Same/Different Concept Formation in Pigeons

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How other kinds of animals think about the world we share is one of the most interesting and difficult of scientific questions to answer. One longstanding approach to this question has focused on measuring and comparing the cognitive capacities of different animals (Darwin 1872; Morgan 1894; Romanes 1883; Thorndike 1911). This comparative approach to animal cognition and intelligence has represented one of the two or three most basic questions defining the field since its inception. Birds play an important role in such comparative cognitive studies because they offer a unique, non-mammalian perspective to our understanding of these issues. Like mammals, over the last 200 million years these endothermic animals have separately evolved to interface with the events and objects of the world by employing a highly dynamic and interactive mode of living. This has placed similar demands on the sensory and cognitive processes of both of these classes of vertebrates. It is no accident that these two groups are the most visually sophisticated animals on the planet, for instance. Unlike mammals, however, the concurrent demands of flight have required birds to keep their body weight to a minimum, limiting them to small, but apparently powerful, central nervous systems for processing this information. Understanding this paradox of how birds meet the perceptual and cognitive demands of their interactive lifestyle with such small and limited neural equipment is one of the objectives of my research.

My research is directed at understanding these various aspects of visual cognition in one kind of bird, the pigeon (*Columba livia*). During the past fifty years, pigeons have become a significant focus animal in the comparative study of perception and learning. This is because a great deal has been established about their basic behavioral processes and nervous system

(Zeigler and Bischof 1993) and powerful and precise laboratory methods developed for experimentally investigating these processes. Possessing a sophisticated visual system with established capabilities for color vision, form perception, pattern recognition, these animals are capable of learning a wide variety of simple and complex visual discriminations (Cook 2000). This can be seen in our research over the last few years, which has explored perceptual segregation and the mechanisms of visual search (e.g., Cook 1992a, b), the discrimination and perception of objects and the contribution of motion to these processes (Cook and Katz 1999; Cook et al. in press), and the learning and use of abstract concepts (Cook et al. 1995; Cook, Katz, and Cavoto 1997; Cook, Katz, and Kelly 1999; Cook and Wixted 1997). Because of its direct implications for the overarching themes developed in this volume, the remainder of this article just focuses on the latter line of research.

The Comparative Psychology of Same/Different Concept Learning.

Human behavior is often rule-based. We can easily answer questions about things with which we have no direct experience, often using simplifying rules or general principles abstracted from the relations among a set of elements. The benefits of this cognitive ability are that it releases behavior from the direct control of the stimulus and its history of reinforcement, allows us to engage in behaviors unbounded by our experience with specific stimuli, and permits highly flexible and adaptive solutions to novel problems. Such relational rule-based concepts allow us to make accurate inductions about new events and their relations, form the basis for our use and appreciation of language, mathematics, analogical reasoning, social relations, and even fine arts such as music. As a species, we are expert at detecting and abstracting the general patterns present in the world's particulars.

While many animals often respond to specific stimulus situations with a fixed or limited repertoire of innate or learned behaviors, it has also become clear that some animals can detect and abstract the patterns present in the world. Understanding the distribution, mechanisms, and conditions of this conceptual behavior in animals is essential to unraveling its evolution and function. The most widely known example of animal conceptual behavior has involved the categorization of object concepts, such as chairs, cars, flowers, fish, birds, mammals, trees and so on, from sets of pictures (Bhatt et al. 1988; Cook et al. 1990; Herrnstein and Loveland 1964; Herrnstein and De Villiers 1980). Far less well studied has been whether animals can form abstract rules regarding the relations of one event or stimulus to another. Research of the latter type has focused on investigations of topics such as serial pattern learning (e.g., Fountain and Rowan 1995), transitive inference (e.g., von Fersen et al. 1991), the development and use of syntactic rules (e.g., Kako 1999), and the learning and formation of relational concepts such as same/different (e.g., Cook, Katz, and Cavoto 1997) and identity (e.g., Wright et al. 1988).

Because of this gap, my recent work has focused on how pigeons perceive and potentially conceptualize same/different (S/D) relations among visual elements. The detection and recognition of difference and identity are among the oldest and most fundamental of psychological discriminations. They are central to many types of advanced intellectual functions and behaviors, and have important roles in the processes of perception, discrimination, choice, sequential behavior, intelligence-related behavior, and its symbolic mediation by language. James (1910) even suggested that the recognition and integration of the "sense of sameness is the very keel and backbone of consciousness" (p. 240).

The S/D task is one of the most powerful means of studying the discrimination of such stimulus relations. In this task, the subject is asked to respond "same" when two or more stimuli are identical and "different" if one or more of the stimuli are different from the others. After learning this discrimination, the degree to which this behavior transfers to novel situations is taken as evidence of concept formation. Early attempts to use S/D procedures with pigeons met with limited success (Edwards et al. 1983; Fetterman 1991; Santiago and Wright 1984). Such results lead some to suggest that this relational concept might be beyond the intellectual faculties of this particular animal (Pearce 1991; Mackintosh et al. 1985; Premack 1978, 1983; Wright et al. 1983).

In contrast, we have recently met with more robust success in producing S/D discrimination and concept formation in pigeons across a wide variety of stimuli and procedures. This variety may be in part responsible for our success, but is also essential to building a convincing argument for any conceptual explanation of this behavior. This is because five operational criteria should be met in order to argue that an animal has formed a conceptual representation. These include: 1) evidence of the successful discrimination of the targeted categories or rule during training, 2) evidence of discrimination transfer to novel exemplars of the target concept as recorded on the first trial or prior to any differential reinforcement, 3) evidence of the discriminability of the individual items within the stimulus classes used during training, 4) evidence of the discriminability of the transfer items from the training items, and finally, 5) evidence ruling out stimulus control by alternative features that are irrelevant to the concept under study. Criteria two and five are typically judged the most important, with three and four generally overlooked in most studies. In the work described below, the evidence of transfer to novel stimuli is rather plentiful (Criterion 2), but because of the *perceptual* origins of the *concepts* of same and different, ruling out alternative accounts of the features controlling this transfer (Criterion 5; Mackintosh 2000) has turned out to be the more critical focus of our studies.

The next two sections describe complementary approaches to providing evidence of conceptual behavior in animals. They serve to illustrate empirical strategies using behavioral techniques for investigating mentalistic notions such as "concepts" and "rules." The first section describes some of our published data on simultaneous S/D conceptual behavior, while the second reports some new data looking at successive S/D behavior. In both, testing is done with computer-driven, touchscreen-equipped operant chambers in which the stimuli are presented on computer monitors, allowing both maximum control and flexibility in our stimulus presentations.

Simultaneous S/D Discrimination and Transfer. Color and shape textured S/D displays, like those depicted in the top row of Figure 1, were the first stimuli with which we established that pigeons could discriminate very large numbers of S/D displays and readily transfer this behavior to novel displays (Cook et al. 1995; see also Wasserman et al. 1995). A typical S/D trial in this procedure starts with a peck at a white ready signal, which is then followed by the presentation of a *same* (all elements identical) or *different* (containing a randomly located block of contrasting color or shape elements) display in which all the elements are simultaneously present on the display. The pigeons then indicate their reaction to the display by choosing between two "choice" hoppers located on opposite sides of the chamber (e.g., left-different / right-same). A correct head entry or choice is then reinforced with food. Based on a variety of evidence at that time, we argued that the pigeons might have used an abstract concept to solve this textured S/D discrimination (Cook et al. 1995). A quick examination of these texture displays reveals, however, that several alternative sources of control still demanded investigation. For example, the simple presence and absence of a perceptually contrasting square "box" could have been the source of control, and not a more cognitive concept of sameness and difference.

To specifically examine such perceptual alternatives, Cook et al. (1997) conducted an experiment testing pigeons with four types or classes of highly variable S/D stimulus displays, examples of which are shown in Figure 1. The top row shows the texture display type tested by Cook et al. 1995 and also used in this second study. The second row shows the *feature* display type, which because of its design required the animal to detect the global S/D relations of the display (Cook 1992b). The third row shows the *geometric* display type, which defined display difference with only a single odd element. The last row shows the *object* display type, consisting of digitized natural objects (e.g., flowers, birds, fish, and humans; the details and rationale for these four display types are in Cook, Cavoto, Katz, and Cavoto 1997). Taken together, these different classes created an extreme variety and number of ill-defined, polymorphic, global, S/D displays that break any direct correlation between simple perceptual features and the conceptual status of the displays.

We found that pigeons could still easily learn a S/D classification of these multidimensional classes. Furthermore, learning proceeded at the same rate for all four types suggesting that only a common discrimination rule was being applied to each distinct type. We also found that these birds transferred to novel examples of each class (see Figure 2). In subsequent experiments (Cook et al. 1999), we were further able to established that the majority of these pigeons could transfer this S/D discrimination behavior to a fifth novel stimulus class (color and gray-scale photographs) they had never seen before. This latter transfer is particularly important in showing the relative degree of abstractness of their discrimination. The more abstract a conceptual representation, the greater the range of novel conditions over which it should apply, and Cook et al.'s (1999) results are among the first to our knowledge that establish transfer to stimuli far outside of the range of values experienced during training. As such, the pattern of results from these three studies are consistent with the idea that pigeons can detect, recognize, and abstract simultaneously presented S/D relations. While appeals to simple features seem no longer tenable, a skeptic could, nevertheless, still argue that perhaps they only learned to detect the generalized presence or absence of large-scale spatial discontinuities among the repeated elements of these displays and not acquired a true concept.'

Successive S/D Discrimination and Transfer. To begin dealing with such alternatives, we have recently developed a new S/D procedure that eliminates the spatial discontinuities created by simultaneously presenting the S/D relations. Using a go/no-go discrimination, new pigeons were shown an alternating *sequence* of either identical (AAAA... or BBBB...) or different (e.g., ABAB…) photographic stimuli over time (See Figure 3). Pecks to *Same* sequences (S+) were reinforced on a VI-10 schedule, while pecks during *Different* sequences (S-) eventually received a brief time-out. During each 20-second trial, each photograph was successively presented for 2 seconds each with 0.5 second blank ISI separating each one. We have now successfully trained four pigeons to discriminate the successive pairwise S/D arrangement of 60 photographic stimuli. Of most importance, evidence of concept formation was confirmed by finding significant transfer to novel photographs. These data can be seen in Figure 4, which shows peck rates to baseline Same and Different trials for both non-reinforced probe training stimuli and novel transfer stimuli. Although, the discrimination was reduced with the novel stimuli, the peck rates to Same sequences were significantly higher than to the Different sequences for all birds. These data show that pigeons can learn a two-item S/D discrimination and concept even when these relations are presented successively over time. These results help to argue against concerns that our previous S/D results may have just been due to detecting generalized spatial/perceptual patterns within the displays.

Conclusion

Our results suggest that pigeons may have a previously unappreciated capacity for learning and using abstract S/D relations among individual elements across a wide variety of stimuli (texture, feature, geometric, object, photographs) and can do so whether these relations are presented simultaneously or successively. Returning to our criterion for concept formation outlined earlier, our pigeons easily learn these types of discrimination (Criterion 1) even with markedly different stimuli (Criterion 3). Most importantly, they readily show transfer to novel items (Criterion 2). This transfer of the discrimination is typically reduced in comparison to the familiar training items, indicating that the birds recognize and discriminate between the training and transfer items (Criterion 4). Further, multiple tests for simpler alternatives have not yet been supported (Criterion 5). Taken together, these different lines of evidence support the hypothesis that our birds are learning a single discriminative rule that is broadly applied to both familiar and novel stimuli from both within and outside the range of past training experiences. Our newer results indicate that this decision can be reached with as few as two stimuli. Such evidence strengthens the claim that pigeons may be capable of abstracting rule-based concepts that permit them previously undocumented behavioral flexibility in regards to identity and difference judgments, much like higher primates. Thus, this integral component of intelligent behavior may be more widespread in the animal kingdom than previously supposed. Further, it challenges prior claims that S/D behavior (Premack 1978, 1983), and rule-based behavior more generally (Ashby et al. 1998) are critically tied to language.

Looking to the future, our results do create something of a paradox that needs further exploration. Despite our results, there is very good evidence that pigeons are often extremely stimulus-specific and capable of memorizing large numbers of exemplars and their relations (Carter and Werner 1978; Edwards and Honig 1987; Vaughn and Green 1984). This type of stimulus specific learning restricts transfer to novel situations, exactly the opposite of what we find. Thus, evidence of both exemplar *and* conceptual-driven behaviors seem to coexist in the pigeon. How then are these two distinct forms of learning to be reconciled? Do they reflect different aspects of the same process or separate and distinct processes as proposed for humans (Ashby et al. 1998)? One popular solution in the human categorization literature is that they reflect the same exemplar learning process. The notion here is that categorical behavior is derived from judging the similarity of any new stimulus to a set of stored exemplars. Several exemplar-based theories of pigeon discrimination learning have recently been proposed (Astley and Wasserman 1992; Chase and Heinemann, in press; Pearce 1991), and it will be interesting to see how they fare with accounting for concept results like those briefly described above. Future work clearly needs to focus on a resolution of such issues. Another important issue for us to address is the degree of transfer between simultaneous and successive procedures. If the pigeons are truly abstracting general S/D relations, it shouldn't matter which procedure is used for training and which is used for testing, the behavior should readily transfer back and forth.

Nevertheless, in conjunction with research investigating insects, amphibians, mammals, and computers, the promise of the current comparative approach is that we can differentiate those general information processing principles and mechanisms that are shared by many species from those that are unique or specific to individual species or groups, their functions, and the conditions for their development. Such information is critical to understanding the evolution of cognition in both human and non-human animals. For the moment, however, our goals are far more limited as we continue to try and understand the challenge of just how one small, complex, autonomous biological system, the pigeon, acquires information about object and event relations of the world and the basis by which it flexibly extrapolates this knowledge to new situations.

References

Ashby, F.G., Alfonso-Reese, L. A., Turken, U., and Waldron, E. M. (1998). A neuropsychological theory of multiple systems in category learning. *Psychological Review* 105: 442-481.

Astley, S. L. and Wasserman, E. A, (1992). Categorical discrimination and generalization in pigeons: All negative stimuli are not created equal. *Journal of Experimental Psychology: Animal Behavior Processes* 18: 193-207.

Bhatt, R. S., Wasserman, E. A., Reynolds, W. F., Jr., and Knauss, K. S. (1988). Conceptual behavior in pigeons: Categorization of both familiar and novel examples from four classes of natural and artificial stimuli. *Journal of Experimental Psychology: Animal Behavior Processes* 14: 219-234.

Carter, D. E., and Werner, J. T. (1978). Complex learning and information processing in pigeons: A critical analysis. *Journal of the Experimental Analysis of Behavior* 29: 565-601.

Chase, S., and Heinemann, E. G. (in press). Exemplar memory and discrimination. In *Avian Visual Cognition*, ed. Cook, R. G., [On-line]. Available: www.pigeon.psy.tufts.edu/avc/chase/.

Cook, R. G. (1992a). Acquisition and transfer of visual texture discriminations by pigeons. *Journal of Experimental Psychology: Animal Behavior Processes* 18: 341-353.

Cook, R. G. (1992b). Dimensional organization and texture discrimination in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes* 18: 354-363.

Cook, R. G. (2000). The comparative psychology of visual cognition. *Current Directions in Psychological Science* 9: 83-88.

Cook, R. G., Cavoto, K. K. and Cavoto, B. R. (1995). Same/Different texture discrimination and concept learning in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes* 21: 253-260.

Cook, R. G., Cavoto, B. R., Katz, J. S., and Cavoto, K. K. (1997). Pigeon perception and discrimination of rapidly changing texture stimuli. *Journal of Experimental Psychology: Animal Behavior Processes* 23: 390-400.

Cook, R.G. and Wixted, J. T. (1997). Same-different texture discrimination in pigeons: Testing competing models of discrimination and stimulus integration. *Journal of Experimental Psychology: Animal Behavior Processes* 23: 401-416.

Cook, R. G., Katz, J. S., and Cavoto, B. R. (1997). Pigeon same-different concept learning with multiple stimulus classes. *Journal of Experimental Psychology: Animal Behavior Processes* 23: 417-433.

Cook, R.G. and Katz, J.S. (1999). Dynamic object perception in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes*. 25: 194-210.

Cook, R.G., Katz, J.S., and Kelly, D. M. (1999). Pictorial same-different concept learning and discrimination in pigeons. *Cahiers de Psychologie Cognitive* 18: 805-844.

Cook, R. G., Wright, A. A. and Kendrick, D. F. (1990). Visual categorization in pigeons. In *Quantitative Analyses of Behavior: Behavioral Approaches to Pattern Recognition and Concept Formation*, ed. M.L. Commons, R. Herrnstein, S. M. Kosslyn and D. B. Mumford, pp. 187-214. Hillsdale, NJ: Lawrence Erlbaum Associates.

Cook, R.G., Shaw, R., Blaidell, A. P. (in press). Dynamic object perception by pigeons: Discrimination of action in video presentations. *Animal Cognition*.

Darwin, C. (1872). *The expression of the emotions in man and animals*. London: Murray.

Edwards, C. A., and Honig, W. K. (1987). Memorization and "feature selection" in the acquisition of natural concepts in pigeons. *Learning and Motivation* 18: 235-260.

Edwards, C. A., Jagielo, J. A., and Zentall, T. R. (1983). "Same/different" symbol use by pigeons. *Animal Learning & Behavior* 11: 349-355.

Fetterman, J. G. (1991). Discrimination of temporal same-different relations by pigeons. In *Signal detection: Mechanisms, models, and applications. Quantitative analyses of behavior series*, ed. M. L. Commons, J. A. Nevin, pp. 79-101. Hillsdale, NJ: Lawrence Erlbaum Associates.

Fountain, S. B. and Rowan, J. D. (1995). Coding of hierarchical versus linear pattern structure in rats and humans. *Journal of Experimental Psychology: Animal Behavior Processes* 21: 187-202.

Herrnstein, R. J., and De Villiers, P. A. (1980). Fish as a natural category for people and pigeons. In *The psychology of learning and motivation*, ed. G. H. Bower, pp. 59-95. New York: Academic Press.

Herrnstein, R. J., and Loveland, D. H. (1964). Complex visual concept in the pigeon. *Science* 146: 549-551.

James, W. (1910). *Psychology*. Henry Holt and Co: New York.

Kako, E. (1999). Elements of syntax in the systems of three language-trained animals. *Animal Learning & Behavior* 27: 1-14.

Mackintosh, N. J. (2000), Abstraction and discrimination. In C. Heyes and L. Huber (Eds), The Evolution of Cognition (pp. 123-142). Cambridge, MA: MIT Press

Mackintosh, N. J., Wilson, B., and Boakes, R. A. (1985). Differences in mechanisms of intelligence among vertebrates. In Animal Intelligence, ed. L. Weiskrantz, pp. 53-65. Clarendon Press, Oxford.

Morgan, C. L. (1894). *An introduction to comparative psychology*. London: Walter Scott.

Pearce, J. M. (1991). The acquisition of concrete and abstract categories in pigeons. In *Current topics in animal learning: Brain, emotion, and cognition*, ed. L. Dachowski and C. F. Flaherty, pp. 141-164. Hillsdale, NJ: Lawrence Erlbaum Associates.

Premack, D. (1978). On the abstractness of human concepts: Why it would be difficult to talk to a pigeon. In *Cognitive processes in animal behavior*, ed. S. H. Hulse, H. Fowler and W.K Honig, pp. 423-451. Hillsdale, NJ: Lawrence Erlbaum Associates.

Premack, D. (1983). The codes of beast and man. *Behavioral and Brain Sciences* 6: 125-167.

Romanes, G. J. (1883). *Animal Intelligence*. New York: Appleton.

Santiago, H. C., and Wright, A. A. (1984). Pigeon memory: Same/different concept learning, serial probe recognition acquisition, and probe delay effects on the serial-position function. *Journal of Experimental Psychology: Animal Behavior Processes* 10: 498-512.

Thorndike, E. L. (1911). *Animal Intelligence: Experimental studies*. New York: Macmillan.

Vaughan, W., Jr., and Green, S. L. (1984). Pigeon visual memory capacity. *Journal of Experimental Psychology: Animal Behavior Processes* 10: 256-271.

von Fersen, L., Wynne, C. D, , D., Staddon, J. E. (1991). Transitive inference formation in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes* 17: 334-341.

Wasserman, E. A., Hugart, J. A., and Kirkpatrick-Steger, K. (1995). Pigeons show same-different conceptualization after training with complex visual stimuli. *Journal of Experimental Psychology: Animal Behavior Processes* 21: 248-252.

Wright, A. A. (1997). Concept learning and learning strategies. *Psychological Science* 8: 119-123.

Wright, A. A., Cook, R. G., Rivera, J., Sands, S. F., and Delius, J. (1988). Concept learning by pigeons: Matching to sample with trial-unique video picture stimuli. *Animal Learning & Behavior* 16: 436-444.

Wright, A. A., Santiago, H. C., Urcuioli, P. J., and Sands, S. F. (1983). Monkey and pigeon acquisition of same/different concept using pictorial stimuli. In Quantitative analyses of behavior, Vol. 4, ed. M. L. Commons, R. J. Herrnstein, and A. R. Wagner, pp. 295-317. Cambridge, MA: Ballinger.

Zeigler, H. P., and Bischof, H. J. (1993). *Vision, brain, and behavior in birds*. Cambridge, MA: MIT Press.

Figure Captions

Figure 1. Representative examples of the original four display types used by Cook, Katz, and Cavoto (1997) in training the pigeons tested in these experiments. The left column shows examples of Same displays for each display type (the example for the feature display type depicts a shape-Same display). The right column shows examples of Different displays differing in shape for each display type. For the texture, feature, and geometric display types there were also corresponding displays where the elements differed in color. Multiple different color and shapes and pictures were used to create the large number of displays. Adapted from the *Journal of Experimental Psychology: Animal Behavior Processes* 23: 417-433. Copyright 1997 by the American Psychological Association.

Figure 2. Mean choice accuracy on Baseline (B) and non-reinforced novel Transfer (T) trials for each of the four display types in Cook et al., (1997). The dotted reference line represents chance performance in the task. From the *Journal of Experimental Psychology: Animal Behavior*

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Figure 3. A schematic representation of Same and Different trials in our successive S/D procedure. Each item appears for 2 seconds followed by a .5 sec blank period that separates it from the presentation of the next item. Using a Same+/Different- go/no-go procedure, the stimuli alternate in this manner for 20 seconds for each type of trial.

Figure 4. Mean peck rates for Same (S+) and Different (S-) trials for four birds from non-reinforced probe Baseline (left side) and novel Transfer (right side) trials collected using the successive S/D procedure.

They are â€˜polymorphousâ€™ concepts. They constitute difficult concept formation tasks. FIGURE: An example of a polymorphous concept. What is the concept? Q. Can pigeons really learn complex visual concepts? A. Several experimental studies suggest that they can.Â The degree of difficulty here was the same as for the previous case for pigeons, but very different (much. harder) for humans. But, maybe thatâ€™s because CB doesnâ€™t have meaning for pigeons and the images used are line-drawings.Â - What is the right model for pigeonsâ€™ visual concept formation processes? Can we test it on real images to determine if it can qualitatively replicate pigeon performance? - Do humans need to learn to see images as representations of objects? acquire the "same/different" concept. cept transfer than did pigeons whose training did not. Recently, however, Premack (1983a, 1983b) has include negative-instance trials.Â 43.1% correct, by the fourth test session, it was at formation because the green-red configuration also. 66.7% correct, and by the sixth test session, it was at involved this cue. Similarly, in the green-green con Same-different concept formation in pigeons. In M. Bekoff, C. Allen & G. M. Burghardt (Eds.), The cognitive animal (pp. 229 â€“237). Cambridge, MA: MIT.Â Same-different abstract-concept learning by pigeons. Journal of Experimental Psychology: Animal Be-havior Processes, 32, 80 â€“ 86. Katz, J. S., & Wright, A. A., & Bachevalier, J. (2002). Mechanisms of same/different abstract-concept learning by rhesus monkeys (Macaca. mulatta). Journal of Experimental Psychology: Animal Behavior Pro-cesses, 28, 358 â€“368. Katz JS, Wright AA (2006) Same/different abstract-concept learning by pigeons. J Exp Psychol Anim B 32:80â€“86. doi:10.1037/0097-7403.32.1.80. Article Google Scholar. Katz JS, Wright AA, Bachevalier J (2002) Mechanisms of same-different abstract-concept learning by rhesus monkeys (Macaca mulatta). J Exp Psychol Anim B 28:358â€“368. doi:10.1037//0097-7403.28.4.358.Â Pepperberg IM (1987) Acquisition of the same/different concept by an African Grey parrot (Psittacus erithacus): learning with respect to categories of color, shape, and material. Anim Learn Behav 15:423â€“432. Article Google Scholar. Piaget J, Inhelder B (1969) The psychology of the child (trans: Weaver H). Basic Books, New York (Original work published 1966). Google Scholar.