A3

In [90]:

```
import mne
import numpy as np
import matplotlib
import matplotlib.pyplot as plt
import os
import pathlib

import eelbrain
import eelbrain.datasets._alice
from scipy.stats import ttest_1samp #import 1 sample t-test
from scipy.stats import pearsonr #import pearson correlation library

DATA_ROOT = eelbrain.datasets._alice.get_alice_path() #gets dataset from C:\User\<U

STIMULUS_DIR = DATA_ROOT / 'stimuli' #stimulus data
EEG_DIR = DATA_ROOT / 'eeg' #eeg data
LOW_FREQ = 0.5 #definitions to be used throughout
HIGH_FREQ = 20

print(f"{mne.__version__=}")
print(DATA_ROOT)
```

```
mne.__version__='1.9.0'
C:\Users\snowy\Data\Alice
```

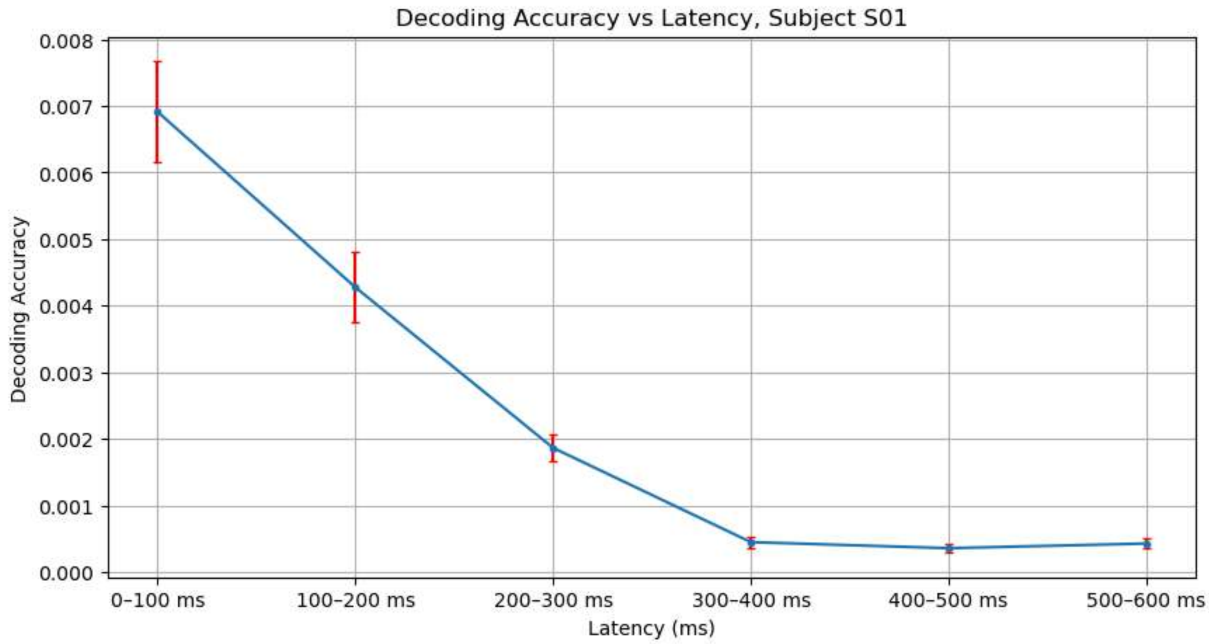
1

In [91]:

```
#---------------------# PREPROCESSING #---------------------#

SUBJECT = 'S01' #uses the first subject for part 1

raw = mne.io.read_raw(EEG_DIR / SUBJECT / f'{SUBJECT}_alice-raw.fif', preload = Tru
raw.filter(LOW_FREQ, HIGH_FREQ, n_jobs = 1) #filters the raw based on tutorial reco
raw.interpolate_bads() #interpolate bad channels

events = eelbrain.load.mne.events(raw) #extracts events from the raw data
# events

#---------------------# GENERATE ENVELOPE #---------------------#

envelopes = []
for stimulus_id in events['event']:
    wav = eelbrain.load.wav(STIMULUS_DIR / f'{stimulus_id}.wav') #NOTE: there are 1
    envelope = wav.envelope() #computes acoustic envelope
    envelope = eelbrain.filter_data(envelope, LOW_FREQ, HIGH_FREQ, pad='reflect')
    envelope = eelbrain.resample(envelope, 100)
    envelopes.append(envelope)
```

```
events['envelope'] = envelopes #adds the envelopes to the events table

#----------------------# EEG PROCESSING #----------------------#

events['onsets']  = [envelope.diff('time').clip(0) for envelope in envelopes] #iden
events['duration'] = eelbrain.Var([envelope.time.tstop for envelope in events['enve
events['eeg'] = eelbrain.load.mne.variable_length_epochs(events, 0, tstop='duration
```

In [92]:
```
#----------------------# TRF #----------------------#

latencies = [(0,100), (100,200), (200, 300), (300,400), (400,500), (500,600)] #defi

accuracy = [] #array for accuracy in each latency window
error = [] #arry for error in each latency window
pVals = [] #array for p values for t-test

for i in range(len(latencies)):
    tmin, tmax = latencies[i] #defines tmin and tmax to be used in eelbrain.boostin

    trf = eelbrain.boosting('eeg', ['envelope', 'onsets'], tmin/1000, tmax/1000, de

    predPower = trf.proportion_explained.x #predictive power across the sensors, ba
    # print(type(predPower))

    meanAcc = np.mean(predPower) #mean accuracy across all points in the latency wi
    errAcc = np.std(predPower)/np.sqrt(len(predPower)) #error across all points in
    ttest = ttest_1samp(predPower, 0) #single-sample t-test from the accuracy of ea

    accuracy.append(meanAcc)
    error.append(errAcc)
    pVals.append(ttest[1]) #appends just the p value to the array (don't care about

#----------------------# PLOTTING #---------------------#
x_labels = [f"{tmin}-{tmax} ms" for tmin, tmax in latencies] #labels indicating ran

plt.figure(figsize=(10,5)) #strched for better readability
plt.errorbar(x = x_labels, y=accuracy, yerr=error, fmt='.-', ecolor='r', capsize=2,
plt.xlabel('Latency (ms)')
plt.ylabel('Decoding Accuracy')
plt.title(f'Decoding Accuracy vs Latency, Subject {SUBJECT}')
plt.grid() #shows gridlines for readability
plt.show()
```



In [93]:
```
print("Latency ranges with above-chance decoding:")
for i, p in enumerate(pVals):
    if p < 0.05:
        print(f"{latencies[i][0]}-{latencies[i][1]} ms (p = {p:.10f})") #outputs th
```

```
Latency ranges with above-chance decoding:
0-100 ms (p = 0.0000000000)
100-200 ms (p = 0.0000000000)
200-300 ms (p = 0.0000000000)
300-400 ms (p = 0.0000010560)
400-500 ms (p = 0.0000013982)
500-600 ms (p = 0.0000010193)
```

As we can see, it seems that at EVERY time step (aka latency window) there is a statistically significant amount of information encoded by the cortical EEG response. This was determined by using a 1-step t-test, to determine the p-values of each point. While a p-value of 0.05 was chosen as the threshold, each of the points was actually much much smaller, meaning that even if we were to use a significantly lower value (aka much higher confidence interval) we would still see that each of the 6 latency windows would give relevant information.

While the current output shows subject S01, it should be noted that the same results were found for both subject S18 and S20.

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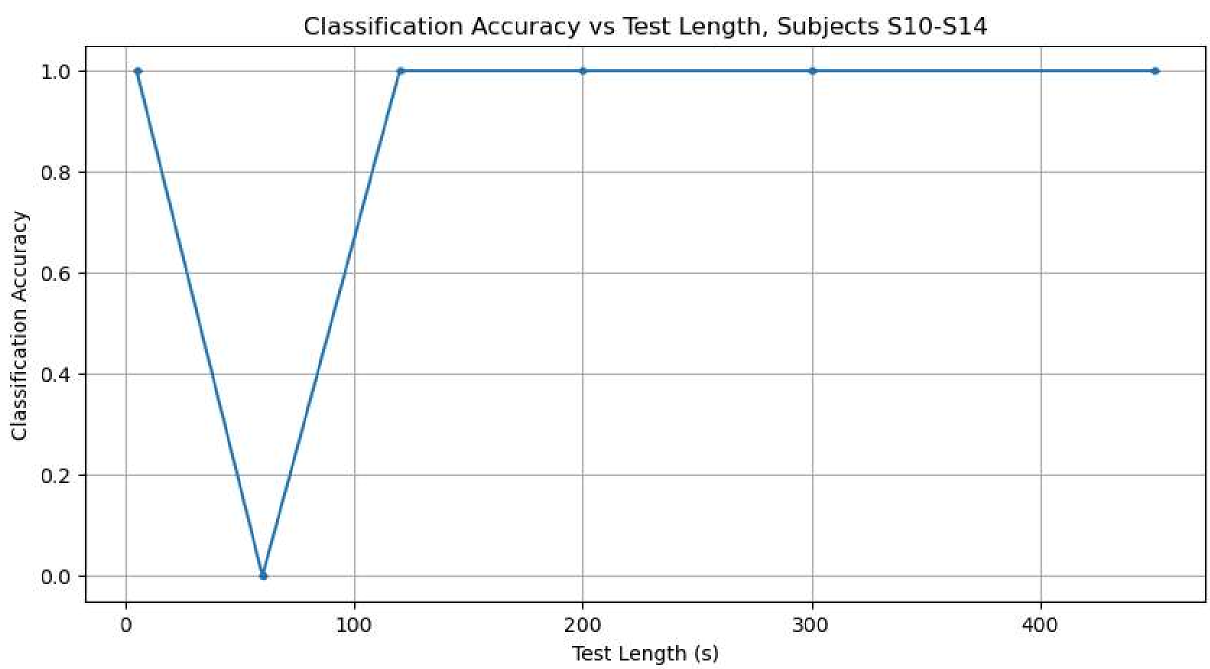
In [134…
```
SUBJECTS = [f'S{i:02d}' for i in range(10, 15)]  #S10 to S19, since all exist (not
# SUBJECTS = ['S10','S11']
# print(SUBJECTS)

lenTests = [5, 60, 120, 200, 300, 450] #different test lengths, randomly selected
```

```
# lenTests = [5, 60]

results = {length: [] for length in lenTests} #dictionary for storing each subjects

for subject in SUBJECTS:

    #--- LOADING/PREPROCESSING ---#
    raw = mne.io.read_raw(EEG_DIR / SUBJECT / f'{SUBJECT}_alice-raw.fif', preload =
    raw.filter(LOW_FREQ, HIGH_FREQ, n_jobs = 1)
    raw.interpolate_bads()

    events = eelbrain.load.mne.events(raw)
    # print(events)


    #--- GENERATING ENVELOPE ---#
    envelopes = []
    for stimulus_id in events['event']:
        wav = eelbrain.load.wav(STIMULUS_DIR / f'{stimulus_id}.wav')
        envelope = wav.envelope()
        envelope = eelbrain.filter_data(envelope, LOW_FREQ, HIGH_FREQ, pad='reflect
        envelope = eelbrain.resample(envelope, 100)
        envelopes.append(envelope)

    events['envelope'] = envelopes

    #--- EEG PROCESSING ---#
    # events['onsets']  = [envelope.diff('time').clip(0) for envelope in envelopes]
    events['duration'] = eelbrain.Var([envelope.time.tstop for envelope in events['
    events['eeg'] = eelbrain.load.mne.variable_length_epochs(events, 0, tstop='dura

    #--- TRF N-2 TRIALS ---#
    numTrials = len(events)
    trainEvents = events[:numTrials-2]

    trf = eelbrain.boosting('eeg', 'envelope', -0.100, 0.500, delta=0.05, data=trai

    #--- CLASSIFYING TRIALS ---#
    trialN = events[numTrials-1] #trial N
    trialN_1 = events[numTrials-2] #trial N-1

    # print(f"envN total length: {np.shape(trialN['eeg'])}") #shows that each eleme
    # print(f"envN_1 length: {np.shape(trialN_1['eeg'])}")
    # tempRes = []

    for length in lenTests:

        eegN = trialN['eeg'].sub(time=(0, length/100)) #subset of EEG data from 0 t
        eegN_1 = trialN_1['eeg'].sub(time=(0, length/100)) #subset of EEG data from

        predEnv = eelbrain.convolve(trf.h, eegN) #predicted envelope for trial N, u

        envN = trialN['envelope'].sub(time=(0, length/100)) #real envelope for tria
        envN_1 = trialN_1['envelope'].sub(time=(0, length/100)) #real envelope for

        #--- PEARSON CORRELATION ---#
```

```
        rN = pearsonr(predEnv.x, envN.x)[0] #r-value correlation between the real a
        # print(type(predEnv), type(envN))
        # print(np.shape(predEnv), np.shape(envN), np.shape(envN_1))
        rN_1 = pearsonr(predEnv.x, envN_1.x)[0]

        results[length].append(1 if rN > rN_1 else 0) #appends whether or not we ha
        # print(f'Subject {subject}, Time {length}')
        # print(f'r(N) {rN}, r(N-1) {rN_1}')
        # tempRes.append(1 if rN > rN_1 else 0)
    # print(f'Results: {tempRes}')

# print(results)

#--- MEAN/ERROR ---#
means = []
stdevs = []

for length in lenTests:
    accuracies = results[length]
    means.append(np.mean(accuracies))
    stdevs.append(np.std(accuracies)/np.sqrt(len(accuracies)))

#--- PLOTTING ---#
plt.figure(figsize=(10,5))
plt.errorbar(x=lenTests, y=means, yerr=stdevs, ecolor='r', fmt='.-', capsize=2, lab
plt.xlabel('Test Length (s)')
plt.ylabel('Classification Accuracy')
plt.title(f'Classification Accuracy vs Test Length, Subjects {SUBJECTS[0]}-{SUBJECT
plt.grid() #shows gridlines for readability
plt.show()
```



I would have expected for the classification accuracy to react somewhat linearly with test length, this does not seem to be the case. As far as I was able to display, it seems that every point has perfect accuracy across subjects (note that this was also tested across subject S10-

S19, but was reduced for time efficiency), except for at the 60s point at which the accuracy is a perfect 0. As we can see, since the error bars don't appear at all, there is also NO variance.

I believe that this result may come from the fact that the events are the EXACT same for each subject (I tried printing it out and saw that they were all the same). This would lead to identical TRFs, and since the TRF is used to predeict the envelope, it would lead each subject to have an identical r-value when using pearson correlation. I am unsure as to how I would be able to solve the problem, as I do not believe that this should be the output.