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TIME-BASED SCHEDULES AS TREATMENT FOR SEVERE BEHAVIOR DISORDERS

PROGRAMAS DE REFORZAMIENTO INDEPENDIENTE DE LA RESPUESTA COMO TRATAMIENTO PARA DESÓRDENES CONDUCTUALES SEVEROS

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ABSTRACT

This paper describes some recent work involving the application of time-based schedules as treatment for severe behavior disorders. In time-based schedules, reinforcer delivery depends on neither the occurrence or nonoccurrence of behavior. For example, in a fixed-time (FT) schedule, reinforcer presentation is at set time intervals whether or not behavior occurs. Such schedules are a logical form of treatment because they disrupt preexisting response-reinforcer relations when problem behavior is maintained by socially mediated reinforcement. Numerous applied studies on time-based schedules have been published in the past five years; this paper is intended primarily to introduce the logic of using such schedules as treatment, but not to provide an exhaustive literature review.

Key words: response-independent reinforcement, self-injurious behaviors, children

RESUMEN

Este artículo describe investigación reciente relativa al uso de programas independientes de la respuesta para el tratamiento de desórdenes en la conducta. En este tipo de programas, la entrega del reforzador no depende ni de la ocurrencia, ni de la no ocurrencia de la respuesta. Por ejemplo, en un programa de tiempo fijo (TF), la

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presentación del reforzador se fija a intervalos de tiempo regulares, ocurra o no la respuesta. Tales programas son una forma lógica para el tratamiento porque interrumpen relaciones respuesta-reforzador preexistentes cuando la conducta problema se mantiene por reforzamiento mediado socialmente. En los últimos cinco años se han publicado numerosos estudios aplicados que se han basado en el uso de programas temporales de reforzamiento; este artículo tiene como propósito principal hacer una introducción sobre la lógica para el uso de esos programas como tratamiento, pero no intenta hacer una revisón exhaustiva de la literatura.

Palabras clave: reforzamiento independiente de la respuesta, conducta auto-destructiva, niños

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The purpose of this paper is to describe the logic and application of time-based schedules as treatment for severe behavior disorders. In addition, some current and future research directions will be described. The paper is intended as an overview of this line of treatment research, but not an exhaustive literature review.

A time-based schedule is one in which the schedule of reinforcers is not influenced by behavior, i.e., the reinforcers occur response independently. The fixed-time (FT) schedule is one example of such a schedule, because reinforcers are delivered at pre-set intervals independently of responding. For instance, in an FT 1-min schedule, reinforcers are delivered once per minute, whether or not any behavior occurs. The other variation is the variable-time (VT) schedule, in which the interval between reinforcers revolves around some average value. The FT and VT schedules can be contrasted with otherwise analogous response-*dependent* schedules, such as fixed-interval (FI) and variable-interval (VI) schedules. Reinforcer delivery in the FI and VI arrangement requires the occurrence of a response after the interreinforcer interval elapses. For instance, in an FI 1-min schedule, a reinforcer is delivered upon emission of the first response after 1 minute has elapsed. No such response requirement exists with FT and VT.

For many behavior analysts, the notion of time-based schedules as treatment is counterintuitive. We are taught that treatment effects require some contingency between behavior (or its omission) and reinforcer delivery. One of the most common behavioral treatment schedules is differential reinforcement of other behavior (DRO), which requires the omission of behavior prior to reinforcer delivery; instances of behavior reset an interval timer (Poling & Ryan, 1982). For example, a therapist might deliver a reinforcer if and only if a client has not engaged in aggressive behavior for 5 minutes (this is a 5 min DRO). If aggression does occur, the therapist resets the interval timer. Differential reinforcement procedures are intuitively appealing as treatment because they simultaneously ensure that the target response is not reinforced and some other

or alternative behavior is reinforced. Time-based schedules, on the other hand, inherently contain no omission requirement. The logic of using such schedules as treatment rests in the disruption of response-stimulus contingencies.

Terminology

My colleagues and I published a paper in 1993, in which time-based schedules were call "noncontingent reinforcement" or "NCR" (Vollmer, Iwata, Zarcone, Smith, & Mazaleski, 1993). A more thorough discussion of that study will be presented later, but it is mentioned here because there has been a great deal of recent discussion about usage of the term "NCR." Poling and Normand (in press), for example, pointed out that use of the term NCR is incorrect. The procedure is neither noncontingent (i.e., it depends on the passage of time) nor does it necessarily involve reinforcement (i.e., the target behavior is not strengthened). I have always agreed that the term was incorrect, but I have described elsewhere some of the historical and procedural considerations that led to its use (Vollmer, in press). The purpose of the present paper is not to analyze terminology, so the reader is referred to the recent commentaries for that purpose.

The name "time-based schedules" is used in this paper because it is technically more accurate. However, it should be noted that the name is itself somewhat limited, insofar as it does not capture an essential property of the treatments: In the treatments, the response-independent event bears a known functional relationship to the target behavior. That is, the event has been shown, via a pre-treatment experimental analysis, to reinforce the target behavior. Thus, the general classification of "time-based" is too broad in that it does not recognize that *known* reinforcers for the target behavior are made available independent of behavior. In short, there is currently no ideal name for the procedures described herein, but "time-based schedules" is used because, albeit overly general, it is technically accurate.

The Logic of Time-Based Schedules as Treatment

Four general factors contributed to the implementation of time-based schedules as treatment for severe behavior disorders: Basic research findings, the use of time-based schedules as a control procedure, the development of functional analysis assessment methods, and the results of applied experimentation on differential reinforcement and extinction as behavior reduction techniques.

First, a review of basic research shows that time-based schedules function similarly to extinction (e.g., Lattal, 1972; Rescorla & Skucy, 1969).

In both, the contingency between a response and a reinforcer is disrupted. In extinction, the contingency is disrupted because the reinforcer is withheld. In time-based schedules, the contingency is disrupted for two reasons: (a) the response no longer produces the reinforcer, and (b) the reinforcer is frequently available when no response has occurred. Typical laboratory preparations involve contingency disruption from a FI or VI baseline to a FT or VT schedule. Because access to reinforcers is no longer response-dependent when the FT or VT schedule begins, response rates are characteristically lower in comparison to baseline schedules (e.g., Zeiler, 1968). This information is useful in considering treatment for severe behavior disorders: Aberrant behavior may be less likely to occur if reinforcers are delivered freely (as in FT and VT schedules) *and* if the behavior does not produce access to those reinforcers (they are response-independent).

Second, a review of early applied research using time-based schedules as a control procedure shows that response rates decrease in comparison to reinforcement conditions. In a response-dependent reinforcement condition two changes are introduced in comparison to a "no reinforcement" baseline: Reinforcers occur *and* they occur contingent on behavior. The time-based schedule controls for the mere occurrence of the reinforcers and, therefore, allows for a proper test of the role of the contingency. For example, Baer and Sherman (1964) reinforced imitation in children with social praise from a puppet. During a so-called extinction reversal (which was actually a time-based schedule), the social reinforcers (praise) from the puppet were delivered response independently. Imitative behavior was decreased during the response-independent praise phase in comparison to the reinforcement phase. Thus, Baer and Sherman showed the necessity of response-dependency to obtain a reinforcement effect (that is, the mere introduction of praise did not sustain imitation), but they also showed that previously reinforced behavior decreased when praise was response-independent. By extension, it follows that problematic behavior might be decreased if the reinforcers maintaining it could be identified and then presented independently of responses.

Third, the development and refinement of functional analysis methods made it possible to identify the reinforcers maintaining severe behavior disorders (e.g., Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994). Iwata et al. developed an assessment for self-injurious behavior (SIB) that tested for the reinforcing effects of social attention (positive reinforcement), escape from instructional activity (negative reinforcement), and automatic reinforcement. Fifteen-min sessions were conducted in a multielement experimental design. In the attention test, SIB produced a brief reprimand from an adult. In the escape test, SIB produced a short break from instructional activity. In the alone test, the participant received no social interaction and SIB produced no social

consequences. For some participants, the highest rates of SIB were observed in the attention condition (in comparison to other test conditions), and it was concluded that SIB was sensitive to attention as positive reinforcement. For other participants, high rates of SIB were observed in the escape condition, and it was concluded that SIB was sensitive to escape as negative reinforcement. Finally, some participants showed high rates of SIB even when they were left alone, suggesting that SIB was not maintained by social reinforcement. The importance of the functional analysis assessment format for research on time-based schedules is as follows: It became possible to identify reinforcers maintaining problem behavior, and therefore it became possible to present those reinforcers independently of responses, just as basic researchers do in the laboratory (e.g., Lattal, 1972; Rescorla & Skucy, 1969; Zeiler, 1968), and just as applied researchers do in developing control procedures (e.g., Baer & Sherman, 1964). Previously, the use of behavioral treatment procedures involved guesswork about how reinforcers were related (if at all) to the function of a target behavior.

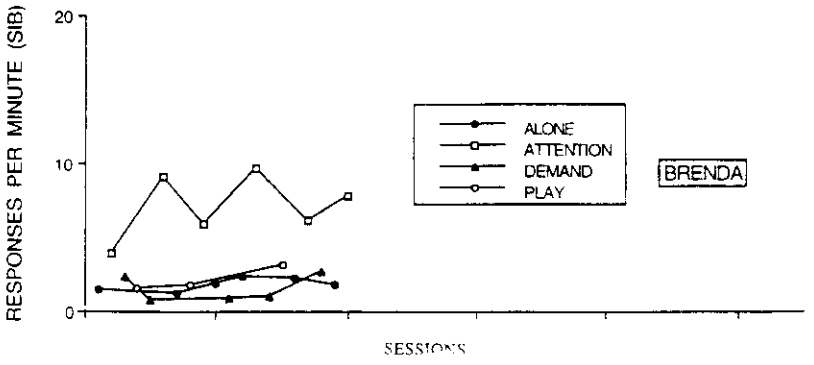
A final set of factors in the development of time-based schedules as treatment was that other commonly-used treatment procedures can be difficult to implement or have negative side effects. For instance, DRO requires continuous monitoring of behavior in order to reset an interval timer whenever problem behavior occurs. It is unlikely that most care providers can monitor one individual's behavior with precision continuously throughout an entire day. Time-based schedules have no such requirement. For example, a careprovider could be preparing dinner or paying bills while providing attention on a time schedule. In addition, both DRO and extinction may be prone to the response burst at the outset of treatment; that is, when a previously reinforced problem behavior (e.g., a tantrum) no longer produces reinforcement, there is, at times, a tendency for behavior to increase in rate, intensity, or duration, before it begins to decrease. Extinction bursts can be dangerous in the case of self-injury or aggression; and many care providers are unlikely to follow-through with procedures if the burst becomes intolerable (such as with an embarrassing tantrum, or a life-threatening self-injury). Also, DRO and extinction can yield very low rates of reinforcer access (such as social interaction). For example, if DRO is set at 5-min and problem behavior occurs on average once every 3 minutes, the participant might never obtain social interaction if the procedure is followed with perfect fidelity. Low rates of attention or other reinforcement would be especially undesirable for people with developmental disabilities who already do not have enough access to reinforcement. Time-based schedules might attenuate extinction-induced phenomena and provide relatively enriched access to reinforcers because those reinforcers would be available freely and frequently.

The factors enumerated above set the occasion for research on time-based schedules as treatment for severe behavior disorders. For example, Mace and Lalli (1991) showed generally positive effects using VT attention after a functional analysis assessment showed that a client's bizarre vocalization were maintained in part by attention. Thereafter, my colleagues, students, and I conducted a series of studies that evaluated time-based schedules as treatment for severe behavior disorders.

General Findings of Treatment Research

Our first question about time-based schedules as treatment can be summarized as follows: For individuals with SIB maintained by attention, what would happen to SIB if attention occurred on an FT schedule? Intuitively, the SIB rates should decrease because the behavior would no longer produce attention and attention would be delivered freely and frequently; in short, the reinforcement contingency would be eliminated. Three participants were identified whose functional analysis showed a reinforcement effect of attention. In the functional analysis, a series of 15-min sessions was conducted based on the procedures described by Iwata et al. (1994). Figure 1 shows the outcome of one such analysis for a participant we called Brenda, a 42-year-old woman diagnosed as profoundly mentally retarded (see Vollmer et al., 1993). The important finding was that SIB during an attention condition occurred at consistently higher rates than during other test conditions. These results suggested Brenda's SIB was positively reinforced by attention, and hence she qualified for participation.

To test the effects of time-based attention, we first conducted a baseline, in which attention was delivered for about 10 s following each instance of SIB. Next, we implemented the treatment (called "NCR" on the figure). At the beginning of the treatment condition, attention was delivered continuously; gradually, the schedule of FT attention was increased across sessions until an FT 5-min schedule was obtained. Figure 2 (also from Vollmer et al., 1993) shows that, during baseline, Brenda's SIB rates were as high as 50 per minute (nearly continuous SIB). The FT attention condition (NCR) immediately decreased SIB rates; and the decrease was sustained through the end of the condition when the FT value was 5 minutes (FT values are not depicted in the figure). Following a brief reversal to baseline, a resetting DRO condition was implemented as a point of comparison.



Figue 1. A functional analysis showing SIB maintained by attention. (Reproduced with permission of society of the Experimental Analysis of Behavior; from Vollmer, T. R., Iwata, B. A., Zarcone, J. R., Smith, R. G. & Mazaleski, J. L. (1993). The role of attention in the treatment of attention-maintained self-injurious behavior: Noncontingent reinforcement and differential reinforcement of other behavior. *Journal of Applied Experimental Analysis, 26,* 9-21).

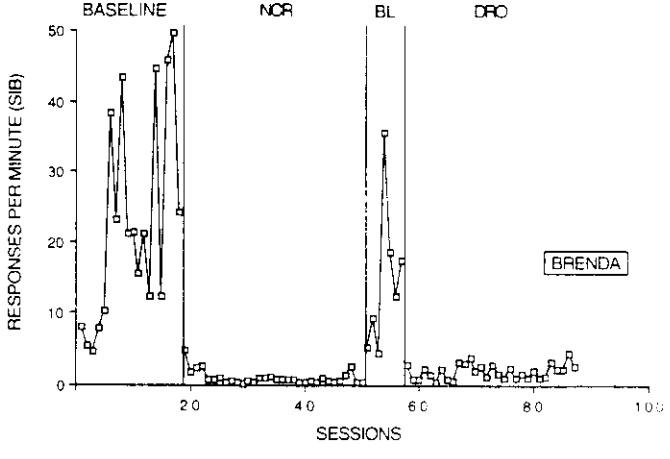


Figure 2. A treatment analysis showing rapid and substantial reductions in self-injury. NCR refers to "noncontingent reinforcement," as the schedule was described in the article. (Reproduced with permission of the Society of the Experimental Analysis of Behavior; from Vollmer, T. R., Iwata, B. A., Zarcone, J, R., Smith, R. G., & Mazaleski, J. L. (1993). The role of attention in the treatment of attention-mainained self-injurious behavior: Noncontingent reinforcement and differential reinforcement of other behavior. *Journal of Applied Behavior Analysis, 26,* 9-21).

Some general findings of the Vollmer et al. (1993) study were as

follows: (a) FT was about as effective as DRO in suppressing SIB, and (b) reinforcer rates were considerably higher during FT than during DRO; in fact, for Brenda the reinforcer rate was zero at the DRO interval of 3 min. Thus, had we recommended DRO as treatment for Brenda, we would have prescribed a treatment that involved zero attention. By definition, FT 5-min yielded a reinforcer rate of .2 per minute. Finally, there was evidence that FT attenuated some of the extinction-induced phenomena sometimes associated with DRO. Specifically, during DRO, one participant exhibited higher rates of aggression correlated with the onset of treatment and another participant exhibited a response burst of SIB at the onset of DRO but no response burst at the onset of FT. What is not known, however, is the mechanism(s) by which the FT schedule reduced the target behavior. Some possibilities include extinction (some occurrences of the response did not directly produce access to attention), satiation ("enough" attention was available freely and frequently, especially at the outset of treatment), and discriminative control (the delivery of attention in the absence of the target behavior marked a discriminable change in the response-reinforcer relation), among others.

A systematic replication was conducted by testing the effects of response-independent escape for individuals with SIB maintained by negative reinforcement in the form of escape from instructional activity (Vollmer, Marcus, & Ringdahl, 1995). Participants again were screened using the functional analysis assessment method described previously. In this study, however, differentially high rates of SIB in the escape (rather than attention) condition qualified an individual for participation. Figure 3 shows the results for the two participants in the study. For Kevin (upper panel) the instructional activity involved walking around a physical education classroom. For Mark (lower panel) the instructional activity involved seatwork. During the functional analysis, SIB produced escape from those activities. The differentially high rates of SIB during the escape condition suggest the participants' SIB was maintained by escape.

Figure 4 shows the results of the treatment evaluation. Time-based access to escape was presented as treatment for Kevin (upper panel). At pre-specified time intervals he was given a "break" from walking and allowed to sit in a chair. The breaks were response independent. As in Vollmer et al. (1993), the FT escape schedule was gradually increased across sessions (denoted on the figure). At the conclusion of the treatment analysis, the schedule was FT 10-min. For Mark (lower panel), who was a preschooler, the terminal schedule was FT 2.5-min. In Mark's preschool, activities were no longer than 5-min, so FT 2.5-min provided one break per activity. In addition to the FT analysis for Mark, a DRO procedure based on negative reinforcement also was implemented. During this procedure, SIB reset a timer and breaks were "earned"

by the omission of SIB for X period of time. During both the DRO and time-based escape conditions, the schedule was adjusted according to the new mean interresponse time (IRT) from the preceding five sessions. For example, if the mean IRT was 30 s, the DRO or FT interval was set at 30 s.

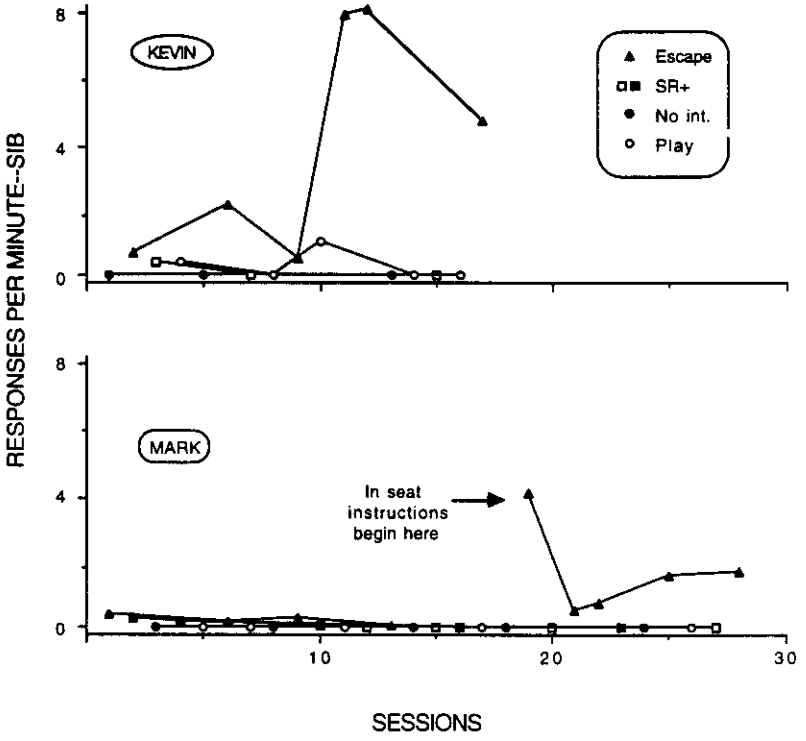


Figure 3. Two functional analyses showing SIB maintained by escape from instructional activity. In the legend "escape" refers to a test condition in which SIB produced escape from instructions; "SR+" refers to test conditions in which SIB produced access to attention or materials; "No int." refers to a test condition in which the therapist did not respond to SIB and did not interact with the participant. (Reproduced with permission of the Society of the Experimental Analysis of Behavior; From Vollmer, T. R., Marcus, B. A., & Ringdahl, J. E. (1995). Noncontingent escape as treatment of self-injurious behavior maintained by negative reinforcement. *Journal of Applied Behavior Analysis, 28*, 15-26).

The general finding of the study was that time-based escape schedules were effective as treatment for escape-maintained behavior. In addition, results for Mark suggested that IRT-adjusting strategies for increasing the FT interval might allow for a faster increase of the FT interval. However, an experimental

comparison of schedule escalation techniques was not conducted.

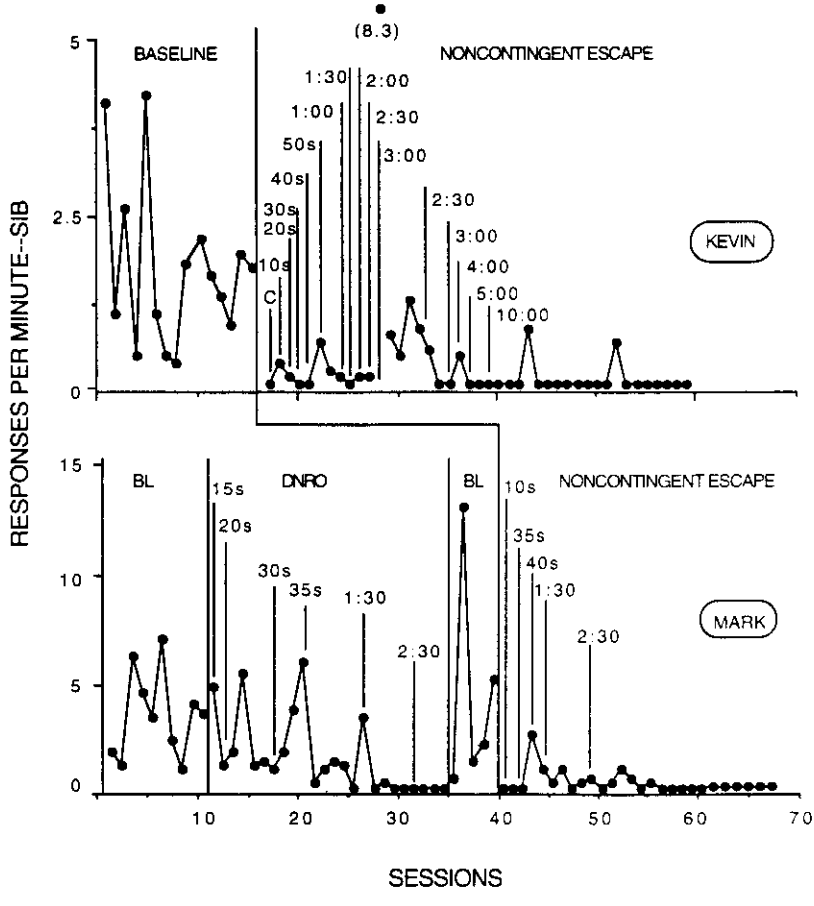


Figure 4. Two treatment analyses involving escape-maintained SIB. "DNRO" refers to a DRO procedure in which escape from instructions was reinforcer. Noncontingent escape refers to the time-based access to escape. Time intervals pointing to data points show the fixed-time or differential reinforcement interval increments. (Reproduced with permission of the Society of Experimental Analysis of Behavior; from Vollmer, T. R., Marcus, B. A., & Ringdahl, J. E. (1995). Noncontingent escape as treatment of self-injurious behavior maintained by negative reinforcement. *Journal of Applied Behavior Analysis , 28*, 15-26).

Collectively, the results of the studies on time-based attention and time-based escape strongly suggested extinction bursts and other extinction-related phenomena could be avoided by presenting reinforcers response independently

However, neither study directly compared FT or VT schedules to extinction. Such a comparison was the purpose of a more recent study (Vollmer et al., 1998). Three individuals with severe behavior problems participated in functional analyses showing that the behavior problems were maintained by either attention (one case) or escape (two cases). Next, a baseline was conducted in which problem behavior was reinforced with the maintaining consequence. Finally, extinction and FT schedules were compared directly. One therapist was correlated with extinction (e.g., attention or escape was withheld) and another therapist was correlated with FT (e.g., attention or escape was delivered response independently at set points in time; the FT interval increased across sessions).

Figure 5 shows the results of the comparison for the participant with attention-maintained problem behavior. During baseline, disruption and SIB produced attention on a continuous reinforcement schedule (fixed-ratio 1). Also during baseline, tantrums did not produce attention (hence, the decreasing trend in baseline). When the extinction/FT comparison commenced, response bursting was observed in the extinction condition for all three behavioral topographies and responding in extinction was variable throughout the analysis. In the FT condition, no bursting was observed and low rates of the target behavior were observed throughout the comparison. The terminal FT schedule was 5 minutes. In general, results for the other two participants were similar. Thus, although it had been previously hypothesized that FT schedules attenuate extinction-induced phenomena, this comparison demonstrated that effect empirically. It is important to note that these findings appear opposite to those derived from laboratory work comparing extinction and FT or VT schedules, which shows that response-suppressing effects of extinction are more rapid and sustained when compared to FT or VT (e.g., Lattal, 1972; Rescorla & Skucy, 1969). However, as will be discussed shortly, procedural differences may account for these seemingly discordant effects.

Potential Limitations of Time-Based Schedules

One concern about time-based schedules is that they may reduce the probability of appropriate behavior. If a problem behavior is decreased using a FT 5-min attention schedule, it is possible that more appropriate attention-maintained behaviors (such as communication) also may decrease. This possible limitation of time-based schedules assumes that satiation plays a role when the terminal FT value is achieved. The maintenance of appropriate behavior in the context of time-based schedules probably depends on two factors: (a) a contingency between appropriate behavior and reinforcement, and (b) the parameters of the FT schedule. Consider an analogy: Suppose a street cleaner

receives $100.00 per day to clean streets. If he or she is given $100.00 per day response-independently, would the individual stop working? In part, continuation of work depends on whether payment is still received for working: Many people would continue working because they can double their money. Continuation of work also likely depends on the reinforcement parameters, FT 24 hr of $10.00 probably would not stop the work, but FT 1 hr of $1,000,000 might well do so (unless, of course, reinforcers other than money are maintaining street cleaning).

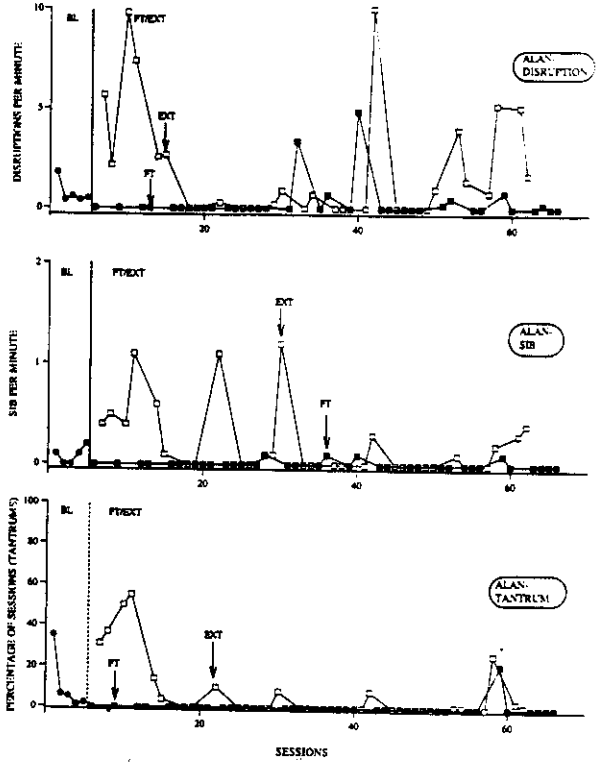


Figure 5. A comparison of fixed-time and extinction schedules as treatment. (Reproduced with permission of the Society of the Experimental Analysis of Behavior; from Vollmer, T. R., Progar, P. R., Lalli, J. S., Van Camp, C. M., Sierp, B. J., Wright, C. S., Nastasi, J., & Eisenschink, K. J. (1998). Fixed-time schedules attenuate extinction-induced phenomena in the treatment of severe aberrant behavior. *Journal of Applied Behavior Analysis, 31*, 529-542).

The general issue of FT effects on appropriate behavior was addressed in a study by Marcus and Vollmer (1996), who superimposed FT schedules on

differential reinforcement schedules. In one case, a functional analysis showed that a young girl's SIB was maintained by access to preferred toys. During treatment, an FT schedule was implemented in which the FT interval value increased from one session to the next (sessions were 10 min in duration); simultaneously, any appropriate vocalization (e.g., "toys please") was reinforced with brief access to the toys (differential reinforcement). Thus, the participant could obtain toys either independently of the response or dependent on it (i.e., contingent on appropriate behavior). Relatively high and increasing levels of appropriate vocalizations accompanied low rates of SIB. In addition, the rate of appropriate vocalizations increased as the FT interval was increased. The conclusion was limited because the reduction of SIB cannot be attributed to the FT schedule alone (because the reinforcement of alternative behavior was presented simultaneously), but the results did show that FT schedules did not preclude reinforcement of alternative behavior. These results also emphasize an important treatment consideration when using time-based schedules: Some alternative behavior should be strengthened to replace the target behavior.

Another potential concern with time-based schedules is the possibility of incidental reinforcement. It is possible that incidental pairings of a response and a reinforcer could produce reinforcement effects (Skinner, 1948). This concern seems especially relevant for behavior with a history of reinforcement with the FT or VT stimulus. Unexpectedly, my colleagues and I did not encounter incidental reinforcement effects until we had conducted dozens of experimental and clinical trials of the treatment. Recently, however, we have encountered incidental reinforcement on a few occasions (e.g., Vollmer, Ringdahl, Roane, and Marcus, 1997).

The participant in the Vollmer et al. (1997) study was an adolescent girl exhibiting severe aggression maintained by access to preferred materials (magazines). Often, she held her magazines throughout most of the day at school and when she was asked to put them away or share them, she became aggressive. Following a functional analysis and baseline, we implemented a continuous-access condition to show that aggression did not occur when she had continuous access to the magazines. Figure 6 shows the effects of an attempt to increase the FT interval across sessions: When the FT interval was increased from nearly continuous to FT 1 min (which occurred at session 18), high rates of aggression occurred. An analysis of within-session response patterns showed that high rates of aggression occurred in the moments prior to reinforcer deliveries at FT 1 min. High rates of responding culminated with a reinforcer on almost every FT interval, and these contiguous relations may have supported the aggression despite an absence of a programmed contingency between aggression and magazine access. Implementing a momentary DRO, in which any aggression within 10-s of the scheduled access

to magazines eliminated that particular access period, controlled the problem. Figure 7 shows the within-session pattern of responding for one high-rate session (session 19). The frequency of aggressive responses within 10-s bins increased as the FT interval elapsed, with the highest frequencies occurring in the intervals just prior to the reinforcer delivery. In addition, the frequency and intensity of aggression continued to increase until session 20 was terminated halfway into the session, to protect the therapist.

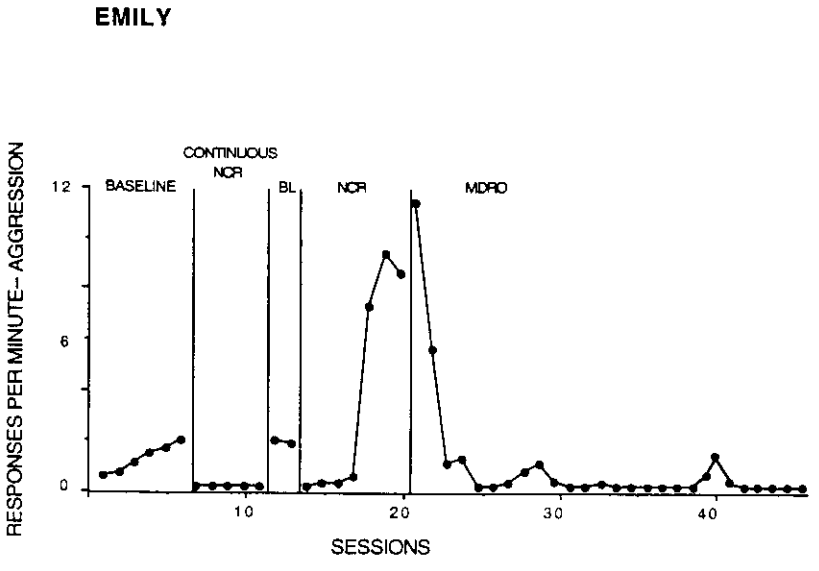


Figure 6. An example of a treatment failure with time-based schedules. When the FT schedule was escalated to 1 min in session 18, aggression rates increased markedly. "NCR" refers to "noncontingent reinforcement," as the schedule was called in the article. (Reproduced with permission of the Society of the Experimental Analysis of Behavior; from Vollmer, T. R., Ringdahl, J. E., Roane, H. S., & Marcus, B. A. (1997). Negative side effects of noncontingent reinforcement. *Journal of Applied Behavior Analysis, 30*, 161-164).

Incidental reinforcement effects seem to be rare in applications of time-based schedules as treatment, but a momentary DRO is a logical solution to the problem when it does occur. The momentary DRO assures that there are no contiguous pairings because of the omission requirement. However, momentary DRO may be more difficult for careproviders to implement because reinforcers are not delivered at set points in time. From a clinical standpoint, it seems advisable to first use time-based schedules, then, if responding is maintained or strengthened, invoke an omission component (such as

momentary DRO). From a conceptual standpoint, the incidental reinforcement effect reported in Vollmer et al. (1997) raises issues about the necessary and sufficient conditions for reinforcement, which leads to a discussion of some ongoing and future research on time-based schedules.

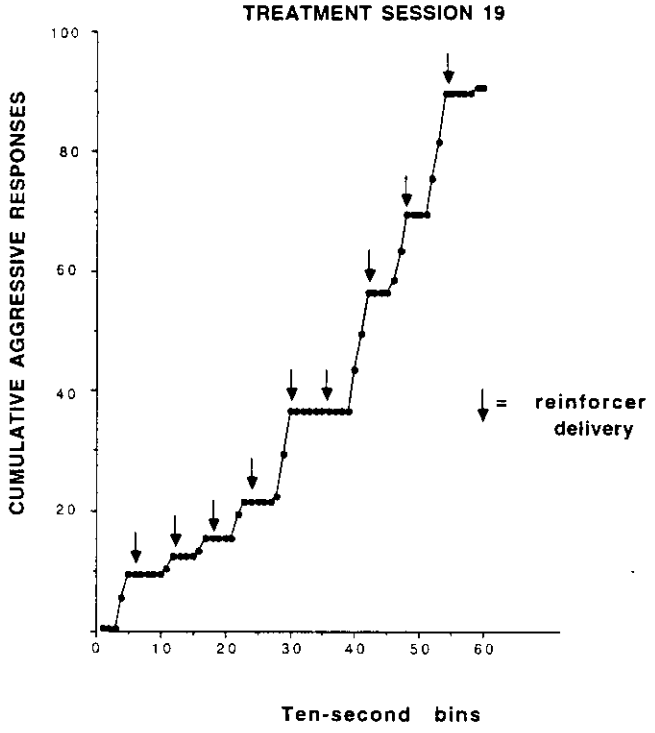


Figure 7. Within-session response patterns, represented as the cumulative frequency of responding within 10-s bins for the participant in Vollmer et al. (1997). Arrows represent reinforcer deliveries. (Reproduced with permission of the Society of the Experimental Analysis of Behavior; from Vollmer, T. R., Ringdahl, J. E., Roane, H. S., & Marcus, B. A. (1997). Negative side effects of noncontingent reinforcement. *Journal of Applied Behavior Analysis, 30*, 161-164).

Ongoing and Future Research

One question arises from the seemingly discrepant results of basic and applied work on time-based schedules. Laboratory research suggests that extinction reduces a previously-reinforced behavior more effectively than FT or VT. Applied research suggests that FT schedules reduce a previously-

reinforced behavior more effectively than extinction. An examination of laboratory methods shows that time-based schedules are usually arranged to mimic the response-dependent schedule from baseline; for example, when a behavior is reinforced on a VI 2-min schedule in baseline, the test condition involves VT 2-min (e.g., Rescorla & Skucy, 1969). An examination of applied methods shows that the treatments using time-based schedules typically begin with continuous, free access to reinforcers, and then the FT interreinforcer interval is gradually lengthened. Thus, the baseline-to-test transition in laboratory work is perhaps less discriminable than the baseline-to-treatment transition in treatment studies: In the laboratory, the baseline and test conditions are intentionally arranged to yield roughly similar reinforcer rates. Thus, we are currently using human operant preparations in a laboratory context (i.e., using arbitrary responses such as button pressing) to evaluate the effects of FT and VT schedules that are either similar or dissimilar to baseline schedules (in terms of reinforcer rate).

Given that similarities between response-dependent and response-independent reinforcer rates might result in maintained responding, it may be advisable for practitioners to recommend time schedules dissimilar to baseline, response-dependent schedules. For example, if a parent attends to bedtime tantrums on a VI 5-min schedule, a practitioner probably should not recommend a VT 5 schedule as treatment. The results of some basic research has shown not only that the relation between baseline VI and (subsequent) VT *reinforcer* rates can influence VT effects, but that the baseline *response* rate may influence subsequent VT efficacy (Lachter, 1971). In our clinical research, we currently are evaluating the relationship between baseline and treatment reinforcement and response rate parameters.

A related question involves the identification of necessary and sufficient response-reinforcer relations (so-called contingencies) to strengthen and maintain responding. Lattal (1995) described historical interpretations of the concept of "contingency," and pointed out that many interpretations of the concept exist. Although there is no consensus on what constitutes a contingent relation, one thing is clear: Interpreting a contingency as a simple if-then relation is insufficient to explain reinforcement effects (i.e., if the behavior occurs, then the reinforcer is presented). In the Vollmer et al. (1997) study, a reinforcement effect occurred despite the response-independent delivery of reinforcers. This occurred presumably because the probability of a stimulus presentation without having been preceded by a response was very low (recall that the participant responded in bursts up until the point in time when a reinforcer was presented). Thus, although no programmed contingency was in effect, behavior developed as if a contingency was in effect. On the other hand, a simple contiguity account is insufficient, because records from

numerous successful applications of time-based schedules show dozens of incidental pairings of response and reinforcer. Future research will need to evaluate the conditional proportions of reinforcers following a response versus the proportion of reinforcers that did not follow a response. In addition, histories of response-dependent reinforcement are likely to alter behavioral sensitivity to incidental reinforcement. For example, a few contiguous pairings may be sufficient to maintain behavior if those pairings occur following a history of response-dependent reinforcement, in which a strong contingency between response and reinforcer is established.

The concept of contingency also is critical in understanding how response-reinforcer relations are initially established when aberrant behavior occurs. Presumably reinforcers such as attention are presented both dependent on such behavior and independently of it from time to time during parent-child interactions. Indeed, additional response-reinforcer pairings probably occur incidentally. Thus, when evaluating parent-child interactions in the clinic, natural environment, or laboratory, it seems important to evaluate the conditional probability of a reinforcer given aberrant behavior in comparison to the probability of a reinforcer occurring independently of the aberrant behavior. In other words, is an increased probability of a reinforcer (e.g., attention) correlated with the occurrence of aberrant behavior?

Descriptive information on reinforcer probabilities would be useful in developing functional analysis procedures. The functional analysis contingency arrangement developed by Iwata et al. (1982/1994) represents a very strong positive contingency (Hammond, 1980): The probability of a reinforcer (say, attention) given SIB is 1.0; the probability of a reinforcer given no SIB is 0. It is unlikely that such contingency values always occur in naturally occurring parent-child interactions. For example, the probability of attention given SIB might be high (e.g., .5) and the probability of attention given no SIB might be low (e.g., .1), but contingency values of this sort might influence behavior differently than the strongest possible values (Lattal, 1974). Contingency values of 1.0 versus 0 may allow the experimenter to determine if a problem behavior is sensitive to a particular reinforcer, but it does not necessarily follow that a particular response-reinforcer relation is currently maintaining problem behavior. In other words, the external validity of functional analyses is improved by testing contingency values identified in naturally-occurring interactions.

Identifying the probability of response-dependent and response-independent events as they occur in the natural environment, however, raises a host of methodological difficulties. To list a few: What constitutes "a reinforcer following a response"? If attention is delivered 18 seconds after a response, does it enter into the calculation? What about 29 seconds after a

response? What constitutes "a response-independent reinforcer" in the natural environment? How many seconds need to elapse between a response and a reinforcer before the events are considered noncontiguous? Again, we are attempting to disentangle some of these methodological issues in our current studies, but there is much work to be done.

On a more pragmatic level, straightforward component analyses should be conducted with time-based schedules as treatment. A component analysis involves testing the individual and combined effects of a treatment package. The treatment packages that have been used to date have a number of components that are likely to influence behavior: Extinction, gradual schedule escalation, reinforcer delivery, prompting, and so on. The independent effects of these components are not well understood and invite further analysis.

CONCLUSION

Time-based schedules are a logical form of intervention for severe behavior disorders. Such schedules disrupt the relation between problem behavior and the maintaining reinforcers. Because reinforcers can be delivered freely and frequently without reference to behavior, the procedure is practical and engenders relatively few negative side effects. The application of time-based schedules should be of interest to behavioral researchers of all sorts, because the issues of response-dependency and contingency are central to our fundamental understanding of reinforcement effects. In turn, our fundamental understanding of reinforcement effects is central to our understanding of human behavior.

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