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Behavior Analysis and Linguistic Productivity

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The greatest intellectual challenge to the field of behavior analysis may be understanding linguistic productivity (e.g., being able to correctly say and understand novel sentences). One of the main issues concerning linguistic productivity is whether behavioral productivity is, itself, a fundamental behavioral process, as claimed by the proponents of relational frame theory, or whether we can understand linguistic productivity in terms of more fundamental behavioral principles.

OUR GREATEST CHALLENGE

The greatest intellectual challenge to our field of behavior analysis might be the development of a clear, comprehensive approach to language and cognition. With regard to language and cognition, we are somewhat like we were with regard to abnormal behavior and clinical psychology 45 years ago. At that time we behavior analysts might be asked, "Why are people crazy?" And we would reply, "They learned to be crazy." And we would be asked, "How could that happen?" And we would reply, "Like the rat in the Skinner box learns to press the lever." Then we would walk away, as rapidly as possible, for fear that we might be pressed to connect the dots between our two replies; we couldn't do that dot connecting. We had great faith that there was a connection between what we studied in the Skinner box and abnormal human behavior; and we took comfort in that faith. And, because of that faith-induced comfort, we didn't spend much time trying to connect those dots—too difficult; let us rest with simplistic explanations. So, we made no progress in helping people with psychological or behavioral problems, or any kind of problems, for that matter.

Then, Ayllon and Michael (1959) started connecting the dots with their empirical article showing that abnormal behavior was a function of reinforcement contingencies. And for the last 44 years the *Journal of the Experimental Analysis of Behavior* and then the *Journal of Applied Behavior Analysis* have continued connecting that path of dots from the Skinner box to abnormal behavior. In addition, early on, Staats and Staats (1963) added a whole lot of dots between the Skinner box and complex human behaviors, providing very persuasive connections. So, during these 44 years, we have made much progress in lighting the path between the Skinner box and applied areas.

But not even Skinner's *Verbal Behavior* (1957) connected the dots between the Skinner box and human language with enough detail to convince the brilliant linguist Noam Chomsky. And though Chomsky may have been born with a nativist need to gore Skinner's rat, his critical review of Skinner's behavioral theory of language was far from shoddy, far from uninformed (Chomsky, 1959). Instead, it was scholarly and thorough, a devastating critique of the behavioral theory, at least for anyone not trained in Skinner's lab. Even the brilliant Chomsky would have had to do a sabbatical with Skinner to understand that the concept of stimulus generalization might provide some of those connecting dots; and even then it would require an athletic leap of faith to jump from green-trained stimulus-generalizing pigeons pecking yellow Skinner-box keys to Chomsky's linguistic concerns. And Chomsky's concerns may be the weakened Achilles tendon that has prevented most scholars from leaping to the faith of behavior analysis. Essentially, Chomsky's concerns deal with linguistic productivity—how can we understand a sentence we've never heard before; and how can we say a meaningful sentence we've never said or heard before?

These are profound questions for which we behavior analysts have mainly given a simplistic answer—stimulus generalization? Perhaps,

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but where are the dots? And the dotless simplicity of our answers to this profound question has been grease on the skids as the faithless hoards slip from behavior analysis to mentalistic, nativistic cognitivism.

Chomsky's issue of linguistic productivity is a subcategory of a larger issue; and to extend the linguist's terminology, let's call that larger issue *behavioral productivity.* By *behavioral productivity*, I don't mean the number of widgets the assembly line workers produces per hour. I mean something more like creativity. *Behavioral productivity* means responding appropriately in novel circumstances, where the stimuli may be novel or the appropriate response may be novel. By *behavioral productivity* I don't mean random, chaotic newness; instead, the response must be appropriate.

Productive, Conceptual Stimulus Control

Abstract Conceptual Stimulus Control

Perhaps we can best understand behavioral productivity in terms of productive stimulus control. Consider, for example, abstract conceptual stimulus control. We reinforce the pigeon's pecking at pictures of green objects and not at pictures of objects of any other color, across a wide variety of pictures of different sizes, shapes, and complexity. This stops being an example of simple stimulus control and becomes an example of abstract conceptual stimulus control, of productive stimulus control, when the pigeon pecks at novel pictures of small green objects and not at novel pictures of objects of any other color. The pigeon is discriminating across the color dimension and generalizing along the stimulus dimensions of size, shape, and complexity. The pigeon is showing behavioral productivity, because it is responding appropriately in novel circumstances—in the presence of novel instances of green and non-green pictures.

We may be impressed that pigeons can come under the control of an abstract stimulus property such as its greenness, but we understand how this stimulus control works—discrimination between green and other colors and generalization along all other stimulus dimensions.

Multi-dimensional Stimulus Control

We can establish slightly more complex conceptual stimulus control, if we reinforce pecking only at pictures of large, green objects and not at pictures of small green objects or objects of any other color, regardless of size, shape, and complexity. This becomes an example of multi-dimensional stimulus control, when the pigeon pecks at novel pictures of large, green objects and not at novel pictures of small green objects or novel pictures of objects of any other color.

We may be slightly more impressed by this slightly more complex example of conceptual stimulus control (the concept of picture of large green objects), but it is still an obvious example of the combined operation of our two basic behavioral processes, discrimination along two clearly described stimulus dimensions, and generalization along other clearly described stimulus dimensions.

N-dimensional Stimulus Control: The People Concept

But behavior analysts have carried conceptual stimulus-control research to amazing levels of complexity, and the pigeons have hung in. For example, we can reinforce pecking only at pictures of people and extinguish pecking at pictures of anything but people, regardless of color, number, size, shape, and complexity. This becomes an example of n-dimensional stimulus control, when the pigeon pecks at novel pictures of people and not at novel pictures containing no people. (Hernstein & Loveland, 1964; Siddal & Malott, 1972)

We may be more than slightly more impressed (I'm amazed) by this enormously more complex example of conceptual stimulus control (the concept of picture of person); but presumably this conceptual stimulus control it is still an example of the combined operation of our two basic behavioral processes, discrimination and generalization, except now it is far from clear, at least to me, what are the stimulus dimensions along which the discrimination and generalization processes are operating. Incidentally, this phenomenon is so robust that our students used to establish people–concept stimulus control as a standard, cookbook, undergraduate, pigeon-lab experiment (Milar & Malott, 1968).

N-dimensional Stimulus Control: Fine-Arts Concepts

Furthermore, this conceptual stimulus control can get so complex and so subtle that the concepts of impressionist and cubist painting can exert productive conceptual stimulus control over the behavior of pigeons. For one group of pigeons, Watanabe and his colleagues reinforced pecking at pictures of some of Monet's impressionist paintings. For another group they reinforced pecking at some of Picasso's cubist paintings. Pecking correctly at novel pictures of Monet's and Picasso's paintings demonstrated that these art concepts were exerting conceptual stimulus control over the birds behavior.

Furthermore, the pigeons correctly pecked at pictures of impressionist paintings by Renoir and cubist paintings by Braque. And even when the pictures were black and white and when they were out of focus, novel impressionistic and cubistic paintings continued to exert conceptual stimulus control (Editors,1995).

Productive behavior indeed. Again, we assume the underlying behavioral processes are generalization within a conceptual stimulus class and generalization between those classes, though, also again, we don't know what the relevant stimulus dimensions are; however, the researchers did demonstrate the irrelevancy of two-color and sharpness of the detail.

Stimulus Matching

Stimulus matching is another area that generates productive stimulus control. For example, we can train pigeons to peck a disc when the two halves of the disc are the same color and not when they are differing colors. Then we can present novel colors, and the pigeons will correctly peck the key when the two halves of the disc match and not peck when they do not match, demonstrating productive, conceptual stimulus control, where the concepts are matching and non-matching colors—discrimination between matching and non-matching colors and generalization across colors.

The concept of stimulus matching is more complex than the concept of red, in that it involves the relation between two or more components of a stimulus, the relation between the colors of the two halves of the disk. Such relational discriminations are often called *conditional discriminations*, in that whether the right half of the disc is part of a discriminative stimulus (S^D) or part of non-discriminative stimulus (S^{Δ}?) depends upon (is conditional upon) the color of the left half of the disc.

The concept of conditionality makes more intuitive sense in the case of traditional stimulus matching, called *matching to sample.* As an example of matching to sample, whether or not a reinforcer will follow the pigeon's pecking the comparison disc of a particular color is conditional upon the color of the sample disc. In other words, customarily we would say reinforcement of pecking the green comparison disc is conditional upon the color of the sample disc.

(Incidentally, though much less intuitively obvious, we are probably justified in defying custom and saying reinforcement of pecking a particular comparison disc in the presence of a particular sample disc is conditional on the color of that comparison disc. In other words, which stimulus has it effect conditional upon which stimulus is probably arbitrary; we are probably being arbitrary when we say the red comparison key's being the correct key to peck is conditional on the color of the sample key. This arbitrariness is more obvious with the split-disc stimulus matching procedure described earlier than with matching to sample.)

Note that these examples of abstraction and conceptual stimulus control are based on the inherent physical properties of the stimulus: its greenness, its cubisticness, its matchingness. Now we will consider stimuli where the stimulus control is arbitrary, based on the whim of the experimenter or the culture controlling the contingencies of reinforcement.

SYMBOLIC STIMULUS CONTROL

Simple Symbolic Stimulus Control

Stimulus matching is always a good place to start. Our previous examples were of identity matching, where the two parts of the stimulus are related by physical identity. Now we will consider arbitrary matching (i.e., symbolic matching), where the two parts of the stimulus are related by an arbitrary rule. In the case of symbolic matching to sample, we might reinforce pecking the comparison disc with the letter A on it, when the sample disc was green; and we might reinforce pecking comparison disc with the letter Z on it, when the sample disc red. The relation between the colors and the letters is arbitrary in that we could just have well reinforced pecking the comparison disc with the Z, when the sample disc was green, and vise versa with the red disc; or we could have used completely different letters.

But, by itself, this simple symbolic matching, cannot generate productive stimulus control. For example, if we now present novel colors with novel letters, there is no basis for reinforcing the pecking of any particular novel color.

Productive Symbolic Stimulus Control

However, at least logically, we could develop and demonstrate a higher-order symbolic matching procedure that might generate productive stimulus control. This would require three major steps: First, we would train a larger "vocabulary," by doing symbolic matching to sample with a larger set of letter–color pairs.

Second, we would train a "grammar" using relational symbolic matching: Now, the sample stimulus would consist of two colored discs, one larger than the other; for example, the green disk might be larger than the red disc. And one of the comparison stimuli could consist of A > Z, while the other consists of Z > A. Pecking the A > Z disc would be correct, in that such pecks would be reinforced. We would then train this *larger-than* symbolic matching with all combinations of *some* of the other previously trained letter–color pairs. (Understand, of course, that the ">" symbol is as arbitrary as the colors and letters; for example, it could have pointed in the other direction or been any other symbol or stimulus configuration.)

Finally, we would test for productive stimulus control; in other words, we would test to see if this *larger-than* symbolic-matching training transferred to letter-color pairs that had not been involved in the *larger-than* training but had been part of the earlier simple symbolic matching (i.e., the vocabulary training).

I don't know if we could actually demonstrate productive symbolic matching with pigeons; and if we could, I don't know how many intervening steps we would needed. But, whether it is merely a *gedanken* experiment or has potential as a real PhD dissertation, I think it does get at the essence of language.

Language

The linguist C. F. Hockett (1960a, 1960b) developed a set of criteria behavior must meet before it should be called language (unfortunately, most behavior analysts seem unaware of his brilliant work). Perhaps, because of the linguist's traditional bias to deal only with spoken language or perhaps because he was interested in natural animal signal systems, Hockett included several criteria that restricted language to the auditory modality (e.g., that the language system be *transmitted over a vocal–auditory channel*). However, he did include some more interesting criteria to help us discriminate between language and pale imitations thereof (e.g., the language stimuli must be *specialized, semantic, arbitrary, discrete, and combinatorial*).

But, Hockett's most crucial and most challenging requirement may be his productivity criterion. Examples of stimulus control that meet the productivity criterion include correctly matching a novel sentence to a novel non-verbal stimulus and vise versa. Matching a descriptive sentence to a novel combination of familiar objects would be an example of language productivity (Skinner's *tact*), as would matching a novel combination of familiar objects to a descriptive sentence (somewhat like responding to Skinner's *mand*). And as we saw in the previous section, this is also an example of productive symbolic stimulus control. Thus such symbolic matching meets what may be linguist Hockett's most crucial criterion for a language system. (However, note that a pigeon's performing simple symbolic matching would not meet this criterion to be consider language [aka *verbal behavior*], no matter how many symbolic stimuli the bird could match ["tacting"], nor would differentially pecking a food key vs. a water key, etc. meet this language criterion, no matter how many different establishing-operation/reinforcer combinations would correctly control the bird's key pecking ["manding"].) (For a more detailed behavior analysis of Hockett's criteria, see Whaley & Malott,1971, pp 257-261.)

To my limited knowledge, no one has presented a comprehensive, theoretical analysis of linguistic productivity from a behavior-analytic prospective, not until Hayes, Barnes-Holmes, and Roche (2001) published their new book, *Relational Frame Theory: A Post-Skinnerian Account of Human Language and Cognition.*

Relational Frame Theory

Stimulus-Equivalence Training

The highly researched procedure *stimulus-equivalence training* generates productive, symbolic stimulus control. And behavior analysts all seem to agree that stimulus-equivalence productivity and language are related; however, they do not seem to agree on the nature of that relation and on whether language is a prerequisite to stimulus-equivalence productivity or vise versa. In any event, the symbolic productivity of this procedure seems to have been the inspiration for the development of relational frame theory; and Hayes and his colleagues (2001) argue, as do I, that such symbolic productivity is the essence of language.

However, the authors also argue that this symbolic productivity illustrates a new principle of behavior. In essence, the principle of behavior is that stimulus-equivalence training can result in symbolic productivity, including productive, symbolic stimulus control. They seem to suggest that this stimulus-equivalence principle is a fundamental behavioral principle, not to be understood in terms of more fundamental behavioral principles. And, we part company there, because Trojan and I have suggested that one can understand the productivity generated by stimulus-equivalence training in terms of the existing, elementary principles of behavior (Malott, Malott, & Trojan, 2000), without invoking a new principle of behavior.

An Analysis of Symbolic Productivity Resulting from Stimulus-Equivalence Training Symmetry

For example, consider a study by Cowley, Green, and Braunling-McMorrow (1992). They worked with a brain-injured client who could not identify his three therapists by name.

Entering deficit: (S^D: Photo) ⇨ (R: Client speaks name)

However, he could match the therapists' written names (comparison stimuli) when the trainer spoke their names (sample stimuli).

Entering skills: (S^D: Trainer speaks name) ⇨ (R: Client touches written name)

In other words, the client could read.

As an intervention, these researchers did stimulus-equivalence training. That is, the client received symbolic-matching training, where he touched the photo of one of the three therapists (e.g., Mark), a comparison stimulus, when the trainer said the name of the person in the photo (e.g., *Mark*), the sample stimulus.

Training: (S^D: Trainer speaks name) ⇨ (R: Client touches photo)

After symbolic matching had been established, the trainer then pointed to one of the photos (e.g., Mark's), now a sample stimulus; and without further training, the client readily said *Mark*, now, essentially the comparison stimulus.

Results: (S^D: Trainer points to photo) ⇨ (R: Client speaks name)

They had corrected the client's entering deficit. This demonstrates *symmetry;* in other words, the novel reversing of the sample and comparison stimuli still generated appropriate stimulus control—a relatively simple form of productive, symbolic stimulus control—simple for you and me but perhaps impossible for animals and non-verbal human beings.

Theory

Trojan and I suggested that the following scenario might have accounted for this symmetrical productivity: In the original training, suppose the client had vocal imitative skills;

and suppose he tended to imitate the trainer by saying *Mark*, either overtly or covertly, while touching Mark's picture.

Assumption: (S^D: Trainer speaks name) ⇨
(R: Client speaks name)

If that were the case, then when the trainer reinforced touching Mark's picture, he would also be reinforcing the client's saying *Mark* in the presence of that photo and perhaps establishing the photo as a discriminative stimulus that could evoke the client's saying *Mark*.

Assumption: (S^D: Photo) ⇨
(R: Client speaks name) ⇨ (Reinforcer)

So, because of that accidental, but crucial, reinforcement contingency, when the trainer showed Mark's picture and asked, *who's this,* that question would cause the possibly covert vocal response to become covert; and the client would say *Mark*.

Results: (S^D: Trainer points to photo) ⇨
(R: Client speaks name)

Transitivity

But, not only could the client now "match" his own speaking of the names to the photos, he could also match the written names to the photos; for example, when the trainer pointed to one of the photos (e.g., Mark's), now a sample stimulus, without further training, the client readily touched Mark's written name, the comparison stimulus.

Results: (S^D: Trainer points to photo) ⇨
(R: Client touches written name)

And the client would do this even though he had never had symbolic matching-to-sample training with both the photos and the written names in the same procedure. This also is productive stimulus control and demonstrates *transitivity:* The novel combination of the photos as the sample stimuli and the written names as the comparison stimuli still generated appropriate stimulus control. In other words,

If A = B; and A = C; then B = C

And in terms of this experiment,

Training: (S^D: Trainer speaks name) ⇨
(R: Client touches photo)

Entering skills: (S^D: Trainer speaks name) ⇨
(R: Client touches written name)

Results: (S^D: Trainer points to photo) ⇨
(R: Client touches written name)

Theory

Trojan and I suggested that the following scenario might have accounted for this transitive productivity: Because of the accidental reinforcement contingency described earlier, the client had acquired the following symbolic matching repertoire:

(S^D: Trainer points to photo) ⇨
(Client speaks name)

And, as mentioned earlier, because of his pre-experimental history, the client has acquired this symbolic matching repertoire:

(S^D: Trainer speaks name) ⇨
(R: Client touches written name)

And, if the stimuli arising from the trainer's speaking the name generalizes to the stimuli arising from the client, himself, speaking the name, then the client will not only touch Mark's written name (comparison stimulus) when the trainer says it (sample stimulus), but he will also touch Mark's written name when he himself says it (novel sample stimulus).

(S: Extroceptive or proprioceptive stimuli
from client's speaking name) ⇨
(R: Client touches written name)

Then these three links can then combine to form the following *behavioral chain:*

(S^D: Photo) ⇨ (R: Client speaks name,
overtly or covertly) ⇨
(S: Extroceptive or proprioceptive stimuli
from client's speaking name) ⇨
(R: Client touches written name)

Thus we get transitive productivity, because the client was never directly trained to touch the written name in the presence of the photo.

And we can account for both the cases of reflexive productivity and transitive productivity, in terms of the basic principles of behavior without evoking a new behavioral principle. Therefore, we have a more parsimonious solution, though parsimony is rarely as simple as inventing a new causal factor, whether it be a new reification or a new behavioral principle. (I should mention that Hayes and his colleagues are also concerned with parsimony and seem to feel it more parsimonious to explain a result in terms of one new principle of behavior than two existing principles. [p. 150]).

Concerns

I don't know whether Trojan and I did a correct analysis of the example of productivity resulting from this experiment on stimulus equivalence training. But, at least, our attempt illustrates the possibility of analyzing such stimulus-control productivity using only the basic principles of behavior, without evoking an additional principle. And by extension, it also illustrates the possibility of analyzing linguistic productivity without invoking new principles.

Therefore, our analysis suggests there may be no need for a new behavioral principle, the *principle of symbolic productivity* or, as Hayes and his colleagues might call it, the *principle of relational framing*. My concern about this new principle is that it seems to be merely a molar *description* of that which we are trying to understand rather than an explanation of what we are trying to understand. It seems a little like asking, *why do human beings have language*, and being told, *it's because they have the language capacity*.

However, the authors do an outstanding job of detailing the diverse, fascinating, and important areas of complex human behavior that illustrate symbolic behavioral productivity. They show that though these areas are diverse, their crucial essence is that they do all illustrate symbolic behavioral productivity. But I fear that the authors may be stopping short of a more fundamental analysis in terms of the basic principles of behavior, such as behavioral chaining, combined with stimulus discrimination and generalization. However, Hayes and his colleagues are familiar with the sort of analysis I have presented here and seem to feel that it is better to invent a new principle of behavior than to infer underlying processes, such as behavioral chaining.

So I recommend that behavior analysts stay agnostic about the existence of a new behavioral principle but that they do study the book by Hayes and his colleagues to see how the rich world of analogies, metaphors, stories, thinking, problem solving, understanding, language (grammar, sentences), rule governance, psychological development, education, social processes, psychopathology, therapy, and religion all exemplify behavioral productivity and/or relational framing.

This book is an impressively thoughtful and subtle treatment of an area that is so conceptually complex, I would have anticipated it to be a place where most would fear to tread; but, instead, many seem to be rushing into the field of stimulus-equivalence research. So, I hope in the popular concern for generating empirical research, those working in this area give it the thoughtful analysis it deserves, as modeled by the authors of this book.

At the beginning of this essay, I suggested the greatest intellectual challenge to our field of behavior analysis might be the development of a clear, comprehensive approach to language and cognition. I also suggested that our approach to language and cognition would need to address Chomsky's issue of linguistic productivity. Furthermore, the simplistic nature of our efforts to address this profound issue has been grease on the skids as the faithless hoards slip from behavior analysis to mentalistic, nativistic cognitivism. Well, the analysis of Hayes and his colleagues is far from simplistic, but also far from simple. In fact, the complexity and difficulty of understanding their analysis may be so great that their analysis will also fail to persuade the faithless hoards, so complex and difficult that it won't remove the grease from the skids going down the slippery slope from behavior analysis to mentalistic, nativistic cognitivism. But I hope their analysis will be an effective anti-greaser.

In any event, I, and perhaps those faithless hoards, would appreciate *Relational Frame*

Theory for Dummies. The main problem I have with RFT is that, to really understand it and be fluent with its terms and concepts, I'd need to do a sabbatical at the University of Nevada, Reno, or National University of Ireland, Maynooth. Or is that just a problem with me? This is not to suggest that the theory is unnecessarily complex, not to suggest that its exposition is unnecessarily convoluted; the subject matter may just be that difficult. In any event, you should set aside a long weekend and read their book, *Relational Frame Theory: A Post-Skinnerian Account of Human Language and Cognition* (Hayes, Barnes-Holmes, Roche, 2001)

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