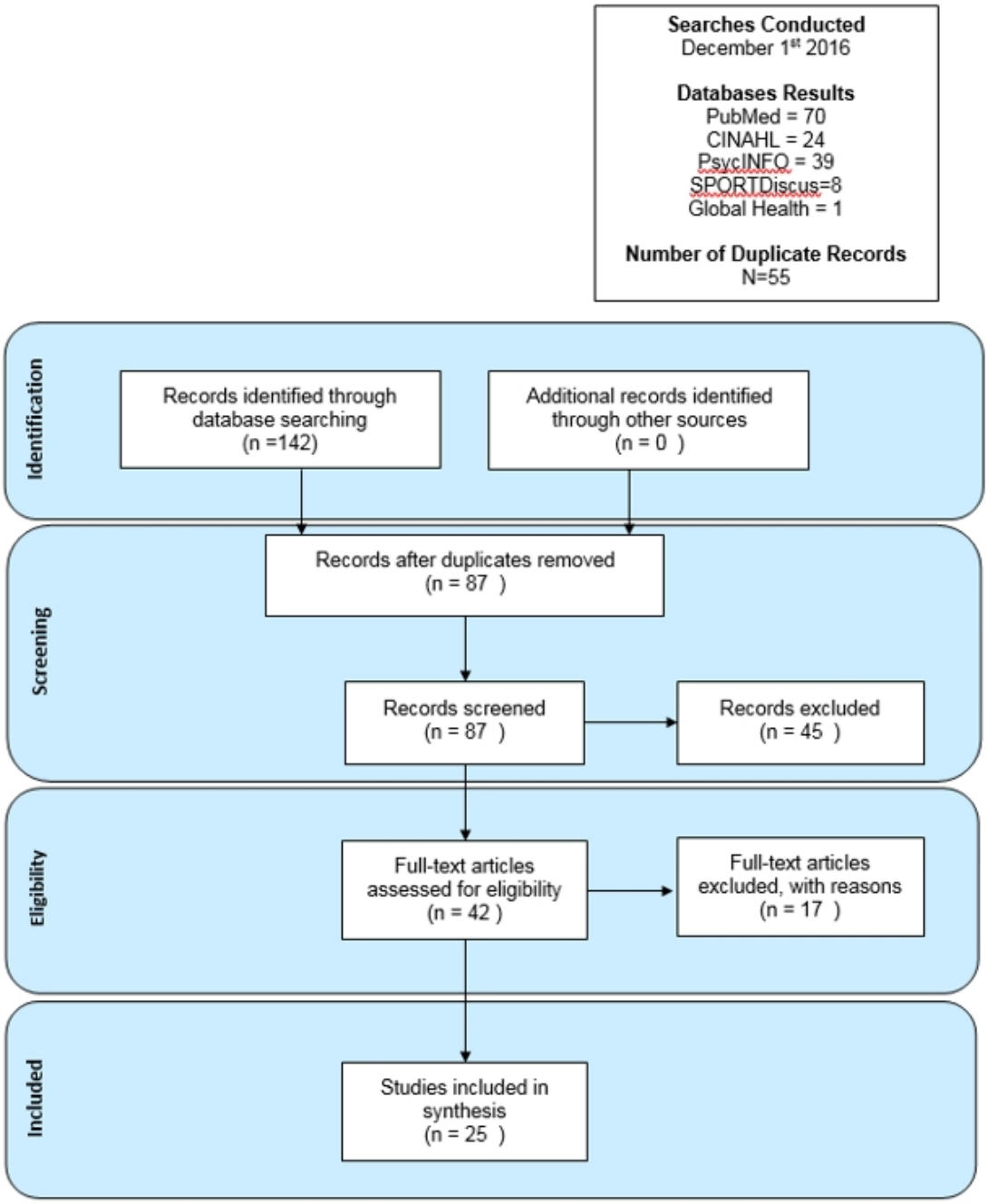


Figure 1
PRISMA 2009 figure demonstrating the process of the search.

Figure 11.1: PRISMA 2009 Example

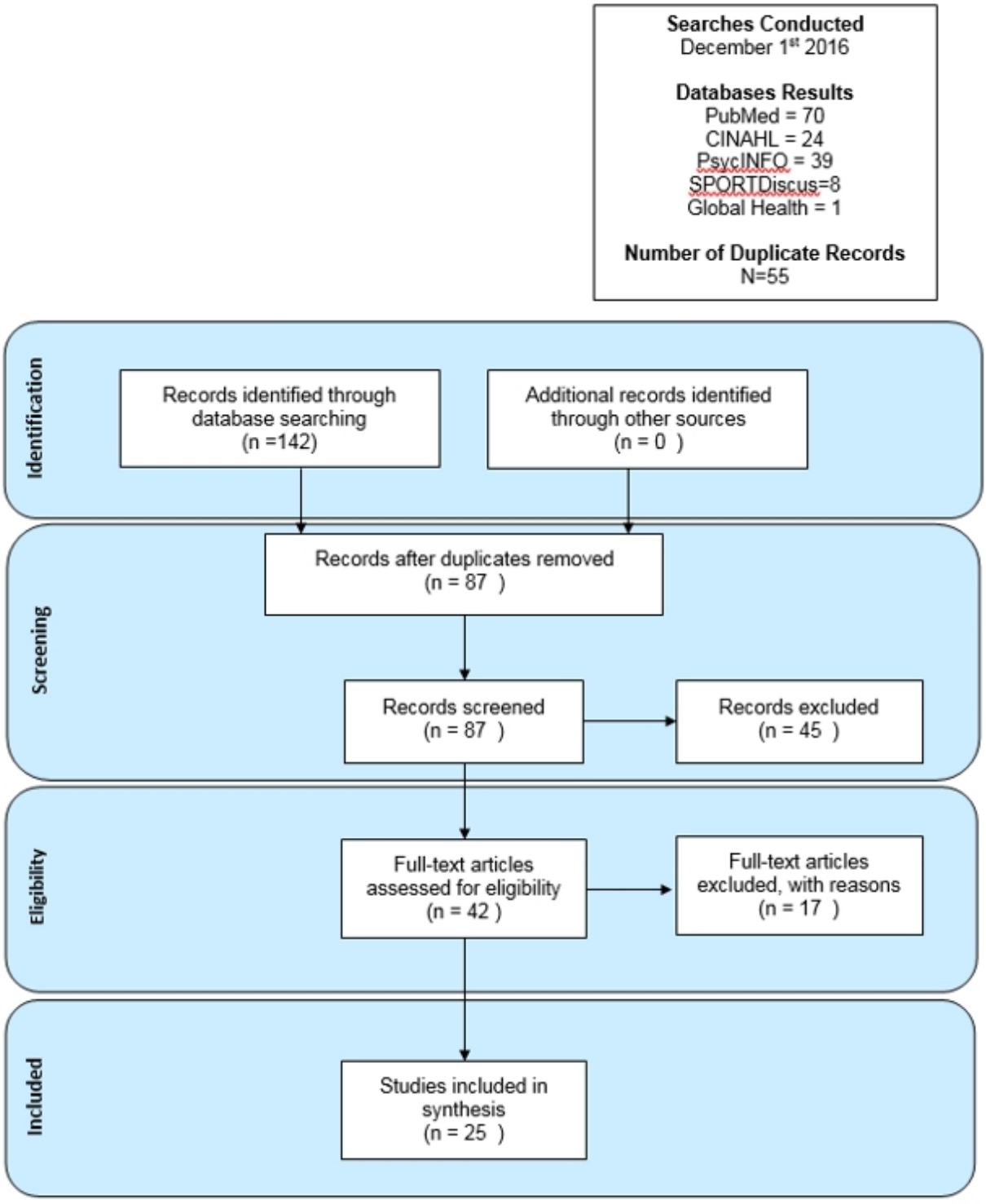


Figure 1
PRISMA 2009 figure demonstrating the process of the search.

PubMed, PsycINFO and JSTOR databases from January 1970 to October 20th 2016 were searched using a

table created based on the guidelines presented by Bartels(**?**).

An original PubMed search using the following terms rendered 2075 results

```
fnirs [Title/Abstract] OR NIRS [Title/Abstract] OR Spectroscopy, Near-Infrared [MeSH Terms] OR
Near-Infrared Spectrometry [MeSH Terms]
```

A second searching adding terms of interest resulted in 190 results

```
(fnirs [Title/Abstract] OR NIRS [Title/Abstract] OR Spectroscopy, Near-Infrared [MeSH Terms] OR Near-In
```

11.1 Exclusion Criteria

Review papers and theoretical papers

11.2 Clinical Applications

fNIRS has been successfully applied in humans in the study of stroke(**?**), traumatic brain injury

cancer(**?**), panic disorder(**?**), depression(**?**), anxiety(**?**), monitoring renal disease[@]

NIRS has also been shown to be useful in the detection of intracranial hematoma and brain oxygenation (for Review see (**?**))

Chapter 12

Methods

We describe our methods in this chapter.

Chapter 13

Applications

Some *significant* applications are demonstrated in this chapter.

13.1 Example one

13.2 Example two

Chapter 14

Final Words

We have finished a nice book.