**Plan for Phase 1 and Phase 2 study for iMeditate**

**Based on Commercially Available Platforms**

The goal of this effort is to utilize an appropriate out-of-shelf device to measure certain types of biomedical signals and context factors, such that we can interpret the mental states (agitation, sinking, and mindfulness) from those signals and factors. The purpose of this strategy is to focus our energy in developing the predictive models, and to avoid re-building the “wheels”.

Identifying the appropriate commercially available platforms requires the following efforts:

1. Narrow down the types of features/signals which could be used for metal state prediction. Based on our literature study, and taking the consideration with the feasible form factors, we narrowed down two possible solutions: 1) the heart rate variability (HRV) based approach, and 2) the neural oscillations based approach. For both approaches, other types of signals, such as skin conductance, skin temperature, inertial measurements, could be used to extracting additional features.
2. Locate out-of-shelf products which have equipped specific sensors that could provide the narrow-downed features or signals. For example, an earphone with a PPG sensor could provide HRV, and an EEG headband could measure the power of neural oscillations. It’s worth to note that the out-of-shelf products may not be able to provide the raw data by their original design.
3. Contact the manufacturers of such products and seek their collaboration for the raw data real-time streaming.
4. Define proxy mental states that are associated with agitation and sinking, to ease the experimental design and data collection. For example, we may use the task-engagement/mental demanding conditions to mimic agitation state and may use fatigue/drowsiness conditions to mimic sinking state. Using proxy mental states, instead of agitation and sinking, for the data collection, is because that the scientific definitions of “agitation” and “sinking” are still an open question, while the proxy states have been extensively studied with various experimental paradigms.
5. Develop and implement a dual binary classification system to differentiate the agitation and sinking states, respectively. If both agitation and sinking states were not detected, the state is assigned as mindfulness. Alternatively, develop and implement a three-state classification system to differentiate the agitation, mindfulness, and the sinking states.

To achieve this goal, two phases of developments are defined.

**Phase 1**

**The Phase 1 is a study performed before the ready of commercially available platform.**

The objective of Phase 1 is to deliver a benchtop system to demonstrate the concept of the product and to validate the feasibility of the approaches. An end-to-end predictive model for mental states combining both the neural oscillation based and HRV based approaches is to be established and validated.

The milestones for Phase 1 is described below and in Figure 1.

1. The proxy states that are associated with agitation and sinking, respectively, are defined (by 5/14).

**Deliverables**: a table for the projection between proxy states and the agitation/sinking.

1. The usable features, and their theoretical tendency, are determined for potential solution, based on the literature research (by 5/22).

**Deliverables**: a summary.

1. Setup the Muse based EEG data streaming/visualization/recording system. Setup the synchronization system between the EEG data and the E4 based PPG/Skin conductance/skin temperature data (by 5/31).

**Deliverables**: source code/script on GitHub.

1. The useful data processing methods for data preprocessing, feature extraction, and other functional blocks are selected, optimized, and validated using a variety of database (by 6/7).
   1. Select appropriate open source tools. Validate them with the associated demo data. These tools should cover all the types of signals that will be used for the selected approach, such as EEG, HRV, skin conductance, and motion activity data.
   2. Validate the tools by analyzing the other public accessible datasets.
   3. Optimize the tools according to our datasets, if needed.

**Deliverables**: a summary, the source codes and the script on GitHub.

1. Apply the optimized tools on data collected from previous in-house experiments to extract features of the identified types. The feasibility of the determined features is validated by statistical analysis (by 6/14).

**Deliverables**: a summary, and the script on GitHub.

1. The experimental paradigms for data collection are determined and executed (by 6/21).

**Deliverables**: a summary.

1. The open source tools are integrated into AlayaTec Reporting Pipeline (by 6/28).

**Deliverables**: source code/script on GitHub.

1. Different preprocessing, feature extraction, classification strategies are compared based on the Reporting Pipeline. The best strategies are determined. New methods are developed and implemented, if necessary (by 7/12).

**Deliverables**: source code/script on GitHub.

1. Build a real-time prediction system using the defined best strategies and send the results to a Demo App. The Demo App could be the one adapted from the AffectioNet Demo App (by 7/26).

**Deliverables**: source code/script on GitHub.

1. [Test] A validation strategy is defined and executed for the Prototype 1 (by 8/30).

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Figure 1 Development Flowchart for Phase 1

**Phase 2**

At the end of Phase 2, the Prototype 2 is to be delivered, which is a functionable system including:

a) the customized commercially available platform,

b) the functional dedicated App,

c) the content, and

d) the server/cloud database.

The complete of this phase indicates that the commercially available platform is determined and systemically validated. Based on the selected commercially available platform, there might be no speakers on board. In this case, the antidote could be delivered by the dedicated App. The dedicated App is reliably connected to the platform to extract users’ mental states, and to deliver the correct antidote, whenever necessary. Overall, the prototype 2 should be a full functional system and are ready for validation by advanced meditators in real-life scenario.