An Agent Model of Temporal Dynamics in Relapse and Recurrence in Depression

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Extended Abstract

Unipolar depression is a mental disorder characterized by a persistent low mood and loss of awareness or contentment in usual activities [1]. Despite the modern era of pharmaceutical and holistic intervention, one of the primary problems with unipolar depression (i.e. a depression not related to other mental disorders) is that it has a very high rate of recurrent and relapse cases. At least 60 percent of individuals who have had one depressive episode will have another, 70 percent of individuals who have had two depressive episodes will have a third, and 90 percent of individuals with three episodes will have a fourth episode. Although the risk of relapse may decline with time, even for those who remain well for 5 years after an index episode, the rate of recurrence/relapse is 58 percent. Despite the magnitude of the problem of recurrence and relapse, little attention has been focused on the symptom pattern in recurrent episodes of major depression [4]. In practice, there is a need to have a mechanism to monitor the condition of individuals who have had a previous encounter with unipolar depression, eventually improving their quality of life. In order to achieve this objective, the aim of the embedding research project is to develop an agent-based application that is able to support humans in the long term. The software agent is expected to have capabilities to understand its environment and the individual, providing a better monitoring and assessment of the situation. To implement this capability in any software agent, it is required to incorporate a human agent model that shows how humans might fall into relapse / recurrence or stay healthy. In case a relapse or recurrence is predicted, the agent can provide to support by providing adequate remedies. In this model, there are four major components that will represent dynamic interactions of human agent abilities involved in recurrence/relapse namely; *environment*, *personality*, *social support*, and *coping strategies* [2][3][4][5][6]. By combining these characteristics together, it will allow a hypothesis or expected behavior for the human agent to be monitored.

These characteristics are represented in a form of several interconnected nodes. Once the structural relationships in the model have been determined, the model can be formalized. In the formalization, all nodes are designed in a way to have values ranging from 0 (low) to 1 (high). The interaction will determine the new value of it, either by a series of accumulations or an instantaneous interaction for each node. The model was executed to simulate a large number of conditions of individuals. During this experiment, three examples are shown: a healthy individual (*A*), an individual with a potential risk of relapse and recurrence (*B*), and an individual with severe conditions (*C*). All of these individuals are exposed to several conditions, such as prolonged fluctuating stressors, and decrease stressors. For the **first simulation**, each type of individual has been exposed to an extreme stream of stressor events which follow each other quickly. This kind of pattern is comparable to the repeated strike event, where stressor events always occur when the previous events were ended (e.g. daily events). During this experiment, it is shown that individual *C* (*high neurotic, low in assertive* and *immunity*) tends to get into onset much faster compared to other individuals. The individual *B* (*moderate neurotic, assertive,* and *immunity*) shows a gradual increasing level of potential onset and possibly will experience relapse / recurrent if that individual is having constant exposure towards stressors. Individual *A* however is less prone to develop a potential onset condition within a short period of time. For the **second experiment**, two types of events are introduced. It begins with a very high constant and later by a very low constant stressor event. These events occurred in a constant behavior for a certain period of time. The experimental results shown that individual *C* gets into a bad mood much faster than the others. Moreover, even at the end of the simulation time, the mood of individual *C* is worse than the mood of the other two individuals. These two experimental results can be summarized as that the individuals with higher assertiveness, immunity and less neurotic levels develop less often a relapse compared those who are not. In addition, a higher neurotic level eventually aggravates the potential risk of onset, as illustrated in all simulation traces. The effects of stressor events on relapse/ recurrence onset are also exemplified. It is apparent that frequent or high stressor events contribute to the potential risk of onset [4][6].

In addition to the simulation trace, a mathematical analysis has been performed to demonstrate the occurrence of equilibrium conditions. The equilibria describe situations in which a stable situation has been reached. Those equilibria are interesting as it should be possible to explain them using the knowledge of the domain that is modeled. As such, the existence of reasonable equilibria is an indication for the correctness of the model. To analyze the equilibria, the available temporal and instantaneous equations are filled with values for the model variables such that the derivatives or differences between time point t and $t + \Delta t$ are all 0. To conclude, the paper contributes a model that is able to explain the onset of recurrence and relapse based on personal characteristics and stressor events has been developed and described. The proposed model is heavily inspired by scientific findings about the relapse or recurrence onset. Having this foundation, a formal model has been developed and used to simulate different individuals' situations, which corresponded to their personality and characteristics. The proposed model provides a basic building block in designing a software agent that will support the human. Future work of this agent and model integration will be specifically focus how interactions and sensing properties can be further developed and enriched, to promote a better way to fluidly embedded this into any monitoring and health informatics system.

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