Stress Diffusion through Complex Networks

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ABSTRACT

Research has proven that stress reduces quality of life and causes many diseases. It is not clear how stress spreads among the population and how its diffusion in a society can be estimated. From a complex system perspective, this paper defines the rules of stress transmission, including input and output factors. Stress transmission flow is defined to describe an entropy-derived measure of stress between two interconnected individuals, and the analysis is extended to networked individuals to analyze stress diffusion in a theoretical setting that includes the modeling of complex networks and the use of agent-based models in a simulated framework. These approaches endow artificial, interacting agents with behavioral rules, allowing the authors to determine the important components that must be considered as the nature of the equilibrium that exists between two distinctly different classifications of individuals. The first classification is “isolated individuals” who experience self-induced stress. The second classification consists of “too connected individuals” who have a high perception of social pressure, have a higher probability of being stressed, and who are surrounded by a higher number of stressed people.

Keywords: Agent-Based, Complex Networks, Contagion, Diffusion, Intersubjectivity, Stress

INTRODUCTION

Growing interest has surrounded the roles of cognitive appraisal and emotions in physiological responses to psychological stress (Tomaka et al., 1993; Feldman et al., 1999, 2004). According to Cohen, Janicki-Deverts, and Miller (2007), psychological stress occurs when an individual perceives that the environmental demands exceed his or her adaptive ability to meet them. This gap gives rise to the label of oneself as stressed and elicits a concomitant negative emotional response.

The previous definition of stress integrates and extends the following classical approaches to stress:

- Response-based model (Selye, 1974): “Stress is the nonspecific response of the body to any demand made upon it.”
- Stimulus-based model (Holmes & Rahe, 1967): Stress involves “…events whose
advent... requires a significant change in the ongoing life pattern of the individual.”

• Transactional model (Lazarus & Cohen, 1977): Stress involves the “judgment that environmental or internal demands tax or exceed the individual’s resources for managing them.”

From a systemic point of view, stress can be seen as a dynamic process that affects many individuals, but not all, and which is transmissible through a “relationship.” Although it is often simple to determine how stress is transmitted between lovers, relatives, and close friends, it is more difficult to determine the causes of stress diffusion among people in other kinds of categories. For example, it can be quite difficult to predict stress transmission between two classmates who just say hello to each other once or twice a week. Likewise, it would be difficult to foresee stress transmission between people and other people whom they encounter in daily activities but whom they really do not know.

Recent research on complex systems, statistical physics, network analysis, and other disciplines has given us the opportunity to explore the diffusion process in complex phenomena, such as stress.

However, to study stress diffusion among individuals, we must develop complex mathematical models of psychological systems. To accomplish this challenge we must start by assessing the dynamics of stress caused by and experienced by an individual. Thus, we will consider two interconnected individuals, define the stress transmission, and, eventually, extend the analysis to many networked individuals and to stress diffusion through complex net-works (Figure 1).

PSYCHOLOGICAL STRESS: DOES IT AFFECT OR INFECT?

Psychological stress can be analyzed as a dynamical system in which a state can have an input variable that changes the original state, and an output variable that changes others’ states.

Two different subject-focused perspectives address stress from a dynamical point of view:

1. STRESS AFFECTS: How stress is contracted from others (input)
2. STRESS INFECTS: How stress is infected to others (output)

Through this approach, we can structure stress dynamics into subjects as input factors, which “affect” subject’s stress level, and output factors, which “infect” others. Such a dichotomy allows us to analyze a single subject under a systemic perspective, particularly as an input-output system. In the following discussion, we extend such two systems further in order to better understand the general dynamics of stress.

How Stress is Contracted from Others and Self-Contracted (INPUT)

Recently, psychologist Csikszentmihalyi (1997) has studied extensively, under controlled conditions, the experiences of playfulness, relaxation, happiness, and success. This can be best expressed with the help of an approach based on “challenges” and “skills.” Such an approach helps researchers to better understand the personal and situational state of stress levels conveyed both from others and oneself. In fact, here stress is due to the combination of high challenge and low skill, which could depend on others or not.

More in general, psychological stress is affected mainly by the following:

• The person’s appraisal of the stimulus: When faced with a stimulus, a person evaluates the potential threat (primary appraisal). Primary appraisal refers to a person’s judgment about the significance of a stimulus as stressful, positive, controllable, challenging, or irrelevant.
• The personal, social, and cultural resources available: the secondary appraisals ad-
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