Homework 3 - Travis Hammond - s2880024

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1 Homework 2: First J&S Model

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First, let's import everything like in the previous homework and copy over the noise, time_to_pulses and pulses_to_time functions that were given during the lecture. I moved the plot function (to reproduce the plot from the paper) to the ACTR folder without changing it, to not repeat myself. The init_model function is also unchanged from last time.

[1]:
```
from pathlib import Path
from typing import List

import sys; sys.path.append(Path().resolve().parent.as_posix())  # noqa

from ACTR.model import Model
from ACTR.dmchunk import Chunk
from ACTR.plot import plot

import pandas as pd
import numpy as np
from scipy.stats import truncexpon


rng = np.random.default_rng(seed=111)


def noise(
            s: float
        ) -> float:
    rand = rng.uniform(0.001, 0.999)
    return s * np.log((1 - rand) / rand)


def time_to_pulses(
            time: float,
            t_0: float = 0.011,
            a: float = 1.1,
            b: float = 0.015
```

```python
        ) -> int:
    pulses = 0
    pulse_duration = t_0
    while time >= pulse_duration:
        time = time - pulse_duration
        pulses += 1
        pulse_duration = a * pulse_duration + noise(b * a * pulse_duration)
    return pulses


def pulses_to_time(
            pulses: int,
            t_0: float = 0.011,
            a: float = 1.1,
            b: float = 0.015
        ) -> float:
    time = 0
    pulse_duration = t_0
    while pulses > 0:
        time = time + pulse_duration
        pulses = pulses - 1
        pulse_duration = a * pulse_duration + noise(b * a * pulse_duration)
    return time


def init_model(
            id: int
        ) -> Model:
    """We create a (model of a) participant here.

    This gives us a way to initialize them with some prior knowledge if
    necessary, and give them a unique id.

    Args:
        id (int): The unique id of the participant.

    Returns:
        Model: A fresh subject to experiment on.
    """
    subj = Model()
    subj.id = id
    return subj
```

The first interesting change is the do_trial function, in which we now convert the sample interval to pulses using the given functions and then add a memory chunk with the recorded pulses to memory. Then, after the SET signal, we retrieve the most activated pulse-related memory (and reinforce it) and convert it to time to return as the resulting production time. The latency is simply added to the subj.time counter because I don't consider overlap for now.

[2]:
```python
def do_trial(
            subj: Model,
            sample_interval: float
        ) -> float:
    """This function takes a subject and an interval time, and goes through
    the process of an experiment trial.

    Args:
        subj (Model): The subject which will do the trial.
        sample_interval (float): The interval time defining the trial.

    Returns:
        float: The (re)production time.
    """
    # "Trials began with the presentation of a central fixation point for 1s,"
    subj.time += 1
    # "followed by the presentation of a warning stimulus ..."
    # "After a variable delay ranging from 0.25-0.85s drawn randomly from a
    # truncated exponential distribution, ..."
    subj.time += truncexpon(0.6, 0.25).rvs(1, random_state=rng)[0]
    # "two 100ms flashes separated by the sample interval were presented."
    subj.time += 0.1  # READY
    subj.time += sample_interval

    # convert time to pulses and remember how many it took
    pulses = time_to_pulses(sample_interval)
    subj.add_encounter(Chunk(
        name=f'pf_{pulses}',
        slots={'isa': 'pulse-fact', 'pulses': pulses}
    ))

    # "Production times, t_p, were measured from the center of the flash, (that
    # is, 50ms after its onset) to when the key was pressed"
    subj.time += 0.05  # SET

    # retrieve the most activated memory
    request = Chunk(
        name='pulse-request',
        slots={'isa': 'pulse-fact'}
    )
    chunk, latency = subj.retrieve(request)
    subj.add_encounter(chunk)
    subj.time += latency

    # convert pulse to time, then add and return the production time
```

```
    production_time = pulses_to_time(chunk.slots['pulses'])
    subj.time += production_time  # GO
    return production_time
```

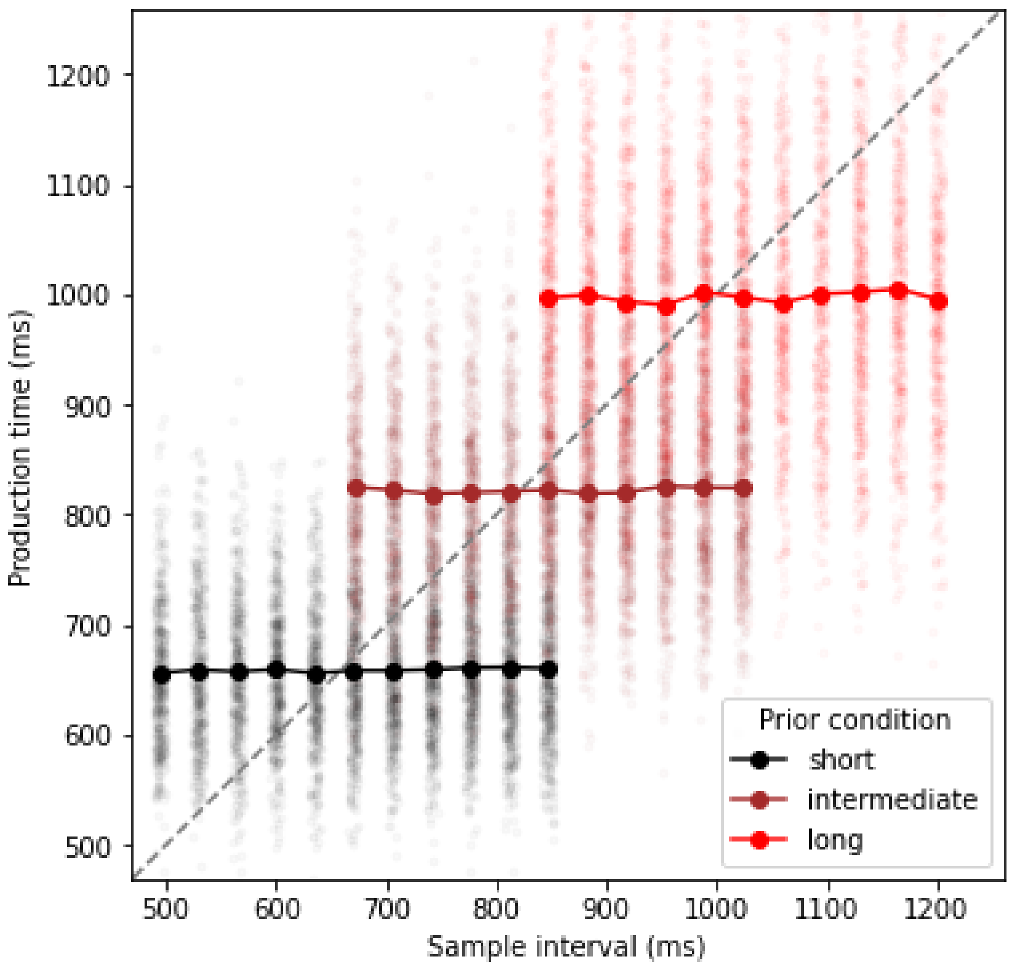
Finally, there is only a slight change to the do_experiment function: The subjects memory is erased after each block (done here by re-initializing the model). Also, I convert the time into milliseconds because the plotting code expects ms units instead of s and otherwise the jitter would be too large resulting in the datapoints being too spread out as opposed to crowded around vertical lines.

[3]:
```
def do_experiment(
            participants: List[Model],
            n_test_trials: int,
            n_train_trials: int
        ) -> pd.DataFrame:
    """Perform the experiment on a list of participants.

    Args:
        participants (list(Model)): The volunteering participants.
        n_test_trials (int): The number of testing trials.
        n_train_trials (int): The number of training trials.

    Returns:
        pandas.DataFrame: The collected data as a pandas DataFrame.
    """

    # "All priors were discrete uniform distributions with 11 values, ranging
    # from 494-847 ms for the short, 671-1,023 ms for the intermediate and
    # 847-1,200 ms for long prior condition."
    prior_distributions = np.array([
        (1, np.linspace(start=0.494, stop=0.847, num=11)),
        (2, np.linspace(start=0.671, stop=1.023, num=11)),
        (3, np.linspace(start=0.847, stop=1.200, num=11)),
    ], dtype='object')

    # create the DataFrame
    row_idx = 0
    data = pd.DataFrame(columns=[
        'Subj', 'Cond', 'line', 'Trial', 'Ts', 'Tp', 'MaxTrial', 'Main'
    ])

    # each subject goes through the experiment
    for subj in participants:

        # "For each subject, the order in which the three prior conditions were
        # tested was randomized."
        rng.shuffle(prior_distributions)
        for condition, distribution in prior_distributions:
```

```python
            # "For each prior condition, subjects were tested after they
            # completed an initial learning stage." (here: train, then test)
            for trial_idx in range(1, n_train_trials + n_test_trials + 1):

                # "sample intervals are drawn randomly from one of three
                # partially overlapping discrete uniform prior distributions."
                sample_interval = rng.choice(distribution)

                # perform the actual trial
                production_time = do_trial(subj, sample_interval)
                # don't give feedback

                # record the results just like the authors did
                data.loc[row_idx] = [
                    subj.id + 1,
                    condition,
                    row_idx + 1,
                    trial_idx,
                    # the plotting code expects (ms) units for some reason
                    # else the jitter is all over the place
                    sample_interval * 1000,
                    production_time * 1000,
                    n_train_trials + n_test_trials,
                    False if trial_idx <= n_train_trials else True
                ]
                row_idx += 1

            # reset declarative memory by re-initializing the subject
            subj = init_model(subj.id)

    return data
```

[4]:

```python
def main(
            n_participants: int = 5,
            n_train_trials: int = 500,
            n_test_trials: int = 1000
        ) -> None:
    # create the participants, do the experiment and record the data. then, plot
    participants = [init_model(sid) for sid in range(n_participants)]
    simulated_data = do_experiment(participants, n_test_trials, n_train_trials)
    plot(simulated_data)


if __name__ == '__main__':
    main()
```



In Homework 2, we just got results on the identity line because we simply returned the same time as was given. There was also no noise involved. Now, we have very straight and horizontal lines and each condition is distinct. Furthermore, there is for each condition a consistent amount of noise for the production times. Still, this is not the same as the original J&S data, which shows slanted lines biased towards the identity line and they (seem to) be a bit less straight and have slightly less noise.

The horizontal lines can be explained by the fact that in our model, we retrieve the most activated chunk of memory each time, which is always the first chunk because it is the most enforced. The fact that we have noise can be attributed to the noisy process of converting pulses to time and vice versa. Due to the fact that the declarative memory of a subject is cleared after each block, we have the same effect for each condition.