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The Big Bang Theory and Behavior Analysis: Sheldon's misunderstanding of Skinner's concepts

The Big Bang Theory e a Análise do Comportamento: O equívoco de Sheldon acerca dos conceitos Skinnerianos

SANDRO IÊGO[1]

[1]INDEPENDENT RESEARCHER, BRAZIL

Abstract

Scientific knowledge may serve to improve people's lives, and hence should be available to both scientists and non-specialists. However, facile access to scientific information by non-specialists also risks misunderstanding, as well as the subsequent misuse of technical-scientific procedures. This case study aims to examine, from an analytic-behavioral perspective, the procedures applied by a fictional television series character who misguidedly attempts to employ operant conditioning techniques, which he barely understood. In the third episode of season three of The Big Bang Theory, the protagonist Sheldon Cooper attempts to modify behaviors exhibited by his neighbor, Penny, based on his misinterpretation of Skinner's works. The procedure applied, rewarding Penny with chocolates immediately following behavior he desires, ends up unintentionally promoting the opposite behavioral effect than what he originally intended. By disregarding the complexity of human behavior and underestimating the entire body of scientific knowledge related to Behavior Analysis, he inadvertently and naïvely reinforces Penny's 'behavioral chains' instead of just an isolated behavior. Consequently, the likelihood of Penny's 'undesirable' behaviors occurring in the future become increased. This case report exemplifies how implementing science-based psychological procedures in the absence of a comprehensive understanding of relevant underlying scientific concepts can lead to disastrous consequences.

Keywords: behavior contingency analysis, operant conditioning, shaping, BF Skinner, The Big Bang Theory.

Resumo

O conhecimento científico deve servir para melhorar a vida das pessoas e, portanto, deve estar disponível tanto para cientistas quanto para o público leigo. No entanto, o acesso fácil de informações científicas pelo público leigo também favorece o risco de equívocos, bem como ao subsequente uso indevido de procedimentos técnico-científicos. Este estudo de caso tem como objetivo avaliar, numa perspectiva analítico-comportamental, os procedimentos aplicados por um personagem de uma série televisiva que erroneamente tenta aplicar técnicas de condicionamento operante que ele mal compreendia. No terceiro episódio da terceira temporada de The Big Bang Theory, o protagonista Sheldon Cooper tenta modificar alguns comportamentos de sua vizinha Penny, baseando-se na sua interpretação deturpada dos trabalhos de BF Skinner. Ocorre que o procedimento aplicado por Sheldon de recompensar Penny com chocolates depois dela se comportar como que ele desejava, paradoxalmente promove o efeito comportamental justamente oposto ao que ele originalmente planejou. Ao desconsiderar a complexidade do comportamento humano e subestimar todo o arcabouço científico relacionado à Análise do Comportamento, ele inadvertidamente e ingenuamente acabou acidentalmente reforçando toda uma cadeia comportamental de respostas de Penny, ao invés de um único comportamento isoladamente. Consequentemente, a probabilidade de comportamentos "indesejáveis" de Penny ocorrerem no futuro é aumentada. Este relato de caso exemplifica como a implementação de procedimentos psicológicos científicos, na ausência de uma compreensão abrangente dos conceitos científicos subjacentes, pode levar a consequências desastrosas.

Palavras-chave: análise de contingências do comportamento, condicionamento operante, modelagem, BF Skinner, The Big Bang Theory.

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✉ sandroiego@gmail.com

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"Science is human behavior, and so is the opposition to science" (Skinner, 1971, p. 23)

Psychological concepts are widespread in countless contexts, and can be easily applied in several ways. This is notably evident in mass media, where non-specialists employ techniques and practices used by psychologists (Azoubel & Saconatto, 2022; Morris, 1985), as exemplified by the present case report on S03E03 of *The Big Bang Theory* (TBBT) TV Series. TBBT was a global phenomenon that mixed comedy and science in its scriptwriting. One episode paid tribute, in a well-humored way, to a widely recognized psychologist, Burrhus Frederic Skinner (1904-1990). Ironically, the *operant conditioning* procedure utilized in this episode, to illustrate one of Skinner's contributions to behavioral science, was employed incorrectly.

BF Skinner was an influential psychologist in the last century, who he argued that Psychology should establish scientific methodologies in order to reach a status similar to that attained by the natural sciences (Skinner, 1953). Skinner defended the concept that psychology's object of study should be behavior (Skinner, 1938, 1956, 1957a), which is susceptible to measurement and can therefore be studied scientifically: "I am interested, first, in setting up a system of behavior in terms of which the facts of a science may be stated and, second, in testing the system experimentally at some of its more important points" (Skinner, 1938, p.5). He then developed methods of studying behavior scientifically, and conducted experimental research that allowed him to collect sufficient data to conclude that a scientific understanding of behavior could truly be achieved.

Over decades, Skinner meticulously and experimentally studied *operant behavior*, a behavioral category functionally different from both the respondent behavior described by Pavlov (1927) and the innate reflexive behavior examined by physiologists. In both respondent and reflexive behaviors, responses are exclusively caused by prior environmental stimuli (antecedents). Skinner observed that, differently from innate reflexive and respondent behaviors, operant behavior is also affected by the consequences generated by the response: "The word 'operant' will be used to describe this class. The term emphasizes the fact that the behavior operates upon the environment to generate consequences" (Skinner 1953, p. 65). An example of innate reflex behavior is the event of yawning as elicited by the yawning of others. On the other hand, automatically yawning when listening to lullabies is an instance of respondent (learned reflex) behavior. However, when an individual voluntarily opens his/her mouth to passionately kiss another, this is an example of operant behavior. Indeed, many human behaviors are operant behaviors. Based on his findings, Skinner proposed the model of *operant contingency* as a way to comprehend operant behavior using a three-term contingency as the minimal unit of behavior analysis:

An adequate formulation of the interaction between an organism and its environment must always *specify three things*: (1) the *occasion* upon which a response occurs, (2) the *response* itself, and (3) the reinforcing *consequences*. The interrelationships among them are the "contingencies of reinforcement" (Skinner, 1969, p. 27, italics and underline emphasis added).

Contingency is a conceptual tool used to describe the relationship(s) between two or more variables, in which one conditionally affects the other(s), i.e., "if-then". These relationships may arise between two or more environmental events (stimuli), or between these events and behaviors (Catania, 2013). A contingency is designated as operant when it consists of a minimum of three terms, with at least one operant behavior included. In general, the first term of an operant contingency is the *antecedent*, the situational context that precedes and/or establishes an opportunity for a certain behavior to occur. This may be a physical stimulus, an event (or a combination of events, and/or relationships between events), and/or an environmental condition. The second term is the behavioral *response* itself, which encompasses all of an individual's doings, including their actions, sensations, and thoughts. Finally, the third term is the *consequence*, an event subsequently produced by a response, which may entail a change in, or the maintenance of the antecedent condition. Through scientific experimental research, Skinner observed that operant behavior is selected by its consequences (Skinner, 1981) in a process analogous to Darwin's natural selection:

(…) in certain aspects operant reinforcement resembles the natural selection of evolutionary theory. Just as genetic characteristics which arise as mutations are selected or discarded by their consequences, so novel forms of behavior are selected or discarded through reinforcement. (Skinner, 1953, p. 430)

Skinner also found that certain consequences of a particular behavior could increase the likelihood of it to occur again in the future, while others could decrease this probability. He termed the former "*reinforcement"* and the latter "*punishment"* (Skinner, 1938, 1953). In general, consequences can be classified as *natural* or *arbitrary* (also known as *contrived*). The effects of natural consequences are directly produced by the response itself upon the behavioral environment. For instance, the movement of hands across guitar strings (response) produces reverberating sound as a

natural consequence. By contrast, contrived consequences are presented indirectly by a mediator following response emission. In the case above, receiving compliments or money for playing the guitar are examples of contrived consequences. Both natural and contrived consequences can produce either reinforced or punitive *behavioral effects* on responding, depending on the respective increases or decreases in rates of functionally similar responses in the future. *Operant conditioning* was the term Skinner attributed to the process of strengthening a behavior by its consequences: "The strengthening of behavior which results from reinforcement is appropriately called 'conditioning'. In operant conditioning we 'strengthen' an operant in the sense of making a response more probable or, in actual fact, more frequent" (Skinner, 1953, p. 65). Another important behavioral process described by Skinner was *shaping*, a variation of operant conditioning by which novel behavior can be generated by gradually modifying some of the properties of responding (Skinner, 1969). "Operant conditioning shapes behavior as a sculptor shapes a lump of clay" (Skinner, 1953, p.91). As a technical procedure, shaping consists of the differentially systematic reinforcement of successive approximations of variations along one or more dimensions of a target operant class (Catania, 2013).

Inspired by the principles and practices described by Skinner, the protagonist of the TBBT TV series, Sheldon Cooper, devised a procedure to, in his words, "sand" the behavior of Penny, another character on the series. The present study is a case report that aims to examine, from an analytic-behavioral perspective, the procedures applied by Sheldon in a misguided attempt to employ operant conditioning techniques to modify Penny's behaviors in the third episode of season three (S03E03). First, we will examine the actions that comprise his procedure, as well as the underlying premises and hypotheses. Next, the potential effects and ramifications will be described, as well as the expected changes in Penny's behavior. Finally, we will discuss the consistency of his procedure in light of both the scientific results from Skinner's work and experimental behavior analysis, which Sheldon believed he was applying.

Methods

Study Design

The present case report aims to describe and evaluate, from an analytic-behavioral perspective, a behavioral procedure developed by a non-expert to produce behavioral changes in a specific individual. To this end, behavioral measures will be analyzed at three different points (prior, throughout and after intervention).

Participants and Variables of Interest

The participants are two fictional adult characters from the TV series *The Big Bang Theory*, and the selected behavioral interactions between these two constitute the variables of interest. The character Sheldon Cooper plays the role of experimenter who applies his own behavioral procedure, and his behaviors constitute the independent variables under study. Penny is the experimental subject submitted to Sheldon's procedures, and the measures of her behavior were adopted as dependent variables. It is worth noting that Penny had not been informed that she would be subjected to a behavioral procedure.

Data Collection and Analysis

All interactions between Sheldon and Penny related to the employment of "positive reinforcement techniques" [*sic*] in TBBT episode entitled "*The Gothowitz Deviation*" (S03E03) were included in the sample. No exclusion criteria were adopted. Behavioral interactions were classified as reinforcement contingency components: Penny's behaviors composed the response terms of the behavioral contingency, while Sheldon's actions corresponded to prior stimuli (antecedent terms) and/or consequent environmental stimuli (consequence terms).

In order to standardize the nomenclature used in this article, the following definitions were adopted: a) *behavioral episode* – the functional unit of behavior, consisting of the minimal number of behavioral interactions between Sheldon and Penny needed to reach an understanding of behavioral function with respect to a given behavior. A behavioral episode can be represented by a simple behavioral contingency consisting of two, three or more terms (Matos, 1999; Thompson & Lubinski, 1986); b) *behavioral contingency* – a description of interrelationships between the behavioral responses under analysis (e.g., Penny's behaviors) and the environmental events (e.g., Sheldon's behaviors) that affect and/or are affected by these responses. Behavioral contingencies may be operant contingencies consisting of three or more terms, or two-term respondent contingencies (Skinner, 1969); c) *contingency terms* – categories that group, limit and distinguish (among) sets of behavioral events that temporally participate in a behavioral episode. Behavioral contingencies consist of these terms, which may be classified as antecedent, response or consequence

terms; d) *behavioral event* – each topographically described environmental or behavioral occurrence participating in the behavioral contingency under analysis (e.g., 'Penny sat down in Sheldon's spot'). These are considered components of contingency terms.

All behavioral episodes were investigated using Behavioral Contingency Analysis in two different phases. First, the behavioral events that composed each contingency term were *identified* and *described*. Then, each behavioral event was *analyzed* in order to identify its behavioral function within the contingency.

Procedures

Initially, all interactions were identified between Sheldon and Penny in every scene that Sheldon tried to change Penny's behavior by (in his words) "employing positive reinforcement techniques" [*sic*], hereinafter referred to as EPRT. Second, to compile the *Contingency Terms,* Penny's *Responses* were firstly identified by determining her actions throughout each behavioral episode, with simultaneous actions grouped into a single term where appropriate. Next, using Penny's responses as observational criteria, the following related contingency terms were identified in sequence: i) the events triggered by her responses (*Consequences*); ii) the situational context (*Antecedents*) that provided an occasion for her response to occur; iii) Penny's chained responses, where applicable. Each behavioral episode's length was established by the sequence of contingency terms necessary to perform behavioral contingency analysis in order to determine the behavioral function of each behavioral event.

Case Report

The fictional characters Sheldon Cooper and Leonard Hofstadter are scientists who study theoretical and experimental physics, respectively, at a university in the USA. They share an apartment across the hall from where Penny, a beautiful waitress who is also Leonard's girlfriend, lives. Sheldon considers Penny uneducated because she does not hold a PhD (actually, she has not even graduated from college), and he is very displeased with her non-conformity to his odd rules. As a result, he attempts to shape her behavior to better suit his arbitrary lifestyle.

In TBBT S03E03, Sheldon decides to employ what he calls "operant conditioning techniques" [*sic*] to modify some of Penny's behaviors that he considers inappropriate. He was operating under the assumption that issuing a "*positive reinforcement"* [*sic*] for what he considered good behavior, the frequency of behavior he considers appropriate would increase by rewarding her with chocolates. In the past, when Penny did something that he disliked, he reacted with punishment. For example, TBBT S02E07 illustrates how Sheldon dealt with those who dared not follow his bizarre rules. In this previous episode, Penny committed a series of petty infractions when ignoring Sheldon's exaggerated requests, despite Leonard's advice to Penny to capitulate to Sheldon like they all do. Consequently, Sheldon enforced a 'three strikes you're out' policy and banished her from his apartment after she sat in his spot on the sofa. After Penny decided to take a stance against him, he reacted so harshly that Leonard warned her: "Penny, you don't want to get into it with Sheldon. The guy is one lab accident away from being a supervillain."

In S03E03, upon listening to Leonard's request to find a better way of dealing with Penny, Sheldon thought he found a solution in Skinner's work, by means of a procedure through which he could train her while also being "nice" [*sic*]. As a scientist, Sheldon decided to apply a "harmless scientifically valid protocol" [*sic*] to resolve his issues with her. He told Leonard: "You weren't happy with my previous approach dealing with her, so I decided to employ operant conditioning techniques, building on the works of Thorndike and BF Skinner".

The procedure that Sheldon devised to alter Penny's behavior was based on one of Skinner's experimentally demonstrated behavior principles: operant behaviors are affected by their consequences. Based on this premise, without considering a sizeable set of variables that also influence behavior, Sheldon decided to offer chocolates and praise Penny every time she demonstrated behavior that was agreeable to him. He believed this was a technical procedure and he termed it "employing positive reinforcement techniques" [*sic*] (EPRT). Under his hypothesis, by rewarding Penny with praise and chocolate immediately following behavior he approved of, he would be able to increase the frequency of any behavior he desired. Furthermore, he believed that by doing this, he was indeed applying a scientifically valid procedure based on Skinner's work.

In five different scenes, Sheldon tries to shape Penny's behavior using his EPRT. All of these scenes take place in the living room of Sheldon and Leonard's apartment, with both roommates present, as well as Penny. In the first scene, Penny offers to take Sheldon's plate to the kitchen after they finish dinner. In return, Sheldon praises her and gives her a chocolate. In the second scene, Penny gets up and apologizes to Sheldon for sitting in his spot on the sofa. Oddly, Sheldon kindly accepts her apology and offers her a chocolate. In the third scene, Sheldon complains when

Penny laughs loudly while Leonard and Sheldon watch TV silently. She makes a 'zip-your-lips' gesture, ceases laughing and then Sheldon gives her another chocolate. Soon afterwards, in the fourth scene, Penny's cell phone rings and she answers it next to Sheldon, who looks at her disapprovingly. She gets up to talk in the hall far away from him and he rewards her with a chocolate. Finally, after finishing her conversation on the phone, she comes back complaining about her friend in a high-pitched voice. Sheldon makes her repeat a single word until she says it in a regular voice, after which he gives her another chocolate. Figure 1 shows a list of examples illustrating Sheldon's misguided attempts to modify Penny's behavior using his EPRT.

Figure 1

Situations in TBBT S03E03 Illustrating Sheldon's EPRT, a Procedure to Modify Penny's Behavior Based on his Misinterpretation of Both Operant Contingencies and Shaping Procedures

	BEHAVIORAL EPISODE AS APPARENTLY INFERRED BY SHELDON*		Behavioral Effect expected by Sheldon**
	PENNY'S RESPONSE	CONSEQUENCE	
SCENE 1	Volunteering to remove dirty plates after meals	*Chocolate*	Positive Reinforcement***
SCENE 2	Getting up from Sheldon's sofa spot	*Chocolate*	Positive Reinforcement
SCENE 3	Stopping to talk	*Chocolate*	Positive Reinforcement
SCENE 4	Moving away from Sheldon after answering the phone	*Chocolate*	Positive Reinforcement
SCENE 5	Ceasing to speak in a high-pitched voice	*Chocolate*	Positive Reinforcement

Note. * Based on the dialogues involving Sheldon we can assume that he inferred a two-term-contingency (Response – Consequence) to be the entire behavioral episode. ** This refers to the effect *expected* by Sheldon concerning the likelihood of Penny behaving similarly in the future, resulting from his procedure of presenting chocolates as a consequence to her response. *** I.e., behavioral effect of *increasing* rates of desirable responses by Penny (strengthening of analogous behavior in the future) via presentation of an appetitive stimulus.

Under Sheldon's hypothesis, chocolate should function as a reinforcing stimulus. Accordingly, Penny's responses would be reinforced and occur more frequently upon receiving chocolates from Sheldon. In addition, he also assumed that, at the same time, her undesirable responses would occur less frequently, e.g., leaving dirty plates on the table, sitting in Sheldon's sofa spot, laughing loudly, answering calls next to him and speaking in a high-pitched voice. However, his ERPT did not seem to recognize the antecedent term as an indispensable component of the behavioral episode. The following case analysis serves to illustrate the significance of Sheldon's error.

Case Analysis

In order to adequately conduct an analysis of Sheldon's EPRT in accordance with behavior analysis methodology, it is necessary to submit the procedure itself to *behavioral contingency analysis* by examining both Sheldon's behaviors and the impacts of his actions upon Penny's behavior. Likewise, it is also necessary to understand the operant contingencies that were in effect during their past interactions by investigating the behavioral variables that prompted Sheldon's prior aversive practices, as well as the consequences of his previous actions upon Penny's past behaviors. This, in turn, enables us to identify behavioral changes both before and after the implementation of

Sheldon's 'shaping'[1] procedure (EPRT). Therefore, in order to explore the expected results of Sheldon's procedure on Penny, we will firstly evaluate interactions between Sheldon and Penny to describe and functionally analyze the operant contingencies in effect prior to his 'shaping' procedure. Secondly, the operant contingencies in effect upon initiation of and following Sheldon's procedure also will be described and analyzed and, finally, the resulting behavioral changes after his procedure will be analyzed.

Investigation of Operant Contingencies in effect PRIOR to Sheldon's EPRT

Prior to implementing EPRT, Sheldon had not devised a strategy to deal with Penny's undesirable behavior. When Penny behaved in a certain manner that did *not disturb* Sheldon, he did nothing as a consequence of her "agreeable" behavior. Indeed, his reaction was simply to pay no attention at all. However, when her behavior *disturbed* him, he instinctively overreacted and impetuously punished her by issuing reprimands, penalties and/or restrictions, as mentioned previously. Based on Sheldon's behavioral patterns in other episodes of TBBT, the typical approach Sheldon likely applied to manage Penny's behaviors in the past, prior to his EPRT, would be analogous to that *described* in Figure 2.

The behavioral episodes presented in Figure 2 represent a probable depiction of interactions between Sheldon and Penny prior to his EPRT. These episodes are composed of at least three-term-contingencies (Antecedents – Responses – Consequences). These triple contingencies can be *described* as follows: in the context of environmental events that set up occasions for Penny to behave in Sheldon's presence (A1s + A2s in Figure 2), she could either behave in a way that would disturb him or be pleasing to him. If she behaved in a manner that disturbed him (R1s in Figure 2), Sheldon would often react by reprehending, sanctioning and/or commanding her (C1s in Figure 2). On the other hand, when her behavior was pleasing to him (R2s in Figure 2), he often paid no attention to it and did nothing to encourage her desirable behaviors.[2]

Accordingly, it is plausible that the response rates of Penny's behaviors deemed *undesirable* to Sheldon could have decreased as a result of his aversive conduct; however, this could only occur in his presence. In other words, Penny might behave "appropriately" (R2's in Figure 1) *exclusively* to avoid being punished by him, as exemplified in the previously mentioned scene in S2E07. Otherwise, she would probably continue to behave as she always did, as Sheldon did not previously bother to administer any reinforcing consequences subsequent to Penny's *desirable* behaviors. Since her "appropriate" behaviors were not strengthened by any of Sheldon's previous tactics, it is not expected that these "desirable" behaviors would be selected.

Behavioral contingency analysis of the behavioral elements that make up this behavioral episode reveals that Sheldon's presence (A2) in all scenes described in Figure 2 functions as a *warning stimulus*,[3] signaling a forthcoming *aversive stimulus* (C1). R2 responses function as *avoidance behavior* because they prevent aversive consequences (C1) and are not selected by Sheldon's specific behaviors. In contrast, R1 responses are *behaviors susceptible to punishment* that are followed by Sheldon's actions (C1), which function as *aversive stimuli.*

Investigation of Operant Contingencies in effect *upon initiation* of and *following* Sheldon's EPRT

After listening to Leonard complaining about Sheldon's hostility towards Penny, i.e., issuing punishments following Penny's 'undesirable' behavior, Sheldon decided to change his tactics by applying his superficial knowledge of Skinner's methods to 'sand' (in his words) Penny's behavior using chocolate as a reinforcing stimulus. His procedure consisted merely of granting a reward (chocolate) immediately following the occurrence of a behavioral response that

[1] The term shaping is used in this paper under two circumstances: firstly, referring to the technical use of the behavioral procedure conceptually aligned with Skinner's approach, or as incorrectly used by TBBT characters to portray Sheldon's EPRT procedure, which stems from their misunderstanding of Skinnerian concepts. In order to not confuse readers, wherever the term shaping is improperly employed, it will be placed in single quotation marks (i.e., 'shaping').

[2] It is worth mentioning that, in this hypothetical case, it is probable that other antecedents may also be affecting the emission of R2s. However, the comprehensive identification of all possible antecedents (all contextual conditions resulting Penny's behaviors) is outside the scope of the present analysis.

[3] The terminology used in this article is derived from Skinner's concepts, of which the misunderstanding of said concepts represents the object of analysis of this paper. Although post-Skinnerian researchers have since attempted to refine some of his original concepts, a discussion of what constitutes the most appropriate terminology is outside the scope of this manuscript.

he desired, regardless of the contextual situation in which this response occurred. As mentioned previously, this intervention strategy considered only two terms of contingency (*Response* and *Consequence*), ignoring the antecedent term, i.e., the context in which the response behavior occurs. Although many observers would argue this distinction appears to be quite subtle or even unnecessary, the lack of comprehensive analysis and inappropriate characterization of all terms involved in a particular contingency can result in extremely different variations in behavioral understanding and adversely influence the conduct of interventions, as well as outcomes.

Figure 2

Description of Probable Operant Contingencies in Effect Prior to Sheldon's EPRT

	BEHAVIORAL EPISODES *			Probable Behavioral Effect**
	ANTECEDENT(S)	PENNY'S RESPONSE(S)	CONSEQUENCE(S)	
SCENE 1	(A1) Meal is finished; dirty plates are on the table	(R1) Leaving dirty plates on the table after a meal	(C1) *Sheldon complains and tells her to remove the plates.*	Punishment***
	(A2) Sheldon is present	(R2) Volunteering to remove dirty plates after a meal	(C2) *No consequence presented by Sheldon*	No behavior selection
SCENE 2	(A1) Sheldon's sofa spot is unoccupied	(R1) Sitting down in Sheldon's sofa spot	(C1) *Sheldon complains and tells her to move.*	Punishment
	(A2) Sheldon is present	(R2) Sitting down in another spot	(C2) *No consequence presented by Sheldon*	No behavior selection
SCENE 3	(A1) Everyone watching TV silently	(R1) Laughing loudly	(C1) *Sheldon complains and tells her to be quiet.*	Punishment
	(A2) Sheldon is present	(R2) Keeping silent	(C2) *No consequence presented by Sheldon*	No behavior selection
SCENE 4	(A1) Penny's cell phone rings	(R1) Answering a call next to Sheldon	(C1) *Sheldon complains and tells her to go away.*	Punishment
	(A2) Sheldon is present	(R2) Moving away from Sheldon to answer a call	(C2) *No consequence presented by Sheldon*	No behavior selection
SCENE 5	(A1) Sheldon asks Penny something	(R1) Replying in a high-pitched voice	(C1) *Sheldon complains and asks to her to stop speaking in a high-pitched voice.*	Punishment
	(A2) Sheldon is present	(R2) Using a regular voice	(C2) *No consequence presented by Sheldon*	No behavior selection

Note. * Behavioral episodes composed of operant contingencies with three terms of analysis (Antecedent – Response – Consequence). ** This refers to the *probable* behavioral effect regarding the likelihood of Penny behaving similarly in future. *** I.e., behavioral effect of *decreasing* undesirable response rates via the presentation of an *aversive* stimulus

In fact, to conduct a comprehensive analysis of all of Penny's behaviors and Sheldon's interactions, a minimum unit of analysis must mandatorily consider a behavioral chain composed of an operant contingency with five terms of analysis. A behavioral chain is a complex unit of behavior consisting of a number of individual responses emitted in a specific sequence, in which one response produces the stimulus for the next (Keller, 1969; Miltenberger, 2016). Figure 3 presents a behavioral contingency analysis of the chained operant contingencies in effect upon implementation of and following Sheldon's EPRT on Penny's responses, using Scene 2 presented in the previous section as an example.

Figure 3

Behavioral Contingency Analysis of Operant Contingencies in Effect Upon Initiation of and Following Sheldon's EPRT in Scene 2 of TBBT S03E03

	BEHAVIORAL EPISODES					
	ANTECEDENT 1	PENNY'S RESPONSE 1	CONSEQUENCE 1 / ANTECEDENT 2	PENNY'S RESPONSE 2	CONSEQUENCE 2	*Effect*
Behavioral Events	Sheldon's sofa spot unoccupied Sheldon is absent	*Sitting down in Sheldon's sofa spot*	Sheldon catches Penny in his spot	*Getting out of Sheldon's spot, apologizing*	Sheldon praises her and gives her a chocolate	Reinforcement
Behavioral Function (Initiation of EPRT)	*Warning Stimulus*	*Response susceptible to punishment.*	*Conditioned Aversive Stimulus*	*Escape-Avoidance Response*	*Contrived Reinforcer: Strengthening the entire chain*	
Behavioral Function (Following EPRT)	*Discriminative Stimulus*	*Chained Response produces the presentation of a reinforcing stimulus.*	*Conditioned Reinforcer: (1) Strengthening previous response; (2) Signaling availability of another Reinforcement*	*Chained Response produces the presentation of an contrived reinforcing stimulus.*	*Contrived Reinforcer: Strengthening the entire chain*	

Figure 3 describes a 5-term contingency analysis of Scene 2, firstly described as a 3-term contingency in Figure 2. The first term (Antecedent 1) of the behavioral episode is a stimulus antecedent that precedes Penny's first response, i.e., the unoccupied condition of Sheldon's spot on the sofa. This antecedent stimulus initially assumes the behavioral function of a *warning stimulus*, i.e., a stimulus that signals a forthcoming aversive stimulus. Penny's sitting in Sheldon's spot is the second term (Penny's Response 1), a *response susceptible to punishment*. The third contingency term (Consequence 1/Antecedent 2) is being caught by Sheldon while sitting in his spot, which functions as an *aversive conditioned stimulus* prior to EPRT by signaling that she would be chastised.

The following term (Penny's Response 2) consists of Penny's simultaneous response of getting up, apologizing and performing other actions aimed at avoiding Sheldon's punishment, which functions as an *escape-avoidance response* prior to EPRT. In the past, we can assume that Sheldon would complain and threaten Penny until he felt that she was duly punished as a final consequence (see *Scene 2* in *Figure 2*). However, in his attempt at shaping, he arbitrarily decides to provide a *contrived consequence* to her response by giving her a chocolate (Consequence 2 in Figure 3), which serves to strengthen the entire chain: "Some chains have a functional unity. The links have occurred in more or less the same order, and the whole chain has been affected by a single consequence" (Skinner, 1953, p. 224).

Paradoxically, the entire behavioral chain becomes affected due to Sheldon's contrived reinforcement when Penny receives a chocolate: after being caught by Sheldon in his spot (Antecedent 2 in Figure 3), Penny's response of getting up and apologizing (Penny's Response 2) becomes strengthened when followed by a chocolate (Consequence 2). Consequently, when faced with a future opportunity to sit in Sheldon's unoccupied spot (Antecedent 1), it is therefore more likely that Penny will emit the response of sitting in it (Penny's Response 1) rather than not. It is well-known that human behavior is continuously being shaped and maintained by its consequences by way of operant conditioning, which is, contrary to what Sheldon likely believes, the process by which consequences modify behavior (Overskeid, 2018). Accordingly, considering that Sheldon may continue employing EPRT repeatedly over time, it would be expected

that, through the process of operant conditioning, Penny's response rates would gradually become altered. At the same time, the behavioral functions of both antecedent and consequent stimuli would also be modified.

Investigation of Operant Contingencies in effect AFTER Sheldon's EPRT

Whereas Sheldon's prior tactics produced the collateral effect of not decreasing Penny's 'troublesome' behavior in Sheldon's absence (Figure 2), his EPRT produced the unintended and paradoxical effect of increasing the behaviors he desired to eliminate, particularly when he is around her. This phenomenon results from the accidental strengthening of the entire behavioral chain, instead of just a single reinforced response through the arbitrary use of contrived reinforcers in the context of chained responses.

The operant conditioning resulting from repeatedly offering chocolates when Penny gets out of Sheldon's sofa spot produces behavioral function changes in all behavioral elements presented in Figure 3. The behavioral stimulus *"Sheldon's spot unoccupied"* (Antecedent 1 in Figure 3) initially served as a *warning stimulus,* but then acquires the function of *discriminative stimulus*, signaling a reinforcement opportunity (chocolate) if the chained responses are emitted (sitting and subsequently getting up). Interestingly, the behavioral function of being caught by Sheldon may also change from *conditioned aversive stimulus* to *conditioned reinforcing stimulus*. By sitting in Sheldon's spot (Penny's Response 1), Penny is now able to establish an occasion for reinforcement by Sheldon (chocolate in Consequence 2), provided that, after being caught by him (Antecedent 2), she gets up and apologizes (Penny's Response 2). Thus, the behavioral function of Penny's latter response changes from an *escape-avoidance response* to a *discriminated operant*, i.e., an operant response more likely to occur in the presence of a discriminative stimulus.

While Penny's behaviors exhibited upon initiation of EPRT are morphologically identical to those following EPRT (Figure 3), they are functionally distinct and therefore constitute significantly different behaviors. As Skinner observed, "But they are under different kinds of stimulus control and hence are different operants. The difference appears when the scientist examines his behavior" (Skinner, 1969, p.161). In summary, following EPRT, the condition of Sheldon's spot being unoccupied now becomes a discriminative stimulus throughout the behavioral chain, signaling the availability of future reinforcement as long as the following chained response occurs: Penny sitting in Sheldon's spot being her first response, followed by her getting up and apologizing.

Similarly, the detrimental effects of Sheldon delivering chocolates in Scene 2 are also applicable in other situations (Figure 4). It follows that Sheldon's attempts at modifying her behavior by EPRT may lead Penny to leave dirty plates on the table after meals, as this will present an opportunity for her to be rewarded by chocolate when she removes them (Scene 1, Figure 4). In Scene 3, it also becomes more likely that she will make noise in a silent environment in order to be compensated by a chocolate when she stops. Similarly, her cell phone ringing in Scene 4 now presents a favorable circumstance for receiving a chocolate upon moving away from Sheldon after answering a call near him. And finally, in Scene 5, one can assume that she would be more inclined to answer Sheldon in a high-pitched voice, since having the tone of her voice 'shaped' by Sheldon is likely to produce a chocolate reward.

Although Sheldon aimed to exclusively reinforce Penny's second responses in the behavioral chains, his presumptuous use of behavioral techniques in the absence of a comprehensive scientific understanding of those techniques led to his misguided implementation of his EPRT, which promotes exactly the opposite effect than what he intended.

Discussion

"The scientist may not be sure of the answer, but he's often sure he can find one." (Skinner, 1948. p. 107)

Sheldon's procedures for modifying Penny's behavior, based on his *misinterpretation* of both operant conditioning and shaping procedures, were chosen as a suitable illustration of the potential misuse of scientific techniques due to the lack of a comprehensive understanding of the knowledge needed to support technical intervention (Morris, 1895). Sheldon's misunderstanding and misuse of Skinner's concepts resulted in his performing interventions that were destined to produce precisely the opposite effect of what he originally planned. Considering Sheldon's actions in TBBT S03E03, one could assume that he holds a common misconception regarding Skinner's theory: in order to change someone's behavior, it is merely necessary to introduce a simple consequence (either a reinforcing or a punishing stimulus) subsequent to a particular behavior. Presumably, he mistakenly interpreted that shaping merely entails 'delivering stimuli'.

Sheldon's conduct illustrates common errors committed by non-specialists when trying to perform Skinnerian-based interventions, which contributes to the spread of incorrect notions regarding Skinner concepts and Behaviorism.

Although Skinnerian theory is recognized worldwide, and some of the conceptions he described have become household words, few non-behaviorists, including those in the humanities, educational and social sciences, accurately understand the concepts proposed by Skinner (Arntzen et. al. 2010; Sheldon, 2002; Todd & Morris, 1983). Today, some people continue to naïvely believe that Skinner's entire contribution to psychology, developed through more than 60 years of scientific research, can essentially be summarized as follows: the delivery of rewards (reinforcements) or sanctions (punishment) can easily change the behavior of others to suit one's own desires.

Figure 4

Accurate *Behavioral Contingency Analysis of Behavioral Episodes Following the Implementation of Sheldon's EPRT in TBBT S03E03*

	BEHAVIORAL EPISODES*					
	ANTECEDENT 1	PENNY'S RESPONSE 1	CONSEQUENCE 1 / ANTECEDENT 2	PENNY'S RESPONSE 2	CONSEQUENCE 2	*Behavioral effect*
SCENE 1	Table without dirty plates	*Leaving dirty plates on the table*	Sheldon notes the dirty plates	*Removing dirty plates*	Sheldon praises her and gives her a chocolate	Positive Reinforcement
SCENE 2	Sheldon's sofa spot unoccupied	*Sitting down in Sheldon's sofa spot*	Sheldon caught her in his spot	*Getting out of Sheldon's spot and apologizing.*	Sheldon praises her and gives her a chocolate	Positive Reinforcement
SCENE 3	Silent environment	*Talking too much*	Sheldon is disturbed by her noise.	*Stopping Talking*	Sheldon praises her and gives her a chocolate	Positive Reinforcement
SCENE 4	Cell phone rings	*Answering call next to Sheldon*	Sheldon looks at her annoyedly	*Answering calls outside of Sheldon's apartment*	Sheldon praises her and gives her a chocolate	Positive Reinforcement
SCENE 5	Opportunity to talk	*Speaking in a high-pitched voice*	Sheldon makes her repeat one word	*Using her normal tone of voice*	Sheldon praises her and gives her a chocolate	Positive Reinforcement
Behavioral Function	*Discriminative Stimulus*	*Chained Response that produces the presentation of a reinforcing stimulus.*	*Conditioned Reinforcer: Strengthens previous response and signals availability of another Reinforcement*	*Chained Response that produces the presentation of a contrived reinforcing stimulus.*	*Contrived Reinforcer: Strengthens the entire chain of responses*	

Note. * Behavioral episodes composed of operant contingencies with five terms of analysis

Contradictory to this perspective, Skinner stated that a given behavior must be considered as an integral part of its environmental context (Skinner, 1981, 1984), thereby constituting a balanced system. In this sense, there is no dysfunctional or unadapted behavior; all behaviors have an adaptive function for both the person who behaves and for the environment in which the person is interacting (Sidman, 1960). Even when a particular behavior is evaluated as incorrect or inappropriate, it nonetheless exerts a function that must be considered with regard to its implications on the entire behavioral chain, i.e., changing a particular behavior implies alterations in the entire balanced system. Accordingly, behavior analysts are strongly advised to perform comprehensive behavioral contingency analysis before conducting any interventions in order to properly identify the functions associated with particular behaviors (Carr, 1994; Neno, 2003). In TBBT S03E03, there is no evidence indicating that Sheldon made any attempt to perform comprehensive behavioral analysis before implementing interventions. Functional contingency analyses are necessary prior to conducting any behavioral interventions, as they aim to comprehend the functions of a particular behavior.

When not adequately performed, behavioral contingency analysis appears to be a simplistic procedure of contestable relevance. Moreover, the performance of behavioral contingency analysis is neither easy nor simple. There are several aspects of behavior that must be considered in any analysis, and it is also necessary to identify the variables that participate in a given behavioral phenomenon, as well as the functions of all the elements in a given contingency. Performing behavioral interventions without previously conducting behavioral contingency analysis can be as harmful as taking medicines in the absence of a diagnosis, or as disastrous as constructing a building without a proper foundation.

In general, the procedure consists of the following steps, which is an adaptation of Matos (1999): (1) selecting a particular behavior for analysis; (2) identifying the contingency in which the behavior is linked to, as well the contingency's minimal unit of analysis (at least a three-term, or even more complex contingency), and all behavioral events associated with each term of the contingency; (3) analyzing the behavioral function of each contingency event; (4) interpreting the

behavior with regard to its adaptive function within the surrounding environmental context, and, finally, understanding its effects upon this environmental context and how the same context can select the behavior under analysis.

In the absence of relevant information derived from behavioral contingency analysis, combined with his poor understanding of the principles of behavior analysis, Sheldon made no less than two critical errors in his EPRT. Namely, he employed contrived reinforcement to strengthen low-probability behaviors and accidentally reinforced undesirable behavioral chains due to his deficient knowledge of basic behavior analysis concepts. Behavior analysts have been studying and discussing the technical implications of using natural or contrived reinforcers in clinical interventions (Rosenfarb, 1992). From a scientific perspective, both seem to produce advantageous and disadvantageous effects depending on the contingency under analysis. In general, behavior analysts have collected sufficient data to defend the notion that natural reinforcement is preferable to contrived reinforcement, although the latter is justified in some situations: "Contrived reinforcers are necessary when natural consequences are long deferred" (Skinner, 1982, p. 8). When employed, contrived reinforcement should be carefully managed and conducted under highly specific and well-planned conditions. Specially, a relevant risk associated with contrived consequences is the extinction of behavior in the absence of contrived reinforcing stimulus.

If he were to have employed natural reinforcement, Sheldon should have revealed to Penny the effects that her behavior produced on him when she acted in agreement with his requests. Penny's behavior may have directly affected Sheldon in several ways, especially by arousing feelings and emotions, or altering his mood. However, since those effects were privately experienced by Sheldon, Penny would only have become aware of them if he had made them known to her. Had Sheldon successfully revealed those effects to her, she would have then had the opportunity to be affected by the natural consequences of her actions: "Men act upon the world, and change it, and are changed in turn by the consequences of their action" (Skinner, 1957b, p. 1). For instance, it is possible that she eventually would not sit in his spot given the opportunity; this would go unnoticed by Sheldon, in spite of the effects of her actions on him, e.g., his feeling of satisfaction due to his spot being unoccupied. Nonetheless, in this particular example her behavior would not be strengthened by its natural consequences. Accordingly, instead of using chocolates to strengthen Penny's behavior, Sheldon probably would have achieved greater success had he said something along the lines of:

Penny, I recognize that sometimes it can be tough for you to deal with me because of my idiosyncrasies. I also acknowledge and appreciate your effort to respect my peculiarities, and to try to peacefully co-exist with me. I suspect it may be hard for some people to understand the reasons that make me act like I do, and maybe my behavior seems strange to others…perhaps even to you. In fact, some kinds of sensory stimulation really disturb me and cause uncomfortable sensations accompanied by agony, anxiety, distress, and suffering. That is why I have asked you to avoid some behaviors that trigger these sensations in me, and I have noticed your efforts to honor my request. Especially, thank you for not sitting in my spot!

This type of discourse would function as a natural consequence of Penny's behavior as, if communicated sincerely, it would refer to a description (i.e., pure tact) of the direct effects produced by her behavior. It is likely that Penny would develop empathy towards Sheldon's condition. Moreover, she may even increase her intrinsic motivation to respect his wishes in the future. It is also important to note that this type of approach is more in line with Skinner's original intent.

Furthermore, it is worth considering the relevance of Sheldon's decision to implement a non-aversive strategy to manage Penny's behavior. Although his reinforcement-based procedure failed in the aforementioned aspects, it is still nonetheless less harmful, and more effective, than other punishment- or coercion-based approaches (Sidman, 1989, 1993). According to Skinner, "a person who has been punished is not thereby simply less inclined to behave in a given way; at best, he learns how to avoid punishment" (Skinner, 1971, p. 81). Thus, Sheldon's EPRT represents a step forward in terms of behavior management compared to his previous punitive approach.

Finally, in light of the abovementioned considerations, we highlight the importance of disseminating true and unbiased information regarding radical behaviorism and behavior analysis to society as a whole. In line with other behavior analysts, such as Morris (1985) and Schlinger (2015), we seek to inform the public by providing accurate perspectives on the concepts and principles underlying behavior analysis, and to help dispel inaccuracies, fallacies and misconceptions. Similar concerns led Skinner to write, 50 years ago, an entire book dedicated specifically to demystifying many common criticisms of behaviorism, or the science of behavior, which he believed were wrong (Skinner, 1974). Misconceptions, misunderstandings, misinterpretations, and even miseducation in the fields of behaviorism and behavior analysis, are all regularly presented in newspapers (Azoubel & Saconatto, 2020), psychology textbooks (Todd & Morris, 1983), public forums (Morris, 1985), websites (Sheldon, 2002), as well as among students and teachers (Arntzen et. al., 2010). Another way of viewing this predicament is to assume it is a contextual condition (antecedent) that demands actions by behavior analysts to provide sufficient information (responses), which will result in the general public's better

understanding of the principles and laws that govern human behavior (consequences). As astutely observed by Morris (1985) decades ago, the future of behavior analysis field's may in part depend on such activity.

Declaration of conflict of interest

The author declares that there is no conflict of interest regarding the publication of this article.

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