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Self-confidence at Workplace: Cognitive Agent Modeling and Analysis

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Abstract: In the workplace, indications of self-awareness and emotional intelligence will be unavoidable. Certain standards consider these symptoms to be appropriate because they are a vital element of keeping people informed (or commonly known as self-confidence). Recent research, on the other hand, has focused on external characteristics of self-confidence and has lacked adaptable strategies for dealing with individual self-confidence dynamics. This study investigated the use of an agent-based modelling approach for workplace self-confidence. It focuses on the dynamic influences of environmental and personal factors on work self-esteem, self-efficacy, self-concept, and self-confidence. Based on several personality characteristics and environmental conditions, the results included four scenarios (self-esteem, self-efficacy, self-concept, and self-confidence). In order to describe self-confidence agent-based modeling of complex sociotechnical systems in the literature based on empirical investigation, automated logical verification was used to validate this computational model. Finally, equilibria analysis was performed to evaluate this computational model in order to discover if there were any weaknesses. The suggested computational agent-based model has shown realistic behavior patterns that are compatible with workplace self-esteem, self-efficacy, self-concept, and self-confidence.

Keywords: Dynamical model, Agent-based modelling, Self-confidence at workplace, Self-confidence.

1. Introduction

The majority of today's age spends the bulk of their life at work; therefore, work is engrained in most people's lives. Their workplaces have replaced their own families, friend groups, and social organizations as their most significant community. As a result, work organizations must acknowledge that workers are more than just a cost center; they have souls, objectives, and a desire to be happy at work. If employees are seen as persons with sensitive needs who must coexist as mutual beings, the workplace must be as compassionate as possible. A negative work environment can lead to major mental illnesses such as psychotic, neurotic, or cognitive difficulties [1, 2].

Emotional intelligence (EI) is a key concept in organizational psychology. In social contexts, EI has been highlighted as a valuable personal advantage. Commentators highlight EI's beneficial impact on job performance in order to persuade employers to include it in their recruitment and training programs [3, 4]. EI is important and helps to support workers' intelligence quotient [5]. The relationship between EI and self-awareness has also been addressed. When we analyse self-awareness as a characteristic, we can see that it is determined by a variety of perspectives and ways of thinking. Individuals with heightened self-awareness, for example, have made the initial step in studying their own beliefs and actions, and as a consequence, they may discover challenges that they need to address, such as by consulting with their own mentor. Self-awareness

may be divided into two categories: intrapersonal and interpersonal. The intrapersonal aspect is concerned with one's own resources and internal state of mind (for example, self-confidence), whereas the interpersonal aspect is concerned with one's influence on others (for example, situational awareness) [6-8].

The definition of self-confidence is the belief that one must act in accordance with one's needs in order to attain the required results [9, 10]. The self-confidence characteristics associated with workplace dangers could point to a communal cause of negative self-awareness emotional intelligence symptoms such as a lack of self-concept, self-efficacy, and self-esteem [11, 12].

Self-esteem is a person's subjective measure of their own value (For instance, "I am unloved," "I am deserving") [13]. We start by looking at self-esteem as a matrix: a set of concepts based on two factors: competence and worthiness [14, 15]. Workers' self-worth (worthiness) is determined by their skill, effort, and performance [16]. Competencies are a basis for considering knowledge and abilities [17]. According to the Conscious Competence principle, we move through the levels of competence when we get beneficial results in a new skill [18, 19]. Experience and job control may influence the workers' abilities [20, 21]. Employees' knowledge is influenced by their ability and experience, with a lack of skill and experience at work reducing workers' knowledge [22, 23].

The term "self-efficacy" refers to an individual's confidence in their ability to carry out the actions necessary to attain particular performance goals [24]. The self-efficacy of a worker may boost their self-esteem [25]. Workers' self-efficacy may be influenced by their vicarious experiences, forms of social persuasion, performance, and low physiological conditions [26]. Social Influence and Influence Tactics improve workers' forms of social persuasion [27-29]. Based on the psychological principles of operant conditioning, vicarious reinforcement and punishment might be used to describe vicarious experiences [30]. The vicarious reinforcement of workers is affected by their motivation, and active avoidance of workers reduces vicarious reinforcement [31, 32]. Work motivation is impacted by employees' self-esteem and self-efficacy at work [33]. Effort, ability, self-esteem, and self-efficacy are four characteristics that influence work performance [16, 33].

Finally, a self-concept is a collection of conscience [34]. Self-concept is the response to the question "Who am I?" in general. The three components of self-concept are self-ideal, self-image, and self-esteem. In addition, the self-ideal is also known as the current condition of self-concept [35, 36]. The personality and risk society of employees influence the worker's self-image [26, 37].

As a consequence, a variety of theories and elements are needed to explain the non-dynamic components of self-confidence in emergency situations. Self-efficacy showed more significant effects on four factors when trust in the organization was high: work satisfaction, task performance, and citizenship behaviors [38]. The manager or dispatch leader should concentrate on improving the following three emotional skills: emotional self-efficacy, emotional management of others, and emotional usage. The significance of emotional self-efficacy in the workplace is therefore demonstrated by these research results [39]. A prior study looked at the role of resilience in mediating the relationship between perceived self-efficacy and psychological well-being. Self-efficacy and resilience are flexible qualities that may be enhanced through observation and learning [40]. Previous research revealed that various factors influenced both job motivation and self-efficacy belief at the same time [41]. Previous research has found that perceived overqualification encourages innovative work behavior both directly and indirectly by improving creative self-confidence [42]. These studies concentrate on external self-confidence factors and lack adaptive techniques for interacting with individual self-confidence dynamics. The dynamic agent-based computational model, main theories of self-confidence, and factors/barriers that affect worker self-confidence are all used in this research to address the aforementioned issue. The goal of this study is to look into the emergency phenomena of collective worker behavioral processes in order to predict employee self-efficacy, self-esteem, and self-concept at work.

The next section depicts the model's graphical and numerical conceptual design, as well as the development process of the cognitive agent modeling. After that, detailed cognitive agent-based modeling explanations will be provided. The suggested agent-based model's simulation and evaluation findings are detailed in Sections 4 and 5. Finally, Section 5 contains the paper's conclusion.

2. Agent-based modeling

The state-determined system is used to describe what a dynamical system is since its current state always dictates a distinct future behavior [43, 44]. This idea of a state-determined system is related to the concepts of temporal factorisation and criterial

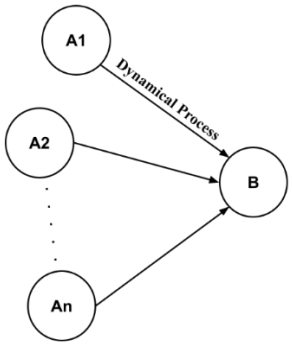

Figure. 1 Dynamical network systems in graphical representation

causation discussed in [45]. This approach may be used to represent both graphical and numerical representations. The diagram may appear to be a complex network structure with nodes (circles and arrows). A dynamical process (arrow) links a set of $A_1, \ldots\ldots, A_n$ (circles) to B (circle) as demonstrated in Fig. 1. This is how the causality requirements are stated.

Dynamical systems can be specified using mathematical forms. A limited number of states (or state variables), $A_1, \ldots\ldots, A_n$ is assumed, with time t functions $A_1(t), \ldots\ldots, A_n(t)$ specifying how the system evolves. For each of the states A_i, the impact on B at time t is equivalent to both the value $A_i(t)$ and the connection weight $\omega_{A,B}$, and is denoted as:

$$\boldsymbol{impact}_{A,B}(t) = \omega_{A,B} A(t) \quad (1)$$

A function that combines two or more functions ς_A (such as, the sum function or any learning function) is used to model the combined impact of many factors. For example, $impact_1, \ldots\ldots, impact_n$ of $A_1, \ldots\ldots, A_n$ on state B at time t, as:

$$\boldsymbol{aggimpact}_B(t) = \varsigma_A(\boldsymbol{impact}_{A_1,B}(t), \ldots\ldots, \boldsymbol{impact}_{A_n,B}(t)) \quad (2)$$

Where

$$\boldsymbol{aggimpact}_B(t) = \varsigma_A(\omega_{A_1,B}(t), \ldots\ldots, \omega_{A_n,B}(t)) \quad (3)$$

The $\boldsymbol{aggimpact}_B(t) - B(t)$ is the difference between this aggregated effect value $\boldsymbol{aggimpact}_B(t)$ and the current value $B(t)$ of A. Step by step from t to $t + \Delta t$, where t is the value of $B(t)$will increase in accordance with the value of $\boldsymbol{aggimpact}_B(t)$. The proportion factor (η_B) makes this increase proportional to the difference between the two values. However, the $\boldsymbol{aggimpact}_B(t)$ value (which is dependent on other states) is controversial and might alter throughout the concentration process, boosting the process' dynamism. The differential equation is used to numerically characterize a dynamical model as follows:

$$B(t + \Delta t) = B(t) + \eta_B \left(\boldsymbol{aggimpact}_B(t) - B(t)\right).\Delta t \quad (4)$$

Any numerical dynamical modeling language or software environment, such as Matlab or Excel, could be used to model or execute the differential equation formulation above. The models are declarative, which means that they may be used with computational methods for simulation or analysis without changing the model representations [46]. This type of modeling is still quite popular. The generated cognitive agent model, for example, might be beneficial in the implementation of a covid-19-aware analytics software agent that can analyze healthcare practitioners' mental health [47]. The paper used a computational model based on a conceptual model developed from generalized anxiety disorder theories to give a foundation for analyzing the interviewees' anxiety state [48]. Another recent study investigated the usage of an agent-based modeling technique for workplace situational awareness [49].

3. Cognitive agent model of self-confidence

The proposed temporal-casual model of workplace self-confidence is supported by several underlying theories such as the Two-Factor Self-Esteem Meaning Matrix [14, 15], Conscious Competence [18, 19], the Self-worth Model [16], A multidimensional, hierarchical model of self-concept [50], and Constructions of self [51]. To model the temporal-casual of workplace self-confidence, a number of important processes have been identified. These processes are: 1) factor identification, 2) conceptual model based on recognized theories and factors, 3) formalization using differential equations, 4) simulation, and 5) evaluation.

A collection of endogenous or internal (local) and exogenous or external (non-local) features are utilized to determine factors based on the literature review. Exogenous (from social and environmental specifications) provide a collection of inputs to the model, while endogenous components (from social and environmental specifications or mechanisms) offer the model a set of linkages with factors and theories. Besides, the output of the model is

Table 1. Formalized concept

Concept	Formalization
Competence	Co
Worthiness	Wo
Knowledge	Kn
Ability	Ab
Performance	Pe
Experiences	Ex
Skills	Sk
Personality	Pr
Effort	Ef
Time pressure	Tp
Motivation	Mo
Norm Motivation	Nm
Vicarious Reinforcement	Vr
Vicarious Punishment	Vp
Active Avoidance	Aa
Influence Tactics	It
Social Influence	Si
Vicarious Experiences	Ve
Forms of Social Persuasion	Sp
Physiological States	Pi
Job Control	Jc
Job demand	Jd
Risk Society	Rs
Self-image	Im
Short-term Self-esteem	SEs
Long-term Self-esteem	LEs
Short-term Self-efficacy	SEf
Long-term Self-efficacy	LEf
Short-term Self-concept	SCo
Long-term Self-concept	LCo

temporal relationships effects of self-concept, self-efficacy, and self-esteem at the workplace. Table 1 contains a list of nomenclatures for formal representation.

The model's overview is represented in Fig. 2. Note, states (circles) and their dynamics as processes (arrows) are included. Fig. 2. explains the metacognitive (thinking about thinking) of a self-confidence model based on three relationships (exogenous, endogenous, and temporal). Each concept is linked together based on relevant findings in the literature on self-confidence theories, mechanisms, or factors at the workplace.

This is accomplished by adding additional dynamics to the network as processes (called arrows), which indicate (adaptive) network features. Based on the literature research, such states are portrayed in the following states. Table 2 shows several sorts of characteristics, along with their model states and responsibilities. The connections weights play a role in linking states by having weights that are all the same affected values. The weight value of linking state performance (*Pe*) to

Table 2. Model states for various network characteristics

Characteristics	Concepts	Notations
Connectivity	Connections weights	$\omega_{Pe}, \omega_{Mo}, \omega_{Wo}, \omega_{SEs}, \omega_{SEf}$, and ω_{SCo}
Aggregation	Evaluating a state's many effects	$\mu_{Jc}, \gamma_{Kn}, \delta_{Sk}, \vartheta_{Mo}, \alpha_{Sp}, \delta_{Wo}, \beta_{Co}, \beta_{SEs}, \vartheta_{SEf}$, and δ_{SCo}
Timing	Speed factors	η_{LEs}, η_{LEf}, and η_{LCo}

ability, effort, self-esteem, and self-efficacy states is, for example, ω_{Pe}. The mechanism from literature research is used to evaluate the numerous consequences of a situation. In comparison to the personality (Pr) state, μ_{Jc} represents the high priority to alter the state job control (Jc). Finally, the speed factors of mental model states determine how quickly states change. The η_{LEs}, for example, is the rate of learning between "short-term self-esteem" and "long-term self-esteem".

The job control of workers is affected by two factors which are workers' experience and personality [52, 53] in which a worker's personality highly affects the worker's job control compared to the worker's experiences.

$$Jc(t) = \mu_{Jc}.Pr(t) + \left(1 - \mu_{Jc}\right).Ex(t) \quad (5)$$

The knowledge of workers is affected by workers' ability and experience where lack of ability and experience at the workplace may decrease the workers' knowledge [22, 23]. The workers' skills may affect by their experience and job control [20, 21].

$$Kn(t) = (1 - \gamma_{Kn}).Ab(t) + \gamma_{Kn}.Ex(t) \quad (6)$$

$$Sk(t) = \delta_{Sk}.Jc(t) + (1 - \delta_{Sk}).Ex(t) \quad (7)$$

The effort of workers depends on his/her motivation and low job demands [54, 55].

$$Ef(t) = Mo(t) + (1 - Jd(t)) \quad (8)$$

Performance is high during the work based on four factors effort, ability, self-esteem, and self-efficacy [16, 33].

At work, work motivation is influenced by the workers' self-esteem, and self-efficacy [33].

$$Pe(t) = \omega_{Pe}.Ab(t) + \omega_{Pe}.LEs(t) + \omega_{Pe}.LEf(t) + \omega_{Pe}.Ef(t) \quad (9)$$

$$Mo(t) = \vartheta_{Mo}.Nm(t) + (1 - \vartheta_{Mo}).(\omega_{Mo}.LEf(t) + \omega_{Mo}.LEs(t)) \quad (10)$$

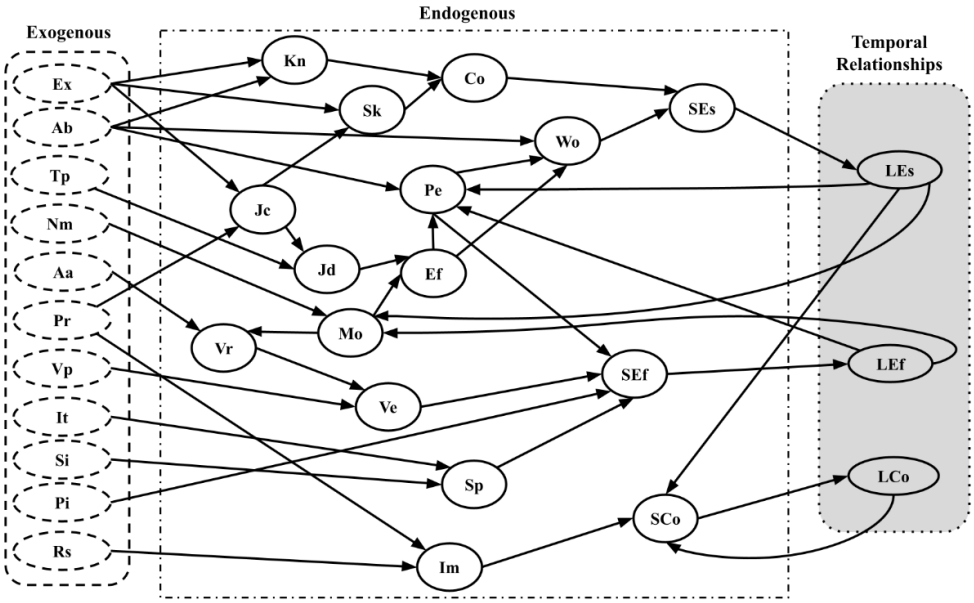

Figure. 2 Conceptual model of self-confidence

The worker's motivation affects the vicarious reinforcement [31], active avoidance of worker is decreased the worker's vicarious reinforcement [32]. The vicarious reinforcement and punishment could define the vicarious experiences based on the psychological principles of operant conditioning. [30].

$$Vr(t) = Mo(t).(1 - Aa(t)) \quad (11)$$

$$Ve(t) = Vr(t).(1 - Vp(t)) \quad (12)$$

The Forms of Social Persuasion of workers are increased by Social Influence and Influence Tactics [27-29].

$$Sp(t) = \alpha_{Sp}.Si(t) + \left(1 - \alpha_{Sp}\right).It(t) \quad (13)$$

The workers' time pressure has a strong effect on job demands during work including low job control [53, 56].

$$Jd(t) = Tp(t) \ .(1 - Jc(t)) \quad (14)$$

Workers' self-esteem can be boosted by a person's worthiness and competence [50], and a worker's self-efficacy might improve their self-esteem [25]. Competencies are a way of thinking about knowledge and skills [17]. Workers' ability, effort, and performance are used to determine their self-worth (worthiness) [16].

$$Wo(t) = \delta_{Wo}.\left(\omega_{Wo}.Ab(t) + \omega_{Wo}.Ef(t)\right) + (1 - \delta_{Wo}).Pe(t) \quad (15)$$

$$Co(t) = \beta_{Co}.Sk(t) + (1 - \beta_{Co}).Kn(t) \quad (16)$$

$$SEs(t) = \beta_{SEs}.\left(\omega_{SEs}.Co(t) + \omega_{SEs}.Wo(t)\right) + (1 - \beta_{SEs}).LEf(t) \quad (17)$$

The vicarious experiences, forms of social persuasion, performance, and low physiological states of workers may control workers' self-efficacy [26].

$$SEf(t) = \Big(\left(1 - \vartheta_{SEf}\right).Pe(t) + \vartheta_{SEf}.\left(\omega_{SEf}.Ve(t) + \omega_{SEf}.Sp(t)\right) \Big).\left(1 - Pi(t)\right) \quad (18)$$

The worker's self-image is dependent on the personality and risk society of workers [26, 37]. Self-ideal, self-image, and self-esteem are the three components of self-concept [35], and self-ideal is also referred to as the current state of self-concept [36].

$$Im(t) = \left(1 - Rs(t)\right).Pr(t) \quad (19)$$

$$SCo(t) = \delta_{SCo}.\left(\omega_{SCo}.LCo(t) + \omega_{SCo}.Im(t)\right) + (1 - \delta_{SCo}).LEs(t) \quad (20)$$

Long-term self-esteem evolves over time in this situation. As a result, when short-term self-esteem is raised, the contribution factor η_{LEs} magnifies the preceding value. In the same vein, this condition

could also be used to characterize all temporal relations (self-concept and self-efficacy), as well as the parameters and characteristics that correspond to them. The change process is calculated between *t* and *t*+Δ*t*. Furthermore, flexibility rates (nonzero speed factors) η_{LEs}, η_{LEf}, and η_{LCo} determine the rate of change for all temporal characteristics throughout time.

$$LEs(t+\Delta t) = LEs(t,l) + \eta_{LEs}.\big(SEs(t,l) - LEs(t,l)\big).\big(1 - LEs(t,l)\big).LEs(t,l).\Delta t \quad (21)$$

$$LEf(t+\Delta t) = LEf(t,l) + \eta_{LEf}.\big(SEf(t,l) - LEf(t,l)\big).\big(1 - LEf(t,l)\big).LEf(t,l).\Delta t \quad (22)$$

$$LCo(t+\Delta t) = LCo(t,l) + \eta_{LCo}.\big(SCo(t,l) - LCo(t,l)\big).\big(1 - LCo(t,l)\big).LCo(t,l).\Delta t \quad (23)$$

A simulator was created for experimentation purposes using all given formulas; in particular, to study notable patterns and traces that represent the dynamics of the self-confidence connected with the workspace.

4. Simulation results

This section explains how a group of fictitious workers in various settings develop behaviors or patterns that have been seen in other empirical investigations. To see how these patterns are related, four fictitious workers are shown: a strong personality and ability, as well as a wealth of knowledge, and motivation (#1), a strong ability, as well as persuasion techniques, motivation, and social influence (#2), in the same way as case 1, but with low time pressure (#3), in the same way, that all of the preceding cases, but without a physiological history such as stressful depression or anxiety including a lack of a risk society, vicarious punishment, and active avoidance during the work (#4).

Table 2 shows the preliminary values for each fictitious worker. During this method, some settings can be modified to produce different results. The following settings were used for the sake of brevity: $\Delta t = 0.3$, $t\_mix = 800$ (predicting the worker mental duration, which is anticipated to be 13 hours), regulatory rates (such as β_{SEs}, ϑ_{Mo}, and μ_{Jc}) equal to 0.7, nonzero speed factors (η_{LEs}, η_{LEf}, and η_{LCo}) equal to 0.3, the weights (ω_{SEf}, ω_{SEs}, ω_{SCo} and ω_{Mo}) equal to 0.50, and weights (ω_{Pe}) equals 0.25.

Table 2. Default configurations

Factors	**Case #1**	**Case #2**	**Case #3**	**Case #4**
Experiences	0.9	0.1	0.9	0.9
Personality	0.9	0.1	0.9	0.9
Ability	0.9	0.9	0.9	0.9
Norm Motivation	0.9	0.9	0.9	0.9
Active Avoidance	0.9	0.1	0.9	0.1
Vicarious Punishment	0.9	0.1	0.9	0.1
Influence Tactics	0.1	0.9	0.1	0.9
Social Influence	0.1	0.9	0.1	0.9
Time pressure	0.9	0.9	0.1	0.1
Physiological States	0.9	0.1	0.9	0.1
Risk Society	0.1	0.9	0.9	0.1

Case #1: a strong personality and ability, as well as a wealth of knowledge, and motivation: In this situation, the employee has a high self-concept at work. Fig 3. shows the simulation traces based on Case #1.

Case #2: a strong ability, as well as persuasion techniques, motivation, and social influence: The individual has a high self-efficacy at work in this situation. Fig. 4 depicts the simulation traces for Case #2.

Case #3: in the same way as case 1, but with a low time pressure: In this condition, the individual has a high self-esteem at work. The simulation traces for Case #3 are shown in Fig 5.

Case #4: In the same way that all of the preceding cases, but without a physiological history such as stressful depression or anxiety including a lack of a risk society, vicarious punishment, and active avoidance during the work: The worker has a high self-confidence as well as high of "self" based on Constructions of self [51]. Fig. 6. illustrates the simulation traces for Case #4.

To summarize these findings, a worker with high ability and motivation can face a variety of work-related self-confidence risks. The relationships stated in the literature are properly justified by the aforementioned obtained traces. With numerous conclusions offered in section one, the simulation

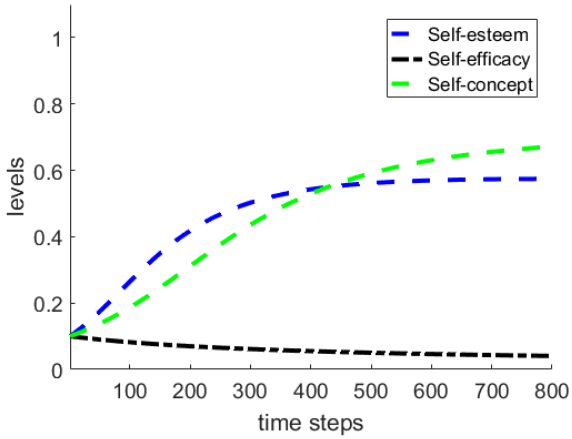

Figure. 3 Self-concept simulation results

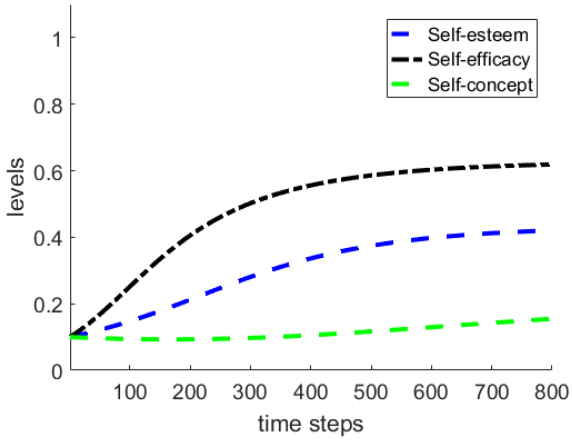

Figure. 4 Self-efficacy simulation results

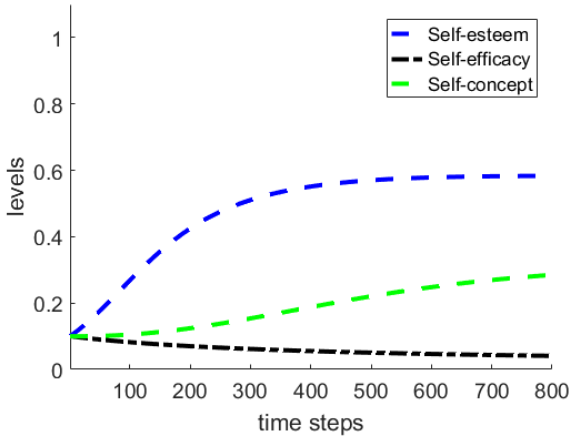

Figure. 5 Self-esteem simulation results

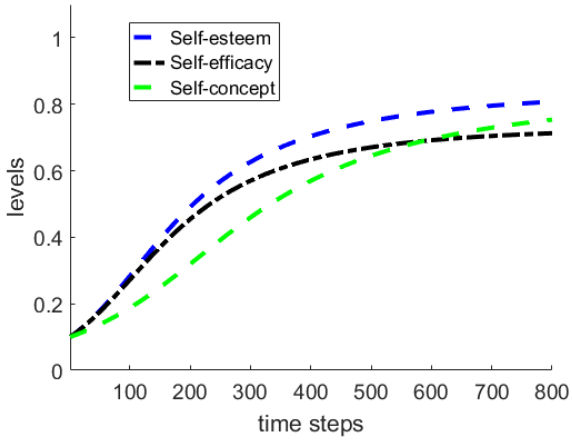

Figure. 6 Self-confidence simulation results

results, for example, reveal that worker with strong ability, as well as persuasion strategies, motivation, and social influence.

5. Evaluation

The suggested model has the advantage of giving the individual a better possibility of conquering potential hazards and creating self-confidence in the face of more diverse scenarios and dangers. Furthermore, because this dynamical model is already assumed to relate to actual brain functions, it will be easier to connect mental and neurological processes when it is applied to mental processes.

Furthermore, because this dynamical model is already assumed to relate to actual brain functions, it will be easier to connect mental and neurological processes when it is applied to mental processes. Three benefits apply to this modeling technique as well, but in a broader sense [57]: (1) Simple dynamical network models are temporal-causal network models. (2) A temporal-causal network model may be used to represent any smooth dynamical system, making them universal dynamics modelers (which is a state-determined system by definition). (3) They have a logical interpretation in terms of scientific information (from any area) that is frequently defined by causal linkages.

The suggested agent-based modeling of self-confidence is put to the test via automated analysis. Because numerical data to define the agent's dynamic causal behaviors is difficult to come by, the automated analysis evaluates simulated behaviors to the constructed model's internal validity. However, some behaviors or patterns may be identified in the literature based on empirical investigation. The Temporal Trace Language is a formal language that may be used to describe agent-based modeling of complex sociotechnical systems. The Temporal Trace Language is a logic-based language for clearly describing dynamic aspects of systems and formalizing agent-based modeling [58]. The set of well-formed temporal trace language equations is inductively presented in a formal manner using Boolean connectives (such as $\neg, \forall, \exists, \equiv, \wedge, \vee, \Longrightarrow$).

High self-concept while retaining a high level of self-esteem is the first state property (P1) [59].

$$P1 \equiv \forall\theta{:}TRACE, \forall t1, t2{:}TIME,$$
$$\forall f1, f2, h1, h2{:}REAL$$
$$[state(\theta, h1)| = self\_esteem\_value(\theta, t1)\ \&$$
$$state(\theta, h2)| = self\_esteem\_value(\theta, t2)\ \&$$
$$state(\theta, f1)| = self\_concept\_value(\theta, t1)\ \&$$
$$state(\theta, f2)| = self\_concept\_value(\theta, t2)\ \&$$
$$h2 \geq h1\ \&\ t1 \leq t2]$$
$$\Rightarrow f2 \geq f1$$

The second state property (P2) is that workers' self-efficacy may be influenced by their vicarious experiences, social persuasion techniques, performance, and low physiological conditions [60-62].

$$P2 \equiv \forall\gamma{:}TRACE, \forall t1, t2{:}TIME,$$
$$\forall r1, r2, s1, s2, c1, c2, h1, h2, k1, k2{:}REAL$$
$$[state(\gamma, t1)| = physiological\_states(\gamma, s1)\ \&$$
$$state(\gamma, t1)| = vicarious\_experiences(\gamma, c1)\ \&$$
$$state(\gamma, t2)| = physiological\_states(\gamma, s2)\ \&$$
$$state(\gamma, t2)| = vicarious\_experiences(\gamma, c2)\ \&$$
$$state(\gamma, t1)| = performance(\gamma, h1)\ \&$$
$$state(\gamma, t1)| = social\_persuasion(\gamma, k1)\ \&$$
$$state(\gamma, t2)| = performance(\gamma, h2)\ \&$$
$$state(\gamma, t2)| = social\_persuasion(\gamma, k2)$$
$$state(\gamma, t1)| = self\_efficacy\_value(\gamma, r1)\ \&$$
$$state(\gamma, t2)| = self\_efficacy\_value(\gamma, r2)\ \&$$
$$t1 \leq t2\ \&\ s1 < 0.5\ \&\ s2 < 0.3\ \&\ c1 > 0.5\ \&$$
$$c2 > 0.7\ \&\ c1 < c2\ \&\ s1 > s2\ \&\ h1 > 0.5\ \&$$
$$h2 > 0.7\ \&\ k1 > 0.5\ \&\ k2 > 0.7\ ]$$
$$\Rightarrow r1 < r2$$

The third state property (P3) is that the worthiness and competence of employees can increase their self-esteem [63].

$$P3 \equiv \forall\mu{:}TRACE, \forall t1, t2{:}TIME,$$
$$\forall o1, o2, a1, a2, s1, s2{:}REAL$$
$$[state(\mu, t1)| = worthiness\_value(\mu, a1)\ \&$$
$$state(\mu, t1)| = competence\_value(\mu, s1)\ \&$$
$$state(\mu, t2)| = worthiness\_value(\mu, a2)\ \&$$
$$state(\mu, t2)| = competence\_value(\mu, s2)\ \&$$
$$state(\mu, t1)| = self\_esteem\_value(\mu, o1)\ \&$$
$$state(\mu, t2)| = self\_esteem\_value(\mu, o2)\ \&$$
$$t1 \leq t2\ \&\ a1 > 0.5\ \&\ a2 > 0.7\ \&\ s1 > 0.5\ \&$$
$$s2 > 0.7\ \&\ a1 < a2\ \&\ s1 < s2\ ]$$
$$\Rightarrow o1 < o2$$

The fourth state property (P4) is that self-concept consists of three components: self-ideal, self-image, and self-esteem. The current condition of one's self-concept is also known as self-ideal [64].

$$P3 \equiv \forall\delta{:}TRACE, \forall t1, t2{:}TIME,$$
$$\forall o1, o2, a1, a2, s1, s2{:}REAL$$
$$[state(\delta, t1)| = self\_ideal\_value(\delta, a1)\ \&$$
$$state(\delta, t1)| = self\_image\_value(\delta, s1)\ \&$$
$$state(\delta, t2)| = self\_ideal\_value(\delta, a2)\ \&$$
$$state(\delta, t2)| = self\_image\_value(\delta, s2)\ \&$$
$$state(\delta, t1)| = self\_esteem\_value(\delta, r1)\ \&$$
$$state(\delta, t2)| = self\_esteem\_value(\delta, r2)\ \&$$
$$state(\delta, t1)| = self\_concept\_value(\delta, o1)\ \&$$
$$state(\delta, t2)| = self\_concept\_value(\delta, o2)\ \&$$
$$t1 \leq t2\ \&\ a1 > 0.5\ \&\ a2 > 0.7\ \&\ s1 > 0.5\ \&$$
$$s2 > 0.7\ \&\ r1 > 0.5\ \&\ r1 > 0.7\ \&\ o1 = a1\ \&$$
$$o2 = a2]$$
$$\Rightarrow o1 < o2$$

P1, P2, P3, and P4 may all be used to check if the simulation traces are valid, meaning that the model's generated patterns are correct. The correctness and dependability of models are the primary issues in the construction of any computational cognitive agent model. In this context, model correctness is typically understood to refer to how closely a model's behavior matches its formal specifications. The suggested agent-based model is evaluated using mathematical analysis. The equilibrium or stability points are drawn in mathematical analysis to ensure that the model develops as anticipated. The goal of mathematical analysis is to determine potential equilibrium values for other variables. When the temporal-causal networks are connected, they may be written as a set of differential equations:

$$\frac{dLEs(t)}{dt} = \frac{dLEf(t)}{dt} = \frac{dLCo(t)}{dt} = 0 \qquad (24)$$

Each stable-state temporal equation's resulting combinations can be rewritten as:

$$\begin{gathered}(LEs = SEs \vee LEs = 0 \vee LEs = 1) \wedge \\ (LEf = SEf \vee LEf = 0 \vee LEf = 1) \wedge \\ (LCo = SCo \vee LCo = 0 \vee LCo = 1)\end{gathered} \qquad (25)$$

Applying the Law of Distributivity, it can be re-created into a set of relationships by combining three logical conditions:

$$\begin{gathered}(LEs = SEs \wedge LEf = SEf) \vee (LEs = SEs \wedge LEf \\ = 0) \vee (LEs = SEs \wedge LEf = 1) \vee \\ (LEs = SEs \wedge LCo = SCo) \vee (LEs = SEs \wedge LCo \\ = 0) \vee (LEs = SEs \wedge LCo = 1) \vee \\ \ldots\ldots\end{gathered}$$

$$(LCo = 1 \wedge LEf = SEf) \vee (LCo = 1 \wedge LEf = 0) \vee (LCo = 1 \wedge LEf = 1) \quad (26)$$

Note that utilizing the other non-dynamic equations, more evidence concerning the equilibrium conditions of other variables can be uncovered for each of the selected examples and linked to literature.

Case #1: $(LEs = 1 \wedge LEf = 0)$

When a worker is both long term high self-esteem and self-efficacy, according to the equation of self-concept (Eq. (20)), the worker's self-concept/self-ideal is determined by his or her self-image specification as follows:

$$\delta_{SCo}.(\omega_{SCo}.LCo + \omega_{SCo}.Im) + (1 - \delta_{SCo}).LEs = 0 \quad (27)$$

Where $LEs = 1$

$$\delta_{SCo}.(\omega_{SCo}.LCo + \omega_{SCo}.Im) + (1 - \delta_{SCo}) = 0 \quad (28)$$

Where $\delta_{SCo} = 1$

$$(\omega_{SCo}.LCo + \omega_{SCo}.Im) = 0 \quad (29)$$

Hence,

$$LCo = -Im \quad (30)$$

The simulation trace is shown in Fig. 7 shows the worker's self-concept is controlled by the worker's self-image as well as the self-actualization is difficult based on Abraham Maslow's theory [65]. Thus, by taking $LEf = 0$, the worker's ability is solely based on effort which means that the worker's effort is used to boost his/her ability and may lead to failure situation at work based on the theory of attribution [65, 66] as shown in Fig. 8, and from equations of performance (Eq. (9)) as follows:

$$\omega_{Pe}.Ab + \omega_{Pe}.LEs + \omega_{Pe}.LEf + \omega_{Pe}.Ef = 0 \quad (31)$$

Where $LEs = 1 \wedge LEf = 0$

$$\omega_{Pe}.Ab + \omega_{Pe} + \omega_{Pe}.LEf = 0 \quad (32)$$

Where $\omega_{Pe} = 1$

$$Ab + 1 + LEf = 0 \quad (33)$$

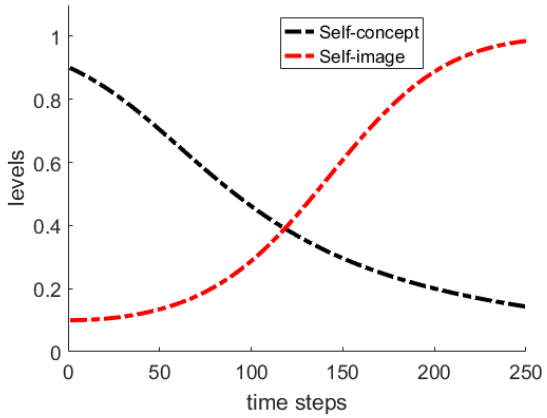

Figure. 7 Simulation results of worker's self-concept and self-image

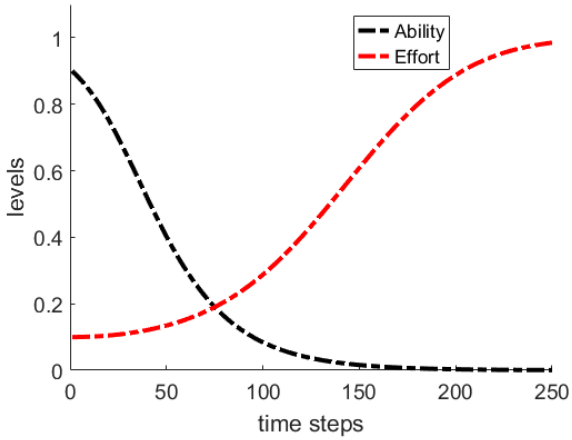

Figure. 8 Simulation results of worker's ability and effort

Hence,

$$Ab = -Ef - 1 \quad (34)$$

Case #2:$(LEs = 0 \wedge LEf = 0)$

When a worker is on low self-esteem and self-efficacy for a lengthy period at the same time, he or she may not feel motivated during the work, according to the equation of motivation (Eq. 10), the norm motivation of the worker is too low [67] as follows:

$$\vartheta_{Mo}.Nm + (1 - \vartheta_{Mo}).(\omega_{Mo}.LEf + \omega_{Mo}.LEs) = 0 \quad (35)$$

Where $LEs = 0 \wedge LEf = 0$

$$\vartheta_{Mo}.Nm = 0 \quad (36)$$

Where $\vartheta_{Mo} = 1$

$$Nm = 0 \quad (37)$$

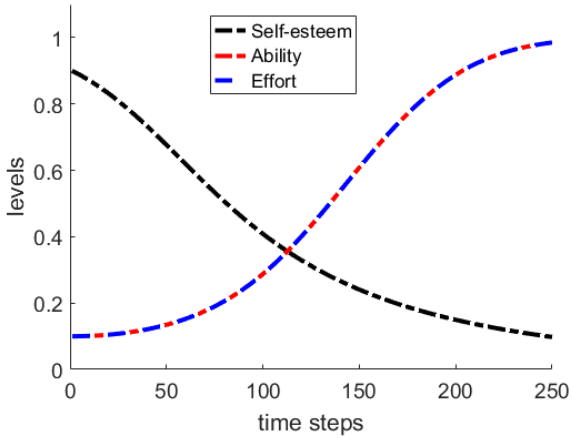

Figure. 9 Simulation results of worker's self-esteem, ability and effort

Thus, by taking $LEf = 0$, the self-esteem becomes conflicted, unstable, or even weak as a result of this condition which means the worker may be in worthiness-based self-esteem or competence-based self-esteem [14, 15], from equations of performance (Eq. (9)) as follows:

$$\beta_{SEs}.(\omega_{SEs}.Co + \omega_{SEs}.Wo) + (1 - \beta_{SEs}).LEf = 0 \quad (38)$$

Where $LEf = 0$

$$\beta_{SEs}.(\omega_{SEs}.Co + \omega_{SEs}.Wo) = 0 \quad (39)$$

Hence,

$$Co = -Wo \quad (40)$$

Or

$$Wo = -Co \quad (41)$$

Case #3: $(LEs = SEs \wedge LEf = 0)$

When a worker is on short-term self-esteem and lack self-efficacy for a lengthy period of time at the same time, the worker's self-esteem may be controlled by the ability and effort of the worker [67, 68], according to the equation of performance (Eq. (9)) and as shown in Fig. 9 as follows:

$$\omega_{Pe}.Ab + \omega_{Pe}.LEs + \omega_{Pe}.LEf + \omega_{Pe}.Ef = 0 \quad (42)$$

Where $LEs = SEs \wedge LEf = 0$

$$\omega_{Pe}.Ab + \omega_{Pe}.SEs + \omega_{Pe}.LEf = 0 \quad (43)$$

Where $\omega_{Pe} = 1$

$$Ab + SEs + LEf = 0 \quad (44)$$

Hence,

$$SEs = -(Ef + Ab) \quad (45)$$

6. Conclusion

The development of a computational model to scientifically contribute to the interpretation of dynamical self-confidence at work was described in this paper. To construct the model, a range of fundamental ideas in self-confidence and their causal interplays were explored and related in the literature. Differential equations were also employed to formalize the model and execute the simulation. The proposed model was tested in four of situations (self-esteem, self-efficacy, self-concept, and self-confidence) to examine how well it matched the core principles of workplace self-confidence using different personality characteristics and environmental factors. To examine feasible equilibrium conditions and compatible cases in the literature, mathematical analysis was used. The model's validity was also tested using temporal trace language via automated logical verification.

The proposed model's limitations are focused on three basic self-confidence: self-concept, self-efficacy, and self-esteem. In future work, the Self-Modeling Networks approach [69] will be used to model other underlying theories in self-awareness emotional intelligence symptoms at work. In addition, one of our future efforts will be to integrate the proposed dynamical model into the hyper-automation strategy.

Conflicts of Interest

This research has no ethical implications.

Author Contributions

The theoretical framework was built by the first author, who also carried out the analytic computations and numerical simulations. The second and third authors finished the literature review. The fourth and fifth authors analyzed the literature review.

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