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Carrying the baton: Evolution science and a contextual behavioral analysis of language and cognition

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ABSTRACT

The contextual behavioral science (CBS) tradition is now carrying the baton passed forward by its progenitor, B. F. Skinner: a request to explore the implications of evolution science concepts for behavioral science. This article examines the 30-year history of Relational Frame Theory (RFT) research in the light of modern evolution science concepts. It distills an evolutionary approach into six interlocking features: variation, selection, retention, context, dimension, and level. Most of these dimensions have been touched upon in RFT research to date. By making the connection between CBS and evolution science explicit, however, important lines of existing and potential RFT research are emphasized and key evolutionary concepts that have not been emphasized are given greater weight. CBS researchers in general, and RFT researchers in particular, are positioned to carry the evolution science baton and to use it to help advance a natural science of behavior. It will need to be gasped firmly as CBS runs through the ultimate challenge faced by behavioral science: creation of a comprehensive and pragmatic analysis of human language and cognition.

A productive empirical alliance between evolution science and contextual behavioral perspectives has long been sought, but has proven difficult to bring into existence. There is considerable irony and a sense of lost opportunity in that fact.

Philosophically speaking, the contextual wing of behavioral psychology emerged from an evolutionary approach. Radical behaviorism (Skinner, 1974), and its offshoot, functional contextualism (Hayes, 1993; Hayes, Hayes, & Reese, 1988), are fundamentally based on pragmatism, which was formed in an attempt to explore the philosophical implications of Darwin (James, 1907; Wiener, 1949). Radical behaviorism has been clearly stated since Skinner (1945) and over 70 years certainly provides the time to build an alliance based on this philosophical compatibility.

Theoretically speaking, functional contextual behaviorists have made repeated but largely unsuccessful attempts to place their work into the broad spectrum of evolution science. B. F. Skinner, who can be viewed as the progenitor of a contextual behavioral approach (Hayes et al., 1988), was especially energetic in attempting to formulate this connection, claiming that "the whole story will eventually be told by the joint action of the sciences of genetics, behavior, and culture" (Skinner, 1988, p. 83). Skinner took the view that "human behavior is the joint product of (i) the contingencies of survival responsible for the natural selection of the species and (ii) the contingencies of reinforcement responsible for the repertoires acquired by its members, including (iii) the special contingencies maintained by an evolved social environment" (1981, p. 502). Even his most important scientific concept, operant conditioning, was viewed by him as part of the larger process of evolution and selection by consequences "since operant conditioning is an evolved process" (Skinner, 1981, p. 501).

Until quite recently, evolutionists have not seen contextual behaviorists as allies. Skinner expressed interests in biology, physiology, and evolution over his entire career (Morris, Lazo, & Smith, 2004), and early researchers in a contextual behavior tradition worked extensively in such areas as behavioral toxicology, psychopharmacology, brain injury, and comparative psychology as a websearch of the impact of operant psychology on these fields will quickly reveal. Despite those facts, the supposed lack of interest in biology is frequently cited by evolutionists as an explanation for the disconnection between evolution science and a behavioral perspective. For example, Steven Pinker claimed "behaviorists believed that behavior could be understood independently of the rest of biology, without attention to the genetic make-up of the animal or the evolutionary history of the species" (Pinker, 2002, p. 20). He is hardly alone. A long line up of well-known theorists with stated interests in evolution have made similar comments, such as J. L. Gould (Gould & Marler, 1987), Franz de Waal (2001), and Martin Seligman (1970). Indeed, complaints of disconnection hardened into an outright rejection by early evolutionary psychologists, who contrasted their approach with what they viewed as a failed

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standard social science model, which was explicitly said to include behavioral psychology (Tooby & Cosmides, 1992).

From the behavioral side, this disconnection dominantly looked like a failure to communicate. Evolutionists and ethologists seemingly mistook the *strategic* decision in animal learning to focus on simple responses in relatively barren environments in the hopes of finding principles that might cross tips of evolutionary branches, for a *foundational belief* that such principles *must* exist. Such a claim would be tantamount to a view that the form of action and its evolutionary and ethological context did not matter. Continuity across tips of evolutionary branches cannot just be assumed because doing so would require assuming continuity backward through time, not just forward through time – which is not evolutionarily sensible (Hayes, 1987). That does not mean, however, that common general principles of learning cannot exist, nor that the strategy behaviorists used to find them was incoherent. Both open and closed systems of adaptation exist in many areas of life, such as the immune system, and many phenotypic facts apply to the current tips of most evolutionary branches. Both the behavioral and ethological strategies were inductive – but the behavioral strategy emphasized the detection of interspecies similarities, while the ethological strategy emphasized the detection of interspecies differences. Logically both approaches are complimentary.

Rejecting general process learning theory led to a certain lack of clarity in evolutionary accounts of behavior, because it is difficult or impossible to know what is different if one is not clear on what is the same. For example, when seemingly new behavioral phenomena such as taste aversion were encountered, they were often unhelpfully cast as the evolution of entirely new forms of learning (e.g., Garcia, Lasiter, Bermudez-Rattoni, & Deems, 1985; Seligman, 1970) rather than as evolved modifications of the temporal or other parameters impacting existing principles of operant or classical conditioning (e.g., Revusky, 1971).

Behaviorists role in this disconnection between the two fields was not just a failure to communicate, however – it was also a failure to engage. Contextual behaviorists rarely tested or expressed specific evolutionary ideas. For example, in an attempt to bring attention to learning principles, Skinner rarely qualified his hopes or claims with specific biological data, especially in his popularization of behaviorism in books such as Walden II (Skinner, 1948). The evolutionary areas of the time that were most clearly stated and most empirically testable were in the area of genetic modifications of learning principles. Skinner partially laid out such a program of research (Skinner, 1969, pp. 201–202), but neither he nor other behavior analysts mounted it. In that context, one cannot blame critics too harshly when they concluded that behaviorists were not very interested in biology, since only those inside the field would recognize that this connection was a long-term goal. Thus, in hindsight:

> Everyone was wrong, and progress requires movement on all sides. Evolutionists need to consult the human behavioral sciences and humanities respectfully – to discover what these disciplines know about learning and symbolic systems. Scientists and scholars from the human behavioral sciences and humanities will benefit by thinking about their work as inside the orbit of evolutionary theory (Wilson, Hayes, Biglan, & Embry, 2014a, p. 401).

The present day provides an opportunity to change this state of affairs. Evolutionists require knowledge about human behavior in order to use evolutionary principles to rise to the challenges of the current day human situation (Wilson et al., 2014a). Furthermore, evidence for the impact of environment and behavior on genetic expression is now so strong (Jablonka & Lamb, 2014) that a failure to address these topics leaves evolutionary theory without fundamental knowledge about some of the key contributors to an Extended Evolutionary Synthesis (Pigliucci, 2007). As a more traditional gene-centered approach weakens, there is an increased awareness that learning is a ladder in evolution (Bateson, 2013) because it leads to niche selection, niche construction, and the creation of extended functional behavioral episodes that can then serve as a benchmark for further genetic, epigenetic, and cultural adaptations. Even down to the cellular level, environment and behavior is constantly adjusting biology, through development and epigenetic regulation of gene expression (Slavich & Cole, 2013).

Meanwhile, contextual behavioral scientists have their own reasons to want to build a bridge to evolution science. Perhaps the most important is the consilience that is possible from linking learning and behavioral principles to evolutionary processes in other dimensions, very much as Skinner described when speaking of the breadth of selection by consequences (1981). Behavioral science is part of life science, but as the link between biology and behavior is explored it is easy to adopt a reductionistic biological approach, or to take up a different kind of reductionism when claiming primacy of psychology over group actions and cultural practice. Evolution science can be corrective in both cases. Furthermore, thinking of behavioral issues in evolutionary terms gives additional precision, scope, and depth to contextual behavioral accounts. In particular, the degree of depth afforded to the analytic concepts within contextual behavioral science is considerably increased when such concepts cohere with those of evolution science (Wilson, 1998).

In this paper, we wish to argue that (1) research programs in contextual behavioral science (CBS) are consistent with the core of modern evolutionary thinking, but not uniformly and often in a more assumptive than explicit way, and (2) these programs will become more efficient and effective if evolutionary thinking is used explicitly to guide their development. We intend to make this argument using as an extended example the 30-year research program investigating Relational Frame Theory (RFT: Hayes, Barnes-Holmes, & Roche, 2001) as a general account of human language and higher cognition.

Our strategy in this paper will be to distill an evolutionary approach down to six concepts (see Hayes, Monestès, and Wilson (in press); Hayes & Sanford, 2015; Wilson et al., 2014a), which can be brought to bear on Tinbergen (1963) four-part general program for a full evolutionary account. We will then use this "six concept" structure briefly to assess the degree to which evolutionary thinking comports with the canonical literature of a contextual behavioral approach, using especially the writings of B. F. Skinner as the focus. Then, after summarizing an evolutionary account of relational framing, we will apply the "six concepts" structure to an analysis of the RFT research program itself. In each area, our focus is both on whether contextual behavioral thinking and research comports with issues of importance to an evolutionary account, and whether a science of behavior can be more effectively guided by consciously adopting an evolutionary approach.

1. The six key conceptual features of an evolutionary account

A complete evolutionary account is one that examines the function, mechanisms, development, and history of phenomenon (Tinbergen, 1963) in terms of multi-level and multi-dimensional variation and selective retention in context, within and across lifetimes (Hayes & Sanford, 2015; Wilson et al., 2014a). We will briefly unpack the six primary terms in that sentence (variation, selection, retention, context, level, dimension), and examine whether the concept is consistent with the classical literature on contextual behavioral thinking.

1.1. Variation

Variation is a *sine qua non* of evolution. Variation initially is blind. It simply occurs, for no purpose. From these variations, effective adaptations can then be selected. Skinner explicitly affirmed this perspective as foundational to behavioral thinking when he examined the role of variation and selection across genes, behavior, and culture:

> Variations are random and contingencies of selection accidental. What evolved is not a single slowly developing species but millions of different species, competing with each other for a place in the world. The product of operant conditioning is not a single coherent repertoire but thousands of smaller repertoires, conflicts among which must somehow be resolved. The evolution of social environments has produced not a single culture but many often conflicting ones (Skinner, 1990/1999, p. 579).

The fact that evolution originates in blind variation has been emphasized by most behavioral science applications of evolutionary theory (e.g., Campbell, 1959), but that emphasis becomes wrong in its details over time because variability itself can evolve. For example, under stressful conditions mutations will occur at a higher rate and DNA repair at a lower rate (Galhardo, Hastings, & Rosenberg, 2008). Thus, in its modern form evolution is widely viewed not just a matter of survival of the fittest: it is also a matter of "survival of the most evolvable" (Wagner & Draghi, 2010, p. 381).

To some degree, Skinner's thought anticipated these developments in modern views of random variation. It was not yet widely known in science before his death more than 25 years ago that genetic variation and expression is itself regulated, but he appreciated that random variation in behavior can be excessively slow and viewed the evolution of guided variation of behavior as scientifically plausible. He pointed out that blind variation is not necessarily "a problem for natural selection because evolution could take millions of years, but a repertoire of operant behavior must be constructed during a lifetime. Operant conditioning must solve the 'problem of the first instance': How and why do responses occur before they have been reinforced?" (Skinner, 1990/1999, p. 579).

He pointed to two processes of guided behavioral variation that helped ensure that effective variants occurred within the lifetime of an individual: social learning (e.g., imitation) and verbal behavior. In both cases, he appealed to evolution itself as the source of these restrictions on blind variation, describing them as "the evolution of processes through which individuals take advantage of behavior already acquired by others" (Skinner, , 1990/1999, p. 579).

1.2. Selection

In evolution theory, variations that correlate with differences in lifetime productive success – including survival, access to mates, and competitive ability – are more likely to increase as a portion of available alternatives within a population. In some inheritance streams, these variations are also selected within the lifetime of the individual, not just between them. For example, social learning and imitation may allow effective cultural practices to evolve, but they do so based on reinforcement contingencies for individuals.

A dramatic example is supplied by the well-known story of the troop of Japanese macaques on the island of Koshima (Kawai, 1965) who were being fed potatoes periodically by the scientists watching them. In 1953 an individual female named Imo discovered that washing the potatoes in a river removed the sand more efficiently than the troops' previous behavior of bushing off the sand manually. The practice spread through the troop and within a decade all of its members washed potatoes before eating them. Removing dirt from food by brushing, rolling on clean rocks, or washing is a negative reinforcer that has been documented in several studies (e.g., Nakamichi, Kato, Kojima, & Itoigawa, 1998). A few years after this innovation, Imo began washing the potatoes in the sea – a practice apparently reinforced by the salty taste that resulted. This interpretation is supported by the fact that younger monkeys who learned the practice soon also began redipping the potatoes after each bite, suggesting that the salt was a positive reinforcer. Both innovations spread rapidly through the troop. These practices remain in the troop to this day even though all of the original animals are long dead (Kawai, Watanabe, & Mori, 1992).

The propagation of these practices involved variation, contact with functionally distinct reinforcers, and social learning effects on others. Behavior of this kind involves selection within the lifetimes of the individual involved, and at the level of a cultural practice they involve selection across lifetimes. Together they define behavior as a distinct inheritance stream.

Such a perspective is as old as behavioral psychology itself. Skinner was taken by selection as a causal process. Throughout his academic life he repeatedly appealed to the parallel between natural selection and contingencies of reinforcement as a form of selection. Skinner began that journey in his first book, *Behavior of Organisms* (1938) with his stated view that "all functions of the organism are explained by appeal to some form of evolutionary development" (p. 403). In his next major book, *Science and Human Behavior* (1953) Skinner claimed more specifically that "operant reinforcement resembles the natural selection of evolutionary theory. Just as genetic characteristics which arise as mutations are selected or discarded by their consequences, so novel forms of behavior are selected or discarded through reinforcement." (p. 430). In the paper, he finished the evening before he died, Skinner (1990/1999) stated forcefully that "the behavior of the organism as a whole is the product of three types of variation and selection" (p. 578), referring to genetic, operant, and cultural selection.

1.3. Retention

Evolution builds on itself through retention of relatively successful variations. Retention of successful variations needs to be defined broadly – at times even including retention of comparatively less *unsuccessful* variants. Genetic evolution is the most understood and common example of retention – selected variations of genes and gene systems are retained in sequences of nucleotides transmitted from parents to offspring. In some ways this provides a bad archetype, however, at the level of connotations. The Latin *tenere* means "to hold" and the etymology of the word "retention" suggests that inheritance requires something physical to *hold on to* or to *store* as a physical object. It is not necessarily so. A canyon in no way holds on to the rain that formed it – and if it did, the canyon would not have been formed in the first place. Rather, events change the physical world in a way that continues their impact, but not necessarily like a cupboard or even a hard drive. Inheritance can mean simply a change in probability. Bending a piece of paper makes it easier to bend it in the same place again. We can appeal to the physical arrangements of the molecules in the paper, but these arrangements are not the bending itself. Bending was not stored as bending. It was not held on to, as one might hold on to an object. Rather the ease and future probability of bending in a particular place was altered via a changed state of the paper. All inheritance streams involve physical substrates, and some involve storage in a literal sense, but others involve retention only in this probabilistic sense.

This discussion is necessary because contextual behavioral thinking has avoided storage as a metaphor, even though retention is a central concern of all forms of learning. Behavior carries on, but the events that establish behavior or alter its strength can be studied directly, without first knowing the physical properties of the organism that change with experience. How the organism and its environment is changed by experience is an important subject matter in its own right, but the first step is to understand how events alter selective retention.

The centrality of selective retention to behavioral thinking is revealed by noting that it is built into the very concept of learning. In this paper, we have attempted to rely primarily on Skinner's account of learning for evidence that a functional-contextual behavioral approach fits evolutionary thinking, but Skinner was not pithy in defining learning and it seems more worthwhile here to rely on a more modern resource that "is inspired by the work of Skinner (1938, 1984)" (De Houwer, Barnes-Holmes, & Moors, 2013, p. 631).

In a short but elegantly argued paper, De Houwer et al. (2013) define learning in this concise way:

> Evolution theory is concerned mainly with the study of phylogenetic adaptation—that is, the adaptation of a species to the environment across generations. Learning psychology,
> on the other hand, can be seen as the study of ontogenetic adaptation—that is, the adaptation of an individual organism to its environment during the lifetime of the individual (Skinner, 1938, 1984). In line with this idea, learning can be defined as *changes in the behavior of an organism that are the result of regularities in the environment of that organism*. From this perspective, learning research should be at the heart of psychology, in the same way as evolution theory is central to biology (p. 633).

It is worth noting that while this extended quote says nothing directly about retention per se, retention is necessary to make sense of the definition. It is a radically *functional* definition in that learning is not itself argued to be the *cause* of these changes: rather learning is behavior change due to a contacted regularity. A regularity is a pattern over time, and the correlation that defines learning is likewise a pattern over time. What is "held" in this kind of retention is change itself. Like the fold in a piece of paper, selective retention is not something that is stored but instead is a pattern or probability of situated action that is changed in a particular way.

1.4. Context

Evolution is always context bound. Context selects adaptations. Organisms with the capacity for contingency learning select their environmental niche, and often construct their environmental niche, changing the selection contingencies to which they are exposed. When the context changes – which it does continuously – an adaptation that worked well previously may no longer work well. No adaptation is forever.

Contextual behavioral science studies the act in context. Behavior is the subject matter of the behavioral sciences, and in a CBS approach all other categories and concepts are subordinate to the goal of predicting and influencing, with precision, scope, and depth, the behavior of whole organisms interacting in and with a context defined historically and situationally (Hayes, Barnes-Holmes, & Wilson, 2012). Skinner defined scientific knowledge as "a corpus of rules for effective action, and there is a special sense in which it could be 'true' if it yields the most effective action possible" adding a few lines later that a "proposition is 'true' to the extent that with its help the listener responds effectively to the situation it describes" (Skinner, 1974, p. 235). It is the combination of that view of truth and the goal of CBS as the prediction *and influence* of behavior that requires that context be a central focus. Behavior is a dependent variable in behavioral science. By definition, that means it is not directly manipulable. The parts of the world that in principle can be manipulated (so as to influence behavior) are the features that can function as independent variables. That is what "context" means in a contextual behavioral approach.

"Context" is not the world outside the skin – it is the world outside the behavior. If understanding the act takes us into understanding the internal environment, for example, then that too is context for the act. If it takes us in a different direction, the boundaries of the behaving unit can extend to include the group. In eusocial species, "the organism" can even *be* a group.

It is sometime hard to know when to stop in a contextual approach, but Skinner was clear there as well: "It is true that we could trace human behavior not only to the physical conditions which shape and maintain it but also to the causes of those conditions and the causes of those causes, almost ad infinitum" but we need take analysis only to the point at which "effective action can be taken" (Skinner, 1974, p. 210). That point is the manipulable context of history and circumstance, because it is only there that successful working toward the goals of CBS are possible (Hayes & Brownstein, 1986).

Clinically, it is worth nothing that this reordering of which parts of context are of importance is also altered by the goals and values of the client. In essence, the "successful working" goals of pragmatism required an a priori goal: that is as true for clients as it is for scientists.

1.5. Multi-level selection

Multi-level selection refers to the fact that selection can operate simultaneously at the level of individuals and groups (Wilson & Wilson, 2008). This is an old idea in evolutionary thinking (Wilson, 1983) but it fell out of favor in the gene centric era of the modern evolutionary synthesis, and in the late 1960's and 1970's this idea "rivaled Lamarkianism as the most thoroughly repudiated idea in evolutionary theory" (Wilson, 1983, p. 159). It arose from the dead on the final decades of the last century, and more recently it has received much stronger empirical and theoretical support (Nowak, Tarnita, & Wilson, 2010).

If physical lifeforms are thought of merely as part of the life cycle of genes as replicating units (Dawkins, 1976), then it is necessary to think of selection as operating at the level of the gene. Altruism in a cooperative group gives obvious competitive advantages to the group, but groups do not replicate. According to a gene centric approach, the selfish individual who takes advantage of others in a cooperative group will be more likely to survive and reproduce, and thus selection at the level of the group should presumably quickly be overwhelmed. To account for seemingly prosocial processes such as altruism, evolutionists who were oriented toward a genetic approach (e.g., Hamilton, 1964) argued these behaviors merely increased the "inclusive fitness" of a gene, provided that the prosocial behaviors focused primarily on kin and thus facilitated the survival of the gene itself.

In contrast, multi-level selection suggests that selection can indeed operate at the level of the group under specific circumstances, namely, when there is inter-group competition that selects for cooperation, advantaging both the group and the average individual, and there is suppression of selfishness at lower levels of organization. When these come together the group as a unit of selection can hit a tipping point much like a see-saw in an evolutionary time frame, causing a fundamental and permanent shift in the dominant unit of selection (Wilson & Wilson, 2007, 2008). Many major evolutionary transitions, such as the emergence of eukaryotic cells, multicellular organisms, or eusocial species, can be thought of as a shift in the unit of selection from individuals to groups. The interests of the individual never disappear – for example, cancerous cells periodically challenge the cooperation between the approximately 37 trillion cells of your body – but when group selection dominates, that selfishness at a lower level is confronted and managed by the group – for example, by your immune system.

Multi-level selection was out of fashion during much of the 20th century and in the canonical papers of contextual behavioral psychology similar ideas were spoken of infrequently, but were invoked more frequently as they applied to the interaction of the behavioral and cultural level (why this is a matter of levels and not dimensions will be clarified shortly). In an article entitled "The Design of Cultures" (Skinner, 1961/1999), for example, Skinner addresses how the good of the individual can be coordinated so as to also serve the good of the group by helping the group become sensitive to longer term consequences, and by adopting practices with the individual that foster cooperation and undermine selfishness. Although still controversial in many ways, multi-level selection is a feature of modern evolution science that is well positioned to have a profound impact on contextual behavioral science.

1.6. Multi-dimensional evolution

Evolution is ongoing in multiple domains and in multiple dimen-

sions. By a dimension of evolution we mean an inheritance stream: a particular kind or strand of variation and selective retention. We have already quoted Skinner as he divided evolutionary streams into genetic, operant, and cultural processes. In a highly influential volume, Jablonka and Lamb (2014) divided them into four: genetic, epigenetic, behavioral, and symbolic. Inside each of these evolutionary dimensions, an almost infinite number of possible domains or features can be distinguished for various analytic purposes: types of behavior, genes, epigenetic processes and so on. These are the more specific units or features that are selected and retained within a given evolutionary stream.

We will use Jablonka and Lamb's system in this paper, with some modification, but there is nothing sacrosanct about these dimensions: they are just useful analytic tools to assist us in understanding more of how to predict and influence behavior. The main point of thinking of evolution in multidimensional terms is to simplify the task of viewing evolution in a systemic and interactive way. A large set of interacting events in a relatively small set of evolutionary dimensions are involved in the production of any given behavioral phenotype. It does little good to try to over-simplify that system *a priori* – what we seek is a manageable approach to complexity that allow analytic goals to be accomplished. Focusing on inheritance streams is an effort to do just that.

The genetic dimension does not require content explication because it is so well known, but it is important to note that our understanding of this dimension has changed dramatically as a result of the successful sequencing of the human genome shortly after the turn of this century. Enormous studies with genomic analyses of hundreds of thousands of participants have since appeared and the results allow us now to state baldly that, in the main, genes do not code for specific phenotypic attributes. Complex genetic (and epigenetic) systems carry that burden (Jablonka & Lamb, 2014).

A good way to document that claim because of its simplicity is physical height. A recent study with genomic analyses of a quarter million participants (Wood, Esko, Yang, Vedantam, Pers, & Frayling, 2014) showed that 20% of the variance in height could be explained using about 700 genetic variations in over 400 sites. The authors speculated that height was likely linked to several thousand of genetic sites and variations. Given that the human being only has about 24,000 genes this makes a more general point: phenotypes are regulated by systems, not by specific genes.

The epigenetic dimension is rapidly coming to be widely known but requires a brief discussion. Epigenetics refers to biological processes other than the sequence of DNA nucleotides, that regulate gene activity, expression, transcription, and function. Almost every day an important new study appears showing that experience alters genetic expression, often in long lasting ways, through epigenetic processes. The best-known example of an epigenetic mechanism (but just one of many) is methylation. When a methyl group is attached to the nucleotide cytosine, RNA is less likely to transcribe regions of DNA containing that nucleotide. It is now known that methylation is regulated by the organisms' behavior and its contact with environmental contexts, and to a degree is heritable (Jablonka & Lamb, 2014). The epigenetic stream is of special importance to the next two inheritance streams: behavior and symbolic events, which we will note before returning to that point.

Jablonka and Lamb organize "behavior" into a single stream because ontogenetic adaptations that are instances of learning tend to survive across lifetimes by spreading to others via social learning, and across generations via culture. We have already provided an example of how this can occur in the story of the Japanese macaques on the island of Koshima. The original adaptations were selected via reinforcement, but the presence of these adaptations years after the original animals died is accounted for also by social learning and cultural practices.

The symbolic stream is the ultimate focus of this paper, so there is no need to expand on it in detail now, except to note its existence as an inheritance stream. You at this very moment are "reading a paper" that is retaining the products of human symbolic actions. You are likely doing so by viewing ink on paper or pixels on an electronic screen; although you could be listening to a machine translating the text, or perhaps interacting with the material via communication devices that did not exist when these words were written. Your behavior may be influenced by these interactions with symbolic material, but the authors could be alive or dead; the year could be 2017 or 2117 or 2417. Much as a seed or a desert plant can lie in the ground for decades waiting for rain, these words could sit unseen for centuries. Language, in a sense, has a life of its own, and thus it seems useful to treat it as a distinguishable inheritance stream.

While a behavioral approach has long included multi-dimensional thinking, the number of dimensions considered have been smaller than we will use here, and often they were described conceptually without being frequently studied empirically. For example, Skinner (1953) noted "it is not difficult to show that an organism which is reinforced by the withdrawal of certain conditions should have an advantage in natural selection" (p. 173). In that quote, Skinner is claiming in a general theoretical way that the genetic stream gave birth to a specific feature of the behavioral stream. Skinner viewed behavioral phenotypes as a given, but noted the conditions under which that might occur:

> The evolution of inherited forms of behavior is as plausible as the evolution of any function of the organism when the environment can be regarded as reasonably stable. The internal environment satisfies this requirement, and a genetic endowment of behavior related to the internal economy—say, peristalsis or sneezing—is usually accepted without question (1961/1999, p. 57).

Modern behaviorists (e.g., Schneider, 2012) have noted that operant conditioning changes selection pressures by maintaining contact with environmental niches, using the example of the flamingo whose digging in river mud was reinforced by the acquisition of edible crustaceans. When that behavioral pattern was well established, selection pressures were altered, allowing adaptations of the flamingo's beak structure to be selected at the genetic level. Such effects are thought by some evolutionists to explain why contingency learning itself may have evolved about 545 myo, driving the explosion of phenotypic diversity in life forms during the so-called "Cambrian explosion" (Ginsburg & Jablonka, 2010).

These broad and conceptual suggestions of multidimensional interactions have been made enormously more precise and empirical by the recent expansion of knowledge about epigenetics. Take the impact of classical conditioning. A recent study showed that mice exposed to aversive olfactory conditioning have pups, and these pups have pups, that show a startle response to the smell used, apparently due to methylation of certain olfactory genes (Dias & Ressler, 2014). Behavioral and symbolic experiences that are protective of mental health have measurable epigenetic effects on stress related genes and other areas of gene expression (e.g., Dusek et al., 2008; Uddin, Sipahi, Li, & Koenen, 2013). Psychotherapy, contemplative practice, and similar symbolic interventions alter the epigenetic regulation of stress related genes (e.g., Kaliman, Álvarez-López, Cosín-Tomás, Rosenkranz, Lutz, & Davidson, 2014; Yehuda et al., 2013).

Epigenetics has made the role of environment and behavior enormously more subject to precise research. For example, it has been known in mouse models for more than 45 years that parental stress before pregnancy has an impact on the behavior of grandpups (Wehmer, Porter, & Scales, 1970) but in both animal and human models we now know that intergenerational transmission of stress effects can occur epigenetically, not just through parenting practices or cultural processes (Dias, Maddox, Klengel, & Ressler, 2015).

These finding are too recent to be fully appreciated, but it is already clear that the "Modern Synthesis" of evolutionary theory is itself due

for a revision. Evolution science is moving beyond a gene-centered approach to approaches such as the Extended Evolutionary Synthesis (Pigliucci, 2007), that emphasize such issues as multi-dimensionality and epigenetics, multi-level selection, the role of development, and the evolution of evolvability. In this new environment, the role of behavior and symbolic events will be far more central in evolutionary accounts than was thought to be the case in the gene-centric era.

1.7. Summary

We have quoted contextual behaviorists, especially Skinner, in all six key conceptual areas we outlined earlier. Contextual behaviorists have been particularly focused on the areas of variation, selection, retention, and context – but notably less so in dimensions and levels. We argued earlier that a full evolutionary account relies on these six concepts (variation and selective retention, in context and across levels and dimensions) to address the classic questions formed by Tinbergen (1963): what is the functional design of behavior; what are its proximate mechanisms; how does it change with age, experience, and environment; and what is its phylogenetic history? There too the coverage by contextual behaviorists is uneven. Examinations of the functions of behavior, development, and phylogenetic history are the bread and butter of behavioral accounts that deal with evolutionary principles, and several of the comments by behavioral theorists in this paper so far are obviously focused on them. The remaining area of proximate mechanisms have often received less attention historically from the contextual behavioral wing, in part no doubt due to concern over reductionism and the dangers of using one level of analysis to explain another. Despite that concern, Skinner (1974) suggested that proximal mechanisms would be addressed by "the physiologist of the future" who "will be able to show us how an organism is changed when exposed to contingencies of reinforcement" (Skinner, 1974, p. 215). Indeed, to some degree this appears to be what is now happening in the fields of epigenetics, physiology, and neuroscience (e.g., Dias et al., 2015). Thus, while coverage is uneven, we find considerable concordance between the classic work of contextual behaviorists and modern evolutionary theory.

Contextual behavioral science is a name for a particular offshoot of contextual behavioral thinking. As such, CBS is an extension of a tradition that is a century or more old. At times it has been important to emphasize what is new about CBS, in order to give that tradition new life, fresh avenues of growth, and to open up new conversations with the life sciences and the culture at large. In this part of the paper, however, we have rather emphasized the opposite, relying in particular on the work of B.F. Skinner. The claim that Skinner is a contextualist (Hayes et al., 1988) can never be fully resolved, and not all agree, but CBS is not shy about laying claim to its historical roots.

We can state the bottom line quite simply: contextual behavioral science views itself as a part of evolution science and always has been. This is not a political claim, nor a recent idea. Rather this conclusion comes from the substance of behavioral accounts, that can be explained in terms of core features of an evolutionary account, across the range of most if not all evolutionarily appropriate questions. It must be admitted that at times this connection has not been easy to see, due to a historical breach that is only now being healed, and when present, it has been uneven across areas and questions.

While contextual behaviorists have spoken often and positively about ethology (e.g., Skinner, 1966; Catania, 2007), ethologists have defined their very field as "a reaction against a tendency prevalent at that time in Psychology to concentrate on a few phenomena observed in a handful of species which were kept in impoverished environments, to formulate theories claimed to be general, and to proceed deductively by testing these theories experimentally" (Tinbergen, 1963, p. 411). Some of this push back was a reaction against hypothetico-deductive S-R learning theory, which conflicted with ethologists yearning to have "an inductive start" (p. 411) that was more in contact with what animals actually *do*. Contextual behaviorists have similar inductive biases, however, and can only applaud that instinct. Some of the disconnect between the fields was simply due to an interest in other questions and a resulting failure to appreciate the possible scientific utility of the strategy deployed by behavioral psychology. Contextual behaviorists wanted to derive general principles from animal learning that would apply to human complexity. Ethologists were more interested in animal behavior for its own sake.

There is a danger, however, that we could encourage intellectual laziness by pointing out that CBS and its historic lineage was always an evolutionary approach. Contextual behavioral scientists themselves need to be much more explicit in adjusting to the implications of an evolutionary focus, and more creative and persistent in using empirical and conceptual developments in evolution science in a specific way. In what follows we intend to show that behaviorists have a great deal to gain from modern evolutionary thinking – but to achieve those gains the implications of evolutionary thinking need to penetrate the CBS theoretical and research agenda more thoroughly. We turn now to an area where that agenda could make an immediate impact: the analysis of human language and cognition.

2. Relational framing as an extension of cooperation

In this section of the paper we will summarize an evolutionarily sensible account of relational framing. The purpose is two-fold: to show that explicit evolutionary analyses can modify and add to our thinking about relational operants, and to establish the foundation for the following sections of the paper in which we extend evolutionary principles to RFT research.

The present account is a précis of the evolutionary analysis presented in Hayes and Sanford (2014). Because a detailed and thoroughly argued account is readily available, the present section is short and presented in summary form.

The distinctive characteristics of human evolution can be summarized with the "three C's" (Wilson, 2007): cognition, culture and cooperation. Skinner's account of verbal behavior ordered these three in a particular way: a culturally established verbal community took advantage of the evolution of operant control of the vocal musculature. In turn, the socially mediated reinforcement of characteristic response forms by others trained to do so led to greater effectiveness and social cooperation (Skinner, 1981, p. 502). Skinner's sequence – culture, cognition, cooperation – was superficially plausible but has faced multiple challenges on evolutionary grounds: (1) no evolutionarily plausible account has explained the emergence of the verbal community, particularly since in Skinner's system the behavior of the listener is not verbal, (2) it is not clear why operant control of the vocal musculature per se is so critical given that a rich variety of response forms could serve verbal functions, and (3) when an artificial verbal community is provided to non-human animals (e.g., in cross fostered chimpanzees) they do not develop human language or show its benefits, even though they readily learn to emit behavior that is only reinforced through the mediation of others trained to do so. The first point is particularly puzzling, as Skinner's definition of language hinges upon ignoring the history of the listener in clarifying the functions of the speaker's behavior (Hayes et al., 2001).

The original RFT book (Hayes et al., 2001) differed from Skinner's account, but its evolutionary plausibility is also questionable. In Chapter 8 of that book, it was claimed that derived stimulus relations in a listener could have immediate adaptive benefits in the avoidance of predation even if speakers did not show mutual entailment, and then:

> As this small difference gains prevalence in a gene pool, a group of listeners capable of deriving bidirectional relations could be created, enabling speaking that is based on bidirectional relations to be socially reinforced. Thus, the biological evolution of a capacity for bidirectionality in a listener would set the stage for the cultural

evolution of verbal communities, particularly for purposes of immediate social control and environmental regulation. (p. 146)

The problem with this account is that the key feature of human language according to RFT – bidirectional stimulus relations – is not itself explained. The account begins there, when it simply emerges as an adaptation. In terms of the three C's it is arguing that cognition came first (in weak form in listeners) which then spread to speakers due to culture, and led to social cooperation. But why would bidriectionality evolve in listeners in the first place? This account provides no answer beyond claiming that an adaptation occurred. This style of reasoning teeters on presenting a "just so" story as a substitute for an evolutionary account.

Hayes and Sanford (2014) construct a more plausible evolutionary path to relational framing by starting with the possibility that cooperation came first. Although it is still somewhat controversial, humans are arguably eusocial and the impact of eusociality on cooperation is fairly well supported empirically (Nowak et al., 2010). In this approach, cooperation was established in human beings by the multilevel selection of cooperative patterns due to the advantages it offered in competition between human groups, when combined with the cultural suppression of individual selfishness. In Hayes and Sanford (2014) it is noted that these same evolutionary processes could establish a small set of related behavioral skills, including: (1) social referencing – seeking of information from another individual, so as to use that information to respond to an object or event; (2) Joint attention and nonverbal forms of perspective taking – responding to the gaze, reaching, or pointing of others as stimuli for directing shared attention or inferring intentionality (Tomasello, Carpenter, Call, Behne, & Moll, 2005); and (3) the social reinforcement of cooperation in others (Schmidt & Sommerville, 2011). We argued that these features could be combined with behavioral features that are common in animal behavior such as the use of vocalizations to regulate the behavior of others (Masataka, 2003) and the emission of characteristic behavior in the presence of particular objects.

If just these evolutionarily plausible features are assumed, "cooperation makes it likely that if a human listener hears a speaker say something characteristic while reaching unsuccessfully for an object, the speaker's action is likely to be reinforced by the provision of the object" (Hayes & Sanford, 2014, p. 121). Furthermore, "the hear symbol → provide object relation of the listener will be reinforced" (Hayes & Sanford, 2014, p. 122) because it will be seen as cooperative by the speaker and by others viewing the exchange. Even human infants will provide social reinforcement to others when they are cooperative (Hamlin, Wynn, Bloom, & Mahajan, 2011).

Hayes and Sanford conclude:

> The entire exchange will build cooperation, perspective taking, and joint attention as patterns that are maintained within the group because it is a functionally useful communication exchange. If we unpack this highly likely sequence it means that in the context of high levels of cooperation, and adequate skills in joint attention, social referencing, and perspective taking, *any characteristic vocalization in the presence of a desired object would likely lead to reinforced instances of symmetry or mutual entailment* (italics in original, p. 122).

In other words, the claim is that mutual entailment is a plausible *social* act of a highly cooperative species given a characteristic sound emitted in the presence of an object or event, provided there are sufficiently high levels of social referencing, non-verbal perspective taking, and reinforcement of cooperation. Once mutual entailment exists as a social act, the benefits of extended cooperation would ensure expansion of this adaptation within a tribe or band. For example, a speaker saying "apple" from across a ravine might be given apples that are only available at the other side by a listener. This would provide a functional unit of relational behavior at the social level that could be made more efficient by further cultural and biological adaptations. For instance, as most individuals are able to complete both halves of this social interchange, speaker may begin to act as their own listener when speaking. Stimulus equivalence would be the result, and as the verbal community grew, equivalence could provide a kind of relational template for further expansion of symbolic abilities, and additional utility in terms of problem solving. The non-verbal perspective taking that afforded the entailment of "hear name → look for object" when the speaker engaged in an act of "see object → say name", could soon be the basis of other relations between speakers and listeners, such as "I'm closer, you're farther" or "I'm little, you're big."

In this account, cooperation led to a social or cultural form of cognition, which then led to interconnected and amplifying processes in all three C's: more cooperation, more useful forms of cognition, and more useful forms of cultural adaptations. It is a more evolutionarily plausible account that never has to appeal to major new forms of behavior emerging in a large step and that is built on well-developed evolutionary accounts in each of its smaller steps.

This account does not mean that relational framing is impossible in non-human animals. The "cooperation came first" account speaks to the issue of the evolutionary development of relational operants. Once established socially, genetic assimilation could leave them simply as unusual operants. Humans may be more prepared to acquire them, but that does not mean that specific operant training will not lead to them in other organisms. RFT would not be disproven by such a development, unless "complex relational frames can be developed in nonhumans, without also seeing some of the effects produced in humans by verbal behavior" (Hayes, Gifford, & Ruckstuhl, 1996, p. 299).

3. Taking an evolutionary approach in RFT research

We turn now to the six core concepts in an evolutionary approach. In each case, we will examine whether this core concept comports with existing RFT research and accounts. For each, we will provide one or two example of how taking this concept seriously suggests future research of applied or conceptual importance.

3.1. Variation

Symbolic events have been argued to be, and have been shown to be, both a source of behavioral variation and a restrictive influence on variation. Indeed, this very anomaly served as an initial empirical door into the development of RFT itself.

Before the development of RFT, one of the primary foci of behavioral research on human language was rule-governed behavior. It was a convenient place to begin empirically because "rules" were defined in the behavior analytic tradition more by example than by a precise technical definition. Skinner defined rules as "contingency specifying stimuli" (1966) but was never able to define what "specification" was; in his system the action of the listener was not verbal, and thus there could be no unique functional properties of rules beyond properties of antecedent stimulus control (Hayes SC, 1989). A rich variety of examples of what was meant by "rules" were provided, however, which allowed research to proceed despite conceptual difficulties. In the 1970's and 1980's (for a book length summary see Hayes (1989)), a body of research emerged showing that verbal rules altered the effect of direct contingencies.

For a time, relative insensitivity to programmed consequences of responding was thought to be an actual marker of verbal control – the so-called "language hypothesis" (e.g., Lowe, 1983). That hypothesis was exciting because it meant that behaviorists might have an empirical way of defining what verbal events were by their *impact*, even if there was no conceptual agreement about the nature of verbal stimulation per se, nor the basic processes involved in their establishment. It seemed for a time that the field could work backwards from insensitivity induction to the discovery of functional properties of

verbal events.

"Insensitivity" as a phenomenon was interpreted both in terms of variation and selection and thus some of what will be said in this section applies to the next. Some researchers argued that "insensitivity is a defining property of instructional control" (Shimoff, Catania, & Matthews, 1981, p. 207). Others thought that insensitivity occurred because rules reduced behavioral variation and thus limited contingency contact (Baron & Galizio, 1983). The research strand that led to RFT was based on a third idea: that rule-governed behavior engaged two sets of contingencies, one of which involved a verbal antecedent (Zettle & Hayes, 1982).

This idea had two major implications. First, whether rules augmented or diminished variation, or enhanced or diminished the regulation by contacted contingencies, would depend on both the degree of contingency contact fostered by the rule, and by the functional processes engaged by the particular verbal antecedents. A series of applied and basic studies showed that both of these properties were relevant to the outcomes obtained. For example, it was shown that rules could readily alter the nature of contingency contact, but also that social consequences for rule-following per se (what came to be called "pliance") could reduce the functional effect of other contacted contingencies (Hayes, Brownstein, Haas, & Greenway, 1986; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986).

The second impact of this approach to rules was the recognition that rule-governed behavior could not be adequately defined in the absence of a functional definition of verbal antecedents, or "verbal stimuli." Skinner defined verbal stimuli as merely the product of verbal behavior, which is not a true functional definition since it is based solely on the history of the speaker as the provider of stimulation, not on the history or circumstances that led the listener to be impacted in a particular way by stimulus events.

The attempt to construct a more adequate account of verbal stimuli soon led to the discovery of relational operants, and to research on functional classes of rule-governance, and their construction and regulation. The first comprehensive oral presentation of RFT (Hayes & Brownstein, 1985) defined verbal stimuli as stimulus events that have their behavioral effects because they participate in relational frames, a definition that was maintained as RFT was formalized (Barnes-Holmes, Hayes, & Dymond, 2001). In essence, this treats verbal and symbolic events as ways of speaking about relational framing.

RFT research has shown that verbal stimuli (defined this way) can increase and decrease behavioral variation. Variation can increase because novel combinations of stimuli in relational frames can produce novel forms of behavior (e.g., Hayes, Thompson, & Hayes, 1989; O'Hora, Barnes-Holmes, Roche, & Smeets, 2004). A repertoire exhibited in the context of one stimulus can be more likely to be established in the context of another if the two are themselves related (Barnes, Browne, Smeets, & Roche, 1995). When networks of relations are related, the functions of entire symbolic networks can be moved from one network to another via analogy and metaphor (Barnes-Holmes, Regan, Barnes-Holmes, Commins, Walsh, & Dymond, , 2005; Lipkens & Hayes, 2009; Stewart & Barnes-Holmes, 2001).

Verbal stimuli can also reduce behavioral variation in at least two senses. Some rules can restrict behavioral topographies when followed (e.g., "don't run into the street"), and verbal stimuli can become more dominant in regulating behavior than other types of stimuli, reducing variation in a functional sense. This effect may help explain why self-reported psychological rigidity correlates not just with various forms of psychopathology but also to insensitivity to changes in operant contingencies after having been given an accurate rule (Wulfert, Greenway, Farkas, Hayes, & Dougher, 1994). To take a more dramatic example, persons diagnosed with schizophrenia who have previously presented with delusional symptoms show less variability in responding to changing contingencies after being given a rule or being asked to generate a rule for themselves (Monestes, Villatte, Stewart, & Loas, 2014). Shaping social skills leads to more generalization of gains than if clients are either given a rule or are asked to generate their own (Rosenfarb, Hayes, & Linehan, 1989). Because of effects such as these, it is often arguably the role of the behavioral health providers to undermine rigid rule-governance that restricts variation in responding (Hayes & Sanford, 2015; Torneke, Luciano, & Salas, 2008).

Some clinical populations are characterized by restricted variation or narrow forms of stimulus control – some of which can be altered by relational operants. Autism Spectrum Disorders (ASDs) provide an example. ASDs are characterized by restricted and repetitive repertoires and have recently been conceptualized as a problem of invariance (Rodriguez & Thompson, 2015). Those diagnosed with ASD perform poorly on relational tasks compared to normative samples, with assessments of arbitrarily applicable derived relational responding (AADRR) covarying with linguistic ability (Moran, Walsh, Stewart, McElwee, & Ming, 2015; Dixon, Belisle, Stanley, Rowsey, Daar, & Szekely, 2015). RFT research has been successful in establishing repertoires for metaphorical reasoning (Persicke, Tarbox, Ranick, & St. Clair, 2012), detecting and responding to deceptive statements (Ranick, Persicke, Tarbox, & Kornack, 2013), responding to sarcasm (Persicke, Tarbox, Ranick, & St. Clair, 2013), telling socially appropriate "white" lies (Bergstrom, Najdowski, Alvarado, & Tarbox, 2016), and preliminary geometry skills (Dixon, Belisle, Stanley, Daar, & Williams, 2016). Each of these interventions contain deliberate efforts to increase variation in relational responding but they also appear to increase useful behavioral flexibility in the repertoires of persons with ASD.

3.2. *Examples of useful contemporary applications of variation as a conceptual guide*

A specific focus on variation in RFT research could be useful going forward in many practical and research areas. We will mention just two of many possible examples. The early work of insensitivity can be thought of as the symbolic inheritance stream altering the impact of the direct behavioral stream. Now that so much more is known about relational framing, and very fine grained tools have been developed to assess and foster relational skills such as the Implicit Relational Assessment Procedure (IRAP; Barnes-Holmes, Barnes-Holmes, Power, Hayden, Milne, & Stewart, 2006; Barnes-Holmes, Barnes-Holmes, Stewart, & Boles, 2010) or Relational Evaluation Procedure (REP: Stewart, Barnes-Holmes, & Roche, 2004), it may be time to return to this research area to see how establishment of more elaborated or fluent relational framing skills can augment sensitivity to changes in the environment, or establish more creative forms of problem-solving, or otherwise augment useful forms of variation.

A second, but related, area is not new but is exciting and in need of considerable development: the beginning work on the impact of relational fluency on intelligent behavior (e.g., Cassidy, Roche, Colbert, Stewart, & Grey, 2016; Cassidy, Roche, & Hayes, 2011). Fluency training involves increasing the speed and accuracy of the integration of increasingly varied and complex relational networks under the control of increasingly varied and complex forms of contextual control. This research is very exciting but requires more and better controls, and to date is limited to a very small range of relational framing skills. There are indications that a broader focus would be productive. Individuals who are encouraged to show a high degree of divergent thinking (e.g., "how many different uses can you think of for this cup?") have shown benefits in creative problem-solving over and above that which could be attributed to intelligence or expertise (Vincent, Decker, & Mumford, 2002). Flexibility in perspective taking and similar areas also appears to have benefits (Levin, Luoma, Vilardaga, Lillis, Nobles, & Hayes, 2016). Thus, an active research program that examines the impact of facilitating variation in a much wider range of relational operants seem warranted.

3.3. Selection

Derived relational responding is initially selected by its consequences by the social community. RFT research shows that this process begins in infancy (Lipkens, Hayes, & Hayes, 1993; Luciano, Becerra, & Valverde, 2007), and continues in the acquisition of a variety of relational framing skills (e.g., Weil, Hayes, & Capurro, 2011). RFT suggests that the coherence and utility of relational networks rapidly becomes an immediate reinforcer of relational framing skills (Bordieri, Kellum, Wilson, & Whiteman, 2016). As it does so, the selection for relational actions enters into a process of selection that is no longer fully controlled by the verbal community, and making sense of the world and interacting with it in predictable and effective ways dominates. Coherence, which is perhaps even more immediate than effectiveness as a reinforcer, is assessed in RFT research by such methods as altering the presence of distractor stimuli during testing (e.g., O'Hora, Tyndall, McMorrow, & Dale, 2013), or by examining the strength of derived versus trained relational responding (Saunders, Saunders, Kirby, & Spradlin, 1988). It can be shown that small differences in explicit training alter exactly how normal adults resolve ambiguous relational networks into coherent ones even in the absence of explicit consequences (Quinones & Hayes, 2014). Thus, today's coherence should be thought of as a distant echo of yesterday's social reinforcement, in much the same way that the success of early adaptation bends the long term direction of genetic evolution.

Relational framing also alters the capacity of other events to function as consequences as they themselves enter into relational networks. Early work in rule-governance from an RFT perspective focused on formative augmenting, which referred to stimuli in relational frames establishing given consequences as reinforcers or punishers; and motivative augmenting, which referred to relational stimuli that temporarily altered the degree to which previously established consequences functioned as reinforcers or punishers (Barnes-Holmes, O'Hora, Roche, Hayes, Bissett, & Lyddy, 2001). Research showed both effects could be readily established. RFT researchers demonstrated that it was possible to establish arbitrary stimuli as effective reinforcers via a transformation of stimulus functions from existing reinforcers (e.g., Barnes et al., 1995; Hayes, Kohlenberg, & Hayes, 1991). It was similarly possible to transform punishers into reinforcers (Whelan & Barnes-Holmes, 2004), or to alter consequences in accordance with comparative framing (Whelan, Barnes-Holmes, & Dymond, 2006). These findings provide a coherent account of the extent to which arbitrary verbal relations can alter selective influence over behavior, and may lead to the identification of idiographic verbal augmentals in promoting or extinguish behaviors.

For example, motivative augmenting was demonstrated (Ju & Hayes, 2008) and shown to operate by the symbolic presentation of some of the stimulus functions of consequences. This line of research has been extended to practical contexts in controlled research both in intervention and assessment. Jackson et al. (2016) utilized the IRAP to identify idiographic consequences for exercise and showed that symbolic presentations of these consequences augmented objectively measured exercise intensity, while no change from baseline was observed when instructional phrases focused either on the optimal topography of the exercise behavior or on consequences the IRAP suggested were not motivating. An assessment study using the IRAP showed that positive immediate relational responses to drug related stimuli predicted poorer treatment outcomes (Carpenter, Martinez, Vadhan, Barnes-Holmes, & Nunes, 2012). A later study showed that the previously identified relationship between "commitment talk" in motivational interviewing and successful substance abuse treatment occurred only in those who readily established derived relations between drug related words and negative consequences of drug use (Carpenter et al., 2016).

There are times that verbal stimuli can entirely block off the ability of direct consequences to control behavior. In an elegant basic demonstration of this phenomenon, Hefferline, Keenan, and Harford (1959) created an apparatus by which small, involuntary thumb twitches would be negatively reinforced by shutting off an aversive noise. When participants were provided no instructions regarding the task, the rate of thumb twitches increased dramatically; conversely, when other participants were told that the noise would be shut off by thumb movements, the participants became unable to produce the requisite movements to terminate the noise. In essence, verbal instructions of the conditions required for a desired set of consequences actually worked to prevent the contingencies from selecting for appropriate behavior.

Conversely, relational responding principles can be used to increase selection by consequences over time. An example is provided by Morrison, Madden, Odum, Friedel, and Twohig (2014), who found that delay discounting could be diminished by emotional acceptance methods drawn from Acceptance and Commitment Therapy (Hayes, Strosahl, & Wilson, 2012), suggesting that verbal intervention methods can reduce the tendency toward impulsive decision making.

3.4. Examples of useful contemporary application of selection as a conceptual guide

There are several areas where an explicit focus on selection might help guide modern RFT research. Some of these would build on the beginnings noted above – we will give two ready examples.

The identification of implicitly valid motivators and consequences (i.e., those arbitrary relations that might sustain the greatest degree of control over the selection of behaviors), could be of great importance if they were plugged into behavioral health programs, media promotion of pro-social behavior, or the nudging of helpful behaviors by agencies. RFT should be able to help better understand the selection criteria at multiple levels that lead to the adoption of cooperative and nurturing cultural practices (Sober & Wilson, 1998). The clinical work on values suggest that verbal motivation can be readily applied in clinical and educational settings (e.g., Chase et al., 2013) but there is also a basic gap between work on values and the specific relational events that make up these verbal events.

Quite a bit is known about how relational operants become established in the first place (e.g., Barnes-Holmes, Barnes-Holmes, Smeets, Strand, & Friman, 2004; Berens & Hayes, 2007), but less is known about the selection criteria by which relational operants strengthen within a repertoire over time. Coherence appears to be key – but other processes may be involved such as parsimony of the resulting relational network; the emotional impact of verbal networks or other transformations of stimulus functions; similarity to more dominant relational frames; and so on. Furthermore, it needs to be known what is selected. For example, if a metaphor leads to successful action, are all the relational phenomena that are subcomponents of metaphorical reasoning strengthened? These questions are key to research on the idea of a symbotype as we will show below. As more is known about how to build powerful relational repertoires, the practical usefulness of RFT concepts in understanding and promoting cognitive development will be greatly enhanced. There is a "calculus of the mind" that could emerge from more knowledge about the dynamic development of relational networks. Research on the selection of relational responding is a vast and seemingly fundable area, with immediate applied and basic importance.

3.5. Retention

Learning involves retention: to some degree learning is shown by the fact that what was learned continues to be emitted, at least in similar contexts. Verbal networks can be strengthened or weakened; be retained as an active part of the repertoire or fade from view. Verbal relations and stimuli can also establish or augment methods that enhance retention. For example, the phrase "practice makes perfect"

points to the key role of repetition in refining and retaining actions (Sheffield, 1949).

Verbal rules as retention-enhancers are common cultural practices – schoolchildren across a variety of cultures are assigned homework, as collective wisdom dictates that engaging in educational behaviors outside of the classroom context makes school-relevant behaviors more likely to be retained. Religious practices often call for members to share their beliefs with others, in the hope that beliefs will propagate and be more likely to be retained if they are enhanced by social processes.

Relational frame theory suggests that our verbal and cognitive networks are constantly being reformed and elaborated upon as we encounter new situations or as what was previously learned weakens. When relational networks are redundant and highly coherent, previously learned verbal relations can largely be recreated by derivation even when elements of the network weaken. The vast field of memory research overlaps enormously with the retention of symbolic relations, but knowing that relational framing is a core skill in verbal unity alters how we think of memory enhancement. For example, mnemonics create frames of coordination between new relational networks and well-practiced or coherent existing networks. As these processes of relations among relational networks come to be better understood (e.g., Ruiz & Luciano, 2011, 2015) they can readily be extended to possible methods of increasing the retention of relational actions. From an RFT point of view it would make sense that younger adults (who have simpler relational networks in given areas) would show greater benefits from memory training than older adults, whose relational networks are more complex (Verhaeghen, Marcoen, & Goossens, 1992). It should also be the case that fluency in relational framing should foster retention.

3.6. Examples of useful contemporary application of retention as a conceptual guide

Extending existing lines of RFT research into memory and the role of symbolic stimuli in the retention of behavioral gains could be done in both the basic and applied areas. Such work may lead to effective interventions for individuals with memory deficit disorders (e.g., Alzheimer's, traumatic brain injury) since it should be the case that training relational framing skills to fluency should have an impact even in disabled populations. There are some early data suggesting that may be the case (e.g., O'Neill & Weil, 2014) but a great deal more research is needed.

A primary way that verbal processes are retained is through the social adaptation of verbal practices. Useful RFT research could be developed around the conditions necessary for attitudinal change at both the individual and group levels. Relational frames involved in perspective taking (i.e., deictic frames) may prove important, especially in cases where the attitudes involved are related to selfish gain at the expense of perceived non-group members. Promoting the flexibility of the relational frames surrounding the "us" in "us vs. them" may lead to the selection and retention of prosocial behaviors, while extinguishing those behaviors that are likely to elicit hostility from non-group members.

3.7. Context

Contextual events influence the variation, selection, and retention of verbal relations in an RFT approach, but it is also the case that relational framing alters stimulus control. One way it does so is through modifications of attention.

Behavior analysts have historically rejected the idea of "attention" as a needless mentalization of stimulus control. Contextual behavioral scientists have a pragmatic need not to let dependent variables be treated as causes when the goal of analysis is prediction and influence (Hayes et al., 1986). This philosophical guidance is sound, but relational operants alter the impact of other behavioral processes and thus need be examined as part of a whole behavioral event in which the relations among actions are themselves considered contextually. "Attention" is a name for overarching symbolically influenced actions that augment or diminish stimulus control. These actions are controlled by context, but they also alter the contextual features that impact other behaviors.

Several studies have shown a relationship between psychopathology and the ability to respond quickly and accurately to modified Stroop tasks which include emotionally salient words (Williams, Mathews, & MacLeod, 1996; Wingenfeld et al., 2011; Atkinson et al., 2009; Jones-Chesters, Monsell, & Cooper, 1998). One explanation for these data is that performance is slowed by strong brief immediate relational responses to the emotional stimuli based on the person's learning history, which are followed by extended elaborated relational responses that constitute the shift in attentional control to the color of the word (Barnes-Holmes et al., 2010). People who are able to regulate such reactions by selecting and being guided by overarching verbal rules that effectively augment or diminish stimulus control are better able to function in a variety of contexts – what has been labeled "executive functioning" (Hayes et al., 1996).

These skills can be trained. For example, a brief mindfulness intervention that focused on attentional training has been shown to ameliorate stimulus over-selectivity in older adults (McHugh, Simpson, & Reed, 2010). A similar intervention has also been shown to effect rates on extinction and resurgence demonstrating that it is effective in increasing sensitivity to changing contingencies (McHugh, Procter, Herzog, Schock, & Reed, 2012; see also Kishita, Muto, Ohtsuki, & Barnes-Holmes, 2014),

The abstraction of event properties that then enter into a relational frame (or what has been called "pragmatic verbal analysis"), is another area in which relational operants alter context control (Hayes, Gifford, Townsend, & Barnes-Holmes, 2001). Only a few experimental studies have appeared on pragmatic verbal analysis (Stewart, Barrett, McHugh, Barnes-Holmes, & O'Hora, 2013) but the application of scientific knowledge itself is an example. It is possible to teach parents to see behavioral contingencies, for example, which makes them better able to specify effective parenting practices (Shayne & Miltenberger, 2013). In effect, after learning to see behavioral contingencies, parents live in a different environmental context. The same kinds of effects have shown utility in teaching critical thinking skills (Halpern, 1998).

In addition to directly altering attentional control or the abstraction of environmental features, RFT research has also investigated the role of contextual factors in influencing variation, selection and retention. Kohlenberg, Hayes, and Hayes (1991) found that the contextual control of equivalence relations could be transferred to other contextual stimuli through their participation in equivalence classes. The transformation of stimulus functions across relations is under contextual control (Dougher, Perkins, Greenway, Koons, & Chiasson, 2002; Perkins, Dougher, & Greenway, 2007). This means that contextual stimuli that regulate framing themselves participate in higher-order frames. This may be one way that relational networks become pervasive. For example, those with lower GPAs more quickly form equivalence classes involving failure words than their high GPA peers (Adcock et al., 2010). In essence, they begin to see "failure" everywhere – even in arbitrary relations.

These relational effects on context may help explain why participants demonstrate a scallop pattern of responding in response to a fixed-interval schedule when they are placed in a room with a television or reading materials and instructed to respond, whereas they exhibit a break-and-run pattern consistent with counting out the interval time before responding when there are no distractors (Barnes & Keenan, 1989; Barnes & Keenan, 1993). In other words, contextual factors alter the relative control exerted by environmental or verbal stimuli over responding.

3.8. Examples of useful contemporary application of context as a conceptual guide

There is a clear need for RFT research on attentional control and pragmatic verbal analysis. It appears to be the case that altering attentional process with mindfulness and defusion exercises may both increase the number of stimuli in an environment a person is responding to and undermine the effect of brief relational responses. It remains to be seen how these effects interplay with contextual control over the transformation of stimulus functions.

The same is true of pragmatic verbal analysis: we know the issue is important but not precisely how symbolic events produce these effects. This area appears to be important to an understanding of creativity, the scientific value of symbolic events, problem-solving, and other key events in the analysis of human language and cognition. It is difficult work methodologically because in RFT research it is usually the case that arbitrarily applicable relations need to be distinguished from formal properties, and in this area of research both need to be intertwined in complex ways. Establishing proper controls to limit the range of possible explanations is both critical and challenging.

3.9. Dimensions

Developmental variations may occur through interactions with the environment, shaping the organism and reinforcing behaviors that are adaptive for survival and procreation (Jablonka & Raz, 2009). Among humans, inheritance streams are heavily confounded with one another, in part because language processes operate on all other inheritance dimensions.

At the level of the individual, networks of symbolic relations (i.e., "symbotypes") produce a set of behaviors in much the same way that genotypes produce phenotypic expression (Wilson, Hayes, Biglan, & Embry, 2014b). RFT, as a program of research that establishes the emergence and development of symbolic thought, provides a critical role in clarifying the behavioral variability that emerges out of symbotypes (Wilson, 2012). The types of predictions afforded by RFT subsequently impact our ability to predict socially-mediated inheritance streams (i.e., the effect of symbotypic variation at the group-level), while continuing the contextual behavioral tradition of influencing human behavior via language processes. Many of the strategies used in Acceptance and Commitment Therapy (Hayes et al., 2012), for example, are applications of RFT that mitigate the kinds of symbotypes that decrease behavioral response flexibility. Efforts are also underway (e.g., see prosocialgroups.org) to marry RFT principles with evolution science to improve prosocial behavior at a group level (Hayes, 2014).

However, symbolic inheritance does not occur within a vacuum – symbolic thought has interacted with the inheritance streams of genetics, epigenetics, and behavior throughout human evolution (Richerson & Boyd, 2005). For example, prior to the invention of sign language, deaf individuals were unlikely to have children as a result of the numerous disadvantages associated with hearing-impairment (Jablonka & Lamb, 2007). However, with the adoption of sign language as a cultural practice, deaf individuals were more likely to survive and reproduce, and were particularly likely to marry other hearing-impaired individuals with whom they could communicate. As a result, the rate of congenital deafness has increased significantly within the United States population over the last 200 years. These genetic shifts, fueled by symbotypic inheritance, are interwoven: as the population of hearing-impaired individuals increases, so too does the cultural practice of sign language. These changes may be similar to the evolution of verbal language in our species, where those more able to relationally frame would be more likely to cooperate to respond to threats or opportunities in the environment, and would be sought out by other language-capable members of the species (c.f., Nance & Kearsey, 2004).

By re-conceptualizing the arbitrary relations that verbal organisms form as a kind of symbolic inheritance that interacts with other dimensional forms of inheritance, the principles developed within Relational Frame Theory become explicitly linked to heritability from the evolutionary perspective in two ways: (1) symbolic inheritance is a transmission stream in its own right, and (2) behavioral changes that occur as a direct result of symbotypes also impact the evolutionary development of a species. Not only do these links harken back to Skinner's (1981) calls to place behavior analysis within the framework of natural selection and evolution, but they also identify important questions that may further advance our ability to predict and influence human behavior.

Contextual behavioral scientists spend most of their effort in developing ontogenetic knowledge about part of the behavioral inheritance stream. If symbolic events are acknowledged as a new inheritance stream, then the research already done on studying how rules impact contingency control are studies of interactions between inheritance dimensions. This work is continuing in exciting ways. For example, it is now known that both the symbolic generalization of fear and the generalization of extinction effects for fear occur through relational networks (see Dymond, Dunsmoor, Vervliet, Roche, & Hermans, 2015 for a recent review).

It may be that we are seeing the development of a new inheritance stream in the enormous increase in efforts to regulate the impact of symbolic control. Just as epigenetic processes emerged to regulate how genotypes lead to phenotypes, it seems possible that defusion, mindfulness, acceptance, and similar practices are emerging in human culture because of their benefits in regulating how symbotypes lead to behavioral phenotypes. We can think of these practices as episymbolic events. Entire research programs are focusing on cognitive defusion, mindfulness, acceptance, metacognition and the like (e.g., Hayes & Strosahl, 2012; A-Tjak et al., 2015). Because of their functionally distinct purposes, it may ultimately be worth thinking of these events as a new inheritance stream.

3.10. Examples of useful contemporary application of inheritance dimensions as a conceptual guide

One crucial step is to establish the degree to which symbolic inheritance interacts with the other dimensions, and the contextual features that moderate this interaction. The attempt to examine symbolic events as an endophenotype for genetic anomalies of known importance (e.g., Gloster et al., 2015) may be a good example. A feature that is worth pointing out as its own question is how moving across different levels (e.g., individuals versus groups) changes such an interaction. Our species is currently behaving in ways that threaten the environment which we inhabit – pollution, global warming, overpopulation – and this behavior could be a product of the kinds of symbotyping that have been reinforced in the past (e.g., benefit *now* is worth expense *later*). The types of interventions that aim to change such behavior may require us to focus on influence the ways in which we relate, starting from a young age; and these interventions may call for different sensitivities to alternative inheritance streams when working with individuals compared to groups compared to the population as a whole.

Another related avenue of research would focus on the basic principles – how do epigenetic phenomena influence relational responding and vice versa? These studies could be as simple as collecting cheek swabs in single-subjects while manipulating the level of relational training encountered or the type of relational activity engaged in. A good example of this approach is presented by mindfulness training, which is now known to produce not just increased psychological flexibility but also epigenetic down-regulation of stress-promoting genes (Dusek et al., 2008). It would be worthwhile looking more broadly at the epigenetic changes produced by human language interactions, such as those occurring between parent and child, therapist and client, or teacher and student, and examining how

language-related changes bring about alterations in genetic expression, and the subsequent impact on social interaction.

The analytic methods of functional genomics and evolution science (e.g., Robinson, McCarthy, & Smyth, 2010) seem applicable to the analysis of symbotypes and their survival, development, and influence. RFT theorists have developed highly precise methods of specifying relational networks. By combining these two methodological approaches, it should be possible to detect how verbal networks evolve and survive, both within lifetimes and across them.

3.11. Levels

Contextual behavioral science has primarily dealt with levels of selection conceptually, and then primarily in terms of behavioral and cultural events. Skinner recognized the importance of the good of the group and referred to it with some regularity. At times he spoke in terms that are now considered passé:

> A tendency to feel compassionate would contribute to the survival of the species if it induced people to protect and help each other, but it is the behavior of protecting and helping others which is selected by the contingencies of survival (Skinner, 1972/1999, p. 309).

Multi-level selection is not a new idea, but as a precise and evidence-based formulation it is new to most wings of behavioral science. The Web of Science shows that articles containing the term "multi-level selection" were absent or in single digits until 2010, and total annual citations were 20 or fewer until 2004 (they were cited 250 times last year). Thus, of all the core evolutionary concepts discussed in this paper, this is the one that is currently least linked to CBS and RFT.

Nevertheless, some forms of RFT research and writing have shown sensitivity to the issue, especially in the analysis of competing components of symbolic events. For example, perspective-taking has been argued to undermine individual selfishness and to promote human interconnection, allowing social caring to increase and social objectification to decrease – predictions that have been empirically confirmed (Levin et al., 2016; Vilardaga, Estévez, Levin, & Hayes, 2012). This is essentially an appeal to the conditions under which multi-level selection is operative. The analysis of the evolution of relational frames described here (Hayes & Sanford, 2014) is also such an example.

3.12. Examples of useful contemporary application of levels of selection as a conceptual guide

Thinking of thoughts and rules virtually as life forms, and of personal repertoires as groups of these and other behavioral life forms, allows the analytic methods and insights of multi-level selection to be applied directly to the dynamics of relational networks. The applied literature in ACT is voluminous in this area. What is missing is a precise RFT analysis of the dynamics of change. Research into multi-level selection provides methods (e.g., Nowak et al., 2010) that may help.

It would be interesting to reinforce large language units if and only if they met the key criteria for producing cooperation from a multi-level approach (see Muir (2009) as an example of such an effort in agricultural science). Peace of mind is an important human goal and multi-level selection should be able to help therapists produce it. ACT work has long taken a view that peace of mind involved finding a way for conflicting sub-repertoires to coexist and thus may provide a beginning focus for this empirical journey.

RFT could also add to the study of multi-level selection in altruism and cooperation. For example, we need to know how in-groups and out-groups are established or modified by relational networks. The use of deictic framing to expand empathy and to reduce stigma and prejudice would be a good example since there are clear empirical leads in hand (Levin et al., 2016).

What this review has shown is that in every conceptual area of central importance to an evolutionary account, RFT research has findings in hand that comport with these concepts, and a ready list of important research projects that could build on this collaboration. An explicit focus on evolutionary concepts is not yet common, however, and many areas of RFT research would improve their coherence and impact if their evolutionary linkages were clearly stated and overtly explored. This article was written in hopes of fostering that process. The examples of future avenues mentioned in this paper were not meant to be comprehensive – they were merely meant as brief examples to show that there are sensible empirical avenues readily and immediately available in every area. As contextual behavioral science brings this approach more to heart, scores more avenues will quickly present themselves.

4. Carrying the baton

In working to place behavioral science within the orbit of evolution science, CBS is positioning a contextual behavioral approach in a way that fits both with current opportunities and the historical vision of its progenitor. That vision is evident in many of the quotes we have presented just in this paper, but it is given a poignant emphasis when you examine the last words B. F Skinner ever wrote.

His race run, Skinner struggled to finish a final article as leukemia took away his life. The article was a short but important piece on the need to build a natural science alternative to the mentalistic study of mind – a written version of the address he had given seven days earlier to the American Psychological Association on receiving its first Citation for Outstanding Lifetime Contribution to Psychology. He concluded the article during the evening of August 17, 1990 and died the next day – with the word "marvelous" on his lips after taking a final sip of water.

That final written sentence can be thought of as a kind of baton that was passed forward as his leg of the indefinitely long scientific relay race against ignorance was concluded. It contains in succinct form a challenge to behavioral psychology to pursue evolutionary principles as a guide to its development, and a promise to the field he created that it would be a worthwhile journey. It also contained a warning to psychology itself of what would be lost if evolutionary accounts could not find a home there. This is what he wrote:

> A better understanding of variation and selection will mean a more successful profession, but whether behavior analysis will be called psychology is a matter for the future to decide (Skinner, 1990/1999, p. 538).

There is every indication that CBS has firmly grasped that baton and is now carrying it forward in the attempt to develop a natural science of behavior that is more adequate to the challenge of the human condition. Contextual behavioral science is indeed no longer merely the domain of psychology: it includes every field of relevance to behavior. CBS is not just "behavior analysis" either. CBS is an offshoot, with considerably expanded theoretical horizons due to its knowledge development strategy and the post-Skinnerian analysis of language and cognition that is RFT. Accomplishing the breadth of its agenda is considerably aided by the consilience that evolution science affords. Creating an understanding of complex human behavior requires a functional analysis of human language and cognition, however. Failure in that area means failure overall.

RFT is arguably the most thoroughly developed experimental approach to language and cognition that intentionally comports with the functional and contextual assumptions that underlie both CBS and multi-level, multi-dimensional evolution science. As this article has shown, the 30-year long empirical program developed by RFT researchers has touched on all of the core areas of an evolutionary approach. In the past, it has done so unevenly and generally without structured guidance by evolution science. By explicitly and purposively integrating behavioral principles with evolutionary principles, rela-

tional frame theorists will be better positioned to run their particular leg of the scientific relay race against ignorance, pursuing the dream of a natural science of behavior that reaches across all domains of human action.

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