RELATIONAL FRAMES AND THE ROLE OF LOGIC IN RULE-GOVERNED BEHAVIOUR

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Abstract

The concept "relational frame" has been proposed by Steve Hayes (1991) as a higher order category in which Murray Sidman's concept of "equivalence class" is subsumed as a special case. Like equivalence, the relational frame concept was originally conceived as an interpretation of the behaviour of human subjects on a matching-to-sample task. While not denying the reality of relational frame abstraction in the case of intelligent human adults, it is suggested that this may be an over-intellectual interpretation of the equivalence responding of children and less intelligent adults. It is proposed that the relational frame concept should instead be seen as an important contribution

(a) to relational logic, and

(b) to our understanding of the role of logic in rule-governed behaviour,

and that the ability to abstract relational frames is something that appears much later in the process whereby linguistic competence is acquired than equivalence-class responding on the matching-to-sample task.

Introduction

I believe I am right in saying that the concept of "a relational frame" was introduced for the first time in public in an address by Steve Hayes and the late Aaron Brownstein to the Eleventh Annual Convention of the Association for Behavior Analysis at Columbus Ohio in May 1985. The title of the address was 'Verbal Behavior. Equivalence Classes, and Rules: New Definitions, Data and Directions.' Those of us who were privileged to hear that address, were aware that an important new idea was being put before us, but, despite many requests to see a copy of the text of the paper, Steve did not feel that his ideas were sufficiently crystallized at that stage to put them in a form in which they could be quoted and otherwise made use of by others. The first officially quotable source for the doctrine is a paper entitled 'A Relational Control Theory of Stimulus Equivalence' which was presented to the First International Institute on Verbal Relations held at Bad Kreuznach in West Germany in June 1986. A revised version of this paper appeared in 1991 in the Proceedings of the First International Institute edited by Linda Hayes and Phil Chase under the title *Dialogues on Verbal Behavior*.

At the Thirteenth Annual Convention of the ABA in Nashville, Tennessee, in May, 1987, there was an symposium organized by Steve Hayes on the 'Implications of Stimulus Equivalence for Analyses of Language'. This included a paper by Steve himself entitled 'Relational frames: Is Stimulus Equivalence a special case of a more general phenomenon?' in which he reported the first experimental test of the relational frame hypothesis. In June 1988, I contributed a paper entitled 'Behavioural Contingency Semantics and the Correspondence Theory of Truth' in which among other things, I suggested a link between the concept of relational frame and Skinner's (1957) concept of an "autoclitic frame" of which I proposed that the relational frame be regarded as a special case. This paper was published in 1992 in the Proceedings of the Second and Third International Institutes edited by Linda and Steve Hayes under the title *Understanding Verbal Relations*.

Relational logic

So much for the history, now for the substance. It will already be apparent from the titles of the papers I have mentioned that the concept of a relational frame arises in the context of and is a development of the concept of "an equivalence class" proposed by Murray Sidman (Sidman and Tailby 1982) and used by him as an interpretation of the behaviour of human subjects in the matching-to-sample experiment which he devised in order to demonstrate the operation of this principle (Sidman, 1971; 1977; 1986; 1990). But although both Sidman's concept of an equivalence class and Hayes' concept of a relational frame are explained in terms of the behaviour of human subjects on the matching-to-sample task it is evident that the ultimate source for both concepts is to be found in the logic of relational inferences.

Relational logic is a branch of logic which was developed during the course of the nineteenth century by mathematicians such as De Morgan and Peano and philosophers such as Peirce and Russell in relation to the problem of defining number and numerical order. This development culminated in Russell's (1903) book *The Principles of Mathematics* and, according to Nidditch (1960), "The current use of 'reflexive', 'symmetrical', 'transitive', and 'equivalence' relations is due to Russell." Needless to say, all of these terms are familiar to anyone who has encountered Sidman's work on stimulus equivalence.

Since Russell's day relational logic has received little attention from either mathematicians or philosophers. The reason for this, I suspect, is that the focus of interest in logic has been on *extensional logic*, on the so-called "propositional" and "predicate calculi" in which the validity of inferences depends on the purely formal or, as Skinner would say, on the purely "autoclitic" properties of the premises. In an extensional logic the validity of an inference does not depend on the meaning of the propositions or predicate expressions which occur in the premises of the argument. Propositions and predicates are variables (represented by the letters *p*, *q* and *r* in the case of the propositional calculus and by the letters *F* and *G* in the case of the predicate calculus) which can be substituted one for the other without in any way affecting the validity of the argument. In the case of the propositional calculus the validity of arguments depends solely on what Skinner calls the "manipulative autoclitics" *both...and*, *either...or*, *if...then*, which connect two or more atomic sentences together. In the case of the predicate calculus or "quantification theory", as it is sometimes called, the validity of inferences depends on the quantifiers (Skinner's "quantifying autoclitics") expressed in English by the definite and indefinite article and by words such as *all*, *every*, *any*, *each*, etc., together with the qualifying autoclitic *not*. The syllogisms of classical Aristotelian logic such as:

All men are mortal.
Socrates is a man.
ERGO: Socrates is mortal.

are arguments of this kind. The extensional character of this particular example is demonstrated if we substitute nonsense names and predicates and show that this in no way affects the argument's validity. Thus:

All toves are slithey.
The Jabberwock is a tove.
ERGO: The Jabberwock is slithey.

In contrast to these extensional logics relational logic is intensional. For although relational inferences depend partly on what Skinner calls the "*relational autoclitic*" features of the sentences which form the premises of the argument, i.e., prepositions such as *of*, *by*, *to*, *from*, etc, and although it is possible to formulate relational arguments symbolically, for example the expression *aRb* is used to describe a situation in which one object *a* stands in a two place or *dyadic* relation ***R*** to another object *b*, we do not know what inferences can and cannot be drawn from premises of this form without knowing the nature of the relation involved. In other words the symbol *R* in the formula *aRb* does not function as a variable standing for *any* relation in the way that *p* and *q* function as variables standing for any two distinct propositions in the propositional calculus or in the way that *F* and *G* function as variables standing for any two distinct monadic predicates in the predicate calculus.

There are, it is true, one or two theorems of relational logic which have been worked out by mathematicians which apply to all dyadic relations, but the common features which these theorems abstract from the different relational frames are much less important than the differences between the different relational frames in determining what inferences can and cannot be drawn.

Russell's taxonomy of relational frames

You will notice that in formulating what it is that determines the validity of inferences within relational logic, I have already made use of Steve Hayes' concept of "a relational frame". For although Steve was the first person to use the term, the concept of a relational frame is implicit in the taxonomy of relations which Russell develops at the beginning of Chapter XXVI of *The Principles of Mathematics* (Russell 1903). In that chapter Russell presents a taxonomy of relations, classified according to the types of inference they support; and it turns out that what Steve Hayes calls "a relational frame" is a type of relation defined in precisely this way, that is to say, in terms of the kinds of inference which are supported by relational statements involving that relation. For although we need to know what particular relation we are dealing with before we know what relational inferences can be validly deduced, the number of different kinds of relational inference is severely restricted. Consequently although there are indefinitely many different relations, the number of different inference patterns they support and, hence, the number of different relational frames to which different relations belong is relatively small.

According to both Russell and Hayes, relational inferences are of two basic types to which Hayes has given the names "Mutual Entailment" and "Combinatorial Entailment". By "Mutual Entailment" is meant an inference such that if we know that *a* stands in relation R_x to *b*, we can infer that *b* stands in relation R_y to *a*, or, in symbols:

$$aR_xb \rightarrow bR_ya$$

According to Russell, there are four different versions of this type of inference. These are laid out on Table 1:

Table 1. Relational Inferences of the Mutual Entailment Type

(1)	*Symmetrical*
	If *a* stands in relation R_x to *b*, then *b* stands in that same relation R_x to *a*, or in symbols: $aR_xb \rightarrow bR_xa$ Russell's example: If *a* is *b*'s *sibling*, *b* is *a*'s *sibling*.
(2)	*Asymmetrical*
	If *a* stands in relation R_x to *b*, then *b* stands in the opposite relation R_y to *a* and does not stand in that same relation R_x to *a*, or in symbols: $aR_xb \rightarrow bR_ya \mathbin{\&} {\sim} bR_xa$ Russell's example: If *a* is *b*'s *descendant*, *b* is *a*'s *ancestor* and not *a*'s *descendant*.
(3)	*Not-symmetrical*
	If *a* stands in relation R_x to *b*, then *b* stands in the opposite relation R_y to *a* and may or may not stand in that same relation R_x to *a*, or in symbols: $aR_xb \rightarrow bR_ya \mathbin{\&} bR_xa \vee {\sim} bR_xa$ Russell's example: If *a* is *b*'s *brother*, *b* is *a*'s *sibling* and may or may not be *a*'s *brother*.
(4)	*Not-asymmetrical*
	Russell does not explain how this inference differs from the not-symmetrical case. Russell's example: If *a implies b*, *b* is *implied* by *a* and may or may not *imply a*.

By "Combinatorial Entailment" is meant an inference such that if we know that *a* stands in relation R_x to *b* and that *b* stands in that same relation R_x to *c*, we can infer that *a* stands in relation R_y to *c*, or, in symbols:

$$aR_xb \mathbin{\&} bR_xc \rightarrow aR_yc$$

According to Russell, there are four different versions of this type of inference. These are laid out on Table 2:

Table 2. Relational Inferences of the Combinatorial Entailment Type

(1)	*Transitive*
	If *a* stands in relation R_x to *b* and *b* stands in that same relation R_x to *c*, we can infer that *a* stands in relation R_x to *c*, or, in symbols: $aR_xb \,\&\, bR_xa \rightarrow aR_xc$ Russell's example: If *a* is *b*'s *sibling* and *b* is *c*'s *sibling*, *a* is *c*'s *sibling*.
(2)	*Intransitive*
	If *a* stands in relation R_x to *b*, then *b* stands in the opposite relation R_y to *a* and does not stand in that same relation R_x to *a*, or in symbols: $aR_xb \rightarrow bR_ya \,\&\, {\sim}\, bR_xa$ Russell's example: If *a* is *b*'s *descendant*, *b* is *a*'s *ancestor* and not *a*'s *descendant*.
(3)	*Not-transitive*
	If *a* stands in relation R_x to *b* and *b* stands in that same relation R_x to *c*, *a* may or may not stand in the same relation R_x to *c* or, in symbols: $aR_xb \,\&\, bR_xa \rightarrow aR_xc \vee {\sim}\, aR_xc$ Russell's example: If *a* is *b*'s *half-sibling* and *b* is *c*'s *half-sibling*, *a* may or may not be *c*'s *half-sibling*.
(4)	*Not-intransitive*
	Russell does not explain how this inference differs from the not-transitive case. Russell's example: If *a* is *different* from *b* and *b* is *different* from *c*, *a* may or may not be *different* from *c*.

Reflexivity and Equivalence

The concept of equivalence, as it has passed from Russell's account of relational logic into the matching-to-sample literature through the influence of Sidman, is a relational frame characterised by three features: (1) Symmetrical inferences, (2) Transitive inferences and (3) Reflexivity. Symmetrical and Transitive inferences we have already encountered in our survey of Mutual Entailment and Combinatorial Entailment inferences. In this taxonomy of relations Reflexivity is an odd man out. The reason for this is that Reflexivity unlike Symmetry and Transitivity is not a type of inference. Reflexivity is a feature which is unique to the Equivalence or "sameness" relational frame whereby an entity can stand in this relation to itself, or in symbols:

aRa

Russell's example: "*a equals a*".

Another unique feature of the equivalence relational frame is that for every variable, every respect in which one thing differs from another, there is an equivalence relation whereby something else either is or could be the same as that thing *in that respect*. This feature gives the equivalence relational frame a special importance from the standpoint of the mathematician. But as was first pointed out by Peano (1894), this distinctive relational frame is not picked out by the fact that such relations "are both symmetrical and transitive", as Russell (1903 p. 219) alleges. For there are relations of which Russell's example *sibling* is one which are both symmetrical and transitive, but which are not instances of equivalence. What shows that *sibling* is not an equivalence relation is the fact that it is not reflexive, that an individual does not stand in the relation of *sibling* to him or herself. For some unaccountable reason, Russell (1903 p. 218) fails to appreciate this point and tries to persuade us to "allow that a man may be his own brother, and a woman her own sister". That this cannot be allowed is clear from the fact that on this argument the not-symmetrical and transitive relations of *brother* and *sister* would be reflexive. Hayes, though recognizing that there is something odd about reflexivity, makes the same mistake when he states that "it is probably not necessary to include reflexivity in the definition of stimulus equivalence. Symmetry and mutual transitivity are sufficient." On the contrary, consideration of examples such as *sibling* and *near* which are both symmetrical and transitive shows that there are examples of what Hayes calls the "Coordination" relational frame which are not cases of Equivalence and that Reflexivity is needed as a criterion by which to distinguish genuine cases of Equivalence from these other cases.

Russell's taxonomy of relational frames in tabular form.

In *The Principles of Mathematics* Russell distinguishes and gives examples of eleven different relational frames or twelve if equivalence (illustrated by *equals*) is distinguished from other symmetrical and transitive cases (illustrated by *sibling*). Except in the case of not-asymmetrical and not-transitive (illustrated by *implies*), symmetrical and not-intransitive (illustrated by *different*) and equivalence (illustrated by *equals*) all Russell's examples are of family relations. They can be set out in the form of a 4 x 4 matrix as in Table 3:

Table 3. Russell's taxonomy of relational frames: his examples

REFLEXIVE *aRa* is true *equals*	SYMMETRICAL $aRb \rightarrow bRa$	ASYMMETRICAL $aR_xb \rightarrow bR_ya \,\&\, {\sim}bR_xa$	NOT-SYMMETRICAL $aR_xb \rightarrow bR_ya \,\&\, bR_xa \vee {\sim}bR_xa$	NOT-ASYMMETRICAL $aR_xb \rightarrow bR_ya \,\&\, bR_xa \vee {\sim}bR_xa$
TRANSITIVE $aRb \,\&\, bRc \rightarrow aRc$	*equals* *sibling*	*ancestor/descendant*	*brother/sister*	
INTRANSITIVE $aR_xb \,\&\, bR_xc \rightarrow aR_yc \,\&\, {\sim}aR_xc$	*spouse*	*father/child*	*only girlfriend/boyfriend* [1]	
NOT-TRANSITIVE $aRb \,\&\, bRc \rightarrow aRc \vee {\sim}aRc$	*half-sibling*	*son-in-law/parent-in-law*	*half-brother/half-sister* [2]	*implies*
NOT-INTRANSITIVE $aRb \,\&\, bRc \rightarrow aRc \vee {\sim}aRc$	*different*			

But since, as we have seen and as the diagram indicates, Russell has failed to substantiate the distinctions he tries to draw between "not-symmetrical" and "not-asymmetrical" and between "not-transitive" and "not-intransitive", we may reduce the diagram to a 3 x 3 matrix as in Table 4:

Table 4. Russell's taxonomy of relational frames (revised): his examples

REFLEXIVE *aRa* is true *equals*	SYMMETRICAL $aRb \rightarrow bRa$	ASYMMETRICAL $aR_xb \rightarrow bR_ya \,\&\, {\sim}bR_xa$	NOT-SYMMETRICAL $aR_xb \rightarrow bR_ya \,\&\, bR_xa \vee {\sim}bR_xa$
TRANSITIVE $aRb \,\&\, bRc \rightarrow aRc$	*equals* *sibling*	*ancestor/descendant*	*brother/sister*
INTRANSITIVE $aR_xb \,\&\, bR_xc \rightarrow aR_yc \,\&\, {\sim}aR_xc$	*spouse*	*father/child*	*only girlfriend/boyfriend*
NOT-TRANSITIVE $aRb \,\&\, bRc \rightarrow aRc \vee {\sim}aRc$	*half-sibling*	*son-in-law/parent-in-law*	*half-brother/sister*

Hayes' contribution to the taxonomy of relational frames.

Although, as I shall explain in a moment, I am not happy with the concept of "relational responding" as an account of the subject's behaviour in the matching-to-sample experiment, I recognize that in thinking about relational frames in the context of behaviour Hayes has been led to make two significant contributions to the taxonomy of relational frames over and above his introduction of the term.

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[1] This replaces Russell's example, *half-brother* which is restricted to a universe in which no man could have children by more than two different women, and no woman could have children by more than two different men.

[2] Russell also gives *brother-in-law* as an example of this relational frame.

The first of these contributions, I would submit, is the introduction of a set of examples illustrating the different relational frames which bring out much more clearly than do Russell's examples the importance of relational inferences in the control of human behaviour. Hayes discusses four examples of different relational frames: *same*, *different*, *opposite* and *larger*. Of these *same* is symmetrical, transitive and reflexive, *different* is symmetrical and not-transitive, *opposite* is symmetrical and intransitive and *larger* is asymmetrical and transitive. Similar examples may be proposed to fill some of the other slots in the matrix. Thus *near* is symmetrical and transitive without being reflexive, *started* is asymmetrical and intransitive, *came from* is asymmetrical and not-transitive, and *likes* is not-symmetrical and not-transitive. I have been unable to think of any examples other than the familial ones given above which are not-symmetrical and either transitive or intransitive. Table 5 shows how these examples map onto our 3 x 3 matrix:

Table 5. Russell's taxonomy of relational frames (revised): Hayes' examples

REFLEXIVE aRa is true *same*	SYMMETRICAL $aRb \rightarrow bRa$	ASYMMETRICAL $aR_xb \rightarrow bR_ya \;\&\; {\sim} bR_xa$	NOT-SYMMETRICAL $aR_xb \rightarrow bR_ya \;\&\; bR_xa \lor {\sim} bR_xa$
TRANSITIVE $aRb \;\&\; bRc \rightarrow aRc$	*same* *near*	*larger/smaller*	
INTRANSITIVE $aR_xb \;\&\; bR_xc \rightarrow aR_yc \;\&\; {\sim} aR_xc$	*opposite*	*started/started by*	
NOT-TRANSITIVE $aRb \;\&\; bRc \rightarrow aRc \lor {\sim} aRc$	*different*	*came from/went to* or *became*	*likes/liked by*

Hayes' second contribution to the taxonomy of relational frames is to give names to those relational frames he distinguishes based on the examples he gives of them. We have already encountered his use of the term "Coordination" to describe a symmetrical transitive relation. In the same vein he uses the term "Comparison" to describe an asymmetrical transitive relation, "Opposition" to describe symmetrical intransitive relations, and "Distinction" to describe symmetrical not-transitive relations. To these we may perhaps add "Initiation" to describe asymmetrical intransitive relations, "Origination" to describe asymmetrical not-transitive relations, and Russell's term "Implication" to describe not-symmetrical not-transitive relations. This nomenclature is laid out on Table 6:

Table 6. Russell's taxonomy of relational frames (revised): Hayes' nomenclature

REFLEXIVE *aRa* is true "Equivalence"	SYMMETRICAL $aRb \rightarrow bRa$	ASYMMETRICAL $aR_xb \rightarrow bR_ya$ & ~ bR_xa	NOT-SYMMETRICAL $aR_xb \rightarrow bR_ya$ & bR_xa v ~ bR_xa
TRANSITIVE aRb & $bRc \rightarrow aRc$	"Equivalence" "Coordination"	"Comparison"	
INTRANSITIVE aR_xb & $bR_xc \rightarrow aR_yc$ & ~aR_xc	"Opposition"	"Initiation"	
NOT-TRANSITIVE aRb & $bRc \rightarrow aRc$ v ~ aRc	"Distinction"	"Origination"	"Implication"

The role of logic in rule-governed behaviour.

You will notice that, apart from indicating that this is the source of Hayes' interest in the topic, I have said nothing in the course of my discussion of the taxonomy of relational frames about what Hayes calls "relational responding" on the matching-to-sample task. This is deliberate. Despite the use of terms such as Reflexivity, Symmetry and Transitivity in this connection, I find it difficult to accept that the behaviour on the matching-to-sample task which Sidman attributes to the emergence of "an equivalence class" and by Hayes to "relational responding" is to be explained in the way that is implied by the use of those terms.

As I understand the matter, if a human subject is trained, when presented with an arbitrarily selected stimulus *a*, to pick another arbitrarily selected stimulus *b* from an array of 2-4 such stimuli, he or she is said to show *reflexivity* if, without further training, he or she picks stimulus *a* from an array which does not include *b*, when presented with *a* as sample. Likewise, he or she is said to show *symmetry* if, again without further training, he or she picks stimulus *a* from an array that does not include *b*, when presented with *b* as sample. Finally he or she is said to show *transitivity* if, given further training to pick another arbitrarily selected stimulus *c*, when presented with *b* as sample, he or she spontaneously picks *c* from an array which does not include *b*, when presented with *a* as sample. A subject who shows all three patterns of generalisation is said by Sidman to have formed an equivalence class which includes *a*, *b* and *c* and by Hayes to be responding in conformity to that relational frame.

Two interpretations of the emergence of stimulus equivalence.

There are two ways of interpreting the claim that subjects who show reflexivity, symmetry and transitivity on the matching-to-sample task have formed the stimuli in question into an equivalence class. On one interpretation all that is being claimed is that, as a consequence of the initial training, the three stimuli *a*, *b* and *c* have become equivalent to one another in the sense that any behaviour which is controlled by one member of the class is now controlled by the other two without any need for specific reinforcement of the untrained connections. In this case what we are talking about is an actual relation that has developed between the three stimuli. All we are doing is describing what happens when the equivalence training procedure is followed, without offering an explanation of why and how an equivalence class emerges under those conditions.

The second interpretation adds to the first by offering an explanation of why and how an equivalence class is formed by the subject under these conditions. The explanation that is offered of the emergence of the equivalence class is that the subject's behaviour in "passing" the tests of equivalence shows that he or she has

(a) grasped the concept of an equivalence relation, in the sense that he or she can distinguish well-formed sentences employing that concept from those that are ill-formed, and inferences validly deduced from those sentences from those that are invalid,

(b) formed an hypothesis on the strength of the evidence provided by the initial training experience that in order to secure reinforcement the stimuli are to be treated as equivalent to one another, and

(c) drawn the appropriate symmetrical and transitive inferences from that hypothesis, when confronted by the test situation.

This second and more theoretical interpretation of the phenomenon of equivalence class formation on the matching-to-sample task is the one which is favoured by Hayes' concept of relational responding", since that notion makes sense only if, in ascertaining the conditions which must be fulfilled in order to secure reinforcement, the subject has a choice between a number of different relational frames of which equivalence is only one.

Of these two interpretations of the emergence of stimulus equivalence I prefer the first and purely descriptive account of what is involved in the formation of an equivalence class. This means that I reject the second and more theoretical interpretation as an explanation of the phenomenon and with it the concept of "relational responding". But in rejecting this explanation of phenomenon of stimulus equivalence, I am not denying

(a) that the phenomenon of spontaneous equivalence formation is in need of explanation, particularly in view of the evidence which shows that animals do not, as far as we know develop such classes and that children only do so, once they have achieved a certain degree of linguistic competence (Devany, Hayes and Nelson 1986; Beasty 1987),

(b) that older children and adults address the matching to sample task in the way that, as John Wearden (1987; 1989) has repeatedly emphasised, they address virtually all psychological experimentation in which they act as subjects, namely, as a challenge to their ability to discern the rule governing the experimenter's reinforcement practices, and that, consequently, hypotheses as to the relations between the stimuli involved in the matching-to-sample task contribute to the formation of equivalence classes on the task in the case of these subjects.

What I do want to deny is that we can use this explanation to account for

(a) the emergence of stimulus equivalence in children in the 2-6 age range,

(b) the role which equivalence class formation undoubtedly plays in the acquisition of skills such as reading which inspired Sidman's (1977) original investigation of the phenomenon, and

(c) the role which, as I see it,[3] is played by the formation of stimulus equivalence classes in the process whereby words and other symbols acquire their meaning in the early stages of first language learning.

Objections to the relational hypothesis explanation of stimulus equivalence: (1) no evidence that subjects choose between relational frames.

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[3] I am indebted to a discussion with Dr. L. Fields of The City University of New York during the Annual Conference of the Experimental Analysis of Behaviour Group at Cambridge in April 1989 at which I presented an earlier version of this paper for convincing me that a symbol, such as a word, acquires its meaning or "sense", to use Frege's term, by virtue of the formation of a two-member stimulus equivalence class which unites the symbol with a naturally occurring discriminative stimulus which prepares the organism for an impending encounter with a particular kind of object, event or state of affairs (See my Place, 1995/6).

I have three reasons for rejecting an explanation of the formation of stimulus equivalence classes during the formative years of childhood in terms of the formation of relational hypotheses. The first of these focuses on the lack of evidence that children who form equivalence classes on the matching-to-sample experiment do so on the basis of a choice between different relational frames as an explanation of the way the sample and comparison stimuli in this experiment are related to one another. For one thing, there is no evidence from the behaviour of younger subjects on this task which demands explanation in terms of the adoption of the hypothesis that the relational frame is something other than equivalence. For another, the evidence provided by the training session in no way justifies the adoption of the hypothesis that the relational frame is one of equivalence rather than any other of the eight or nine alternatives with which the evidence is equally consistent.

It is true that, in an unpublished experiment described by Hayes in his paper to the 1987 ABA Convention, adult subjects were given a conditional discrimination learning task which required them to respond in accordance with a different relational frame (Coordination, Distinction or Opposition) depending on which of three discriminative stimuli were present. But apart from this study, there is no shred of evidence that any subject on the matching-to-sample task has ever spontaneously adopted any hypothesis other than the hypothesis, if that indeed is what is happening here, that the relation between the stimuli involved is one of equivalence.

On the other hand, it might be argued that, on the standard matching-to-sample procedure, the choice of the equivalence hypothesis is forced by the fact that no comparison stimuli are provided which would fit any other hypothesis. It should not, I would have thought, be beyond the wit of man to devise a variation of the standard procedure which offers the subject the chance to select an alternative comparison stimulus which makes sense on the hypothesis that the relational frame is something other than equivalence. But until such a procedure is devised and it has been shown that the alternative hypothesis is chosen in a substantial number of cases, and is chosen by children in the youngest age group in which stimulus equivalence is regularly found, the verdict on the case for the relational hypothesis explanation of the formation of stimulus equivalence classes will remain not-proven.

Objections to the relational hypothesis explanation of stimulus equivalence: (2) equivalence precedes inference.

My second reason for rejecting the relational hypothesis explanation of the formation of stimulus equivalence classes is that in my view, the grasp of relational hypotheses, the ability to form hypotheses as to the kind of relation involved and the ability to draw the correct inferences from such a hypothesis are all beyond the reach of children, some as young as two years of age, who have been shown (Devany, Hayes and Nelson 1986; Beasty 1987) to be capable of forming equivalence classes.

Although I am not in a position to document this claim, it is my impression that studies of the development of the child's ability to make reliable relational inferences would show, if they have not already done so,

(a) that this ability is not present at the age when stimulus equivalence first appears on the matching-to-sample task

(b) that relational inferences based on other relational frames, e.g., *larger* (Comparison) are developed appreciably earlier than those based on *same* (Equivalence).

Moreover, consideration of the role of logical inference in the control of behaviour suggests that it belongs to a much later stage in the development of linguistic competence than that at which stimulus equivalence classes emerge in the behaviour of children.

I owe my conception of the role of logical inference in the control of behaviour partly to Skinner's (1966; 1969; 1984) conception of "rule-governed behavior" and partly to Steve Hayes' (1991) discussion of "arbitrary relational responding". According to Skinner, *rule-governed behaviour* is behaviour controlled by a verbal specification or depiction of contingencies which may never have occurred in the past history of the agent in question and cannot be directly extrapolated from the agent's current stimulus environment. The passage in Steve Hayes' discussion of arbitrary relational responding in which he makes what for me is the crucial point reads as follows:

> For an organism to respond to the relative size of two objects, the two objects need only be seen. If the relation were arbitrary, this alone would not be enough. The relation itself would have to be specified. Suppose a person is asked whether "a" is taller than "b." In a non-arbitrary sense (the size of the letters) the answer is presumably that "b" is slightly taller. If "a" and "b" are merely symbols, as they might be in algebra, they first have to be defined before the question can be answered. (Hayes 1991, p. 25)

The point which I extract from this quotation is this. Suppose that an organism is confronted by two or, in the case of a Combinatorial Entailment relation, three objects which stand in a particular relation to one another. Suppose further that the organism has learned to discriminate cases where objects are related in this way from cases of objects which are not so related, provided that an instance of objects so related is present in the organism's current stimulus environment. Given that such an instance is currently available to it, the organism can simply "read off" the relation in question from the current stimulus pattern. Not only can the organism see that object *a* is taller than object *b* and that object *b* is taller than object *c*. It can also see that object *b* is shorter and not taller than object *a* (Asymmetry) and that object *a* is taller than object *c* (Transitivity). It can do this, moreover, without any additional training over and above that involved in learning to apply the concepts *taller* and *shorter* to visually presented instances.

But now let us suppose that the organism is a linguistically competent human being for whom *a*, *b* and *c* are not present as features of his or her current stimulus environment. Let us also suppose that this individual is trying to construct a verbal specification of a contingency in which the relative heights of *a*, *b* and *c* is crucial to the outcome. All that the individual is told in this case is that *a* is taller than *b* and that *b* is taller than *c*. In this case there is no stimulus on which the individual can rely in order to determine the relation of *a* to *c*, *b* to *a*, *c* to *a* and *c* to *b*. The only solution is to rely on the principles of relational logic to supply the missing pieces of the contingency specification.

It is my contention that this ability to use relational and other logical inferences in order to fill in missing details in a contingency specification when normal stimulus cues are absent requires a much greater degree of linguistic sophistication than does the ability to form an equivalence class on the matching-to-sample task. I recognise, however, that in making this judgment I am assuming that we know a lot more than in fact we do about the order in which different aspects of linguistic competence are acquired in the process of first language learning. Although there is a wealth of relevant information which has been accumulated by developmental psychologists, it has not in recent years been either collected or reviewed from a contemporary behaviourist perspective. In particular we know next to nothing about the way rule-governed behaviour fits into the process whereby linguistic competence in general is acquired.

Objections to the relational hypothesis explanation of stimulus equivalence: (3) an alternative explanation. My final reason for rejecting the relational hypothesis explanation of the emergence of stimulus equivalence classes in the behaviour of young children is that there is an alternative explanation of the phenomenon which has been developed by Neil Dugdale and Fergus Lowe (1990) and elaborated by Pauline Horne and Fergus Lowe (1996). This theory suggests that so-called "equivalence responding" as defined by the tests of Reflexivity, Symmetry and Transitivity is mediated by the response of naming the stimuli involved. The theory that naming is involved in the emergence of stimulus equivalence classes in the case of young children is supported

(a) by the failure of all attempts hitherto to demonstrate the spontaneous emergence of stimulus equivalence in animals,

(b) by the evidence of an association between the emergence of stimulus equivalence in young children and a stage in their linguistic development which does not extend much beyond the ability to name features of their current stimulus environment (Beasty and Lowe 1985; Devany, Hayes and Nelson 1986; Lowe 1986; Lowe and Beasty 1987),

(c) by the evidence that children in this age group who fail to form an equivalence class can be induced to do so simply by teaching them to name the stimuli involved (Beasty 1987; Lowe 1986; Lowe and Beasty 1987; Dugdale 1988),

(d) by the observation that learning to name an object involves learning to respond symmetrically in the sense that the child's behaviour is reinforced both

  (i) if it produces the correct name when presented with a stimulus characteristic of the presence of the object or of an instance of the kind in question, and

  (ii) if it selects the object or an instance of the kind from a group of objects of other kinds on hearing the name assigned to that object or kind of object (Dugdale and Lowe 1990).

So stated, there is a very strong case for thinking that the spontaneous emergence of stimulus equivalence classes in the behaviour of young children is somehow mediated by the ability to name the stimuli involved. However, the same cannot be said for the more precise theory put forward by Dugdale and Lowe (1990) in which the formation of an equivalence class is attributed to the use by the child of a *common* name for all its members. This is not to deny that in the experiment which they describe learning a common name led directly to the formation of an equivalence class consisting of those stimuli to which the common nonsense names "OMNI" and "DELTA" had been assigned by the experimenter. What does not seem to be the case is that this learning of a common name which applies to all members of the equivalence class is a *necessary* condition for equivalence class formation. Evidence both from the verbal reports of subjects in experiments of this kind and from the analysis of the role of naming in the emergence of stimulus equivalence in the Beasty (1987) experiments shows that the equivalence class emerges despite or rather perhaps because of the use of *different* names for different members of the class.

Conclusion.

As I see it, the upshot of this discussion of the proposed explanation of stimulus equivalence formation in terms of naming is that this explanation remains the front runner, a long way ahead of the explanation in terms of the formation of a relational hypothesis as far as the behaviour of young children is concerned. Nevertheless, until the precise role of naming in the mediation of stimulus equivalence is better understood than it is at present, we shall need to keep the relational hypothesis explanation in reserve, as it were, against the possibility of the eventual refutation of the naming explanation. But even if, as I expect it to do, the naming explanation ultimately wins out, this will in no way detract from the important contribution which Steve Hayes' concept of the "relational frame" has made to relational logic and to our understanding of the role of logic in general in the specification of absent contingencies.

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