Temporal Dynamics of Subjective Perception: A Formal Framework for Mapping Cognitive Structures Across Time

Abstract

Subjective perception can be understood as a dynamically evolving process in which incoming information interacts with pre-existing thoughts, beliefs, attitudes, subconscious processes, and conscious representations of reality. This article develops a conceptual and mathematical framework for describing these interactions across time. The proposed model represents an individual's cognitive state as a structured system composed of **thoughts (T), beliefs (B), attitudes (A), subconscious processes (SC), and conscious reality (CR)**. Information entering the system at different temporal points, denoted as $\mathbf{I}_1$ and $\mathbf{I}_2$, is processed through this cognitive architecture and can produce different conscious representations of reality depending on the state of the system at the time of input.

The central proposition is that subjective reality is not determined exclusively by external information. Rather, it emerges from the interaction between information and a temporally evolving internal cognitive state. Consequently, identical information may generate different conscious representations when processed at different points in time. The framework also proposes reciprocal feedback between conscious reality and the underlying cognitive variables, allowing experiences to modify subsequent beliefs, attitudes, thoughts, and subconscious representations. The model provides a formal basis for studying temporal changes in perception and may serve as a conceptual foundation for research in cognitive science, psychology, computational modeling, and human–information interaction.

Keywords: subjective perception, cognition, consciousness, subconsciousness, beliefs, attitudes, temporal dynamics, information processing, cognitive systems, feedback loops

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1. Introduction

Human perception is commonly experienced as a continuous representation of reality. However, the subjective reality experienced by an individual is not necessarily a direct copy of the external world. The same external event can be interpreted differently by different individuals, or by the same individual at different moments in time.

This variability suggests that perception depends not only on incoming information but also on the internal state of the cognitive system processing that information. Previous experiences, beliefs, attitudes, expectations, thoughts, and processes that are not directly accessible to conscious awareness can influence how new information is interpreted.

The present article proposes a formal framework for representing this process as a **temporal cognitive system**. The framework is based on five principal components:

- **T — Thoughts:** currently represented cognitive content or interpretations.

- **B — Beliefs:** relatively persistent propositions or assumptions about the world or oneself.
- **A — Attitudes:** evaluative orientations toward objects, events, people, or situations.
- **SC — Subconsciousness:** processes and representations operating partly outside direct conscious awareness.
- **CR — Conscious Reality:** the individual's currently experienced and consciously accessible representation of reality.

The framework additionally introduces information inputs $\mathbf{I}_1$ and $\mathbf{I}_2$, which enter the cognitive system at different points in time.

The important feature of the model is therefore not simply the presence of these variables but their **temporal organization and mutual interaction**. A cognitive system at time t1t_1 receives information and produces a conscious representation. That representation can subsequently modify the internal cognitive state, which then influences the interpretation of information received at t2t_2.

Thus:

$$\text{Information} + \text{Cognitive State at } t \rightarrow \text{Conscious Reality at } t$$

and subsequently:

$$\text{Conscious Reality at } t \rightarrow \text{Modified Cognitive State at } t + \Delta t$$

This creates a dynamic feedback system rather than a simple linear input-output process.

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2. Conceptual Architecture

2.1 Cognitive State

Let the internal cognitive state of an individual at time tt be represented by the vector

$$X(t) = \begin{bmatrix} T(t) \\ B(t) \\ A(t) \\ SC(t) \\ CR(t) \end{bmatrix}.$$

Here, each component represents a potentially multidimensional state rather than a single numerical value.

For example, T(t)T(t) may contain multiple simultaneous thoughts, while B(t)B(t) may contain a network of beliefs with different strengths. Likewise, attitudes can vary according to their emotional or evaluative valence.

The model therefore treats cognition as a **state space** rather than as a collection of isolated variables.

2.2 Thoughts

Thoughts represent consciously or semi-consciously accessible cognitive contents.

T=T(t)T=T(t)

Thoughts can be generated by current perception, retrieved from memory, produced by reasoning, or triggered by internal and external stimuli.

They are relatively dynamic and may change rapidly following new information.

2.3 Beliefs

Beliefs are represented as

B=B(t).B=B(t).

Compared with individual thoughts, beliefs are assumed to have greater temporal persistence. They function as interpretive structures that influence how subsequent information is evaluated.

For example, two individuals may receive the same statement II, but if their prior belief states B1B_1 and B2B_2 differ, their resulting interpretations may also differ:

$$CR_1(t) \neq CR_2(t).$$

This does not imply that either interpretation necessarily corresponds to objective reality. It describes a difference in subjective representation.

2.4 Attitudes

Attitudes are represented by

A=A(t).A=A(t).

They describe evaluative orientations toward information or objects. An attitude can influence the significance assigned to incoming information and therefore affect the transformation from information to conscious experience.

In simplified form:

$$I(t) \xrightarrow[A(t)]{} \text{Interpretation.}$$

Attitudes can also change as a consequence of experience, producing another feedback pathway.

2.5 Subconscious Processes

The variable

SC=SC(t)SC=SC(t)

represents processes that contribute to cognition without necessarily being directly accessible to conscious introspection.

In this framework, SC should not be interpreted as a single physical location or mechanism in the brain. It is a theoretical variable representing influences on processing that are not fully represented in immediate conscious awareness.

The subconscious component can therefore mediate the transformation of information into conscious experience:

$$I(t), T(t), B(t), A(t), SC(t) \rightarrow CR(t).$$

2.6 Conscious Reality

The central output of the model is conscious reality:

CR=CR(t).

CR represents the individual's currently experienced representation of the world rather than the totality of the objectively existing external world.

The model therefore distinguishes between:

$$R_{\text{external}}(t)$$

and

CR(t)

The two may interact, but they are not assumed to be mathematically identical.

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3. Temporal Structure of the Model

The central feature of the proposed framework is time.

Consider two information events:

$$I_1 \text{ at } t_1$$

and

$$I_2 \text{ at } t_2, \qquad t_2 > t_1 .$$

The first information input is processed by the cognitive system in state X(t1)X(t_1).

This produces:

$$CR(t_1) = F[X(t_1), I_1].$$

After this processing event, the cognitive state changes:

$$X(t_2) = G[X(t_1), I_1, CR(t_1)].$$

The second information input is therefore not processed by the same system state. It is processed by a transformed state:

$$CR(t_2) = F[X(t_2), I_2].$$

This gives the basic temporal chain:

$$I_1 \to X(t_1) \to CR(t_1) \to X(t_2) \to I_2 \to CR(t_2).$$

This structure is important because it implies that **the interpretation of later information depends partly on earlier information**.

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4. Mathematical Formalization

4.1 Perceptual Transformation Function

The conscious representation can initially be represented by a general function:

$$CR(t) = F[I(t), T(t), B(t), A(t), SC(t)].$$

The function FF represents the cognitive transformation through which incoming information becomes conscious experience.

For a simplified linear approximation:

$$CR(t) = w_I I(t) + w_T T(t) + w_B B(t) + w_A A(t) + w_{SC} SC(t) + \epsilon(t),$$

where
wI,wT,wB,wA,wSCw_I,w_T,w_B,w_A,w_{SC} represent influence parameters and ϵ(t)\epsilon(t) represents unmodeled variation.

The linear representation is only a first approximation. A realistic cognitive system would likely require nonlinear interactions.

For example:

$$CR(t) = F(I(t), B(t), A(t), SC(t), T(t))$$

may contain interaction terms such as

$$I(t) \times B(t)$$

or

$$I(t) \times A(t),$$

representing the possibility that the effect of information depends on existing beliefs or attitudes.

4.2 State-Transition Equation

The internal cognitive state can be modeled dynamically:

$$X(t + \Delta t) = G[X(t), I(t), CR(t)].$$

A continuous-time representation can be written as

$$\frac{dX}{dt} = G(X(t), I(t), CR(t)).$$

Because conscious reality is itself a component or output of the cognitive system, this can be expressed as a coupled dynamical system:

$$\frac{dX}{dt} = G(X(t), I(t), F(X(t), I(t))).$$

This formulation captures the central idea that perception is **state-dependent and temporally recursive**.

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5. Information, Interpretation, and Feedback

The diagrams associated with the framework illustrate three cognitive states distributed across time.

At the initial state, the system possesses a particular configuration of:

T, B, A, SC, CR.T,\ B,\ A,\ SC,\ CR.

Information I1I_1 then enters the system and produces a subsequent cognitive configuration.

A second information input I2I_2 may enter later, but the cognitive architecture has already changed as a consequence of the previous processing event.

The system can therefore be represented as:

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          I1
          ↓
 ┌──────────────────┐
 │ Cognitive State  │
 │ T B A SC → CR    │
 └──────────────────┘
          |
          ↓
   State transition
          |
          ↓
 ┌──────────────────┐
 │ Cognitive State  │
 │ T B A SC → CR    │
 └──────────────────┘
          ↑
          |
         I2
```

The important theoretical consequence is that I2I_2 does not encounter the original cognitive state.

Instead:

$$I_2 \to X(t_2),$$

where

$$X(t_2) \neq X(t_1).$$

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6. Cognitive Feedback Loops

The model proposes several potential feedback loops.

Loop 1: Information → Conscious Reality

$$I(t) \to CR(t)$$

Incoming information modifies the current conscious representation.

Loop 2: Conscious Reality → Thoughts

$$CR(t) \to T(t + \Delta t)$$

Experience generates or modifies subsequent thoughts.

Loop 3: Conscious Reality → Beliefs

$$CR(t) \to B(t + \Delta t)$$

Repeated experiences may reinforce, weaken, or reorganize beliefs.

Loop 4: Conscious Reality → Attitudes

$$CR(t) \to A(t + \Delta t)$$

Experiences may modify positive, negative, neutral, or ambivalent evaluations.

Loop 5: Conscious Experience → Subconscious Representation

Experiences may become incorporated into nonconscious representations and subsequently influence later processing.

Together, these pathways produce:

$$CR(t) \to SC(t + \Delta t).$$

This is a recursive cognitive process.

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7. A Formal Two-Event Example

Consider an initial cognitive state:

$$X_0 = [T_0, B_0, A_0, SC_0].$$

The first information event is I1I_1.

The resulting conscious reality is:

$$CR_1 = F(X_0, I_1).$$

The experience then modifies the cognitive state:

$$X_1 = G(X_0, I_1, CR_1).$$

At a later time, the individual receives I2I_2:

$$CR_2 = F(X_1, I_2).$$

Substitution gives:

$$CR_2 = F\big(G(X_0, I_1, CR_1), I_2\big).$$

Thus, the second conscious representation depends not only on I2I_2, but indirectly on I1I_1:

$$CR_2 = f(I_1, I_2, X_0).$$

This is one of the central predictions of the framework.

The effect of information is therefore potentially **path-dependent**.

Two individuals exposed to identical information sequences may still arrive at different subjective states if their initial cognitive states differ:

$$X_0^{(1)} \neq X_0^{(2)}$$

leading to

$$CR_2^{(1)} \neq CR_2^{(2)}.$$

8. Subjective Reality as a Dynamical State

The framework suggests that subjective reality should not be conceptualized exclusively as a static representation.

Instead:

CR=CR(t).

The experienced reality of an individual is therefore a trajectory through cognitive state space:

$$CR(t_0) \to CR(t_1) \to CR(t_2) \to \cdots$$

Each state is influenced by previous states.

This can be expressed as:

$$CR(t + \Delta t) = F[CR(t), T(t), B(t), A(t), SC(t), I(t)].$$

The model consequently provides a mathematical language for discussing **temporal plasticity of subjective perception**.

9. Space and Time

The conceptual diagram also places the cognitive system within a broader space-time representation.

The horizontal axis represents:

t=time

while the vertical axis represents:

s=space

A cognitive state can therefore be represented as:

X(s,t)

This extension is potentially important because information does not necessarily originate at the same spatial location as the individual.

For example:

$$I(s_1, t_1) \to X(s_2, t_2)$$

can represent information transmitted from another location and subsequently incorporated into an individual's cognitive state.

The more general formulation becomes:

$$CR(s,t) = F[I(s,t), T(s,t), B(s,t), A(s,t), SC(s,t)].$$

For an individual-centered model, however, the spatial variable can initially be suppressed:

$$CR(t) = F[I(t), X(t)].$$

This makes the temporal component the primary variable of investigation.

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10. Implications of the Framework

10.1 Perception Is State-Dependent

The model predicts that the same information does not necessarily produce the same conscious representation under different internal states.

Formally:

$$F(I, X_1) \neq F(I, X_2)$$

when

$$X_1 \neq X_2.$$

This provides a conceptual explanation for variability in subjective interpretation.

10.2 Perception Is Path-Dependent

If earlier information changes the cognitive state, then later perception depends partly on the history of the system:

$$X(t) = G[X(t_0), I(t_0 : t)].$$

Consequently, two systems receiving the same information at the present moment may nevertheless produce different outputs because their histories differ.

10.3 Cognitive Structures Have Different Temporal Dynamics

The five proposed variables need not change at identical rates.

For example:

$$\frac{dT}{dt}$$

may vary rapidly, whereas

$$\frac{dB}{dt}$$

may be comparatively slower.

Similarly, attitudes may occupy an intermediate temporal scale, while subconscious representations may involve both rapid and long-term processes.

A more detailed model could therefore assign separate time constants:

$$\tau_T, \tau_B, \tau_A, \tau_{SC}.$$

The cognitive system could then be modeled as a **multiscale dynamical system**.

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11. Potential Applications

The framework is conceptual, but it provides several possible directions for empirical investigation.

11.1 Cognitive Science

The model could be used to investigate how prior cognitive states influence the interpretation of subsequent information.

11.2 Psychology

Experimental studies could measure changes in attitudes, beliefs, interpretations, and reported conscious experience following controlled information sequences.

11.3 Computational Cognitive Modeling

The variables could be implemented as computational states in an artificial cognitive architecture:

$$X_{t+1} = G(X_t, I_t).$$

Such a system could simulate how an agent's previous experiences influence subsequent interpretation.

11.4 Human–Computer Interaction

The framework could potentially describe how repeated interactions with digital environments alter user expectations and subsequent interpretations.

11.5 Learning and Adaptation

Repeated information events could be modeled as trajectories through cognitive state space, allowing researchers to investigate how information accumulation produces longer-term changes.

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12. Testable Predictions

Although the framework is theoretical, it generates experimentally testable predictions.

Prediction 1

Identical information presented to individuals with different prior cognitive states should produce measurable differences in subjective interpretation.

Prediction 2

The interpretation of I2I_2 should depend partly on exposure to I1I_1 when I1I_1 changes the internal cognitive state.

Prediction 3

Repeated information should produce different effects depending on the temporal interval between information events.

Prediction 4

Variables representing beliefs and attitudes should generally exhibit greater temporal persistence than individual thoughts.

Prediction 5

A model incorporating feedback from previous conscious experience should explain temporal changes in subjective reports better than a model treating each information event as independent.

These predictions can be tested using longitudinal experiments, repeated-measures designs, computational simulations, and time-series analysis.

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13. Limitations

Several limitations must be recognized.

First, the variables **T, B, A, SC, and CR are theoretical constructs**, not yet operationalized measurements. An empirical study would need precise definitions and measurable indicators for each variable.

Second, the model does not assume that subconsciousness is a single identifiable mechanism. SC is used here as a conceptual category for processes outside immediate conscious access.

Third, the proposed equations are mathematical representations of the conceptual relationships rather than empirically estimated laws. The parameters wiw_i, functions FF and GG, and temporal constants would need to be estimated from experimental data.

Fourth, the framework distinguishes conscious reality from external reality but does not attempt to provide a complete theory of objective reality.

Finally, cognition is likely to involve additional variables—including memory, emotion, attention, sensory processing, physiological state, and social context—that are not explicitly represented in the current five-variable architecture.

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14. Proposed Empirical Formalization

A future empirical version of the model could define the state vector as:

$$X_t = [T_t, B_t, A_t, SC_t, CR_t]$$

and use a discrete-time state-space model:

$$X_{t+1} = AX_t + BI_t + U_t$$

with

$$CR_t = CX_t + DI_t + \epsilon_t \,.$$

Here:

- AA represents interactions among cognitive variables;
- BB represents the influence of incoming information;
- CC maps internal states onto conscious experience;
- DD represents the direct contribution of incoming information;
- UtU_t represents unobserved changes;
- ϵt\epsilon_t represents measurement noise.

This would transform the conceptual framework into a model that could potentially be estimated from longitudinal observations.

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15. Conclusion

This article has proposed a formal conceptual framework for understanding **subjective perception as a temporally evolving cognitive system**. The framework organizes cognition into five principal components—thoughts, beliefs, attitudes, subconscious processes, and conscious reality—and places them within a dynamic information-processing architecture.

The central mathematical proposition is:

$$\boxed{CR(t) = F[I(t), T(t), B(t), A(t), SC(t)]}$$

combined with the state-transition relationship:

$$\boxed{I_1 \to CR_1 \to X_1 \to I_2 \to CR_2 \to X_2 \to \cdots}$$

Together, these equations describe a recursive system in which incoming information influences conscious experience, while conscious experience subsequently modifies the cognitive state that determines how future information is processed.

Consequently, subjective perception can be conceptualized not as a static mapping from external stimulus to internal experience, but as a **trajectory through a changing cognitive state space**:

$$\boxed{I_1 \rightarrow CR_1 \rightarrow X_1 \rightarrow I_2 \rightarrow CR_2 \rightarrow X_2 \rightarrow \cdots}$$

The framework therefore emphasizes three fundamental properties of subjective perception: **state dependence, temporal dynamics, and feedback**. Its principal value at this stage is as a theoretical architecture that can be operationalized, mathematically refined, and empirically tested.

Future work should focus on defining measurable proxies for each cognitive variable, estimating the strength and direction of the proposed feedback relationships, determining appropriate temporal scales, and comparing the model against alternative computational descriptions of perception and cognition. Such work could establish whether the proposed architecture provides a useful quantitative description of how information, cognitive structures, and conscious experience evolve together through time.