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ARTICLE

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The ontogenetic evolution of verbal behavior

Carsta Simon *

Department of Psychosocial Health, University of Agder,Norway

ABSTRACT

Behavior interacts with its environment both during an organism's lifetime and across generations through natural selection. Speech is a natural event that comes down to sounds that affect the behavior of conspecifics. Merging and enhancing Skinner's work on selection as a cause of behavior change on the one hand and his work on verbal behavior on the other provides a theoretical basis for placing verbal behavior in an evolutionary framework. Data suggests that this interaction between behavior and the environment is best described without using the hypothetical concept of response strength. The article proposes a framework that helps us understand selection processes in conversations. After a brief introduction to the value of and the alternative to Skinner's verbal behavior approach, the paper goes on to propose modifications to the conceptualization of verbal operants before concluding with an outline of the possible implications of these modifications for empirical investigations of verbal behavior.

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The behavior of organisms results from environmental events that occur partly during the history of their species and partly during the lifetime of the organisms. Natural selection explains how physiological and behavioral characteristics of organisms are tailored to the environment across generations. Moreover, natural selection has produced ontogenetic selection processes that, within each generation, tailor the behavior of organisms to their environment. Skinner (1966, 1981) pointed out this relation to behavior analysts. Another of Skinner's seminal contributions is his book *Verbal Behavior* (1957), which paved the way for applying research methods, which have proven successful in predicting and controlling non-verbal behavior, to questions of human communication. The present paper attempts to explicitly connect and refine these two contributions of Skinner by providing a consistent theoretical framework for investigating how ontogenetic processes of selection by environmental events affect (verbal) behavior and how they relate to natural selection. The paper calls for a refinement of Skinner's approach of strengthening discrete behavioral units by reinforcement, which holds good for operant behavior in general and, thus, may be applied to the study of verbal behavior. At first sight, the present refined rationale for studying verbal behavior may raise more questions than it answers. These questions, however, carry the potential to eventually provide insights into the dynamics of verbal interactions in conversations

CONTACT Carsta Simon carsta.simon@uia.no

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that may go beyond those to be gleaned from an approach based on strengthening discrete verbal operants, as Skinner (1957) outlined it.

The behavior of organisms results from evolutionary processes selectively transmitting behavioral variation both in phylogeny, here defined as the history of the species, and in ontogeny, defined as the lifetime history of the individual organism (Ashby, 1961; Campbell, 1956; Gilbert, 1970; Skinner, 1981; Staddon & Simmelhag, 1971). The subject matter of verbal behavior examines, among other things, the evolutionary processes selecting human speech through ontogeny based on an understanding of speech focusing on its similarities with, rather than its differences from, other behavioral patterns. This approach to speech, originating in Skinner's (1957) *Verbal Behavior*, is substantially different from traditional accounts of communication as outlined in the following historical introduction to studies on communication. This introduction by no means attempts to give a complete overview but rather sets the stage for understanding the scope of Skinner's treatment of speech as behavior. Following a brief introduction of Skinner's approach, reasons for amending his approach are discussed. The paper concludes by first suggesting how we may study verbal behavior as a temporally extended process and then providing examples of studies whose results potentially support either Skinner's strengthening by reinforcement approach or an alternative account relying more on stimulus control than on reinforcer control.

Replaced and alive and well: speaking as encoding and sending messages

In 1949, the mathematicians C.E. Shannon and W. Weaver suggested a communication model designed to improve technical communication (Shannon & Weaver, 1949). Subsequently known as the *Shannon–Weaver Model*, their work became the basis for various communication theories. In short, the model proposes that a sender encodes information or an idea before passing it through a communicative channel to a destination where a receiver decodes it. Reminiscent of disturbance in phone calls, noise in the channel may impede correct transmission of the message, for example, if sender and receiver communicate surrounded by a noisy crowd.

Gradually, communication theorists have amended aspects of the model that they found incongruous (e.g., Berlo, 1960; Schramm, 1954). Yngve (1970), for example, added another channel to the original model to account for what he saw as a mismatch between actual conversations and the simple Shannon–Weaver Model:

> [I]t is reasonably frequent that a conversationalist speaks out of turn. In fact, both the person who has the turn and [his or her] partner are simultaneously engaged in both speaking and listening. This is because of the existence of what I call the back channel, over which the person who has the turn receives short messages such as 'yes' and 'uh-huh' without relinquishing the turn. (p. 568)

As the contemporary communication theorists Bavelas, Coates, and Johnson state, this statement demonstrates how the "classic [Shannon–Weaver] model is deeply embedded in the terms we still use to describe conversational participants and processes, such as *sender, receiver*, and *channel*" (2000, pp. 941–942, emphasis in the original). Despite their enduring popularity and appeal to laypersons, sender-receiver models are problematic from an epistemological perspective. Models based on the Shannon–Weaver Model add

little to what we observe. The roaring lion moves its snout, throat muscles and lungs, leading to an auditory stimulus that changes the behavior of other organisms in hearing range. Adding that the lion sends a message that the other animals receive does not clarify the account. Where is the message? What does it consist of? Who encodes and decodes it? As Baum (2017) pointed out, these are questions that will remain unanswered if applying sender-receiver models to communication, be it between people or nonhuman animals. Although describing sounds in terms of *messages* may be practical sometimes, the confusion of useful summary labels with causal explanations can disguise that no causal factors are identified (Ryle, 1949/2009). Circumventing these problems, Skinner (1957), in keeping with Watson's (1924) suggestion, outlined an alternative approach by proposing to regard speaking as doing, that is, as behavior.

Skinner: speaking as behaving

Language is often said to be one of the core characteristics distinguishing humans from nonhuman animals (e.g., Culotta & Hanson, 2004). Compliant with evolutionary theory, Skinner (e.g., 1981), however, sought to analyze all species and all types of behavior in a common framework. Aiming to identify general principles guiding the behavior of many species, he concentrated on the similarities, instead of the differences, between speaking and other kinds of behavior. Consequently, Skinner (1957) chose the label *verbal behavior* as a summary label for "behavior reinforced through the mediation of other persons" (p. 2) who "must be responding in ways which have been conditioned precisely in order to reinforce the behavior of the speaker" (p. 225). Note that this definition is not limited to vocal interchanges but also includes, for example, signing, writing or gesturing. The advantages and drawbacks of the details of this demarcation (as, e.g., discussed by de Lourdes R. da F. Passos, 2012) shall not concern us here. Skinner's (1938, 1953) main contribution was to acknowledge that speaking is what he called *operant behavior* – that is, behavior produced by its environment and acting, or *operating*, upon that environment. Skinner defined operant behavior as behavior affected by its consequences. This is as opposed to non-operant behavior, such as adjunctive behavior, which is orderly behavior occurring when events happen independently of responses (e.g., Zeiler, 1986).

Like other natural events, operant behavior, including speech, results from a combination of variation, transmission, and selection of units. The same is true for natural events as diverse as the workings of the adaptive immune system, antibiotic resistance, the peculiar shape of giraffes' necks, or the ostensible phenomenon of "beginner's luck," which results from the non-successful gambling novice's decision to quit gambling rather than from beginners' winning more often than repeat gamblers. The nature of the units of selection, however, differs from one evolutionary process to another. In attempts to explain natural selection, giraffe lineages are a commonly used example (see Simon & Hessen, 2019 for a discussion of the appropriateness of that example). In a population of giraffes, individuals vary. Partly due to environmental factors such as nutrition and partly due to their genetic inheritance, some giraffes had longer necks than others in the species' history. As vegetation grew taller, those with longer necks were healthier and produced more offspring, who also had, on average, longer necks. Natural selection of neck lengths occurred because phenotypes varied.

Phenotypes are, at least partly, produced by inherited genotypes. Since resources were limited, giraffes competed for them. When the environment changed featuring higher vegetation, longer necks became advantageous. Thus, from the total distribution of neck lengths in the population, the individuals with longer necks reproduced more successfully, leading to an, on average, longer necked offspring population.

An analogous selection process shapes operant behavior during ontogeny. For example, social consequences, such as a mother's attention, act upon the variation of a child's innate babbling sounds until the sounds are shaped into speech sounds common in the verbal community (Goldstein, King, & West, 2003; Goldstein, Schwade, & Bornstein, 2009). We are born prepared to learn to speak, but which language we learn to speak depends on our environment. Our speech sounds evolve through ontogeny just like natural selection produces change in the phylogeny of giraffes. In sum, a lineage of organisms, for example giraffes, changes over time in a particular inherited feature, for example, neck length. The change in this feature is a function of changes in the environment of these organisms. Similarly, a lineage of speech sounds changes over time in a particular feature, for example, nasal sounds. The change of this feature is a function of changes in the environment of these sounds or in the organisms producing the sounds.

Natural selection occurs because resources are limited. Because the total time that an organism can spend behaving is limited, different activities, including verbal activities, compete for the organism's time. Those activities are contingent with what Skinner (1938) called *reinforcers* and *punishers* and what Baum (2012) termed *Phylogenetically Important Events (PIEs)*. Before I turn to the concept of PIEs in the next section, I discuss what it means for an activity to be in a contingency with a reinforcer[1] or a PIE.

The nature of contingencies

Skinner (1948) viewed contingencies the following way:

> To say that a reinforcement is contingent upon a response may mean nothing more than that it follows the response [...] Conditioning takes place presumably because of the temporal relation only, expressed in terms of the order and proximity of response and reinforcement. (p. 168)

In Skinner's (1953) paradigm, "the only important property of the contingency is temporal. The reinforcer simply follows the response [...] We must assume that the presentation of a reinforcer always reinforces something, since it necessarily coincides with some behavior" (p. 85).

Subsequent scholars (Baum, 2012; Rescorla, 1968, 1988), however, have pointed out that Skinner's definition based on temporal proximity between events may not suffice. Instead, a contingency, or dependence of one event on another, requires comparison of at least two occasions. Hiking plans are not contingent upon whether if the probability of going hiking when it is sunny (occasion one) is just as high as the probability of going hiking when it rains (occasion two). Payment is contingent on work if, and only if, the probability of receiving payment is higher if working and lower if not working. Working does not come under control of payment unless two temporally separate occasions, one in which one worked and one in which one did not work, have occurred. The closer the correlation between the activity and the reinforcer, the more likely the activity changes

when reinforcers change. Temporal proximity between reinforcers and activities catalyzes learning in the sense that contiguity increases a behavior's susceptibility to the contingency.

Presumably, the modifiability of activities by reinforcers entering into a contingency whose effect is enhanced by temporal contiguity between the activity and the reinforcers represented an advantage for fitness during our species' history. Contiguity contributes to relative predictability of reinforcers. Accidental contingencies should occur infrequently since they require at least two accidental conjunctions between behavior and reinforcers (Baum, 2012). In many settings, causal roles of contingency and contiguity are difficult to tease apart because delays between the activity and the reinforcers dilute the effect of the contingency.

Different terminology has been suggested to enable us to distinguish between the contingency focused on contiguity and that not focused on contiguity. Baum (2012) phrases his non-contiguity-centered approach to behavioral change in terms of *induction of activities by Phylogenetically Important Events* rather than in terms of *strengthening by reinforcement*. The latter vocabulary implies Skinner's (1938) contiguity-centered view. The following section gives an overview of the implications of the respective alternative terminologies and debates whether such a change in terminology is helpful in building a science of (verbal) behavior.

Induction of activities by Phylogenetically Important Events or strengthening by reinforcement?

Unlike machines, organisms exist as a result of their own activity; they are autopoietic. Their ongoing self-producing activity is as non-optional as their constant metabolic regeneration. Because the existence of organisms depends on their contact with certain events, it is in principle possible to objectively specify what is in an organism's "interest." In principle, we can determine what is intrinsically "good" or "bad" for an organism by evaluating its activities according to the contribution they make towards its preservation (Nicholson, 2018). Baum (2012) introduced the term *Phylogenetically Important Events* (PIEs) to denote events such as food or predators whose possible effect on behavior during ontogeny has been selected during phylogeny because susceptibility of behavior to such events has been advantageous to fitness. To put this simply, those whose behavior was not affected by the availability of food or mates during the history of our species are not among our ancestors. In addition, our behavior is similarly susceptible to proxies of PIEs, which do not affect fitness directly, but which tend to correlate with PIEs. PIE proxies are PIE-predictive events. Organisms learn what signals predict which PIEs and what activities allow them to get in contact or to avoid PIEs or their signals. PIE proxies (or conditioned reinforcers) induce behavior because they can reduce uncertainty about both the occurrence of and the time to contact with the PIE. Since money correlates with resources, people engage in a plethora of activities upon which money is contingent.

As humans evolved largely living in groups (Diamond, 2012), many of the most powerful PIE proxies are social in nature, such as agreement or help. We tend to do more of those activities that work, or that "do the job" (Guerin, 1997) of producing or preventing PIEs or their proxies. When learning a language in a natural context, we

produce a variety of pronunciations and repeat those that are best understood – that is, those that lead to appropriate action.

Skinner (1938) phrased his contiguity-centered approach to behavioral change in terms of *strengthening by reinforcement*. To distinguish his non-contiguity-centered approach from Skinner's view, Baum (2012) speaks of *induction of activities by Phylogenetically Important Events* instead. *Induction* is not used in the sense of *response generalization* denoting the spread of the effects of reinforcement to stimuli other than those defining the operant class (e.g., Catania, 2013). Nor can only new activities be induced – that is, to say that an activity is "induced" is not to make a pronouncement on whether or not the activity was part of the organisms' – or the species' – behavioral repertoire before or if it occurred for the first time. Instead, *to induce* behavior, in Segal's (1972) and Baum's (2000) sense, is *to guide* or *signal* behavior. In contrast to *elicitation*, the term *induction* (see also Baum, 2000, 2012, 2015; Baum & Davison, 2014; Cowie & Davison, 2016; Segal, 1972; Shahan, 2010) resembles *stimulus control* in that it does not imply a one-to-one relation between PIEs and the activities they induce. However, the different definition of the term contingency implied is not the only difference between *inducing* and *strengthening* behavior.

First, contrary to strengthening by reinforcement, the concept of *induction* supplements selection of behavior by contingencies with a reference to the origin of a behavior in our evolutionary history. As Baum (2012) summarized it, "if one allowed that some stimulus control were [*sic*] the result of phylogeny, then induction and stimulus control would be identical, and a PIE would resemble a discriminative stimulus" (p. 101).[2] Baum's call for a terminology incorporating phylogenetic shaping of operant learning is supported by observations such as that omnivorous birds (i.e., *Manorina melanocephala)* need less time to learn to stay in areas where they just found and consumed invertebrates – which, in nature, often indicates availability of more invertebrates – than they need to learn to stay in areas where they found nectar – which naturally depletes.

Second, as Shahan (2017) recently argued, *induction* avoids reliance on an implicit and unfalsifiable process of reinforcement as strengthening of responses stored in a hypothetical operant reserve. This hypothetical reserve was originally suggested and later abandoned by Skinner (1938) and revived and elaborated upon, for example, by Palmer (2009). In this approach, a putative mechanism of response strengthening explains that organisms work to maintain contact with or to avoid PIEs (reinforcers or punishers) or signals which predict them (PIE proxies/conditioned reinforcers). Changes in response strength cannot be measured directly but must be inferred from behavior change. However, after over 80 years of research, it remains unclear which dimension of behavior change is the best basis for inference of response strength. Is it the behavior's frequency or probability? Its inter-response time? The duration of responses or their persistence? The time between reinforcer and the first response or response intensity (Cowie, 2019)?

In the induction approach, "reinforcers" are performance modulators. Behavior may be attributed partly to selection during phylogeny and partly to selection during ontogeny. Changes in performance do not reflect strengthening of responses in a reserve but are an innate response to experienced predictive relations between PIEs and their signals or signposts (discriminative stimuli, or conditioned reinforcers, Shahan, 2017). In this approach, the predictive value of signals, rather than strengthening by reinforcement,

explains the allocation of time to different activities. Whatever event predicts a fitness-relevant event (PIE) will guide behavior so as to produce or avoid contact with the PIE. In this line of reasoning, the matching relation (Herrnstein, 1970; McDowell, 2005; Baum, 1979) describes an innate pattern of behavioral allocation that is guided by detection of the predictive relations about relative PIEs across alternatives. In this sense, organisms' working for PIEs and PIE proxies is induced. One of the advantages of this approach is that it unites a range of behavioral phenomena from operant and respondent learning to "adjunctive" behavior and "misbehavior" (Baum, 2012; Cowie, 2019; Simon & Hessen, 2019).

The alternative to accounting for what organisms do in terms of strengthening discrete units of behavior is presented here in an evolutionary framework. I choose this approach to situate behavior analysis as a proper part of evolutionary biology. After all, Darwinian selection makes for phylogenetic adaptations to the environment, and operant selection acts on top of it making for ontogenetic adaptations to the environment. The view that behavior is an extended process, rendering the concept of strengthening superfluous, is strongly supported by recent developments in the philosophy of biology, which move towards a processual science (e.g., Nicholson & Dupré's, 2018, edited volume). Against the traditional ontological view of the living world as fundamentally composed of enduring things or substantial particles, this movement's metaphysical thesis is that the living world essentially consists of processes. Entities that intuitively appear to be things, such as organisms, are in this view better understood as processes. Streams are more appropriate metaphors for organisms than machines (Nicholson, 2018). This view posits that the main motivation for replacing an ontology of substances with one of processes is to be looked for in empirical scientific findings. As part of evolutionary biology, behavior analysis is the study of behavioral processes, not things. One implication of acknowledging that behavior is a process is that it is thus not necessarily abstracted into something discrete, but also studied as what it is – extended in time. To get from discrete events to rate when studying the process of behavior, behavior analysts have invented the concept of response strength. Here, I ask for an alternative, which investigates how stimuli, such as PIEs, mold the behavioral stream as a landscape molds a river.

Thus, in the following, I argue for research on verbal behavior modifying our understanding of two tightly interwoven characteristics of Skinner's (1957) approach to verbal behavior: the strengthening by reinforcement assumption and the pervasive abstraction of a continuous behavioral process into discrete units of analysis. But first, what does it mean to "strengthen by reinforcement"?

Is reinforcement what Skinner thought it was?

According to the tutorial webpage www.scienceofbehavior.com, *reinforcement* is a process in which a behavior is strengthened (i.e., the behavior's frequency, rate, duration, intensity, or other dimensions increase or persist) as a function of an event that occurs as a consequence of, or contingent on, the response. Reinforcement may occur naturally or be planned. It is defined solely by its function of increasing or maintaining behavior. (Bostow & Murdock, 2019)

"Reinforcers" affect behavior, but how? The essential assumption reflected in the definition above is that reinforcers strengthen the behavior they follow. However, as Skinner (1969) pointed out, behavior is not just a function of its consequences, it *also* depends critically on the stimulus context, that is, stimulus control. The observation that "reinforcers" have discriminative properties that guide behavior is less commonly discussed, but just as evident. Cowie and Davison's (2016) review of recent choice research suggests that stimulus control is much more fundamental than the Skinnerian tradition assumes. Their overview compiles data supporting the notion that the effects of "reinforcers" on behavior may be primarily or solely discriminative and suggests that stimulus control, not reinforcer control by strengthening, may be fundamental.

Krägeloh, Davison, and Elliffe's (2005) findings support this conclusion. They presented pigeons with a choice between two response keys, pecks on which produced food on concurrent variable-interval schedules. Throughout the experiment, the overall food ratio was 1:1 but the probability that food would be obtainable for a peck on the same key as the previous peck ranged between 0 and 1 over the course of the experiment. Instead of always increasing pecking on the same key, food delivery tended to increase pecking on that key in long same-key sequences and to decrease pecking on that key in short same-key sequences. The delivery of food following a peck on one key could "reinforce" or "punish" pecking on that key, depending on what contingencies it signaled. In Krägeloh et al.'s (2005) setup, food did not necessarily increase or strengthen pecking in a location (key). Rather, pecking was sensitive to signals for where to peck in the future. Likewise, Holz and Azrin (1961) showed that "punishers" can have discriminative properties that allow them to increase the probability that the behavior they follow will be repeated. Moreover, Cowie, Davison, and Elliffe's (2011) data from pigeons in a modified choice procedure show that a food delivery can function to both increase and reduce the probability of the behavior it follows. This supports the hypothesis that the main effect of food deliveries, or other "reinforcers," maybe to signal future contingencies, rather than to strengthen previous responses.

Every "reinforcer" is a stimulus event. In the tradition of Skinner, this stimulating property of a "reinforcer" is an epicycle of the reinforcing effects of such events. Baum's (2012) terminology discards the baggage of Skinner's terminology. At the same time, it consolidates one of Skinner's most important and most frequently belied contributions to understanding behavior: Organisms are not born as "blank slates." Although Skinner outlined the causes of behavior in both our phylogenetic and our personal history (Skinner, 1981), behavior analysis is still often misrepresented as viewing newborns as "blank slates" (see, e.g., De Waal, 2016; Kappeler, 2011; Kuczynski, 2012; Pinker, 2003; Tooby & Cosmides, 1995). The interested reader is referred to Shahan (2010) and Cowie and Davison (2016) for an overview and discussion of the pros and cons of the plethora of terms that have been suggested as alternatives to *strengthening by reinforcement*. Which terms we adopt is secondary for the purpose of the present argument. In the previous section, I discussed the implications of Skinner's terminology and Baum's terminology to clarify how fundamental the differences between Skinner's approach to (verbal) behavior and the present alternative approach are. These fundamental differences suggest that misguiding terms such as *strengthening by reinforcement* need to be replaced.

I here adopt Baum's (2012) evolutionary terminology to characterize stimulus control as modulation of response probability in an attempt to manifest the connection between ontogenetic and phylogenetic selection. Opponents to using evolutionary terminology in explanations of ontogenetic behavior change (e.g., Grinde, 2014) have argued that ontogenetic and phylogenetic selection should be dealt with separately, in particular, when designing interventions, because their "differences are more profound than their similarities" (Grinde, p. 425). On the contrary, evolutionary terminology, which reflects the role of natural selection in shaping operant selection, may aid our design of both basic science studies and applied interventions, for example, by reminding us that "reinforcers" with an arbitrary relation to the activity in question are often less effective in teaching or maintaining an activity than "reinforcers" that follow naturally from that activity. Koegel and Williams (1980), for example, found that children diagnosed with autism spectrum disorder learned more quickly to lift boxes when lifting gave access to food positioned under the boxes than when the same lifting of a box resulted in the experimenter's immediately providing the same kind of food.

Evidently, there are limits to the parallels between Darwinian selection and operant selection. It is unclear to what – if anything – the phenotype-genotype distinction in Darwinian selection corresponds in operant selection. Moreover, Darwinian selection increases reproductive fitness, tightly connected to sexual reproduction. Sexual reproduction, and thus mate selection, is critical to passing on successful traits to offspring. Ontogenetic selection of behavior does not have that characteristic, although McDowell (2004) has developed an evolutionary theory of behavioral adaptation along these lines. However, the key notion of the selection parallel used here is reproductive success, not sexual reproduction or mate selection. Many organisms – most, if you include bacteria – reproduce asexually. Recurrence, or copying with error, combined with variation across reproducing organisms in a population and selection in the form of differential recurrence alone, results in evolution.

At first sight, the shift in terminology from *strengthening of discrete operants by contiguous reinforcement* to *inducing the allocation of time to activities by allocation of PIEs*, shifts the focus of the analysis of (verbal) behavior to the *distribution of particular activities* in an ongoing behavior stream as opposed to the *origin* of those activities during a lifetime. The evolution of speech from babbling sounds that I described earlier is an example of an analysis of the *origins* of activities during a lifetime. A closer look at the difference between explanations of *origins* of activities that a particular organism has not engaged in before, say a baby's producing a new nasal sound, on the one hand, and explanations of why *organisms allocate their time to the activities* they do, on the other hand, reveals that both explanations are interdependent. The topography of organisms' speech sounds changes over time dependent on the extent to which the different topographical variants take up an organism's time. For example, we are able to produce sounds that can be characterized on a continuum from nasal to oral. The posture of our soft palate determines the extent to which air goes through our nasal and our oral cavities, producing more or less nasal/oral sounds. If nasal and oral sounds are uttered when the organism, say, is deprived of food, and more nasal sounds more reliably produce access to food – because they are part of the caregiver's language in this hypothetical example – more time will be allocated to more nasal sounds than to less nasal sounds in the future. Over time, the oral characteristic may eventually disappear

from the organisms' allocation of time to food-related verbal activities, and the lineage of food-related sounds will become more nasal. It seems likely that the details of this example are incorrect, but it illustrates the connection between "origins of behavior by shaping lineages" and choice in terms of the distribution of alternative activities to time (as, e.g., in Baum & Rachlin, 1969). The revision of Skinner's terminology that this article suggests allows incorporation of matching law phenomena into a selectionist framework. This may help account for origins of utterances as well as distributions of previously learned verbal behavior in an ongoing behavior stream.

So far, I have suggested two tightly intertwined – though not to be confused – aspects of reconsidering verbal behavior in the light of theoretical developments. First, "reinforcement" may be regarded as signaling what behavior will be successful in the future rather than strengthening preceding behavior. Second, based on Baum's (2012) argument, we may consider extended activities more – and discrete operants less – than we currently do. The latter means neither that we should never study behavior in terms of discrete variables, nor that temporally extended behavioral measures need to have a fixed minimum duration. Unlike conceiving of organisms as processes (Nicholson, 2018), conceiving of behavior as a process is not counterintuitive. Therefore, virtually all behavior analysts agree ontologically that behavior is extended in time. Nevertheless, most researchers divide the behavioral flow into discrete events. In *some* cases, this might very well be the most pragmatic way to go about it. If we are interested in the frequency of onset of a behavior instead of how much time is spent in a particular activity, for example, we need to count onsets. In some cases (e.g., Simon & Baum, 2017), frequency and duration measures lead to the same conclusion. However, our choice of variables should be controlled by the research question, not the dominant research tradition, and counting discrete events is, in many cases, not pragmatic when measuring how the correlation between PIEs and activities selects activities.

To be sure, temporal extension of our units of analysis and the strengthening versus induction debate are interrelated but not interchangeable. Even if it is possible to consider extended activities as being strengthened by reinforcement in the traditional Law of Effect sense, this notion seems inelegant, if not implausible, in the light of the arguments above. No experiment can finally decide between signaling/induction and strengthening, but recent findings presented here render the strengthening interpretation superfluous. If this is true for behavior in general, it must also be true for the study of verbal behavior. The concept of strength was necessary to bridge the gap between discrete responses and response rate, which is the measure most often studied. With the understanding that behavior is process, and thus necessarily temporally extended, the need for a concept like strength, with all its problematic properties, disappears. The idea that activities are strengthened is superfluous; activities just increase and decrease in response to environmental changes. Both experiments using temporally extended independent and dependent variables and those generating findings more readily interpreted as signaling rather than strengthening are proposed as suggestions that may help advance the science of verbal behavior. In many, but not in all, ways, these two aspects are two sides of the same coin. The purpose of the next section is to initiate a conversation on how the investigation of verbal behavior as an extended non-discrete event induced by the likely activity–PIE correlation in the future as extrapolated from the past, rather than as a discrete event strengthened by reinforcement might affect experimental design.

Where do we go from here?

Units of analysis

Reductive analysis has been the most successful approach to understanding, predicting and controlling phenomena across scientific disciplines. Yet, as Harzem (1986) explains,

> it is difficult to defeat the proposition that human actions such as working, spending and saving money, child-rearing, making love, and voting are more interesting than human acts such as button-pressing. And it is undoubtedly true that the last-mentioned is scientifically documented in far more detail than any of the former. (p. 46)

The same may be said for verbal interactions. Best documented (Presti & Moderato, 2016) are the conditions that produce the verbal operants, which Skinner (1957) called "tacts" and "mands." In colloquial terms, to tact means to give a label identifying objects, actions, and so on, and to mand means to request a PIE or a stimulus that has been in a contingency with a PIE earlier in an individual's history. More interesting verbal behavior such as persuading conversational partners, compromising, or building relationships are not extensively investigated.

Undeniably, investigation of Skinner's verbal operants has proved to have great practical value in training speech-impaired children (Drash & Tudor, 2004; Smith, 2001; Sundberg & Michael, 2001), whereas proposed research procedures using rats pressing levers, pigeons pecking keys or humans pressing buttons are of interest almost exclusively because they are thought to shed light on other more complex activities. Nevertheless, basic experimental research that ultimately aims to explain complex verbal activities in conversations has mostly relied on investigation of discrete units. Verbal behavior, however, does not come in neatly divided units such as pecks and lever presses. What are alternative verbal units of selection? Are they words? Topics? Dialects? Grammatical structures?

This article cannot provide a rationale for choosing or rejecting any of these as units, apart from experience from measurement attempts that have revealed which candidates for verbal units of selection might be misguided. Should we base our hypothesis on what can function as a unit of speech from our language conventions? If not, how should we discover "natural lines of fracture" (Skinner, 1935, p. 40)? As Hinson (1987) points out,

> behavior analysis does not reduce behavior to predetermined simple elemental units. Instead, the unit is inferred from observation and manipulation of controlling variables. A given unit of behavior is uniquely defined at a given level of specificity, but there is no ultimate level of analysis. Many valid levels of specification exist and depend solely on observed functional relations. (p. 134)

That means even if an analysis of verbal behavior is inspired by an apparatus used in experimental chambers allowing the quantification of rats' lever presses and pigeons' key pecks, we should not predefine our units of analysis as discrete units. However, the reason we often do not investigate complex activities directly is that the more extended the activities we investigate are, the less scientific precision we achieve. Yet investigating less complex acts as models of extended activities is only sensible if we can confirm that the principles governing such acts also govern more complex acts (Harzem, 1986). An experimental investigation of verbal units of different complexity and duration is a step towards reconsidering the assumed homology between more

and less complex verbal units. Examples of investigations using temporally extended dependent and independent variables are experiments testing the applicability of the matching relation (Herrnstein, 1970; Baum, 1979) to conversations. The allocation of speech to several conversational partners is the dependent variable investigated in these experiments (e.g., Borrero et al., 2007; Conger & Killeen, 1974; Simon & Baum, 2017). Studies investigating variables that affect duration of speech are another example (e.g., Krauss & Weinheimer, 1966; Ohmori & Doi, 2000; Sannomiya, Kawaguchi, Yamakawa, & Morita, 2003; Simon, 2018). Duration of speech might be an interesting dependent variable, and duration of "holding the floor" might be selected. Selection for the duration of "holding the floor" is not necessarily on a par with selection for the spoken content or its origin, which might be selected by different contingencies with PIEs. Such hypotheses are material for future empirical investigations.

Signaling versus strengthening

Even if it is not possible to design an experiment whose results are *impossible* to reconcile with either a strengthening or an induction account, we may design studies whose results are more plausibly accounted for by one or the other framework. This was the goal of our study (Simon & Baum, 2017) in which we replicated Conger and Killeen's (1974) well-known matching in conversations study. In their study, Conger and Killeen had concluded that two conversational partners' (i.e., confederates') approval strengthened participants' speech to these conversational partners. As we point out, Conger and Killeen had measured speech (the response) contingent on gaze, but approval (the "reinforcer") was delivered independent of gaze – which is irreconcilable with the interpretation of strengthening by reinforcement. By definition, a reinforcer strengthens a response when it occurs *contiguously* with the response (Skinner, 1948; Thorndike, 1911/2000).

Thus, in our replication(Simon & Baum,2017,) we added another condition to compare the effect of putative *strengthening of speech by contiguous approval* ("reinforcers") to *induction by non-contiguous approval*. In one of the conditions, confederates uttered approval contiguous with eye contact, whereas in the other session, approval was uttered independent of the participant's gaze. Requiring gaze to be directed toward a confederate for delivery of approval made no difference in the results. The absence of a difference suggests that matching or reverse matching in conversations is more likely due to induction than to strengthening by reinforcement.

The main purpose of the present article is to start a conversation about whether we should change how we study verbal behavior and, if so, what future research could look like. One change suggested here is to use temporally extended dependent and independent variables, as was done in the studies mentioned above. Another possibility is to collect evidence for or against the signaling or the strengthening interpretations of verbal behavior, which will eventually guide how we design future experiments. In an attempt to motivate the collection of such evidence, I provide examples in the following of what kind of procedures would generate outcomes most plausibly explained by the most recent past pushing our behavior into the future (strengthening) versus by control of behavior by the likely future defined by past experience (induction).

Our study (Simon & Baum,2017) is the first study on verbal behavior to both generate data with implications for the strengthening versus induction debate and contribute to the pool of studies investigating the process of verbal behavior based on continuous dependent and independent variables. In the following, I offer two ideas for experimental designs that may further develop this line of research. These examples illustrate some of many possibilities of what studies whose results support either a strengthening or an induction account of verbal behavior could look like.

In the first experiment, a participant talks to any one of the four confederates, with the experimenter signaling when to transition to another confederate. Before the session starts, the participant lists or ranks conversational topics in order of preference. What the participant does not know is that, to begin with, two of the confederates will reliably discuss the preferred conversational topic while the other two will talk only about the non-preferred topic. For instance, whenever talking to confederates A or B, the participant can engage in a conversation about a favorite hobby, but when confederates C and D are available, the conversation is always about a topic the participant finds less interesting. We measure how long it takes the participant to transition from speaking to one confederate to speaking to another confederate, which might, for example, entail finishing off the conversation with confederate A or walking over to the other side of the room where B (or C or D) is waiting. Contrary to the strengthening account, the signaling account predicts that, not only what participants did last – that is, what topic they were discussing – but also the likely future topic influences how long they take when transitioning between confederates. The likely future topic is signaled by the sight of a confederate who always talks about either the preferred or less preferred topic. To increase confidence in the findings, in the following session, the availability of the two topics is unsignaled, that is, the topics are not paired with the four confederates. Participants are still supposed to transition between confederates, but all confederates discuss each topic 50% of the times they become available to the participant. If this removes the difference in transition delays, it would support the hypothesis that the participant's behavior is under control of the likely future as signaled by the past. If, on the contrary, the transition delay is only determined by the last activity and is independent of the upcoming activity, this supports strengthening of most recent activities.

The second study makes PIEs available contingent on a participant's choice of a different alternative than the one previously chosen. A participant and ostensibly two confederates solve short tasks between which they can socialize for a certain time. Confederates provide more PIEs such as smiles, agreement, praise, and nodding, contingent on their not being the confederate with whom the participant talked after the last task, that is, last time they could choose their conversation partner. If participants most often choose to talk to the confederate to whom they talked previously, this suggests that the most recent behavior was strengthened, but if they most often talk to the confederate to whom they did not previously talk to, this suggests that their behavior is under control of the past providing PIEs contingent on switching.

This paper attempts to highlight that the inconsistency of the response-strengthening approach, which has been pointed out both elsewhere in this special issue (Cowie, 2019) and in other places (Baum, 2012; Cowie & Davison, 2016; Killeen & Jacobs, 2017; Shahan, 2017), also affects the study of verbal behavior. To be sure, I am not necessarily arguing for replacing the three-term contingency between antecedent, response, and reinforcer with a two-term

environment-behavior contingency. We perhaps need to analyze the behavior–environment interaction in terms of a four-term contingency in which several environmental events precede behavior in different timeframes or coincide with behavior over time. It is possible that we need a different modification. Many questions remain. The role of motivating variables in a signaling approach remains unclear and experiments on the role of the different elements in a contingency have produced ambivalent results. To give an example, Koegel and William's (1980) study, mentioned above, found that children learned to lift boxes when food was spatially contiguous with lifting, namely under the box, but not when the experimenter immediately handed them the food. Jeffrey and Cohen (1964) found the opposite: Children learned to discriminate between objects only when the stimulus and the response were spatially contiguous, and it made no difference whether the stimulus and the reinforcer, or the response and the reinforcer, were contiguous. Contrary to the later study, the children in the former study had an autism diagnosis, but perhaps there is a fundamental difference between three-term and two-term contingencies that has yet to be discovered.

The two study designs proposed here comparing the explanatory validity of strengthening versus induction, as well as those mentioned above using non-discrete dependent and independent variables, are suggestions generated by the alternative framework argued for in this paper. Does the evolutionary framework suggested for the investigation of verbal behavior carry the potential to inspire future research beyond the replacement of strengthening with induction and of discrete with continuous events? I have recently collected data suggesting that this is so. In line with Wilson's (e.g., Wilson & Sober, 1998) phylogenetic multi-level selection theory, Baum (e.g., 2018) has suggested an ontogenetic multi-scale selection theory. Both theories argue that units of selection are nested into each other. That is, less extended units are part of more extended units, which are themselves part of even more extended units, and so on. To design an experiment investigating nesting of verbal operant units, I conducted a study (in prep.) in which one participant described the relation of geometric objects on a display invisible to another participant, who had to reproduce the overall picture described by rearranging a duplicate of the arrangement that was visible to the other participant. In the arrangements of geometric shapes, smaller shapes and groups of shapes were nested into more extended arrangements. I found that the first words of the describing participant (typically the Norwegian equivalents of "ok", "all right", etc.) reliably functioned to signal the onset of the description of a particular (next) level of complexity in the nested arrangements.

Not only do most studies on verbal behavior conducted today rely on a strengthening framework but these studies – on the allocation of speech to several conversational partners or the duration of speech, for example – are rarely explicitly interpreted in a selectionist framework. By explaining empirical findings both by accounting for selection in phylogeny and in ontogeny, we combine Skinner's contributions of regarding *speaking as behaving* (1957) and *selection of behavior in multiple timeframes* (1981) to a likely story about why we communicate the way we do.

Statement about ethical issues

To the best of my knowledge, all studies reported in this manuscript have been approved by the appropriate institutional and/or national research ethics committees. All research

was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. I do not have any conflict of interest.

Notes

1. Here short for "reinforcer or punisher."
2. Therefore, in the remainder of the paper, I use *induction* (Baum, 2012) and *signaling* by discriminative stimuli (Cowie & Davison, 2016; Shahan, 2010) interchangeably.

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ORCID

Carsta Simon http://orcid.org/0000-0001-8150-3248

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