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‘I Ain’t Like You’ A Complex Network Model of Digital Narcissism

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Abstract. Social media like Twitter or Instagram play a role of fertile ground for self-exhibition, which is used by various narcissists to share their frequent updates reflecting their narcissism. Their belief of saving and assisting others, make them vulnerable to the feedback of others, so their rage is as dangerous as their messiah complex. In this paper, we aim to analyse the behaviour of a narcissist when he is admired or receives negative critics. We designed a complex adaptive mental network model of the process of narcissism based on the theories of neuroscience and psychology including a Hebbian learning principal. The model was validated by analyzing Instagram data.

Keywords: Narcissistic rage · Narcissism · Complex mental network

1 Introduction

“My character has ever been celebrated for its sincerity and frankness, and in a cause of such moment as this, I shall certainly not depart from it. (Pride and Prejudice:56)”.

Narcissism was addressed by various fiction characters like Lady Catherine (Pride and Prejudice), who always tried to be a savior and was overly concerned about how others think of her. Now in the age of technology, they can be observed by people who excessively use social media, like Twitter or Instagram [1], to share their lifestyle updates. These online communities are targeted as fertile grounds for self-presentation and getting the appraisal, especially by millennials, who tend to use whatever chrism and social skills to become quantifiers or influencers [1]. The exponential growth of audience makes narcissists more vulnerable to negative feedback, and usually make them unhappy about others [2]. Narcissistic rage is a psychological construct that addresses a negative reaction of a narcissist person, when he or she assumes that his self-worth is in danger.

Narcissistic rage is a common outcome due to lack of empathy, and it is the more related outcome to an ego-threatening action rather than self-esteem. It is to be made clear, that this is not related to self-esteem, but to the desire of self-admiration [3]. There are two types of narcissism, discussed in the literature: ‘overt’ or ‘covert’. They both share grandiose fantasies, feeling of superiority, but covert narcissists, don’t reveal their true self, thus may show aggression towards others [4]. In literature, different studies were conducted with respect to the psychology and neuroscience of a narcissist in certain surrounding conditions [3, 5]. Also, Artificial intelligence is used to identify a

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narcissist [6]. However, no study has been presented in the domain of Mental Network Modeling, which can address: (a) the mental organization of a narcissist, (b) how his mental processes learn from experience, (c) how to relate a presumed narcissist with his or her cognitive behavior by taking social feedback into account, with respect to his social interaction.

In this paper, we present a complex-adaptive network model of a narcissist, based on psychological and neurological studies. We address non-trivial interaction of a narcissist brain (a) during a reward-seeking behavior, and (b) a consequence of an unwanted remark. We validated our model by case studies. Section 2 follows related work while Sect. 3 presents the model of a narcissist. Section 4 discusses the simulation scenarios, while Sect. 5 validates the model using public data through Instagram. Section 6 concludes the paper.

2 Related Work

This section explains the psychological and, neurological perspective of a narcissist. On the one hand, it provides literature: how a narcissistic behaves when (a) admired or (b) negatively criticized. On the other hand, it will address the problem in relation to complex networks and artificial intelligence.

Psychologically, a narcissist exhibits a higher tendency for self-presentation [2]. Many studies show an association between narcissism and reward-seeking behavior [3]. A survey indicates that Instagram is widely used service among other social networks, to exhibit grandiose narcissism. A narcissist who receives added appreciation often appears to be compassionate and happy [1]. A survey showed that people, who are not satisfied with their appearance are more vulnerable to anger, due to lack of empathy. As a result, narcissists are prone to bullying or violence [3, 5].

In a cognitive and neurological aspect, we would like to discuss cognitive parts of brain, hormones, along with the neurotransmitters, which process the self-relevant stimuli. A narcissist seeks admiration, which activates brain regions, like the Prefrontal Cortex, Anterior Cingulate Cortex (ACC), anterior Insula and Temporal lobe, which is strengthened during self-enhancement and mentalizing [7]. High activations in the anterior insula indicate focus on oneself or representing selfishness [5]. It is indicated that ventral striatum is involved with ACC, and get activated during reward-seeking behaviour. It depends on pre-synaptic and post-synaptic activations along with dopamine release. The facial attractiveness strengthens the synaptic transmission due to contingent feedback and dopaminergic projections [8]. ACC is also related to negative emotional valence which may lead to aggression. Also, stress faced in a social competitive environment makes the brain more vulnerable to experience anxiety [9].

Like in reward-seeking, hormones and neurotransmitters also play a role in aggression. For instance, noticeable levels of progesterone, testosterone and low levels of corticosterone help in mediating aggression along with γ-aminobutyric acid (GABA) receptors activation, due to anxiety [10]. Decreased levels in 5-serotonin (5-HT) leads to aggression. Further, vascular endothelial growth factor (VEGF) is a signal protein in the hippocampal region, which is effected in psychological stress. Damage in its microstructure and decrease in synaptic connections, influence the release of neurotransmitters in the hippocampal region during stress. This decrease in synaptic plasticity hinders the message transfer to the central nervous system along with the changes in the brain structure, learning, and memory [10]. Long term effects of stress can lead to long-term genetic and epigenetic metaplastic effects [11]. Also, a presynaptic receptor 5-HT_{1A}, located in 5-HT has a greater density in people with high aggression, along with brain regions that are related to impulsive control [12].

A study was also presented, which incorporated machine learning techniques to identify a narcissist [6]. A temporal causal model is 'discussed in the context of esteem' [13]. However, no research was found, which could address the vulnerability in a narcissist and his reaction over certain feedback.

3 Complex Adaptive Mental Network Model of a Narcissist

In this section, a complex adaptive mental network of a narcissist is presented based upon studies addressed earlier, using a multilevel reified architecture [14, 15]. This is a layered architecture, where the temporal and adaptive dynamics of a model are represented in layers, from the base model to the evolution of the complex network by first and second order adaption principles, along with its mathematical representation.

A base temporal-causal model refers to a conceptual representation of a real-world scenario, depicted by *states* and *connections* where a *connection* designates a causal relationship among *states*. For example, consider two states *X* and *Y*, if *Y* is affected by *X* then $X \rightarrow Y$ is a causal relationship. More specifically, the activation value of *Y* is the *aggregated impact* of all influencing states along with *X*. The influencing states have different *activation levels* and *connection weights* to influence *Y*, that has a *speed factor* indicating the timing of influence. Such a temporal-causal model is characterized by [16]:

Connection weight $\boldsymbol{\omega}_{X,Y}$ indicates how strong state *X* influences state *Y*. The magnitude varies between 0 and 1. A suppression effect is categorized by a negative connection.

Speed factor $\boldsymbol{\eta}_Y$ indicates that how fast a state *Y* changes its value upon a causal impact; values range from [0–1].

Combination function $\mathbf{c}_Y$(..) is chosen to compute the causal (aggregated) impact of all incoming states $(X_i : i = 1 \text{ to } N)$ for state *Y*. Certain standard combination functions are defined already to compute the aggregated impact of *Y*.

In Fig. 1, layer I presents the base model with 38 states, depicting the mental organization and psychology of a narcissist. It shows reactions of a narcissist when he receives admiration or negative criticism. The extended structure of the model is also explained by Layer II and III. A concise explanation of each state in figures is specified in Tables 1 and 2.

In layer I, a narcissist receives a feedback while using social media (ws_s, ss_s), after sharing his picture or a status. Feedback can be a positive (ws_{pf}, ss_{pf}, srs_{pf}) or a negative (ws_{nf}, ss_{nf}, srs_{nf}) remark which can make him happy or he can feel hurt. On receiving a compliment like 'you are awesome' his self-belief (bs_+) evaluates it as a positive remark (eval+), thus leads to a happy reaction (es_{happy}: i.e. a gratitude). Brain related parts (striatum, pfc and insula) get activated more than usual, along with feelings of self-reward (fs_{reward}) and self-love (fs_{love}). This behavior increases by experiencing the same kind of feedbacks over the time (adaption/learning).

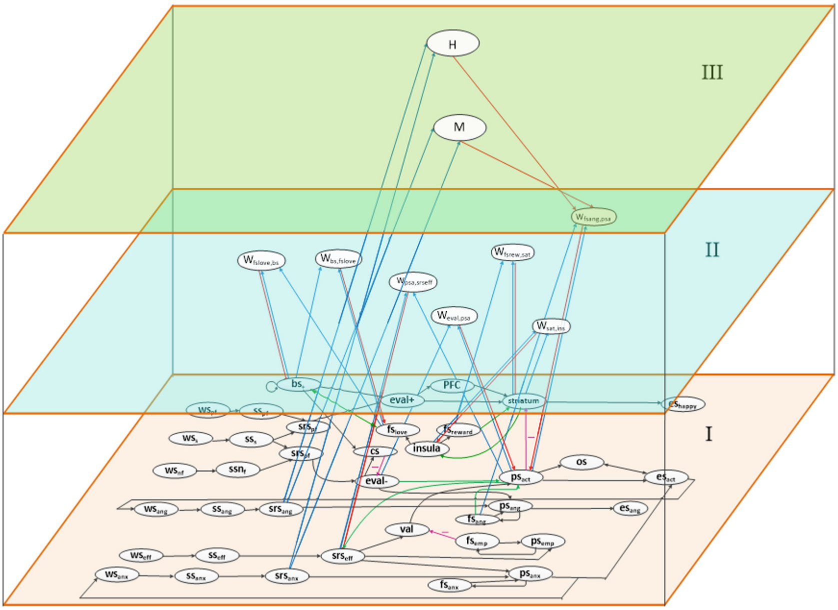

Fig. 1. Reified network architecture for a narcissist person.

Upon a negative critic (ws_{nf}, ss_{nf}, srs_{nf}), a narcissist usually disagrees due to high ego/self-belief, and gets angry, which also induces anxiety in him. To explain it further, consider a poor remark 'you are ugly', activates state (eval-). Self-belief (bs_{+}) tries to suppress eval- through control state (cs). However, eval- is too strong to be suppressed. It has dual influence: a) It stimulates anger (ps_{ang}) along with its body loop (ws_{ang}; ss_{ang}; srs_{ang}; fs_{ang}; ps_{ang}; es_{ang}), e.g. 'a raised eyebrow' and, b) preparation state of action (ps_{act}) is also activated by an aggregated impact of eval-, val and fs_{ang}. Here 'val' is the valuation state which doesn't gets activated if a person has empathy (fs_{emp}; ps_{emp}), which narcissist lacks. So, in turn ps_{act} activates the execution state (es_{act}), i.e. an angry reply. This reaction involves a thought process about predicted effect (ws_{eff}; ss_{eff}; srs_{eff}), and eventually anxiety is induced (ws_{anx}; ss_{anx}; srs_{anx}; ps_{anx}; fs_{anx}). However, anxiety still elevates reaction (es_{act}). Please note, as social media is not controllable, therefore es_{act} doesn't influence ws_{nf}. Black horizontal arrows (layer I) show non-adaptive causal relations, while green show the adaptive ones. Purple arrows shows suppression from one state to another.

Table 1. Categorical explanation of states of base model (layer I).

Categories		References
Stimulus states		*Stimulus is sensed and leads to representation: p51* [16]
ws_i	World state. i = stimulus (s); positive/negative feedback (pf/nf)	
ss_i	Sensory state. i = stimulus; pf/nf	
srs_i	Representation state j = pf/nf	
Attribution/evaluation states		*Narcissism involves states for self-enhancement and mentalizing* [7]
eval+	Positive evaluation of feedback	
eval-	Negative evaluation of feedback	
Happiness related states		*fMRI studies show activations at or near dopaminergic midbrain nuclei and the VS that correlate with both reward expectation and reward prediction errors…* [8]
bs_+	Self-belief state	
striatum	Ventral Striatum: brain part	
PFC	Prefrontal Cortex: brain part	
fs_{reward}	Feeling state of reward (Amygdala)	
fs_{love}	Feeling state self-love (Amygdala)	
es_{happy}	Execution state of happiness	
insula	Anterior Insula: brain part	
Anger related action states		*… predictive and inferential processes contribute to conscious awareness … action" p212* [16]
os	Ownership state	
ps_{act}	Preparation state of action	
es_{act}	Execution state of action	
Body loops (anger and anxiety)		*Body loop via the expressed emotion is used to generate a felt emotion by sensing the own body state… the emergence of states* [16]
ws_i	World state i = anger/anxiety (ang /anx)	
ss_i	Sensor state i = anger/anxiety (ang/anx)	
ps_i	Preparation state of i = ang/anx	

(*continued*)

Table 1. (*continued*)

Categories		References
fs_i	Feeling state i = ang/anx	
es_{ang}	Execution state (Expression of anger)	
Predicted effect of action		*Sensory feedback provides more precise evidence about actions and their effects. p212* [16]
ws_{eff}	World state of effect	
ss_{eff}	Sensor state of effect	
srs_{eff}	Representation state of effect	
Control states		*ACC become active in parallel with the insula when we experience feelings". p109* [16]
cs	Control state	
val	Valuation state	

Layer II, presents the plasticity of the model, while layer III represents meta-plasticity. Each layer is connected by upward (blue) and downward (red) arrows. Layer II incorporates Hebbian principle [17] by upward (blue) and downwards (red) arrows with states at layer I [14]. For instance, for a narcissist receiving appreciation, feeling of reward (fs_{reward}) stimulates ventral striatum (striatum) [8], is represented by connection $fs_{reward} \rightarrow$ striatum. Its increases over the time, this increase is due to pre-synaptic (fs_{reward}) and post-synaptic (striatum) states depend on dopamine based activations (dopamine release) and this is represented through $\mathbf{W}_{fs_{reward},striatum}$.

Layer III represents meta-plasticity, through states M and H, that can control the learning of state $\mathbf{W}_{fs_{ang},ps_{act}}$ at layer-II. Former indicates persistence, while later specifies the learning rate of $fs_{ang} \rightarrow ps_{act}$. Usually, every W state at layer II has meta-plasticity, because of presynaptic and post synaptic states involvement in gaining experience [14]. However, to keep the complex network simple, we only meta-plasticized the angry reaction of a narcissist, which is due to changes in the synaptic connections [10, 11].

Table 2. Explanation of states in layer II and III.

States per layer		References
Layer II (plasticity/omega states)		*1–4: Potentiation in the striatum depends not only on strong pre- and postsynaptic activation … reward prediction … modify behavior* [8] *5–7: Presynaptic somatodendritic 5-HT1… people with a high level of aggression, there is a greater density … with impulse control* [12]
1. $\mathbf{W}_{fs_{love},bs}$	For $fs_{love} \rightarrow bs$	
2. $\mathbf{W}_{bs,fs_{love}}$	For $bs \rightarrow fs_{love}$	
3. $W_{striatum,insula}$	For striatum $\rightarrow$ insula	
4. $\mathbf{W}_{fs_{reward},striatum}$	For $fs_{reward} \rightarrow$ striatum	
5. $\mathbf{W}_{eval-,ps_{act}}$	For eval- $\rightarrow ps_{act}$	
6. $\mathbf{W}_{ps_{act},srs_{eff}}$	For $ps_{act} \rightarrow srs_{eff}$	
7. $\mathbf{W}_{fs_{ang},ps_{act}}$	For $fs_{ang} \rightarrow ps_{act}$	
Layer III (meta-plasticity)		*Damage to neurons in hippocampal CA3 area and microstructure of synapse indicates that anger… harms plasticity….* [10]
H	Speed factor for $\mathbf{W}_{fs_{ang},ps_{act}}$	
M	Persistance factor for $\mathbf{W}_{fs_{ang},ps_{act}}$	

For computation of impacts most speed factors η and connection weights ω at layer I, have values between 0 and 1. Please note that for $\mathbf{W}_{fs_{ang},ps_{act}}$ the speed factor is adaptive, i.e. based on the reification state H, therefore we used adaptive combination function for computation. Here Δt is 0.5. We used three type of combination functions for the simulation of our model (Fig. 1):

(a) For 24 states (ws_s; ss_{pf}; ss_{nf}; ss_s; srs_{pf}; pfc; eval+ ; es_{happy}; eval-; os; es_{act}; ss_{ang}; srs_{ang}; ps_{ang}; es_{ang}; fs_{ang}; fs_{emp}; ws_{eff}; ss_{eff}; ws_{anx}; ss_{anx}; srs_{anx}; ps_{anx}; fs_{anx}), we used Euclidian function, with order $n > 0$ and scaling factor λ as the sum of connection weights of a particular state:

$$\mathbf{eucl}_{n,\lambda} \cdot (V_l, \ldots, V_k) = \sqrt[n]{\left(V_1^n + \cdots + V_k^n\right)/\boldsymbol{\lambda}}$$

(b) For 14 states (srs_{nf}; bs; striatum; fs_{love}; fs_{reward}; insula; cs; ps_{act}; ws_{ang}; val; ps_{emp}; srs_{eff}; H; M), we used the **alogistic** function with positive values of steepness σ and threshold τ less than 1:

$$\mathbf{alogistic}_{\boldsymbol{\sigma},\boldsymbol{\tau}}(V_1, \ldots, V_k) = \left[\left(1/\left(1 + e^{-\sigma(V_1 + \ldots + V_k - \tau)}\right)\right) - 1/(1 + e^{\sigma\tau})\right](1 + e^{-\sigma\tau})$$

where V is the single impact computed by product of state values and its connection weight i.e. $\omega_{X,Y}\, X(t)$.

(c) c) Lastly, for 7 adaptation states ($\mathbf{W}_{bs,fs_{love}}$; $\mathbf{W}_{fs_{love},bs}$;$\mathrm{W}_{striatum,insula}$; $\mathbf{W}_{fs_{reward},striatum}$; $\mathbf{W}_{ps_{act},srs_{eff}}$; $\mathbf{W}_{fs_{ang},ps_{act}}$; $\mathbf{W}_{eval-,ps_{act}}$) we used Hebbian learning:

$$\mathbf{hebb}_{\mu}(\mathrm{V}_1, \mathrm{V}_2, \mathrm{W}) = V_1 V_2 (1 - W) + \boldsymbol{\mu} W$$

Mathematically, a reified-architecture based model is represented as [14]:

1. At every time point t, the activation level of state Y at time t is represented by $Y(t)$, with the values between [0, 1].
2. Impact of state X on state Y at time t is represented by $\mathbf{impact}_{X,Y}(t) = \omega_{X,Y}\, X(t)$; where $\omega_{X,Y}$ is the weight of connection $X \rightarrow Y$.
3. Special states are used to model network adaptation based on the notion of reification network architecture. For example, $\mathbf{W}_{X,Y}$ represents an adaptive connection weight $\omega_{X,Y}(t)$ for the connection $X \rightarrow Y$, while $\mathbf{H}_Y$ represents an adaptive speed factor $\eta_Y(t)$ of state Y. Similarly, $\mathbf{C}_{i,Y}$ and $\mathbf{P}_{i,j,Y}$ represent adaptive combination functions $c_Y(.., t)$ over time and its parameters respectively. Combination functions are built as a weighted average from a number of basic combination functions $bcf_i(..)$, which take parameters $P_{i,j,Y}$ and values V_i as arguments. Universal combination function $\mathbf{c}^*_Y(..)$ for any state Y is defined as:

$$\mathbf{c}_Y^*(S, C_1, \ldots, C_m, P_{1,1}, P_{2,1}, \ldots, P_{1,m}, P_{2,m}, V_1, \ldots, V_k, W_1, \ldots, W_k, W) = W + S\left[C_1 \mathrm{bcf}_1(P_{1,1}, P_{2,1}, W_1 V_1 \ldots W_k V_k)\right.$$
$$\left. + \cdots + C_m \mathrm{bcf}_m(P_{1,m}, P_{2,m}, W_1 V_1, \ldots, W_k V_k)/(C_1 + \ldots + C_m) - W\right]$$

where at time t:

- variable S is used for the speed factor reification $\mathbf{H}_Y(t)$
- variable C_i for the combination function weight reification $\mathbf{C}_{i,Y}(t)$
- variable $P_{i,j}$ for the combination function parameter reification $\mathbf{P}_{i,j,Y}(t)$
- variable V_i for the state value $X_i(t)$ of base state X_i
- variable W_i for the connection weight reification $\mathbf{W}_{X_i,Y(t)}$
- variable W for the state value $Y(t)$ of base state Y.

4. Based on the above universal combination function, the effect on any state Y after time Δt is computed by the following *universal difference equation* as:

$$Y(t+\Delta t) = Y(t) + \left[\mathbf{c}_Y^*\left(\mathbf{H}_Y(t), \mathbf{C}_{1,Y}(t), \ldots \mathbf{C}_{m,Y}(t), \mathbf{P}_{1,1}(t), \mathbf{P}_{2,1}(t), \ldots, \mathbf{P}_{1,m}(t), \mathbf{P}_{2,m(t)}, X_1(t), \ldots, X_k(t), \mathrm{W}_{X_1,Y}(t), \cdots, \mathrm{W}_{X_k,Y}(t), Y(t)\right) - Y(t)\right]\Delta t$$

which also can be written as a *universal differential equation*:

$$\mathbf{d}Y(t)/\mathbf{d}t = \mathbf{c}_Y^*\left(\mathbf{H}_Y(t), \mathbf{C}_{1,Y}, (t), \ldots, \mathbf{C}_{m,Y}(t), \mathbf{P}_{1,1}(t), \mathbf{P}_{2,1}(t), \ldots, \mathbf{P}_{1,m}(t), \mathbf{P}_{2,m}(t), X_1(t), \ldots, X_k(t), \mathbf{W}_{X_1,Y}(t), \ldots, \mathbf{W}_{X_k,Y}(t), Y(t)\right) - Y(t)$$

Our Simulation environment was implemented in MATLAB, and receives input of the characteristics of a network structure represented by role matrices. A role matrix is a compact specification with the concept of the role played by each state with specified information. Detailed information for the designed model can be found online [15, 18].

4 Simulation Scenarios

Simulation scenarios are used to verify the dynamic properties of the model by simulating real-world processes. Simulations of the model are addressed below by two kinds of comment: (a) appreciation or (b) a negative critic.

4.1 Reaction of a Narcissist When Appreciated

Twitter, Facebook [2] or Instagram [1] are a few popular platforms used by narcissists to gain recognition and prominence. Many scholars have been studying "messiah complex" of Donald Trump [19]. To illustrate his behavior related to reward-seeking and self-love, we can take his tweet as an example of self-love and self-reward:

> "…my two greatest assets … mental stability and being, like, really smart … I went from VERY successful businessman, to top T.V Star…." (Tweeted: 1:27 PM – Jan 6, 2018)

Figure 2 shows that when positive feedback arrives, eval+ (purple) is activated, which activates PFC and reward seeking process through striatum. These activations along with self-belief (bs_+) make feelings of self-love ($\mathrm{fs}_{\mathrm{love}}$) and reward ($\mathrm{fs}_{\mathrm{reward}}$) high.

As a result, he expresses his gratitude (es_{happy}). Here, insula indicates the self-thinking process, which increases self-love and feeling of reward more and more.

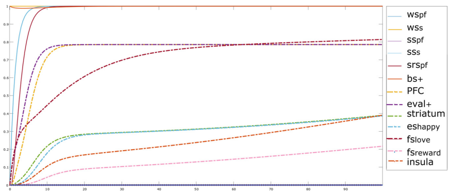

Fig. 2. Simulation of the model when ws_{pf} = 1 and ws_{nf} = 0.

4.2 Reaction of a Narcissist on a Negative Feedback

A narcissist, observing ego-threatening feedback, doesn't hesitate to share his reactions. While studying Donald Trump, we can identify his overtly reactions easily on any of stances, which are evaluated as threat to his ego. For example, consider the tweet of Donald Trump as:

> "… world class loser, Tim O`Brien, who I haven't seen or spoken … knows NOTHING about me … wrote a failed hit piece book…" (Tweeted: 6:20 AM – Aug 8, 2019) [20].

Figure 3 explains the behavior of a narcissist over negative feedback (shaded region) in episodes: i.e. from 100–200; and 300–400. Reward related states in the white region (e.g. fs_{love}, fs_{reward},..) are suppressed, eval- (purple) is raised due to srs_{nf} and cs. It is responsible for two more activations. Firstly, it activates body loop of anger in red (ws_{ang}, ss_{ang}, srs_{ang}, fs_{ang}, ps_{ang} and es_{ang}), which in turn activates the effect related states in green (ws_{eff}, ss_{eff}, and srs_{eff}). Secondly, it stimulates urge to respond by ps_{act}, os and es_{act}, however this leads him to experience anxiety in blue (ws_{anx}, ss_{anx}, srs_{anx}). Narcissists lacks empathy (fs_{emp} and ps_{emp}), therefore valuation (val) is not suppressed. As a result he replies to such feedback. Over the time (X-axis), it can be seen that such behavior continues to aggravate (by Hebbian learning) by similar experiences. Detailed explanation of each curve can be found online [18].

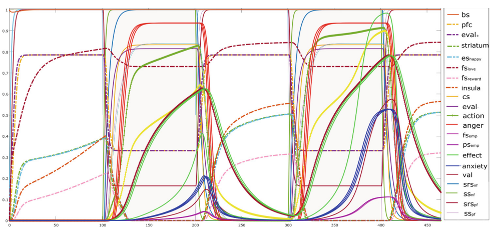

Fig. 3. Simulation of the model with alternative episodes of ws_{nf} = 1 or ws_{pf} = 1.

5 Model Validation and Analysis

The model is validated by three public Instagram users, with presumably narcissistic characteristics (names are not disclosed here). Reasons for choosing Instagram are: (a) users show more tendency towards narcissism [1] and, (b) this platform contain conversational elements, which can be helpful for our study.

5.1 Extraction and Analysis of Data

We extracted data from Jan 2017–July 10, 2019 and tested for three hypothesis: (A) *Frequency of sharing posts increases over a period of time*. (B) *Average number of likes increase with the number of shared posts*. (C) *They get happy when admired, but covert/overt behavior can be seen towards a critic*.

To come up with these hypotheses, data was analyzed in two steps. First, we analyzed a number of posts shared with the average number of likes per month. Figure 4-a shows that each profile user 1/2/3 tends to share more by the passage of time. Similarly, Fig. 4-b indicates that the number of average likes a profile receives increases. For example, Profile 1 (indicated by blue) 2 posts with avg. likes (817.5) (in Jan 2017), raised by 25 posts with avg. likes 7045.5 (July 2019). Please note, we didn't consider the number of followers the user had in mentioned duration, which makes average number of likes a bit subjective. However, the trend line of Fig. 4-a, indicates that Profile1 finds a good reason to share updates with increasing frequency of 25 posts per month.

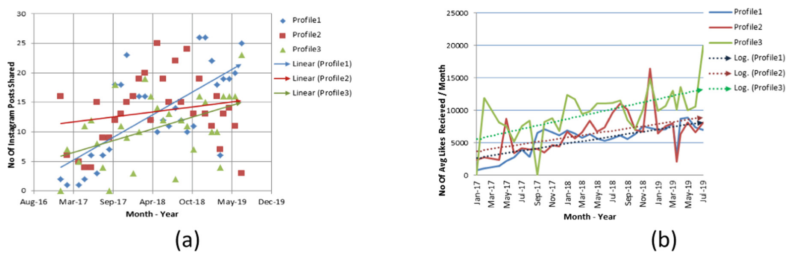

Fig. 4. Number of (a) Posts shared, (b) Average Likes received during a period of time

Our third hypothesis is related to the temporal analysis of data. Each post is deeply analyzed (Fig. 5). We selected conversations in each post, where profile user participated. We used Vader Sentiment Analysis [21] to analyze the first message in the conversation as positive, neutral or negative ones. Looking closely, it was revealed that various elements in negative conversation were an expression of positive assurance, but were misclassified (e.g. comment "🔥🔥 Fierce as fuck" score = −0.54). At this point, we used rule-based classification using further characteristics of data. Algorithm can be found online [18].

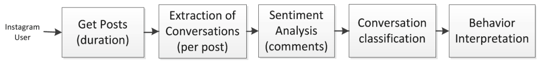

Fig. 5. Steps taken to interpret the behavior of each user

A stacked graph of three categories of conversation for each profile was plotted (Fig. 6). In general, it can be seen that most of the feedbacks received were positive or neutral, which provides a good reason for frequent posting on Instagram (Fig. 4). A mixed ratio of conversations can be seen. Like Profile 1, the users reaction was never negative in 2017. Similarly, Profile 2 has more in 2018 or 2019. On the contrary, Profile 3, had more negative conversations in 2017, a reason can be that he doesn't indulge into conversations anymore.

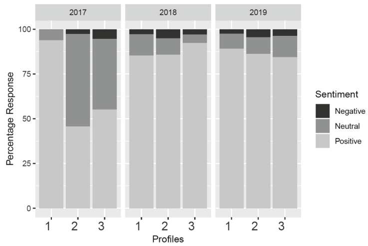

Fig. 6. Conversation ratio per profile from Jan 2017–July 2019

However, it can be concluded that narcissistic people do not hesitate to react over a negative comment in an overtly or covertly manner. Anxious behavior is not studied, as authors don't know them personally. However, it would not be wrong to say that learning from experience facilitates users to go further for sharing in their lifestyle, or responding to different followers. Our model also addresses the experience and reactions after experiences of the users.

5.2 Exhibition of Learning Experience in the Model

While looking into Fig. 4, we can see the complex learning behavior between all three layers over the time (in episodes). As addressed in Sect. 4, that an urge to respond (action: ps_{act}; es_{act}; os) increases on the basis of predicted effect (effect: ws_{eff}, ss_{eff} and srs_{eff}). Similarly, reward related states (striatum, fs_{reward}, fs_{love},insula) are also elevated than before when a narcissist is admired. This can also be seen by the adaptive states (Layer II and III) shown in Fig. 7. For example, considering $\mathbf{W}_{eval-, ps_{act}}$ (purple), we can see that it start increasing its value (e.g. from 0.2) in every negative episode (to 0.7). Similarly, M (brown) and H (blue) increase in every negative episode and suppressed otherwise. However, it can be seen that due to meta-plasticity, $\mathbf{W}_{fs_{ang}, ps_{act}}$ was not much raised (shaded region), which indicates that due to synaptic plasticity learning is effected [10], the similar pattern is observed during analysis of data, that action is followed if effect is assumed to be higher, i.e. if the feedback is really hurting the esteem of a narcissist then he will go towards an angry reaction and a happy gesture is observed upon admiration, the reason can be he wants to show that he is loved by many individuals.

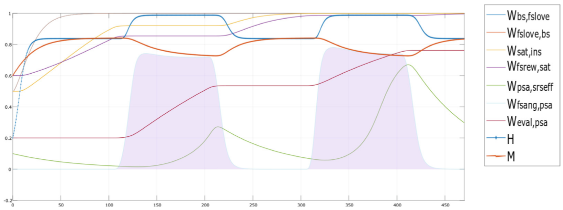

Fig. 7. Effects of plasticity (W states) and metaplasticity for $\mathbf{W}_{fs_{ang},ps_{act}}$ (M and H)

6 Conclusion

In this paper, we discussed the complex adaptive mental network model of the processes of a narcissist, who reacts in different ways after having a positive, or negative feedback, and how prior experiences play role in learning and responding through different layers of reified network architecture. We tested our network model on Instagram data which is assumed to be a fertile ground for people with a narcissistic personality. Through the analysis of temporal data obtained from three users of Instagram, it was concluded that our model indeed depicts the behavior of a narcissist and reflects his/her joy or rage upon feedback.

In future research, we aim to extend our work, to incorporate how to react to a narcissistic person and explore his traits further. Moreover, we aim to detect and model how to support these complex behaviors among narcissists.

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