Why Behavior Analysis Needs a Formal Symbolic Language for Codifying Behavioral Contingencies

Francis Mechner
The Mechner Foundation

A formal symbolic language codifies its discipline's basic units and the relationships among these. In the sciences, formal symbolic languages codify the known events that can be manipulated and controlled—the independent variables, rather than their empirically observed effects. The symbols of the behavioral contingency language codify available behavior, its assumed potential consequences, and parameters of these. This language can accommodate the complexity of the behavioral contingencies that are at the core of such diverse fields as education, sociology, economics, health, business management, law, public affairs, and activity that impacts the environment. Formal symbolic languages can accelerate the progress and maturation of their disciplines by (1) defining basic units, (2) making relationships among these visually accessible, (3) identifying their parameters, (4) recording and communicating the discipline's knowledge, (5) categorizing and conceptualizing it, and (6) teaching it. Examples are presented to show how the present formal symbolic language can perform these vital functions in the behavioral sciences. One example demonstrates how the language makes explicit the parameters of the traditional three-term operant contingency. Another demonstrates how a wide range of behavioral contingencies can be conceptualized and grouped, including prevention, deception, theory of mind situations, contingencies that change, discounting contingencies, and economic phenomena. The methodological significance of the contingency language for the behavioral sciences is discussed.

Key words: parameters of behavioral contingencies, formal symbolic languages, conceptualization of contingencies, independent variables in behavior research, theory of mind behavioral economics.

Introduction

A formal symbolic language is a system of written symbols that represent its discipline's basic units and concepts. Examples: The language of chemistry codifies atoms and the bonds that connect them, the language of western music codifies notes and their pitch and duration, and the language of mathematics codifies numbers and operations. The present behavioral contingency language codifies behavior and its known potential consequences, time delays, and modifiers of these.

Correspondence concerning this manuscript should be addressed to Dr. Francis Mechner, 200 Central Park South, New York, NY 10019; e-mail: fmechner@panix.com

Functions of Formal Symbolic Languages

"Why should anybody care?" was Professor W. N. Schoenfeld's favorite challenge—one that certainly applies to the present formal behavioral contingency language and

[1]The term "codify" refers to the process of representing a discipline's units, concepts, or processes with the symbols of a formal symbolic language.

that reverberates, some 60 years later, for this particular student of his. The reason behavior analysts should care is that such languages have the potential to advance their disciplines by performing certain important functions:

(a) **Visualization** – Making relationships among the discipline's units visually and graphically accessible (Rocke, 2010).

(b) **Abstraction** – Symbolic languages focus selectively on some units and concepts while disregarding others. *Examples*: The vocabulary of chemistry includes atoms and molecules but disregards, for instance, their size or mass; the vocabulary of music includes the pitch and duration of notes while disregarding, for instance, their overtones or pitch slides. Also, the vocabularies of formal symbolic languages typically use discrete units to codify continuous dimensions. Music usually consists of a continuous flow of sound, but notes are discrete abstractions. Behavior, too, is continuous while the language's discrete behavioral units, like "act" or "response," are abstractions.

(c) **Identification of parameters** – Prompting the identification of variables that can be manipulated and adjusted with a view to producing desired results.

(d) **Communication** – Recording and memorializing the discipline's subject matter in terms that cut across all natural languages, with concise codifications that avoid the ambiguities of verbal descriptions.

(e) **Conceptualization** – Categorizing and classifying the discipline's knowledge. In behavior-based disciplines, this can mean grouping behavioral contingencies according to commonalities in such fields as economics, education, health care, business management, law, political science, or environmental science.

(f) **Teaching** – Formal symbolic languages are generally important in pedagogy. It would be unthinkable to teach mathematics without numerals or function symbols, or music without musical notation.[2]

This paper will attempt to show how the behavioral contingency language can be useful in the performance of each of these six important functions.

Behavioral Contingencies Versus Empirical Statements

A simple behavioral contingency statement: "*If* a certain party(ies) performs a certain act(s) in certain circumstances, certain consequences (having certain attributes) may follow." The *if* part of the definition is key, as a behavioral contingency can exist and be in effect without any of the specified acts or their consequences ever occurring. Thus an implied "if" precedes every initiating act or response, because the language codifies only behavior that *could* occur and its likely known consequences *if it does* occur—not behavior that *actually* occurs.

In considering behavioral contingencies as independent variables that have causal status, it is important to distinguish between two kinds of consequences and/or causal relationships: (a) The known or assumed consequence and causal effect that is specified within the contingency statement itself (e.g., "If you drop the glass, it may break," where the specified consequence and causal effect is the breaking of the glass) and (b) the more indirect and distal consequence and causal effect of the entire contingency's existence—for instance, the effect that most people don't drop glasses (a possible dependent variable). In the contingency "If you pay $3, you get a loaf of bread," the assumed direct and specified causal effect of the act, if it occurs, would be getting the loaf, while the indirect and more distal causal effects of the contingency's existence (dependent variables) might include buyers' dispositions to buy these loaves and a store's projected loaf sales. For

[2]And yet, behavior analysis is widely taught by using verbal statements only, with all of their ambiguities, extraneous connotations, and imprecision. Jack Michael (1963) pioneered the teaching of introductory psychology with the use of the original Mechner (1959) research-oriented version of the present language, as others did subsequently, but the present generalized (and therefore somewhat more complex) version of the contingency language is far more serviceable as a pedagogic resource.

the contingency, "Cutting down trees creates grazing land," the assumed direct causal effect may be that trees get cut down (part of the independent variable), while more distant and indirect effects may include soil erosion and increased atmospheric carbon dioxide (dependent variables). Additional examples are provided in Mechner, 2008a, pp 124-225, Sections 1.1, 1.4.

The Analogous Distinction in Other Disciplines

The "if, then" conditionality feature described above is not unique to the behavioral contingency language. Most formal symbolic languages focus on the specifiable and causal events of their disciplines—the independent variables—rather than on the potential effects of those events—the dependent variables. Familiar examples are musical scores (viewable as contingency statements), which state, in effect, that *if* the score is played, certain music will result, but the sounds of possible resulting music are not included in the language's codifications; a cooking recipe may state that *if* certain steps are carried out, a certain dish will result, but the taste, smell, or appearance of the dish itself are not codified; and the codification of a chemical formula or reaction does not include the physical, chemical, or biological properties (i.e., behavior) of possible resulting substances. Thus formal languages codify causal circumstances—independent variables that can be specified, designed, manipulated, controlled, or modified, but not the potential effects of those variables—the dependent variables. The description of such potential effects is the role of science.

A Special Feature of Behavioral Contingencies

There is, however, a difference between the formal symbolic codification of independent variables in the behavioral sciences and in other disciplines. The difference is due to the fact that the behavioral sciences deal with the behavior of organisms. Organisms are special in that they have evolved to be responsive to changes in their environment and to the consequences of their own behavior. Thus behavioral contingency statements, as independent variables, must also reflect or assume relevant attributes of the organism—its history, biological characteristics, capabilities, and present state. When the agent of an act is a responsive organism, the act's consequences, as a result of their very occurrence, change the agent's history and state at least to some small degree, thereby modifying the prevailing contingency for the act's next possible occurrence. *Example*: The contingency "if bar press then pellet" is different for a rat that never previously received a pellet for pressing a bar than it is for a rat that has a history of having done so, and within a training session, the contingency for the rat changes as its state changes from a food-deprived rat to a satiated one.

The analyst may sometimes choose to focus on such feedback mechanisms and sometimes not. But even when contingencies are affected by their effects, they continue to function as independent variables. The same principle applies in other sciences: In a chemical reaction where the reagents in their relative concentrations are the independent variable, they remain the independent variable even when those concentrations change as the reaction proceeds. The contingency language includes techniques for codifying such feedback effects when the analyst wishes to make them the focus of an analysis, as will be discussed later.

It might be noted that *every* statement of a contingency, however formal or informal, makes assumptions about the histories and states of the parties. The contingency statement "if you drive through a red light you may get a ticket" presumably assumes that the party is an adult who can drive, would perceive a red light, and would prefer not to get a ticket. Such assumptions about a party, though they can be framed as empirical state-

ments, must be understood to be preceded by "*ifs*" and therefore to have no effects on the intended empirical emptiness of the contingency statement.

The Significance of the Distinction

One value of distinguishing between behavioral contingency statements and empirical statements about resulting effects resides in the fact that the contingency statement proper has far more generality than its potentially complex and variegated effects, even when these are known or surmised. Like most formal symbolic languages, the behavioral contingency language codifies only events, relationships, and parameters that can function as independent variables. One important reason for this is that behavioral contingencies and their parameters lend themselves more readily to description, classification, and categorization than do the myriad effects they can generate. The relationships between the contingencies and their various possible effects—the dependent variables—constitute the ever-growing body of knowledge of the behavioral sciences.

It may be noted that this distinction runs counter to our customary use of language, which generally conflates causes with their effects. Familiar examples are words like "action," "stimulus," "response," "reinforcement," or "purpose," which are nonetheless useful in ordinary communication. But the distinction assumes special importance when the goal is to engineer a result, which is why the language's function of highlighting this distinction is of special significance to scientists and technologists. Since the generality and usefulness of pure behavioral contingency statements resides in their status as the exclusively causal side of behavioral paradigms, it is valuable to distinguish cleanly between, and avoid conflation of, the independent variable and its effects. Familiar examples of such conflation are the expressions "administer reinforcement," and "present an S^D." By maintaining clarity regarding the distinction, researchers may avoid many types of conceptual confusion, identify open research issues, and enhance the generality of their findings.

This article does not present a detailed or full description of the formal symbolic behavioral contingency language. That is available elsewhere (Mechner, 2008a, 2008b). Only those elements of the language that are needed to illustrate the six previously-listed uses and functions of the language will be presented here, and will be introduced in the context of illustrations of ways in which the language can perform these important functions.

The Three-Term Contingency

B.F. Skinner introduced the contingency concept as the defining feature and overarching independent variable of operant behavior. He was the first to use the term "reinforcement contingency" (Skinner, 1938, pp. 308-309), and described the "three-term contingency" (Skinner, 1953, p.108; Moore, 2008), usually codified as $\mathbf{S^D: R \rightarrow S^R}$. But this paradigm does not meet the present language's criteria for a pure contingency statement. Its S^D and S^R terms both represent behavioral effects of stimuli (i.e., discriminative and reinforcing effects respectively), thereby making the paradigm an empirical statement.

The Distinction Applied to the Three-Term Contingency

To identify its potential parameters, the three-term contingency must first be translated into the contingency language. Why? Because the language's grammar is needed to make the contingency's parameters graphically and visually accessible. Once identified, the parameters can be manipulated and adjusted with a view to producing desired effects. The simplest contingency statement is $\mathbf{A \rightarrow C}$, read as "If **A** then **C**,"[3] where **A** can be any act, response, or behavior, and **C**

can be any assumed consequence, situation, circumstance, or event.[4]

$$\mathbf{S^D: R \rightarrow S^R} \text{ is translated into } \begin{bmatrix} \mathbf{C_D} \\ \mathbf{A \rightarrow C^{(+/-)}} \end{bmatrix}$$

The $\mathbf{S^D}$ becomes $\mathbf{C_D}$. An entity's lower right quadrant (the subscript) is the location for an entity's description. The subscript can be a word, numeral, or symbol indexed to a more extensive description in a separate legend. Here the subscript **D** (which still stands for "Discriminative") is a *subscript* of the **C,** indexed to the diagram's legend, which may explain that $\mathbf{C_D}$ is a prevailing stimulus, situation, or circumstance that was previously associated with that act and consequence. It is a statement about $\mathbf{C_D}$'s history (presumably a history of discrimination training) rather than about a behavioral effect, such as a discriminative effect.

The vertical superposition inside the bracket of the $\mathbf{A \rightarrow C}$ contingency and the $\mathbf{C_D}$, indicates that they are in effect simultaneously, even if **A** never occurs. The vertical order in which they are listed has no significance.

This restated contingency statement is read as: "If act **A** (e.g., reaching for the salt shaker) occurs in the presence of the discriminative stimulus $\mathbf{C_D}$ (e.g., sight of the salt shaker on the table), it produces consequence **C** (e.g. getting the salt), which may have a positive valence for the party." The **C**'s actual description and definition would include the relevant history of the party. On the other hand, the traditional statement of the three-term contingency might be read as "If response R occurs in the presence of 'S^D' the consequence is a 'reinforcing' effect." The concept of "reinforcement," which is represented as S^R in the three-term contingency, refers to a particular behavioral effect of the contingency's existence, i.e., a dependent variable, and therefore, like S^D, cannot be part of a pure behavioral contingency statement, nor of an independent variable[5].

Valences of Consequences

In the above translation of the three-term operant contingency, the act's consequence $\mathbf{S^R}$ is shown as **C** with its "valence" indicated by a plus or minus sign in its upper right quadrant. Unlike "$\mathbf{S^R}$"**,** such a valence indication is the analyst's (optional) conjecture as to likely effects of the **C** on a party, given the particular **C**'s description and the party's history and other characteristics with respect to that **C**. Indicated valences are not intended to represent specific or clearly defined behavioral effects of a **C**. In fact, a rigorous behavioral contingency statement would omit the valence conjecture altogether and would limit itself to an objective description of the **C** (like "food delivery" or "amount of money received (or lost)"). Indications of the valences of consequences can nonetheless aid and enhance a contingency diagram's visualization function by communicating the analyst's educated guess regarding the behavioral significance, within the contingency, of the **C**'s objective description, and the party's history with respect to it.

The Upper and Lower Right Quadrants

An entity's upper right quadrant is reserved for the entity's attributes. If the entity is a consequence **C**, the analyst may want to indicate attributes of the **C** in addition to valence. For instance, the **C**'s presumed probability would be shown as $\mathbf{C^p}$ and its

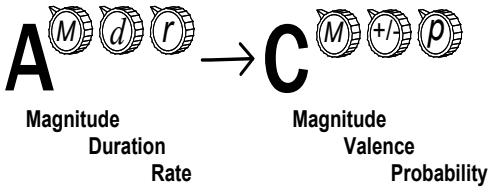
[3]We can say that A, if it occurs, would produce the known consequence C, regardless of whether that consequation is mediated by another organism, by a machine, or by features of an ecological system.

[4]Depending on the particular behavioral discipline, perspective, and application, the **A** for act can be interchanged with **R** for response or **B** for behavior, and the **C** for consequence or circumstance can be interchanged with **S** for stimulus or situation, in all cases without affecting the grammar. **A** and **C** are used here because they appear to be the most general of these symbols and carry the least baggage of connotations in the English language.

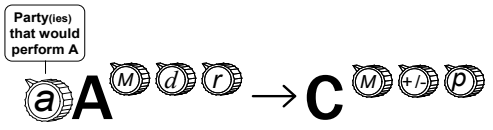
[5]In fact, a more complete account of the "reinforcement" phenomenon remains a complex empirical issue that is still a subject of active research and analysis (Baum, 2002; Davison & Baum, 2006; Killeen, 1998, 2001; Mechner, 1994), and the particular form in which a "reinforcing" effect expresses itself always depends on numerous variables.

magnitude as $\mathbf{C}^{M}$. If multiple parties are involved, the party or parties to whom the attribute applies would be shown in front of the attribute's designation, like this: $\mathbf{C}^{a+}$, $\mathbf{C}^{b-}$, or $\mathbf{C}^{bM}$. Possible parameters of acts or responses, when applicable and relevant, would be shown as $\mathbf{A}^{M}$ for the act's magnitude, $\mathbf{A}^{d}$ for its duration, and $\mathbf{A}^{r}$ for its rate.

In the contingency diagram $\mathbf{A}^{M,d,r}\rightarrow\mathbf{C}^{M,+/-,\ p}$ below, the parameters are shown as knobs for setting or adjusting their values—in the case of the **C**'s parameters, to produce the desired behavioral effects, and in the case of **A**'s parameters, to specify criteria for the behavior that would produce the **C**. Why knobs? To emphasize the fact that adjusting and specifying parameters and setting their values does not change the structure of the contingency.



If relevant, the agent of an act can be designated by an arbitrary lower case letter, such as ***a,*** placed in front of the **A**, like a coefficient (not a subscript) — ***a*****A**. Note that the agent would be a parameter only when there are multiple parties.



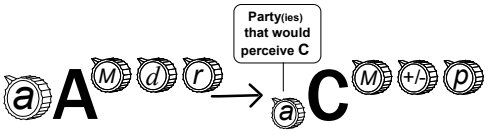
For every **C**, the grammar also prompts consideration of the **C**'s potential delay, which, if pertinent, is codified as **A**→**T**→**C**, read as "if **A,** then upon the termination of **T**, **C** would occur."

Every contingency has potential parameters, as illustrated above for the three-term contingency, but any particular parameter would actually be shown only if it is sufficiently relevant to the analyst's focus and intent, and sufficiently significant in the context of the analysis being performed.

Perception of the Entity

The "perceive" modifier is an implied parameter of any operant contingency. For an operant contingency to have an effect on the organism, the organism must be able to perceive a consequence of its behavior, both in the psychophysical sense and in the sense of an appropriate learning history's outcome.[6] An indication that a consequence would be perceived by a party reflects the analyst's assumptions regarding that party's physiological capabilities and relevant learning history, the nature of the **C**, and the prevailing circumstances. If the "*would perceive*"[7] modifier is not indicated for any **C**, it is implied or assumed. The analyst would indicate the *would perceive* modifier when perceptibility is not self-evident, or when there are multiple parties only some of which would perceive a particular **C**. Note that "perception" can occur with or without "awareness" or "consciousness."

To state explicitly in a diagram that the agent ***a*** of the behavior *would perceive* a consequence, the agent's designation, ***a***, is shown in the **C**'s lower left quadrant as $_{a}\mathbf{C}$. The consequence may also be perceived by a party other than **A**'s agent, whether or not ***a*** would perceive it.



[6] In interaction with the genetic endowment, of course. A consequence is "perceptible" to a party if that party would respond to it in any way whatsoever, i.e.,when it is above the perceptibility threshold and not perceptually blocked.

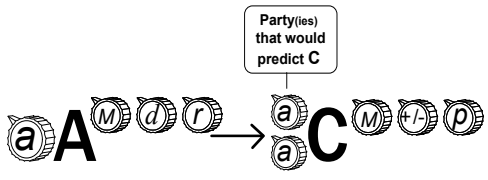
[7] The "would" is needed for grammatical consistency with the conditionality feature of contingency statements--the fact that the C would be perceived only *if* the C and the consequating act actually occured.

Operant Contingencies and Prior History of Exposure

The effects of an operant contingency on an organism depend on the organism's prior history of exposure to the contingency and consequence, or on prior (verbal or non-verbal) cues regarding the contingency and consequence. Examples of such history effects are the **C**'s possible reinforcing and discriminative properties, although these would not be explicitly identified or described in a contingency statement. All such history effects are embodied in the "*would predict*" modifier, which is therefore another implicit parameter of the consequence in operant contingencies. Thus, when stating that a party *would predict* **C**, the analyst reflects his assumptions regarding the net effect of the party's history with respect to similar contingencies and consequences in similar prevailing circumstances. By indicating that a party "*would predict*" **C**, the analyst states, in effect, that based on its history, the party would behave as if the consequence **C** would occur in these circumstances.

Some effects of such histories are also variously referred to in ordinary parlance as anticipations and expectations. While none of these terms are free of undesired connotations, "predict" is used here because it seems to have less connotational baggage than the others, at least in English.

To indicate explicitly that a party *would predict* a consequence, the party's designation, ***a***, is shown in the **C**'s upper left quadrant— $^{a}\mathbf{C}$. Thus every entity's lower and upper left quadrants prompt the analyst to consider whether a party would perceive that entity, would predict it, and whether the issue is relevant to the analysis being performed.

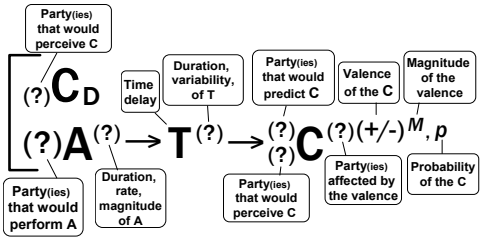


In diagrams of operant contingencies, "*would perceive*" and "*would predict*" are always potential parameters of any indicated consequence. When the analyst does not show these parameters explicitly as modifiers of a consequence, they are either assumed or considered irrelevant. They tend to be most significant in contingencies that involve multiple parties.

Some Common Parameters of the Three-Term Contingency

The diagram below shows the three-term contingency with some of its most obvious potential parameters labeled. The question marks in the locations of the parameters indicate that the parameter may or may not be relevant (and therefore shown) in any particular instance, and may assume different values according to the analyst's focus. The **T** itself may or may not be shown, depending on whether the analyst considers it relevant in the particular case.

The diagram is intended to show the three-term contingency as *the general case* of potentially numerous and varied particular contingencies, that would be defined and differentiated by different values and combinations of parameters as well as by all the possible alternative descriptions of the particular acts and their consequences.



How Prompts can be Used in Contingency Analysis

Insights into a contingency can be gained and subtle wrinkles revealed by using the prompts provided by the grammar. This is one of the uses for the contingency language.

Every entity's upper right quadrant prompts the analyst to ask what the entity's attributes are for each party (e.g., which party or parties would be affected by the valence?) and, as always, whether the answer is relevant to the analysis being performed. The left quadrants prompt such questions as, would the **C** be perceived and/or predicted by the same party whose behavior produced the consequence, or would it also (or only) be perceived and/or predicted by another party? Would the **C** be delayed? If more than one act is involved in the contingency, who is the agent of each act? If there is more than one **C**, what are their relative magnitudes or probabilities? Such prompts can serve as heuristics or templates for analyzing a presumptive independent variable in an experiment, for making it more precise, for identifying uncontrolled variables, or for analyzing contingencies that occur in various realms of human affairs outside the laboratory.

Thus, each of every entity's four quadrants provides a different set of prompts to the analyst regarding the entity's potential modifiers. The analyst decides whether each potential modifier is relevant to the analysis being performed.

Example of a Particular Three-Term Contingency

For one well-known three-term contingency, the act **A** is described as smoking a cigarette.

Language features used: To show that both of two events would need to occur, the symbolic logic symbol ⋂ is used. Thus (**A** ⋂ **T**) → means that both **A** *and* **T** are necessary. A recycling arrow shows that **A** can occur repeatedly. The number of times it would recycle is represented by the letter ***n*** shown above the arrow. The following expression combines these features of the language:

$$\left(\overset{n}{\circlearrowright} \boldsymbol{a}\mathbf{A}_{\text{smoking}} \cap \mathbf{T}\right) \rightarrow$$

It is read as "If party ***a*** smokes ***n*** cigarettes and time **T** has passed, the consequence would be…"

The diagram below shows that the immediate consequence of smoking a cigarette is presumably positive for the act's agent ***a***, and the long-term consequence, which develops concurrently with the act's immediate positive consequence, is described as getting lung cancer (presumably negative for ***a***). The diagram states that this consequence would have a certain probability (the probability can also be shown as a function of ***n*** or **T**), and that ***a*** would predict **C** (shown by the ***a*** in the **C**'s upper left quadrant).

$$\left[\begin{array}{l} \left(\overset{n}{\circlearrowright} \boldsymbol{a}\mathbf{A}_{\text{smoking}} \cap \mathbf{T}\right) \rightarrow {}^{\boldsymbol{a}}\mathbf{C}^{\boldsymbol{a}\text{-},\boldsymbol{p}}_{\text{lung cancer}} \\ \boldsymbol{a}\mathbf{A}_{\text{smoking}} \longrightarrow \mathbf{C}^{\boldsymbol{a}+}_{\text{pleasure}} \\ \mathbf{C}_{\text{history and opportunity}} \end{array}\right.$$

A legend could specify such details as exactly when **T** starts (e.g., with the first cigarette, with the last one, or after a certain number) and/or how **T** may be a function of ***n***, or how ***p*** may be a function of **T**. The diagram and legend could also specify the rate at which **A** would occur or the duration of each **A**, if relevant. All of these are examples of potentially useful prompts to the analyst.

Misprediction and Deception

The analyst may also wish to focus on the contingencies created when tobacco companies run advertisements that cause smokers to *mispredict* the long-term consequences of smoking. The codification of this contingency requires a notation for "*would mispredict*," because a misleading advertisement might cause a party to mispredict a consequence.

When stating that a party ***a*** *would misperceive* or *would mispredict* a consequence **C**, the analyst states, in effect, that ***a*** would perceive or predict some consequence other than **C**, as in an optical illusion, which is a history

effect that overrides the contemporaneous reality (Brown, 1973; Carter & Werner, 1978; Cumming, Berryman, & Cohen, 1965; Mechner 1994, pp. 33-34; Schoenfeld & Cumming, 1963), or a response to misleading cues. As always, such a statement would reflect assumptions regarding ***a***'s physiology and history, and the nature of the **C** and the prevailing circumstances.

The symbol a^x, shown in an entity's upper left quadrant, ${}^{a^x}\mathbf{C}$, means that ***a*** *would mispredict* the entity, and, if a^x is shown in the lower left quadrant, ${}_{a^x}\mathbf{C}$, that ***a*** *would misperceive* it. The symbol $\tilde{a}$, on the other hand, means that ***a*** *would not* perceive or predict the entity at all, perhaps because the entity is physically obstructed, below threshold, out of range, or not within ***a***'s perceptual history. The distinction between *mis*predicting and *not* predicting can be illustrated by ***a*** taking a wrong turn when driving, often due to a *mis*perception, and the car hitting a bump due to a *non*-perception.

This notational device is required for the codification of deception contingencies (Mechner, 2010a), which are pervasive in the animal kingdom. They include camouflage, disguise, impersonation, lying, stealing, tricking, seduction, lulling, stalking, obfuscation, pretense, entrapment, etc. All involve some form of *misperception* or *misprediction*.

$$\left[\left(\overset{n}{\curvearrowright}\mathbf{a}\mathbf{A}_{\text{smoke}} \cap \mathbf{b}\mathbf{A}_{\text{advertise}} \cap \mathbf{T}\right) \rightarrow {}^{\mathbf{b}a^x}\mathbf{C}^{\mathbf{a}\text{-},p}_{\text{lung cancer}} \right]_{\text{history and opportunity}}$$

In the above diagram, the agent ***b*** in ***b*A** denotes tobacco companies. The ***b*** in the upper left quadrant of the a^x indicates that ***b*** *would predict* that ***a*** *would mispredict* the long-term consequence, along with its probability ***p***.[8] The ${}^{b}a^x$ term could also be shown in the upper left quadrant of the ***p*** or the **T** if the analyst wished to focus on the fact that ***a*** might mispredict ***p*** or **T** and that this misprediction would be predicted by party ***b***.

[8]Contingencies in which the agent of an act would predict the act's consequence are related to the concept of "intentionality," as discussed in Mechner (2010a). Thus when party ***b*** predicts ***a***'s misprediction, the deception that results from ***b***'s act can be called intentional.

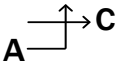
The Conceptualization and Categorization Function

The progress of disciplines is often marked by the appearance of new conceptual frameworks, like the periodic table of elements in chemistry. Formal symbolic languages often accelerate this conceptualization process.

The behavioral contingency analysis language can generate new conceptual frameworks by revealing structural parallels among seemingly diverse contingencies, and by grouping, categorizing, classifying, and conceptualizing these on the basis of such parallels. The deception category, illustrated above, is one important example of such a conceptualization. Some additional potential categories are discussed below.

Prevention Contingencies

Contingencies in which an act *prevents* a consequence are also important and ubiquitous. This category of contingencies can be subdivided further according to whether the valence of the consequence would be assumed to be negative, as in escape, avoidance, averting, or warning; or positive, as in foiling, forfeiting, depriving, or blocking. The diagrams for all of these include a vertical arrow cutting a horizontal arrow:



Theory of Mind Contingencies

All modifiers can also apply to the modifiers themselves, in recursive fashion, as a potentially infinite regress. Thus every entity, whether it is a basic vocabulary item or a modifier of one, has the same four quadrants. This recursiveness feature enables the analyst to express the subtlest nuances of meaning.

Examples include "theory of mind" contingencies (Knoll & Charman, 2000; Lin, Keysar & Epley, 2010), which share the feature of a party perceiving or predicting another party's perception or prediction in a recursive hierarchy. This feature is also needed for the analysis and codification of autistic behavior (Baron-Cohen, 1989; Okuda & Inoue, 2000), game theoretic strategy games like the prisoner's dilemma (Rachlin, Brown & Baker, 2001), as well as deception (Mechner 2010a).

Discounting Contingencies

These include contingencies that feature temporal and probability discounting (Green & Myerson, 2004), seen in most addictions; degradation of the environment; procrastination; costly borrowing; and other such tradeoffs. The smoking contingency described earlier falls into the broad category of discounting contingencies. Such contingencies generally show two or more different consequences that would occur after different time intervals and would have different valences, probabilities, magnitudes, or some combination of these. The discounting effect is not codified within the contingency statement proper, it is the empirically observed behavioral effect that has been studied and described for some such contingencies in the behavior analysis literature (Mazur, 1987; Rachlin, 2000).

Certain Economic and Cinancial Contingencies

This group of contingencies combines features of deception and discounting. Such phenomena as pyramid (Ponzi) processes, the creation of derivatives, securitization, currency creation, reserve maintenance in banking, and bubble formation and bursting, all involve deception and discounting and have similar contingency structures (Mechner 2010b).

Contingencies that Change

As discussed earlier, all behavioral contingencies change in some way if and when the initiating act and its consequences actually occur, if only because the mere occurrence of an act and consequence changes the organism's history and state in some small way. The change is not always the focus of the analysis, but instances where it is include the ripening of a crop; skill improvement by repetitive practice (Mechner, 1994); the contingency in which the longer you wait, the worse it gets; running up debts; depletion of a resource; saving money; accumulating interest; or the long-term cumulative effects of smoking.

When the intended focus is the way a contingency changes, the formal symbolic language is able to codify the dynamics involved. The main applicable technique shows a concurrent "register" within the bracket. The register indicates how a consequence keeps changing as a function of a variable such as number of repetitions of an act, the passage of time, external events, or how one variable changes as a function of another. These notation techniques are discussed and illustrated in Mechner (2008a; 2008b, pp. 44-50, Section 6).

Cycling Contingencies in Which Behavior Lags Behind Perception

Locomotion (perception of upcoming terrain about to be traversed), reading (perception of upcoming words about to be "read"), listening (which requires recall of recent sounds), and the copying of text (requiring recall of just-read text), are all seen to involve continuous successive cycles of perception and execution of behavior. Detailed parallels between locomotion and such complex verbal skills as reading, listening, and copying suggest that locomotion may be their philogenetic ancestor and therefore biologically homologous with them (Mechner, 2009).

Additional Categories and Conceptualizations of Contingencies

There are obviously numerous additional familiar groupings of contingencies that have structural similarities: zero-sum games; racing, cooperation, competition; contracts, agreements, promises; standoffs, deadlocks, mutual deterrence; choice situations; blackmail and kidnapping; and feuds. Regardless of which, if any, of these particular categorizations and conceptualizations will ultimately prove useful or of theoretical interest, it seems clear that the behavioral sciences will always need to conceptualize the behavioral contingencies that lie at their core.

Establishing Linkages to Other Disciplines

The conceptualization function of the behavioral contingency language can create linkages between behavior analysis and other sciences that involve human behavior. A formal symbolic language may prove to be a valuable tool in performing penetrating analyses of the root phenomena in such disciplines as economics and finance (Mechner, 2010b), education, organizational management (Mawhinney, 1992), marketing, sociology, law, government and public affairs, and preservation of the environment.

The Role of The Behavioral Contingency Analysis Language

Any application of the formal symbolic language for the analysis of behavioral contingencies raises the question, "Could the same thing have been done without using the formal symbolic language?" Even when the answer is "perhaps," the language may be viewed like Wittgenstein's ladder—discarded after having been climbed. When an explorer has reached a destination and created a map, it often becomes evident that a shorter route existed. The same principle may apply to applications of the formal symbolic language for analyzing behavioral contingencies.

But regardless of how much the behavioral contingency language eventually contributes to the performance of the six functions described in this paper, the effectiveness with which they are performed, by whatever means, should be expected to influence the progress and maturation of behavior analysis.

References

Baron-Cohen, S. (1989). The autistic child's theory of mind: A case of specific developmental delay. *Journal of Child Psychology & Psychiatry, 30*, 285—297. doi: 10.1111/j.1469-7610.1989.tb00241.x

Baum, W. M. (2002). From molecular to molar: A paradigm shift in behavior analysis. *Journal of the Experimental Analysis of Behavior, 78,* 95—116. doi:10.1901/jeab.2002.78-95

Brown, R. (1973). *A First Language: The Early Stages*. Cambridge, MA: Harvard University Press.

Carter, D. E., & Werner, T. J. (1978). Complex learning and information processing by pigeons: A critical analysis. *Journal of the Experimental Analysis of Behavior, 29*, 565—601. doi:10.1901/jeab.1978.29-565

Cumming, W. W., Berryman, R., & Cohen, L. R. (1965). Acquisition and transfer of zero delay matching. *Psychological Reports, 17*, 434—445.

Davison, M., and Baum, W. M. (2006). Do conditional reinforcers count? *Journal of the Experimental Analysis of Behavior, 86,* 269—283. doi:10.1901/jeab.2006.56-05

Green, L., and Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychological Bulletin, 130*, 769—792. doi:10.1037/0033-2909.130.5.769

Killeen, P. R. (1998). The first principle of reinforcement. In C. D. L. Wynne & J. E. R. Staddon (Eds.), *Models of action: Mechanisms for adaptive behavior* (pp. 127—156), Mahwah, NJ: Erlbaum.

Killeen, P. R. (2001). Rats don't always respond faster for more food: The paradoxical incentive effect. *Animal Learning & Behavior, 29,* 66—78.

Knoll, M., & Charman, T. (2000). Teaching false belief and visual perspective taking skills in young children: Can a theory of mind be trained? *Child Study Journal*, *30*, 273—304.

Lin, S., Keysar, B., & Epley, N. (2010). Reflexively mindblind: Using theory of mind to interpret behavior requires effortful attention. *Journal of Experimental Social Psychology, 46,* 551—556. doi:10.1016/j.jesp.2009.12.019

Mawhinney, T. C. (1992). *Organizational Culture, Rule-Governed Behavior and Organizational Behavior Management: Theoretical Foundations and Implications for Research and Practice.* Binghamton, NY: The Haworth Press.

Mazur, J. E. (1987). An adjusting procedure for studying delayed reinforcement. In M. L. Commons, J. E. Mazur, J. A. Nevin, & H. Rachlin (eds.) *Quantitative analyses of behavior, Vol. 5. The effect of delay and of intervening events on reinforcement value* (pp. 55—73). Hillsdale, New Jersey: Erlbaum.

Mechner, F. (1959). A notation system for the description of behavioral procedures. *Journal of the Experimental Analysis of Behavior, 2*, 133—150.

Mechner, F. (1994). The revealed operant: A way to study the characteristics of individual occurrences of operant responses. In S.S. Glenn (Ed.), *Cambridge Center for Behavioral Studies Monograph Series: Progress in Behavioral Studies, Monograph #3*. Cambridge, MA: Cambridge Center for Behavioral Studies.

Mechner, F. (2008a). Behavioral contingency analysis. *Behavioral Processes, 78*, 124—144. doi:10.1016/j.beproc.2008.01.013

Mechner, F. (2008b). Applications of the language for codifying behavioral contingencies. Retrieved November 30, 2010 from http://mechnerfoundation.org/newsite/downloads.html

Mechner, F. (2009). Analyzing variable behavioral contingencies: Are certain complex skills homologous with locomotion? *Behavioral Processes, 81*, 316—321. doi:10.1016/j.beproc.2008.12.004

Mechner, F. (2010a). Anatomy of deception: A behavioral contingency analysis. *Behavioral Processes, 84*, 516—520. doi:10.1016/j.beproc.2010.02.003

Mechner, F. (2010b). Formal parallels among derivatives, Ponzi processes, and bubbles: a behavioral contingency analysis. Retrieved November 30, 2010 from http://mechnerfoundation.org/newsite/downloads.html

Michael, J. (1963). *Laboratory Studies in Operant Behavior*. New York: McGraw-Hill.

Moore, J. (2008). *Conceptual Foundations of Radical Behaviorism*. Cornwall-on-Hudson, NY: Sloan.

Okuda, K., & Inoue, M. (2000). A behavior analytic view of teaching "theory of mind" to children with autism: Stimulus control and generalization on false belief tasks. *Japanese Psychological Review, 43,* 427—442.

Rachlin, H. (2000). *The Science of Self-control*. Boston, MA: Harvard University Press.

Rachlin, H., Brown, J. & Baker, F. (2001). Reinforcement and punishment in the prisoner's dilemma game. In D. L. Medin (Ed.), *The Psychology of Learning and Motivation: Advances in Research and Theory* (pp. 327—364). San Diego, CA: Academic Press. doi:10.1016/S0079-7421(00)80024-9

Rocke, A. J. (2010). *Image and Reality: Kekule, Kopp, and the Scientific Imagination*. Chicago: The University of Chicago Press.

Schoenfeld, W. N., & Cumming, W. W. (1963). Behavior and perception. In S. Koch (Ed.), *Psychology: A study of a science, Vol. 5* (pp. 213—252). New York: McGraw-Hill. doi:10.1037/10040-004

Skinner, B. F. (1938). *The Behavior of Organisms: An Experimental Analysis*. Oxford, England: Appleton-Century-Crofts.

Skinner, B. F. (1953). *Science and Human Behavior.* New York: The Free Press/Macmillan.