Interactive Behavior Change Model (IBCM 8.0): Theory and Ontology

Brian Cugelman[1(✉)] and Agnis Stibe[2,3]

[1] Statistical Cybermetrics and Research Evaluation Group, University of Wolverhampton, Wolverhampton, UK
brian@alterspark.com
[2] Department of Informatics, Faculty of Engineering, Built Environment and Information Technology, University of Pretoria, Pretoria, South Africa
[3] INTERACT Research Unit, University of Oulu, Oulu, Finland

Abstract. This paper presents the Interactive Behavior Change Model (IBCM 8.0), a system that integrates behavior change principles from neuroscience, psychology, and behavioral science into a behavioral meta-theory. With its broad, application-agnostic nature, the IBCM provides insight into behavior change, how it operates, and offers an alternative explanation for why various behavior change models work or do not work. It has applications as a behavioral system for education, research, analysis, intervention design, and implementation in various technologies, especially self-adaptive systems run by rule-based engines or artificial intelligence (AI). Due to space limits, this paper covers the model structure and theory with a limited high-level overview of its ontology.

Keywords: Behavioral Science · Behavior Change · Persuasive Technology · Affective Computing · Artificial Intelligence · Personalization · Science Philosophy · Evolutionary Psychology

1 Introduction

In recent years, there has been growing interest in implementation science, where scientific models are used for understanding, building, and evaluating real-world products and services [1]. Behavior change systems and taxonomies, herein referred to as behavioral systems, are arguably the most popular scientific tools for use in research and the construction of interventions. They typically contain a model, a taxonomy of behavior change principles, or both. These behavioral systems are usually developed for distinct fields, with behavioral taxonomies curated for specific applications [2–6].

However, many behavioral models are built from abstract constructs that do not explain behavior, despite opportunities to ground these systems in neuroscience, psychology, sociology, etc. Taxonomies tend to be arbitrary, author-curated lists, incomplete,

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and full of overlapping, redundant principles. Domain-specific systems that work in one area may be ineffective or trigger backfires when misapplied [7].

Recognizing these limitations, this paper introduces a universal behavioral meta-system based on neurobiology and psychology. This system merges various behavior change theories and principles into an intuitive format, optimally structured for implementation by adaptive, rule-based systems or artificial intelligence (AI).

2 Behavioral System Challenges

2.1 Popular Behavioral Systems

Researchers and practitioners often utilize *behavioral systems*, science-based models and taxonomies of principles proven to impact people's emotions, thoughts, and actions. People apply behavioral systems in many ways, such as using them for education, research, intervention design, or in impact evaluations.

There are several popular behavioral systems, each with a distinct philosophy, serving a range of applications and taking various forms. In technology are the systems of *CAPTOLOGY* [8] and *persuasive systems designs* [9]. Notable persuasion systems include the extensive work of O'Keefe [10] and Cialdini's simple sales-oriented six principles [11]. Broad theories, such as *stages of change,* provide extensive lists of narrowly focused principles [12, 13]. However, narrow models offer small groupings of broadly applicable principles, such as Ajzen's early persuasion research [14].

Social marketing systems provide simple catalogs to help intervention designers, such as *tools of change* [15] and *community-based social marketing* [16]. *Evidence-based behavioral medicine* began with large taxonomies of health behavior change principles and techniques [17–19], then adapted their earlier systems for practitioners [20]. Perhaps due to problems of behavioral economists inventing and repackaging hundreds of principles, scholars are using data reduction techniques to reduce the massively redundant and ever-expanding cognitive bias taxonomies [21].

2.2 Overcoming Behavioral System Limits

These behavioral systems have made a sizeable impact on scientific research and practice. However, despite their popularity, each suffers at least one of the following shortcomings. Theory-based models like Stages of Change explain behavior through its stage model and offer techniques to facilitate change, with the minor shortcoming that it is domain-focused, limiting its use to situations where a stage model applies.

However, many behavior change systems employ abstractions such as the Behavior change wheel, rendering them a list of principles without a unifying theory. This makes them practical, and grounded in proven behavior/social change strategies. But their structure does not explain what drives individual and social behavior.

In the worst case, most behavioral systems have no central theory, often resembling arbitrary curated lists of principles, like Cialdini's six or seven principles. With no central theory, there are no criteria for deeming the system complete or incomplete–other than when the author arbitrarily decides.

Many behavioral systems are inadequately short, and contain redundant, overlapping principles. Some include principles that authors invented, with no scientific merit. The popular Wikipedia-based cognitive bias wheel is an example of practitioner models that gained massive popularity, despite violating standard scientific criteria.

In this paper, we discuss the Interactive Behavior Change Model (IBCM), a theory-based system for structuring behavior change principles, that can overcome each of these challenges. The IBCM was initially developed as a comprehensive system for studying how behavior change operates in the technology [22, 23], then used in a statistical meta-analysis [5], and used for education and product design in the Behavioral Design Academy (https://www.behavioraldesign.academy). This paper presents the latest edition, its nomenclature, theory, philosophy, and a high-level ontology.

3 Interactive Behavior Change Model

The IBCM's central tenet is that feedback loops provide a wid-reaching mechanism for understanding behavior change from multiple perspectives. It organizes behavior change principles into domains unified by common theories, influence mechanisms, and where we have evidence, psychometrically robust factor structures. The IBCM explains behavior change principles from evolutionary, neurobiological, psychological, and behavioral science perspectives. It offers an alternative explanation for the efficacy of various behavior change principles, theories, models, and practices. It can also be scaled to explain influence within a person, between people, and through complex social interactions. This section describes the IBCM 8.0.

3.1 Nine Domains of Communications and Influence

Presented in Fig. 1, the IBCM encompasses nine communication domains, representing the factors that matter in human interactions and influence. Each domain doubles as an influence sphere when we use those factors for behavior change. This model portrays communication as a flow, one-way from source to audience, or two-way with feedback loops between actors.

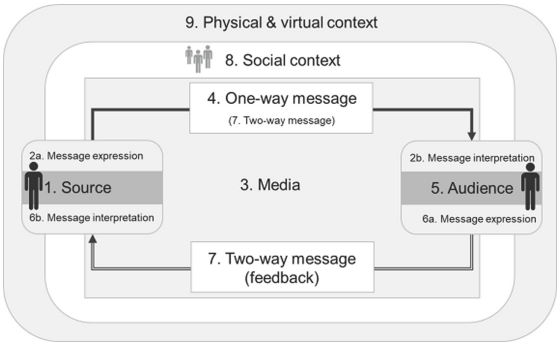

Fig. 1. Interactive Behavior Change Model (IBCM)

The model explains behavior change as the outcome of a two-way feedback loop between agents, that fosters positive feedback leading to adaptive learning that produces a change, we call influence, behavior change, training, nudging, etc… Each domain plays a distinct role in fostering change, with clusters of correlated principles.

The IBCM is built from communication theory. Traditionally, one-way communication, introduced by Aristotle for rhetoric, later extended to signal transmission by the Shannon-Weaver model [24], has been the default model for persuasive messaging. However, the Osgood and Schramm Model introduced the concept of two-way human communication [25], used for interpersonal communication and adaptive self-learning technologies. Communication occurs within a medium and is influenced by the persuasive communication context [10, 14]. It takes place within a social and physical/virtual spatial contexts, and we use the term "spatial" intentionally, as the human brain utilizes spatial processing for both physical and social relationships [26], in both real and virtual environments [27].

3.2 Eight Communication Modes

Behavior change happens within a communication context. The eight communication modes, represented in Fig. 2, describe the macro-level structure of all behavior change contexts. There are eight communication modes, where one or many sources attempt to influence one or many audiences in a one or two-way context. Each mode has practical benefits and drawbacks, depending on the context and behavioral goals.

We treat the actors (sources and audiences) as anything with agency, be they human groups, brands, technology, AI agents, etc… The source (S) is the entity intending to exert influence, while the audience (A) is the target of influence. However, in two-way communication, the audience also influences the source.

The flow of communication may be one or two-way. The shorthand *to* describes one-way communication flow from actor to actor. The shorthand *with* describes two-way communication flow, between actors in a cyclical, iterative loop.

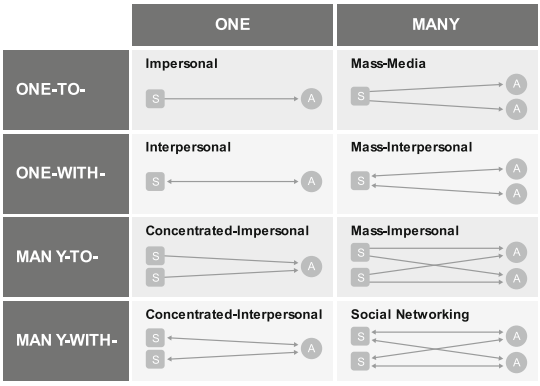

Fig. 2. Eight communication modes

Modes Control Domains of Influence: A core premise is that communication modes govern behavior change principles. There is no feedback in one-way modes, making it difficult and usually impossible to use two-way message principles in a one-way communication mode. Employing reinforcement learning, tailoring, or any adaptive strategy with no audience information is impossible except by luck. Modes that include single versus group contexts have different social influence opportunities and limits.

Description of Each Mode: This model describes various influence contexts, from individual-level interventions like therapist-client relationships to population-level interactions between organizations and their members. It also includes the models utilized by swarm-style network influence campaigns, such as those employed by lobby groups to inundate targets with messages of public disagreement or the multi-nodal covert actions governments run to divide adversarial populations and influence their elections. Here are the eight modes:

The *impersonal mode* (one-to-one) describes the early one-way models where information and influence flow from the source to an audience, such as when the boss dictates what he/she must do to an employee. The *mass-media mode* (one-to-many) describes the traditional mass-media communication flow from one source to many audience members, such as when an organization puts out an advertisement to influence audiences through TV, radio, or newspapers. The *interpersonal mode* (one-with-one) describes two-way communication between a source and an audience, such as a discussion between a salesperson and a potential customer. The *mass-interpersonal mode* (one-with-many) describes a situation where a source conducts two-way communication with multiple audience members, such as an online coaching platform, that supports multiple relationships.

The *concentrated-impersonal mode* (many-to-one) describes a situation where many sources send messages to one audience, such as an advocacy campaign that channels public sentiment to one organization to convey public will. The *mass-impersonal mode* (many-to-many) describes when many sources send messages to audiences, such as a crime network distributing multiple phishing email campaigns, to deceive the audiences. The *concentrated-interpersonal mode* (many-with-one) describes when multiple sources engage in two-way communication with one audience, such as an advocacy campaign encouraging citizens to engage in two-way dialogue with targeted politicians to sway their stance. And finally, the *social networking mode* (many-with-many) describes the two-way relations between multiple sources and audiences, describing a social network where influence is in constant flux.

3.3 Three Communication Methods

Across the eight domains of influence, there are three common ways that intervention designers may leverage behavioral science in direct or mediated communication [28]. Figure 3 presents a generic edition of the three communication methods. This model contains a source (S), that sends behavioral principles (P), through a communication medium (M), to a target audience (A).

The *direct* method is where the source interacts directly with the audience, such as in face-to-face communication, where a politician goes door-to-door. In the case

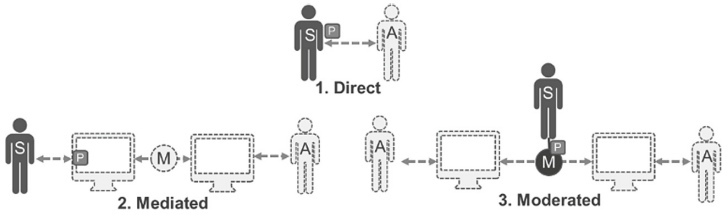

Fig. 3. Communication connectivity

of technology, it is when some interact directly with their smart wearable technology device. The *mediated* method is when the source attempts to influence the audience through technology, such as a salesperson working through online video chat. This also includes using technologies such as a health coaching app, or AI-driven sales agents using telephones to engage and sway a target audience.

The *moderated* method is where the source controls the platform other people use for communication and structures their communication to influence their behavior—a form of "non-choice" architecture. For instance, Twitter didn't have success until they reduced the message size limit from large text to just 140 characters. Social media platform owners routinely abuse this method by placing false words in users' digital mouths by sending misleading messages to users' friends, implying the user wants their friends to take all sorts of actions.

3.4 Communication-Based Influence Components

Many have proposed an "atomic theory" for the behavioral sciences, arguing for the existence of deeper drivers of behavior. This concept has been termed the evidence-based kernels [29]. Susan Michie adopted this philosophy in her pioneering work, where she gathered scientists together for a consensus-based approach to reducing multiple overlapping theories to a set of core theoretical constructs associated with behavior change [18]. She later used a combined approach with methods that were closer to grounded theory combined with scientific consensus to develop high-quality taxonomy of behavior change techniques [17].

The quest to isolate kernels, the factors driving behavior change, is a sacred mission for many. While evolution may have shaped our susceptibilities to influence, evolutionary explanations do not specify the detailed structure of those kernels.

To develop its ontology at the threshold of psychology and neuroscience, the IBCM rests on the hypothesis that the closest we can get to the kernel of behavior is to isolate the latent variables that reflect a web of interacting components, displayed in Fig. 4 and described below.

Physics: At the lowest level, exist our perspectives on the world shaped by atomic theory, chemistry, electromagnetism, and the laws of physics. Though behavioral science rarely reaches this level, behavioral neuroscience works at this level.

Without specialists operating at this level, we would not understand many links between matter, chemistry, electromagnetism, and their impact on people. For example, by understanding the physics of electromagnetic energy, we can better understand the

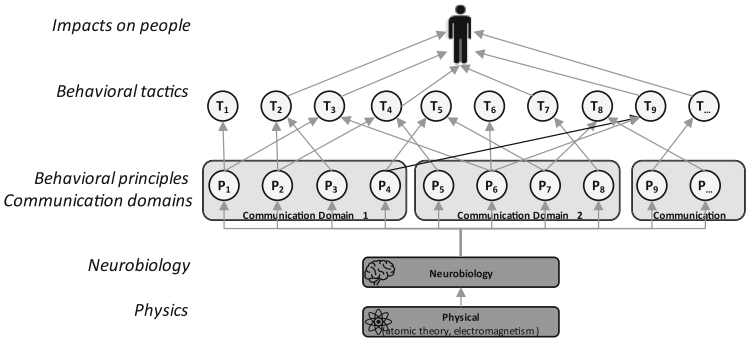

Fig. 4. Influence-components model

visible light spectrum and later translate it into design strategies that impact users through circadian light impacts. Similarly, the first brain-to-brain transmission over the internet came about by using EEG (electrical potential difference) to express a thought, that was transmitted electronically to another person, with transcranial magnetic stimulation used to send a signal into a second person's brain [36].

Neurobiological Predisposition (N): This is the domain of neuroscience, where there should be the fewest mechanical explanations for what behavior change principles are, how they work, and how they operate between physical processes and psychologically conscious experience. We believe the fewest number of principles exist here. For instance, there is only one emotional reward system for motivating and reinforcing behavior, which helps us understand motivation and techniques for shaping behavior. The sympathetic and parasympathetic nervous systems operate simultaneously, creating the conscious experience of a uni-dimensional nervous system response that ranges from low to high-states of arousal, creating a single variable that is present in every emotion.

Behavior Change Principle (P): These are semi-limited principles of behavior change tied to psychology, where the field of Evidence-based Behavioral Medicine provides a helpful metaphor that explains how this mechanism works. According to the field, a behavior change intervention can be built by adding active ingredients proven to elicit a particular outcome, similar to how medicine works. When added to medicine, active ingredients produce a predictable outcome. The medicine will no longer work without active ingredients at an adequate dose [19, 29].

Communication Domain (D): In the communication domains, one-way communication involves the transmission of signals from one entity to another, resulting in an impact of some kind. Conversely, two-way communication involves bi-directional feedback, which is crucial for the evolution of molecular structures, coordinated cellular activity, and the evolution of species, their nervous systems and social behaviors.

This is why communication theory has widespread application for explaining how the body itself adapts to change, such as through its hormone systems which employ chemical messengers delivered via the bloodstream, or its neuronal system that utilizes electro-chemical messages conveyed through neural circuits, as two key systems behind

our adaptive homeostatic and allostatic response [37]. In this regard, the communication framework also encompasses those principles of neurobiology that help us build neuroscience-inspired interventions.

At a higher level, control theory loops, in conjunction with reinforcement learning, is perhaps the most widely used yet unreported design pattern that underpins behavior change interventions, especially those implemented in technology.

The communication domain has the potential to explain influence, at multiple levels, from the molecular, to cellular, to biological systems and social behavior.

Behavior Change Strategy or Tactic (T): These are creative industry practices that apply behavior change principles to achieve specific outcome goals. There are unlimited behavior change strategies and tactics because they create situations that leverage behavior change principles. For instance, asking someone to make a public commitment to support sustainability is a tactic that uses a range of principles, such as committing, being held accountable for commitments, social normative influence, and other possible factors that may emerge depending on the context and implementation details.

3.5 Building Behavioral Theories from Influence Components

As a meta-behavioral system, the IBCM's influence components model follows a simple recipe model, ingredients (influence components that foster change), can be combined into recipes which are groups of principles that deliver impacts greater than the sum of their parts. We further follow the idea that the intensity in which an ingredient is applied, ranges from too weak to make an impact, or so strong that it appears tasteless (manipulative, cliche, annoying)—with a perfect spot calibrated based on what's appropriate for the audience.

Ingredients (Influence Components): In the IBCM, *ingredients* are the components that exert influence on how people perceive, classify information, respond emotionally, respond habitually, deliberate, decide, appraise, and act. No universally accepted phenomenon qualifies as the ultimate causal factor driving these outcomes. IBCM includes physical, neurobiological, and psychological principles as the core ingredients. We generally avoid using tactics, which are usually tied to specific applications and contexts.

Recipes (Conventions, Models, Theories): Individual ingredients are rarely enough to elicit change. For example, to get citizens involved in an issue, McKenzie-Mohr and Smith (1999) did not just advocate obtaining commitments from people; instead, they recommended making those commitments public and encouraging people to see themselves as concerned citizens. In other words, the authors advocated combining three distinct influence strategies: obtaining a commitment, leveraging social influence, and playing on a person's self-identity and consistency.

This combination of success factors is a behavioral recipe. Combinations of principles that produce effects greater than the sum of their parts are likely candidates for becoming conventional pairings or theories of change.

Figure 5 presents a model of the relationship between the number of ingredients and a product's potential influence. Within this model, a product with too few ingredients may not have enough to influence behavior. Conversely, a product with too many ingredients may overwhelm audiences or users with too much irrelevant content. Somewhere

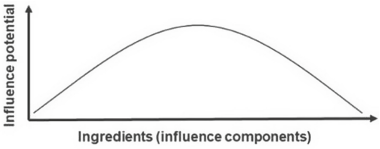

Fig. 5. Theories and models as optimized ingredient groups

in-between is a middle ground where a few relevant, mutually reinforcing influence strategies are most effective [5].

In the IBCM, behavioral design conventions and theories combine broad principles that work well in general, or may offer exceptional benefits in particular contexts. For instance, popular ingredient pairings include costs and benefits [38], punishments and rewards [39], threats and self-efficacy [40]. Popular ingredient triplets include: motivation, ability, and triggers [41]; and motivation, ability/efficacy, and opportunity [42].

Conversely, behavioral models are more practical, and with that, they often use more lay terms and focus on specific industry applications that are popular at the time. These models are often developed quickly and spread through professional networks.

Rather than offering specific recipes, IBCM catalogs principles and recommends theories (combinations of principles) based on the particular applications, following the principle that there are a handful of optimal theories for each application. IBCM also uses tailored psychometrics based on audience demographics and psychographics.

3.6 Influence Principles as Population-level Adaptive Traits

Behavioral scientists hold different views on the factors that shape human behavior. Some favoring a pragmatic approach prefer to isolate scientifically validated principles of influence without getting trapped in wasteful debates about their cause.

Conversely, others pursue deep insight into the essence of behavior change, employing perspectives from neuroscience, psychology, and sociology. Dennis Embry theorizes that the genesis of evidence-based behavioral kernels could be rooted in many sources, like anthropology, and evolution, among others [29].

The IBCM might also shed light on the origin of some behavior change principles via social feedback loops that evolved our species' psychology. Feedback loops are used to explain the existence of ordered physical matter and life in our universe [31]. Some believe feedback loops are an overlooked mechanism of evolution, with positive feedback as a supplementary process to natural selection, contributing to the development of diverse traits (genetic variation) in social organisms, their mating behaviors and social structure [30]. Others focus on the detailed role of positive feedback as the fundamental mechanism driving the evolution of social behaviors and structures [32]. Feedback loops also lay at the crux of cybernetic adaptive technologies [33] and AI [34].

While many focus on behavior change principles as things used by the source, others treat them as traits of the target audience [35]. We theorize that behavior change principles are innate or learned strategies of the source matched to trait variation in audiences,

calibrated by social feedback loops and natural selection. Many traits that make us susceptible to influence may be the traits that enhance our adaptability as a species.

When those traits are too weak or too strong, our adaptive social structure becomes too relaxed or too weak (too chaotic or too structured), leading to mal-adaptive population-level behavior, putting evolutionary pressure to adjust the human distribution of traits till our population either adapts, changes, or disintegrates through social entropy.

Human social structures can be depicted along a spectrum from chaos to order (entropy to negentropy), encapsulating four states: (1) unstructured chaos, (2) structure-emerging positive feedback, (3) structure-dissolving negative feedback, and (4) equilibrium, a stabile state that oscillates between competing forces. We are never static.

Imagine a thought experiment using the IBCM to demonstrate the model's potential. We can use the IBCM to study one-with-one and many-with-many relations, linking individual predispositions to population impacts.

Imagine five separate islands, each inhabited by 10,000 genetically engineered people. We will engineer each population to have a unique predisposition across five levels of susceptibility to persuasion and later examine the population-level impacts. In all social interactions, when sources use influence tactics, their influence is a function of the population distribution of that trait in audiences, causing population-level impacts.

For our first study, we will engineer five populations of 10,000 people with different susceptibilities to social normative influence. Island-1 inhabitants lack this predisposition entirely, rendering social normative influence ineffective. Island-2 exhibits a reduced susceptibility to social normative influence. Island-3, serving as our control, possesses an average predisposition. Island-4 possesses an enhanced susceptibility. And island-5 exhibits maximum susceptibility, with social normative influence operating flawlessly every time it is employed.

Next, we will evaluate the long-term effects of these traits on the population, considering impacts on individuals, families, society, and humanity itself, in time frames of 1, 1,000, 10,000, and 100,000 years. We also measure if the population goes extinct or evolves into another species, or singularity entity.

We speculate that island-1, with no social normative influence, may decline into extreme individualism, weakening from eroded social cohesion as negative feedback cascades social entropy, disintegrating its social structure, preventing adaption due to chaos. Island-5, with maximum normative influence, could become overly structured, losing adaptability due to excessive positive feedback. However, the balanced island-3 would maintain an adaptive equilibrium, achieving optimal adaptability.

Continuing this thought experiment, we next evaluate self-efficacy. We hypothesize that islands with low self-efficacy might struggle due to a lack of confidence, innovation, effort, and risk-taking. Conversely, the island with excessive self-efficacy might display reckless behavior, likely to be detrimental to any population. And the middle island maintains an optimal social structure for adaptation.

We extend our thought experiment to other behavioral change principles like goal setting, source credibility, and social learning. Our speculative findings suggest that traits we call too weak or too strong can lead to maladaptive social structures, either

too chaotic or overly rigid. In contrast, susceptibilities to influence deemed healthy or normal fall within an oscillating equilibrium range, optimized by social feedback and natural selection. Thus the IBCM may help explain the essence of some behavior change principles. We share this hypothesis for broader discussion and theory testing.

4 IBCM Ontology

This section presents the IBCM's ontology of influence principles and tactics, which are organized within the nine domains of communication and influence.

The ontology was initially developed by extracting principles and tactics from the influence systems, systematic reviews, and meta-analyses, with the minimum criteria being proven effective across multiple studies [4, 5, 17, 18, 43–47]. These were clustered and lined to the domains of communication and in some cases, subject to model fit through factor analysis and structural equation modeling [44, 48]. Additional work included linking the principles to theories and using content analysis to associate the principles with applied behavioral science [49].

We use the term ontology, as the ultimate goal of the IBCM is to isolate the fundamental factors of behavior change, which we hypothesize, is clustered around the models' structure, an interactive feedback loop.

IBCM is adaptable, backward compatible, and numbered for research and technology use. This is version IBCM 8.0, with unique numbers for each influence component. Here is the ontology, with a list of principles to demonstrate its organizing structure.

Domain 1. Source

A source is any entity with whom a target audience holds a relationship and interacts. Sources are typically people, organizations, or brands. However, in an abstract sense, a source is anything that can possess a reputation and be trusted or mistrusted, such as a person, organization, brand, product, or technology such as an app, robot, or AI agent.

Ingredients: 101. Source representation; 102. Credibility; 102a. Competence; 102b. Honesty; 103. Charm; 103a. Surface appeal; 103b. Likeable; 103c. Similar; 104. Familiarity.

Domain 2. Source expression and audience interpretation (source to audience)

This domain pertains to how the source constructs a message in media, which is transmitted and then understood by the audience. It encompasses psychological principles that guide effective communication strategies, regardless of the message's content. For example, it covers visual design principles, content organization, shape, size, and other non-content elements where style matters more than substance.

Ingredients: 201. Cognitive ease and strain; 201a. Cognitive ease (fluence); 201b. Cognitive strain; 202. Preattentive processing (salience); 203. Visual cognition (Gestalt); 203a. Proximity; 203b. Connectivity; 203c. Enclosure; 203d. Similarity; 203e. Continuity; 203f. Closure; 203g. Symmetry; 203h. Figure-ground; 204. Ordering; 204a. Serial position: primacy & recency; 204b. Priming (relative to the context); 204c. Anchoring (relative to the anchor); 205. Framing; 205a. Concrete versus abstract framing; 205b. Gain versus loss framing; 205c. Decoy effect; 205d. Zero, one, or two-sided arguments;

205e. Endowment framing; 205f. Defaults; 206. Timing; 206a. Single-session; 206b. Multi-session.

Domain 3. Media

Media is anything we use to record a message and give to another person who can then interpret and understand the message. Single-media is any media that the audience interprets through one distinct sense, such as written words conveyed through the eyes, or audio interpreted through the ears. Multi-media are any media interpreted through multiple senses, such as video interpreted through the eyes and ears. The persuasive qualities of different media come from the different cognitive and emotional artifacts associated with each sensory system.

Ingredients: 301. Images (sight); 302. Words (sight); 303. Numbers (sight); 304. Audio (hearing); 305. Video (sight, hearing); 306. Haptic (touch).

Domain 4. One-way message

A one-way message is when the source expresses its message without prior knowledge of the audience, in a "point and shoot" approach. Although the core elements needed to influence people can be conveyed through one-way messaging, it is hard to have much impact with truly one-way messaging, because there is no ability to judge when a message is relevant. For this reason, one-way messaging describes the core factors required for influence, but does not contain those iterative, feedback-based strategies that exist in two-way communication. Some of these principles are two-way, violating the theoretical basis. However, these violations were introduced to aid education.

Ingredients: 401. Focus; 402. Persuade; 402a. Educate; 402b. Motivate; 402c. Nudge; 402d. Assure; 403. Facilitate; 403a. Pave; 403b. Guide; 403c. Reinforce; 404. Re-engage; 404a. Support (for ability or self-efficacy deficits); 404b. Re-motivate (for motivation deficit); 404c. Restore trust (for source damage).

Domain 5. Audience

This domain describes the target outcomes that we typically use in stage-based models, which tend to be "deal breakers", where failures in any of these usually result in failed influence. The key target outcomes include raising our audience's awareness, comprehension, motivation, intention, confidence, and both short-term and long-term action. However, it's normal for our audience to disengage during the process, which is why abandonment is also a key outcome that should be anticipated from the onset.

Ingredients: 501. Concentrating (aware); 502. Comprehending (informed); 503. Desiring (motivated); 504. Deciding (intent); 505. Trusting (confident); 506. Acting (short-term behavior); 507. Maintaining (long-term behavior); 508. Abandoning (no behavior).

Domain 6. Audience expression and source interpretation feedback

This domain covers the capture, storage, and interpretation of data through research, data science, and algorithms. This is a prerequisite for using many of the feedback psychology principles listed in the two-way message domain.

Ingredients: 601. Research-based feedback; 602. Manual data capture; 603. Interaction-based data capture; 604. Automated data porting; 605. Sensor-based data capture.

Domain 7. Two-way message (adaptive techniques)
This domain covers feedback psychology principles that can only be applied when the source is able to capture and process information from the audience, and deploy strategies inspired by the principles in this domain. In situations where the source is unable to gather information, or has a messy feedback system, the risk of backfiring is great, as many of the worst behavioral science backfires come from failures in data collection, classification, and prediction [7].

Ingredients: 701. Sequential gifts and requests; 701a. Reciprocity; 701b. Foot-in-the-door; 701c. Door-in-the-face; 702. Reminders & prompts; 703. Engaging at the right time; 704. Targeting (segmenting); 705. Personalization; 706. Tailoring; 707. Setting goals & making commitments (intentions); 708. Personal action plan; 709. Personal barriers and friction; 709a. Remove personal barriers & friction; 709b. Add personal barriers & friction; 710. Feedback on performance; 711. Reinforcement; 711a. Reward on success; 711b. Punish on failure.

Domain 8. Social context
A large part of influence comes from the audience's social context, where other people can be more influential than the source. However, there are several distinct forms of social influence that may be leveraged, with social facilitation operating like the ultimate control switch, for turning social influence on/off, just by making the audience aware of others or pushing awareness of others out of sight and out of mind [50].

Ingredients: 801. Anonymity; 802. Social affiliation; 803. Self-identity & expression; 804. Social curiosity & concern; 805. Social facilitation; 806. Social learning (modeling); 807. Social norms (normative influence); 808. Psychological safety; 809. Social recognition (approval/disapproval); 810. Social comparison (upward / downward); 811. Co-ompetition; 811a. Cooperation; 811b. Competition; 812. Social diffusion facilitation.

Domain 9. Physical & virtual context
This domain describes the physical and virtual environment, which covers the built environment, objects, and the availability of things in space and time. This also covers virtual environments, as evidence suggests grid and place cells in the brain, operate the same for physical and virtual environments, underpinning the psychological evidence that we apply spatial navigation to virtual environments. The ingredients in this domain cover spatial navigation, organizing the environment, and resource availability.

Ingredients: 901. Spatial metaphor design; 902. Environmental restructuring; 903. Stimulus control; 904. Scarcity (resource limits); 905. Urgency (time limits).

5 Conclusion

The IBCM is a theory-based behavioral meta-system with diverse applications, bridging work in psychology, neuroscience, and behavioral science. If further validated, its theoretical underpinning could provide substantial insight into human behavior. As a

universal meta-system, it can support behavioural science research, education, design, and the management of behavioral interventions by people, algorithms, and AI.

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