Formal Modeling and Analysis of Social Support Recipient Preferences

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Abstract—**This paper presents formal recipient model of support seeking behavior. Support seeking is significantly dynamic and it includes substantial changes as demanding condition happen. From this perspective, the proposed model covers integrating of both coping strategies, support preferences and network ties. The recipient model can be used to recognize social support and human interaction within social networks during stressful events. The model was able to produce realistic behavior that could clarify conditions for handling stress. This was done by employing simulation experiments under various negative events, personality resources and personality attributes. Simulation results show that a person with problem-focused coping, requests either informational or instrumental support. In contrary, a person with emotion-focused coping request instrumental, emotional, and companionship support. Moreover, informational support leads to higher increase requests from weak tie than other types of supports that request from strong tie. These results were similar to those with the model's mathematical analysis. Finally, a mathematical analysis was used to examine the possible equilibria of the model.**

Index Terms—**Computational Modeling; Social Support Networks; Strong and Weak Ties; Support Recipient.**

I. Introduction

Stress can be defined as a reality of nature where the individual is influenced by the forces from the external world. These forces can be of any form and can influence people irrespective of age and walks of life [1], [3]. However, to overcome this adversity, human has developed its own mechanism [4]. Our cognitive skills are designed to examine the situation mentally via a mechanism known as coping. In case a threatening situation is identified, our coping strategy will decide on which skills to be used and how to deal with the situation. The situation is labelled "stressful" should the demands exceed the available resources of the human, which is met with the classical stress response of the person and vice versa [2], [3]. It is important to consider that situations perceived by everyone can vary and may develop different coping skills. For the same reason, the response of no two people will be identical for a particular situation. Different people react in a different manner to stress.

According to the Cognitive Motivational Relational Theory (CMR) proposed by Lazarus and Folkman, the manner in which the people assess stressful conditions and its relative emotions determines the way in which they handle stress, either by trying to alter the situation itself (i.e., problem-focused) or changing their emotional response or effects due to the stressful events (i.e., emotion-focused) [5], [7]. This paper focuses on the formal model to study the dynamics in the coping process and support preferences. This has become one of the essential components for creating a recipient model that can monitor conditions of individuals during stressful events. The next section (Section 2) presents the underlying principles of support seeking behavior during stressful events. Consequently, the formulation and design of a formal model is developed (Section 3). In the later section (Section 4), simulation traces are shown to demonstrate how this model meets the expected outcomes in social network ties. Section 5 presents a detailed mathematical analysis to evaluate the correctness of the proposed model. Finally, Section 6 concludes this paper.

II. Primary Concepts for Recipient Support

A cognitive appraisal is defined as the study and determination of significant events in any relationship between the person and his surrounding environment. Generally, this is related to the intensity of the stressful events, which is a condition wherein different factors like a personal resource (or support), situational demand (i.e., pressure) or negative events are seen to play an important role [6], [8]. Based on the occurrence of the stressful situations, two kinds of appraisals are considered for any person, i.e., primary and secondary. A primary appraisal takes place when any person carries out a conscious and sensible assessment of the occurring events if he senses a threat or a challenge [3], [9]. The actual idea of a challenge is very different from how it is viewed by the individual, wherein it could be more positive as compared to a threat. Furthermore, this type of appraisal comprises of many personality traits like commitments, beliefs and the values about his individual self along with the surrounding environment which defines the different situations which affect the person. Later, this process combined with emotional experience component will determine individuals' emotion perception; negative or positive. Emotional experience refers to level of experience of persons for handling emotions, where higher emotional experience triggers positive emotion while lower one triggers negative emotion [10], [14].

The second appraisal deals with evaluating the available resources of a person to handle the incoming stressors. This can be compared with the emotional attribution, where a positive emotion can lead to change and acceptance. However, a negative emotion induces a holdback behavior [11], [15], wherein many different coping mechanisms come into play and are evaluated like the problem-focused and the emotion-focused form of coping actions [13], [16]. The problem-focused approach handles the aggressive

interpersonal attempts made by the individual to alter the stressful event along with some rational efforts exerted for solving the issue. On the other hand, the emotion- focused type of coping attempts (which focus more on the thinking than the action for modifying the relationship between the person and the environment) involve many actions for managing the emotional consequences which result from the potentially stressful or the highly stressful situations [18], [20]. A person employs distancing, escape avoidance, and seeks many social comforts for tackling these issues. Many researchers have suggested that these coping strategies are derived depending on the things that are at stake (after primary appraisal) along with the coping options available (secondary appraisal) [17], [19]. In other words, if a person thinks that the situation could be altered into something less harmful or better (i.e., displays a higher perception regarding acceptance and change), then he tends to select the coping mechanism which is more problem-focused. However, if the person thinks that the situations cannot be modified (i.e., a holdback is the high perception), thereafter, he selects the coping mechanism which is more emotion-focused [16], [20].

In addition, problem-focused coping is considered to give satisfactory outcomes (improved coping skills). However, various studies suggest that many individuals with problem-focused coping find it difficult to get appropriate support

from close friends or acquaintances as they perceive this group of people to have limited knowledge or skills required to solve the individual's problems [13]. However, if the individual's objective is to seek emotional-focused coping is greater, he/she tends to select a stronger tie support over weaker tie. Moreover, the types of support required are correlated to the recipients' social tie preferences. For example, a reason for individuals choosing weak tie support members like colleagues (expanded social network) is that these weak ties give greater access to diverse information points (informational support) [2], [16]. However, other types of support, including companionship and emotional, are more related to strong tie (family and close friends) preferences [9], [11].

III. THE SUPPORT RECIPIENT MODEL

As mentioned in the previous section (analysis of cognitive dynamics in appraisal and coping strategy), computational properties for the recipient model can be specified. These computational properties are illustrated to simulate the individual's reaction in coping when exposed to the stressors, as well as the possible consequences of that action (see Figure 1).
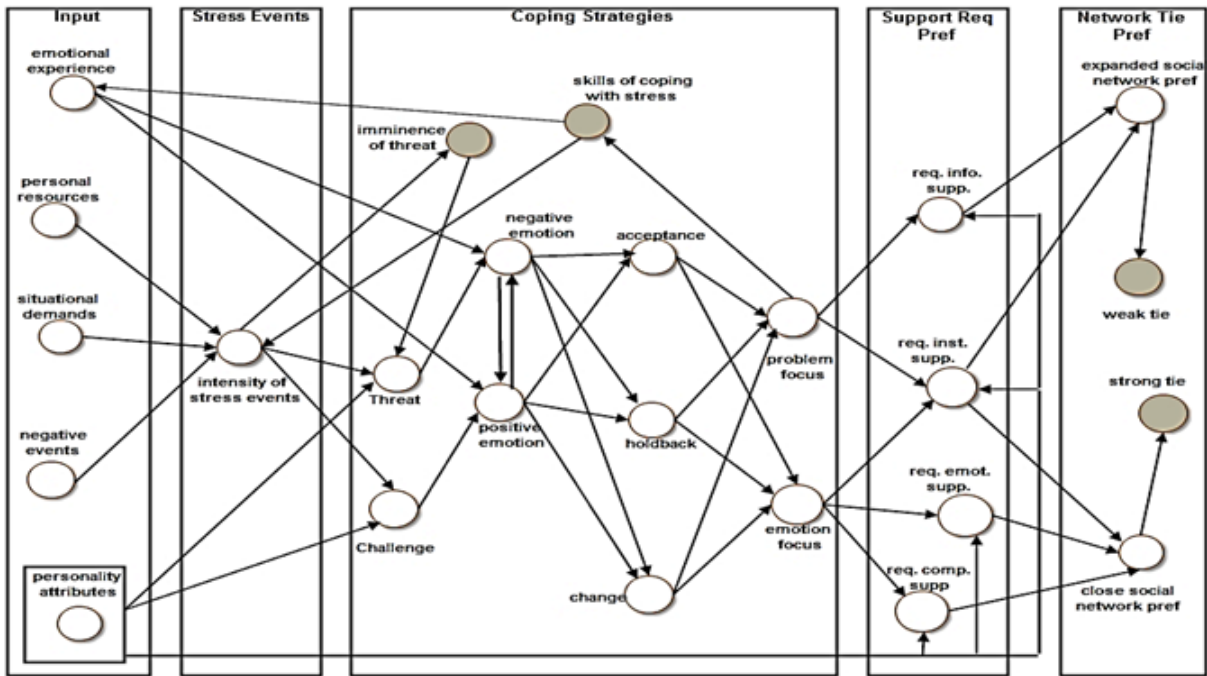

Figure 1: Variables and its Relationships that Involved in the Recipient Modeling

A. Imminence of Threat, Intensity of Stressful Event and Stressor Events

In the model, potential effects are simulated to generate stressor events (Nv) (negative events) throughout time (t) by employing weighted sum (w) of three kinds of events: chronic (C), life (L), and daily (D). The model uses these factors to show a series of events. The intensity of stressful events (Ie) denotes the degree of stress experienced by a person based on stressor events (Nv) and his or her situational demands (Sd), which is controlled by the proportion factor β_i. Also, if the personal resources (Pr) and coping skills (Sc) are high, the intensity of a stressful event is decreased. The long-term concept intensity of stressful event (Ie) can be employed to

measure imminence of threat (Im).

$$Nv(t) = w_1.L(t) + w_2.C(t) + w_3.D(t) \tag{1}$$

$$Ie(t) = [\beta_e.Nv(t) + (1-\beta_e).Sd(t)].(1-Pr(t)).(1-Sc(t)) \tag{2}$$

$$Im(t+\Delta t) = Im(t) + \alpha_i.[(Ie(t)-Im(t)).(1-Im(t)).Im(t)]\Delta t \tag{3}$$

B. Challenge and Threat

Challenge (Ch) is positively related with personality attributes (Pa), while negatively with the intensity of stress

through the proportional factor (ω_c). In contrast, the level of threat (*Th*) can be defined by the proportional contribution (γ_h) on the imminence of threat, and the intensity of stressful events. In this case of a threat, a negative relation is established with personality attributes.

$$Th(t) = [\gamma_h \cdot Im(t) + (1-\gamma_h).Ie(t)].(1-Pa(t)) \qquad (4)$$

$$Ch(t) = \omega_c.Pa(t) +(1-\omega_c).(1-Ie(t))Pa(t) \qquad (5)$$

C. Emotional Experience, Negative Emotion, and Positive Emotion

Emotional experience (*Ex*) is contributed through the proportional combination of basic emotional experience (*Ex_{base}*) and skills of coping (*Sc*)When the threat is perceived, some fractions of emotional experience is translated as a negative emotion (*Ne*). The view of positive emotion (*Pe*) is represented through a proportional factor of τ_p of higher fraction of emotional experience. Additionally, there is an opposite relationship between negative and positive emotion, which a person with a higher positive emotion has directly lower negative emotion and vice versa.

$$Sc(t+\Delta c) = Sc(t)+\eta_s.[[Pf(t)-Sc(t)].(1-Sc(t))Sc(t)]\Delta t \qquad (6)$$

$$Ex(t) = \lambda_e.Ex_{base}(t) + (1-\lambda_e).Sc(t) \qquad (7)$$

$$Ne(t) = Th(t).(1-Ex(t)).(1-Pe(t)) \qquad (8)$$

$$Pe(t) = [\tau_p.Ch(t)+(1-\tau_p).Ex(t)].(1-Ne(t)) \qquad (9)$$

D. Holdback, Acceptance, and Change

Positive emotion increases the level of acceptance (*Ac*) by a proportional factor γ_a, while the opposite effect can be observed through the formation of negative emotion (*Ne*). The relationship between positive and negative emotions contributes towards holdback (*Hb*) levels. In the same vein, change (*Cg*) employs the opposite relationship as existed in holdback.

$$Ac(t) = \gamma_a.Pe(t) +(1-\gamma_a).(1-Ne(t)) \qquad (10)$$

$$Hb(t) = (1-Pe(t)).Ne(t) \qquad (11)$$

$$Cg(t) = Pe(t).(1-Ne(t)) \qquad (12)$$

E. Problem and Emotional-focused Coping

The presence of acceptance, change and holdback generates emotional-focused coping (*Ef*) level. The problem-focused coping (*Pf*), delivers a positive effect. The contribution preferences for both specifications are regulated by parameters η_e and Υ_p.

$$Ef(t) = [\eta_e.(1-Ac(t)).Hb(t))+(1-\eta_e).Hb(t)](1-Cg(t)) \qquad (13)$$

$$Pf(t) = \Upsilon_p.Ac(t).(1-Hb(t))+(1-\Upsilon_p).Cg(t) \qquad (14)$$

F. Recipient Support Preference (Instrumental, Informational, Companionship, and Emotional)

The combination between conscientiousness personality and problem-focused coping generates instrumental preference of support (*Ir*). The integration of emotional-focused and problem-focused coping by a proportional factor ψ_n with extraversion (*Ev*) gives instrumental preference (*Nr*), while neurotic personality (*Nu*) gives emotional preference (*Er*) through a proportional factor η_{er}. Moreover, by combining both extraversion personality and emotional-focused (*Ef* determines the value of companionship preference (*Cr*) through a proportional factor β_c.

$$Ir(t) = \mu_{ir}.Pf(t).Co(t) + (1-\mu_{ir}).Co(t) \qquad (15)$$

$$Nr(t) = (\psi_n.Pf(t) + (1-\psi_n).(Ef(t)).Ev(t)) \qquad (16)$$

$$Er(t) = \eta_{er}.Ef(t).Nu(t) + (1-\eta_{er}).Nu(t) \qquad (17)$$

$$Cr(t) = \beta_c.Ef(t).Ev(t)+ (1-\beta_c).Ev(t) \qquad (18)$$

G. Expanded and Closed Social Network

Instrumental and informational support requests are combined to represent the expanded social network preferences (*Es*). While potential levels are simulated to generate closed social network preference (*Cs*) through the combination of three types of support; instrumental (*Nr*), emotional (*Er*), and companionship (*Cr*).

$$\sum Sr = Ir(t)+ Nr(t) +Er(t)+ Cr(t) \qquad (19)$$

$$Es(t) = [Ir(t) +Nr(t)] /\sum Sr \qquad (20)$$

$$Cs(t) = [Nr(t) + Er(t) + Cr(t)] /\sum Sr \qquad (21)$$

H. Weak and Strong Ties

Two temporal relationships are included: weak-tie preference (*We*) and strong-tie preference (*Se*). Both flexibility parameters, $\psi_{s,i}$ and $\beta_{w,i}$, are employed to determine the rate of change for these temporal relationships.

$$Se(t+\Delta t) = Se(t)+\psi_s.[(Cs(t)-Se(t)).(1-Se(t))Se(t)].\Delta t \qquad (22)$$

$$We(t+\Delta t) = We(t)+\beta_w.[(Es(t)-We(t)).(1-We(t)).We(t)]\Delta t \qquad (23)$$

Here, with time, there is a change in strong tie preference. The strong tie preference increases with higher value of *Cs* compared with the previous strong tie preference multiplied with the contribution factor ψ_s. Or else, it decreases based on its contribution factor and previous level. This condition can be employed to describe all the subsequent temporal relations, which are in accordance to their respective attributes and parameters. The measurement of change process is based on a time interval between *t* and *t*+Δt.

IV. SIMULATION RESULTS

Many simulations have been performed to discover interesting patterns among recipient's support tie preference

behaviors. Some anticipated patterns can be discovered with variations in individual and inter-personal attributes. This paper deals with three fictional individual conditions (see Table 1) exposed to different set of stressful events. Table 1 summarizes the values of these profiles.

Table 1
Individuals Profiles.

Recipient Support Preference Individuals	Profiles							
	Ex	Pr	Sd	Nv	Pa	Co	Nu	Ev
A	0.3	0.9	0.8	0.7	0.9	0.9	0.1	0.2
B	0.3	0.1	0.8	0.9	0.9	0.2	0.1	0.9
C	0.3	0.2	0.9	0.8	0.1	0.1	0.9	0.2

Based on this, three scenarios are presented: an individual likely to select problem-focused coping (**A**), an individual likely to select moderate level between problem and emotional-focused coping (**B**), and an individual likely to select emotional-focused coping (**C**). The duration of our simulation was initialized at 1,000 time points under these flexibility and proportional settings; $\Delta t = 0.3$, $\beta_w = \psi_s = \mu_e = \psi_n = \eta_e = \Upsilon_p = \gamma_a = \beta_i = \alpha_i = \Upsilon_{th} = \omega_c = 0.5$.

For this simulation, these individuals experience high negative events throughout the simulation time. Several systematic experiments were conducted to obtain the most appropriate parameter settings for this model.

A. Simulation Trace for Support Types Preferences

1) Case # 1: Informational Supports

In the case of personality attributes for individual *A*(high conscientiousness level), therefore he/she will cope with the incoming stressors through informational requests (see Figure 2). In this simulation trace, it is shows both individuals (*A* and *B*) developed better coping skills through the selection of problem -focused coping.

2) Case # 2: Emotional Supports

Normally, an individual with a high neurotic personality (individual C), prefers an emotional support as a mechanism the cope with stress (see Figure 2). Similar findings can be found in [6] [14].

3) Case # 3: Companionship Supports

A person with high with extraversion personality (individual *B*), tends to choose companionship support as a coping process (see Figure 3). These results are in line with existing literature as in [5] [16]. In this simulation trace, it is observable that individual *C* also request companionship support but lesser than individual *B* since he/she prefers to have high emotional focused coping (compared to individual *A)* with problem focused coping)
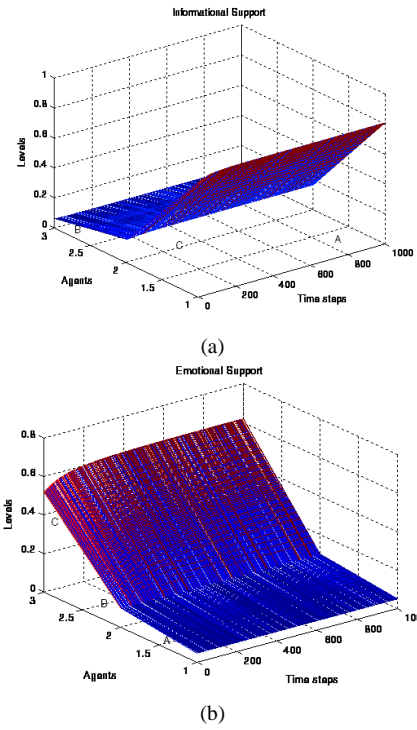

(a)

(b)

Figure 2: (a) Informational Support Request Preferences with Individual A, B, C., (b) Emotional Support Request Preferences with Individual A, B, C.

4) Case # 4: Instrumental Supports

In our simulation, the instrumental support was requested by three individuals but at different levels. For example, an individual *B* requests a higher level of instrumental support than the rest due to his /her high tendency in extraversion personality (see Figure 3).
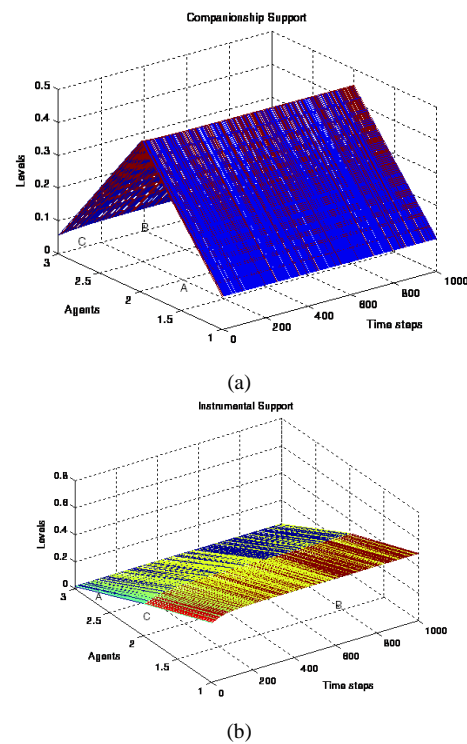

(a)

(b)

Figure 3: (a) Companionship Support Request Preferences with Individual *A, B,* and C., (b) Instrumental Support request Preferences with Individual *A, B,* and *C.*

B. Simulation Trace for Social Network Ties

1) Case # 1: Weak Tie Preferences

The individual *A* requests informational support rather than other types of support. So that, he will receive support from his expanded social network which will trigger weak tie preferences compared with individual *C* request emotional support from closed social network. Therefore, the weak tie preference will be decreased over the time (see Figure 4). Whereas, individual *B* requests more instrumental support from both expanded and closed social network that will trigger weak tie and strong tie preferences This finding was found to be consistent with [2] [7].

2) Case # 2: Strong Tie Preferences

In this case, an individual *C* requests emotional support from his/her closed social network and the strong tie preferences will be amplified over the time for this individual compared to others (individuals *A* and *B*) (as depicted in Figure 4). This finding was found to be consistent with [2] [3] [16] which hold that an individual with a high neurotic personality would get less support from a weak network tie, even during stressful event.
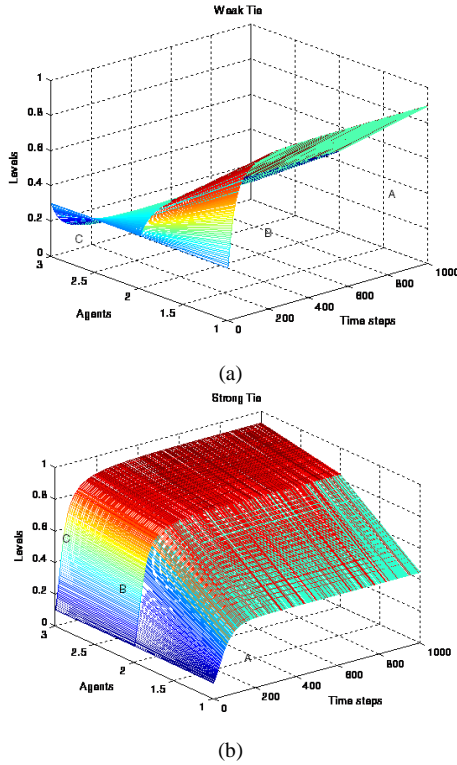

(a)

(b)

Figure 4: (a) Weak Tie Preferences with Individual A, B, and C., (b) Strong Tie Preferences with Individual A, B, and C.

V. MATHEMATICAL ANALYSIS

The determination of the model's equilibria is based on the mathematical formal analysis. The equilibria describe the condition in which the values for the variables that experienced stable situations. This is achieved by assuming constant values for all variables (even the ones used as inputs). The reference to time *t* can be overlooked in all equations, and can be cancelled to simplify differential equations. For example $Se(t+\Delta t)$ against $Se(t)$. This results in the following equations:

$(Cs= Se \lor Se=1 \lor Se=0) \land$

$(Es= We \lor We=1 \lor We=0) \land$

$(Ie = Im \lor Im =1 \lor Im =0) \land$

$(Pf= Sc \lor Sc=1 \lor Sc=0)$

$$Nv = w_1.L + w_2.C + w_3.D \qquad (24)$$

$$Ie = [\beta_e.Nv+(1-\beta_e).Sd].(1-Pr).(1-Sc) \qquad (25)$$

$$Th = [\gamma_h.Im + (1-\gamma_h).Ie].(1-Pa) \qquad (26)$$

$$Ch = \omega_c.Pa + (1-\omega_c).(1-Ie).Pa) \qquad (27)$$

$$Ex = \lambda_e.Ex_{base} + (1-\lambda_e).Sc \qquad (28)$$

$$Ne = Th.(1-Ex).(1-Pe) \qquad (29)$$

$$Pe = [\tau_p.Ch +(1-\tau_p).Ex].(1-Ne) \qquad (30)$$

$$Ac = \gamma_a.Pe + (1-\gamma_a).(1-Ne) \qquad (31)$$

$$Hb = (1-Pe).Ne \qquad (32)$$

$$Cg = Pe.\quad (1-Ne) \qquad (33)$$

$$Ef = [\eta_e.(1-Ac).\quad Hb) + (1-\eta_e).Hb].(1-Cg) \qquad (34)$$

$$Pf = Y_p.Ac.(1-Hb)+(1-Y_p).Cg \qquad (35)$$

$$Ir = \mu_{ir}.Pf.Co + (1-\mu_{ir}).Co \qquad (36)$$

$$Nr = (\psi_n.Pf + (1-\psi_n).(Ef).Ev) \qquad (37)$$

$$Er = \eta_{er}.Ef.Nu + (1-\eta_{er}).Nu \qquad (38)$$

$$Cr = \beta_c.Ef.Ev + (1-\beta_c).Ev \qquad (39)$$

$$\sum Sr = Ir + Nr + Er + Cr \qquad (40)$$

$$Es = [Ir + Nr]/\sum Sr \qquad (41)$$

$$Cs = [Nr + Er + Cr]/\sum Sr \qquad (42)$$

$$\psi_s.(Cs-Se)(1-Se).Se=0 \qquad (43)$$

$$\beta_w.(Es-We).(1-We).We=0 \qquad (44)$$

$$\alpha_i.(Ie-Im).(1-Im).Im=0 \qquad (45)$$

$$\eta_s.[Pf-Sc].(1-Sc).Sc=0 \qquad (46)$$

Assuming the parameters ψ_s, β_w, α_i, η_s nonzero, from the Equation (24) to (46), the following cases can be distinguished:

(Cs= Se) ∨ *(Se=1* ∨ *(Se=0)*

(Es= We) ∨ *(We=1)* ∨*(We=0)*

(Ie = Im *)* ∨ *(Im =1)* ∨ *(Im =0)*

(Pf= Sc) ∨ *(Sc=1)* ∨ *(Sc=0)*

Therefore, the first conclusion can be identified where the equilibria points can only occur when Cs=Se or Se=1 or Se=0. The next step is to combine these three conditions into a new set of relationship, as in (A ∨ B ∨ C) ∧ (D ∨ E ∨ F) expression.

(Cs= Se ∨ *Se=1* ∨ *Se=0)* ∧

(Es= We ∨ *We=1* ∨*We=0)* ∧

(Ie = Im ∨ *Im =1* ∨ *Im =0)* ∧

(Pf= Sc ∨ *Sc=1* ∨ *Sc=0)*

This expression can be elaborated using *Law of Distributivity* as;

(A ∧ D) ∨ (A ∧ E) ∨ (A ∧ F) ∨ … ∨ (C ∧ F)

And this will result;

(Cs = Se ∧ Es = We ∧ Ie = Im ∧ Pf = Sc) … ∨
(Se = 0 ∧ We = 0 ∧ Im = 0 ∧ Sc = 0)

Theoretically, this totals to almost $3^4 = 81$ possible equilibria. As the number of possible combinations is enormous, developing a complete classification of equilibria is rather difficult. However, the analysis can be pursued further for some typical cases. It must be noted that for each distinguished case more information is available regarding the equilibrium values of the other variables based on the additional non-dynamic equations.

A.   Case #1: Cs= Se ∧ Es= We ∧ Ie = Im ∧ Pf= Sc
In this case, from equation (26), this case is equivalent to:

$$Th = [\gamma_h.\text{Im} + (1-\gamma_h).\text{Im}].(1-Pa)$$

Assuming $\Upsilon_h = 0.5$, therefore;

$$Th = (1-Pa)$$

From Equation (27), this case gives;

$$Ch = \omega_c.Pa + (1- \omega_c). (1- \text{Im}).Pa$$

Rearrange this;

$$Pa = [(Ch- \omega_c.Pa)/(1- \omega_c).(1- \text{Im})] \text{ and } \omega_c \neq 1$$

Consider Equation (25) and (28), the equilibria point is

$$Ie = [\beta_e.Nv+(1-\beta_e).Sd].(1-Pr).(1-Pf)$$
$$Ex = \lambda_e. Ex_{base} + (1- \lambda_e).Pf$$

If the initial emotional experience =1 and $\lambda_e = 0$ then;

$$Ex = Pf$$

B.   Case #2: Sc =1
Assuming β_e is nonzero, thus equation (25) provides an equilibria point of;

$$Ie = Nv$$

Using the same principle for equation (28), the effect of the stability point can be summarized as;

$$Ex = Ex_{base}$$

C.   Case #3: Im =1
In this case, from equation (26), this case is equivalent to:

$$Th = [\gamma_h + (1-\gamma_h).Ie].(1-Pa)$$

If γ_h is nonzero nor one, then

$$Th = Ie.(1-Pa)$$

Rearrange this,

$$Pa = 1 - (Th/Ie)$$

VI.   CONCLUSION

In this paper, the authors have developed a computational model for explaining the two coping strategies and selecting the social network ties for the stressed individuals. Depending on a weak tie or a strong tie support network theory, the different personality traits of an individual are connected to their preference for a particular type of support group along with their general willingness to get support. When these factors are considered together, they are seen to offer a more dynamic model which could be used for simulating stress in the individual along with studying the support system and the role played by the social environment. This model was applied in many scenarios which represented particular environmental situations and the personality traits which could determine the selection of the strong or the weak tie support. A mathematical analysis confirmed that these types of equilibriums are a direct result of the model used. This system also helped in monitoring the mood of the individual and provided helpful support and suggestion based on the information regarding the individual's personality traits. Furthermore, this model also helped in establishing a simulation study for the benefits which were gained through the support from the people of a particular network along with the person who was to be contacted for further help.

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