Comparing Monkeys and Humans on Conceptual Oddity and Sameness-Difference Tasks

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Roger K. Thomas
Department of Psychology
University of Georgia
Athens, GA 30602

The significance of oddity and sameness-difference judgments was indicated by Henry Nissen who wrote (1958, p. 194).

> All reasoning reduces to three processes: responsiveness to identity and to difference, and thirdly, the balance or relative weight given to each of these... All class concepts require simultaneous responsiveness to identities among members of classes, and to the differences between them and members of other classes. The balance between the two we may call sagacity; "judgment" might be an even better term.

Nissen iterated this view in several works but apparently never elaborated upon it. No matter, its validity is self-evident. To illustrate with one example, we can learn to recognize the similarities which define a taxonomic category such as the mammalian order, Primates; yet, we can also learn to recognize the differences which distinguish species or subspecies of primates.

Critical to Nissen's view is the third point concerned with the "balance or relative weight" given to identity and difference. Experimentally, such balance or relative weight can be investigated systematically using tasks such as the hierarchy of sameness-difference tasks shown in Figure 1. Task designations such as "3R-0C-0A" indicate the number of relevant cues (distinguish between classes, e.g., same and different), constant cues (common across otherwise distinguishable classes), and ambiguous cues (vary uninformatively across classes).

Figure 2 shows a similarly constructed hierarchy of oddity tasks. Except for tasks 3 and 4 (in both Figures 1 and 2), it is reasonable to suggest that the combinations of cues as indicated result in a hierarchy of tasks along a dimension of hypothetical difficulty to learn. Task 3 has only one relevant cue compared to two relevant cues for task 4, which indicates that task 4 should be easier than task 3. However, task 4 also has an ambiguous cue, but task 3 does not. Frost and I (1983) suggested that the presence of an ambiguous cue in task 4 might make it more difficult than task 3. While only color, form, and size were manipulated here, other attributes could be added and manipulated to increase the range and difficulty of the tasks.

Oddity and sameness-difference are closely related, but there is one notable difference. To see the difference, view Figure 1 again and consider the first three tasks. Because the sameness pair is always identical, the first three tasks involve <u>absolute</u> class concepts; that is, sameness is manifested solely in its exemplar in tasks 1-3 and one need not compare stimulus choices to affirm the exemplar of sameness. However, beginning with task 4, <u>relative</u> class concepts are involved; that is, one must compare the sameness and difference pairs, because sameness has become a matter of relative difference.

When we examine the oddity tasks again, we see that unlike sameness-difference, oddity is a relative property of the stimuli in all six tasks. Oddity tasks such as tasks 4-6, where the nonodd stimuli are not identical but are more similar to each other than to the odd stimulus, are known as "dimension-abstracted oddity" (Bernstein, 1961; Thomas & Frost, 1983). Analogously, sameness-difference tasks such as tasks 4-6 might be called 'dimension-abstracted sameness-difference.'

Our original purpose for undertaking this work was to validate the hierarchy of difficulty of the tasks. The hierarchy is important in the approach to the assessment of comparative intelligence which I proposed in 1980. That approach is based on equating intelligence with learning capacities, and a hierarchy of eight basic types/levels of learning were proposed. It was asserted that <u>all</u> learning could be accounted for by one or combinations of these eight levels. Since two or more species might attain the same level but not the next higher one, it was important to be able to increase the precision of measurement at each level in order to be able to differentiate among species at the same level.

Increasing the precision of measurement at levels 4, 5, 7, and 8 are relatively straightforward (see Thomas, 1980), but it was less obvious how the precision of measurement could be increased at level 6. The oddity hierarchy approach was the first attempt to increase the precision of measurement at level 6. While logically its hierarchical structure was reasonably clear (except for the order of tasks 3 and 4 as noted), it remained to be seen whether it also represented an empirical order of difficulty.

Our first investigation (Thomas & Frost, 1983) involving the hierarchy of oddity tasks was done using four adult, male squirrel monkeys. First, we trained them to criterion (36/40) on task 1. Then, we trained them on tasks 2-6 in that sequence, but training was limited to 400 trials per task if the monkey failed to reach criterion. In another experiment (J. N. Steirn & R. K. Thomas, manuscript in preparation) 10 human subjects were trained to criterion using 20 exemplars each from oddity tasks 1-3 selected randomly, and 10 subjects were trained using exemplars selected from oddity tasks 4-6. The differences in training procedures preclude statistical comparisons of the two species' data, but less formal comparisons are reasonable and useful.

As may be seen in Figure 3, the humans performed at a higher overall level of accuracy. However, with the exception of the monkeys'poorer performances on task 3 compared to task 4, the relative difficulty of the tasks in terms of the proposed hierarchy was comparable. Underscoring the difficulty of task 3 for the monkeys was the fact that none of four monkeys met criterion, whereas two of three monkeys (one of the four monkeys died prior to completing task 3) met criterion on task 4.

The difficulty of task 3 for the monkeys is likely explained by their being deficient in color vision. Research by Gerald Jacobs and colleagues (e.g. Jacobs & Neitz, 1985) has indicated that male squirrel monkeys are dichromatic, whereas our human subjects, presumably, had normal trichromatic color vision (human subjects were excluded from testing if they reported known deficiencies in color vision). Task 3 which has only one relevant cue should be more difficult for squirrel monkeys on some of the trials when color provided the relevant cue. Task 4 with two relevant cues would always have either form or size as an additional relevant cue.

Assuming the monkeys' color vision accounts for the difficulty they had on task 3, the principal finding in terms of "primate perspectives on human cognition" was the similarity of the monkeys' and the humans' performances in terms of the relative difficulty of the hierarchy of oddity tasks. Based on these performances, it is reasonable to suggest that when perceptual stimuli are involved that monkeys and humans may use similar processes with respect to "relative balance and weight" when they make identity-difference judgments. Whether this suggestion applies to other kinds of identity-difference judgments remains to be determined.

Despite our success with monkeys using the oddity hierarchy, we have been largely unsuccessful in our attempts to study the sameness-difference hierarchy using monkeys. I believe that squirrel monkeys are capable of performing successfully on such tasks and that our lack of success may be due to using old, overworked monkeys and to problems associated with our automated testing apparatus. We are redesigning the apparatus and hope to acquire younger, less experienced monkeys.

Meanwhile, we have used the sameness-difference hierarchy with humans. The data were collected in conjunction with the same investigation in which we studied the oddity hierarchy with humans (i.e., Steirn & Thomas, in preparation). Four groups of 10 subjects each were used. One group was reinforced (a green light signaled a correct response) for responding to exemplars of sameness from tasks 1-3, one group responded to exemplars of difference from tasks 1-3, one group responded to exemplars of sameness from tasks 4-6, and the fourth group responded to exemplars of difference from tasks 4-6.

Figure 4 shows the results in terms of percentages of correct responses on the sameness-difference tasks. For comparison, the results from the humans on the oddity tasks are also shown. Comparing sameness-difference when responses to sameness were correct versus when responses to difference were correct, the performances were significantly better at all levels of difficulty when responses to sameness were correct. Obviously, this suggests a preference for sameness which had to be overcome by the subjects in the difference-correct group Performances on sameness-difference/sameness-correct tasks 3-6 were significantly better than those on oddity tasks 3-6. Performances on the oddity tasks did not differ significantly from those on the sameness-difference/difference correct tasks, except for task 2 where performances were significantly better on the oddity task. It is not clear whether a preference for sameness could account for the relative difficulty of the oddity tasks compared to the sameness-correct tasks. The same (or nonodd) stimuli were never isolated in physical space. The odd stimulus was one among the three stimuli, and on many trials, it separated physically the nonodd stimuli.

While we been largely unsuccessful so far with the squirrel monkeys in studies based on the hierarchy of sameness-difference tasks, we have done one successful study with squirrel monkeys involving exemplars of the sameness and difference concepts (Burdyn & Thomas, 1984). In addition to using exemplars of the sameness and difference concepts, we also used exemplars of the concepts of triangularity and heptagonality. Specifically, either a triangle or a heptagon was presented in conjunction with exemplars of both sameness and difference. If a triangle was presented, the correct response was to the exemplar of sameness, but if a heptagon was presented, the correct response was to the exemplar of difference.

After extensive stepwise training the monkeys were able to view new exemplars of either a triangle or a heptagon in random order and use it as the cue to choose accurately between new exemplars of sameness and difference. In the final stages of training, the triangle or heptagon cue was presented and withdrawn before the sameness and difference cues were presented.

We viewed the monkeys' successful performances, especially in the final stages, as suggesting the use of symbolic cues (triangle/same and heptagon/different). We also considered the task to be comparable in abstractness to Premack's task used with chimpanzees (Premack, 1983; Premack & Premack, 1983). If so, the successful performances of our monkeys challenge Premack's assertion that abstract same and different judgments depend on language training or linguistic competence. Obviously, we did not agree that abstract same and different judgments required linguistic competence. It is relevant, then, in terms of "primate perspectives on human cognition" that both human and nonhuman primates share the ability to make correct abstract, symbolic sameness-difference judgments independently of their differences in linguistic development.

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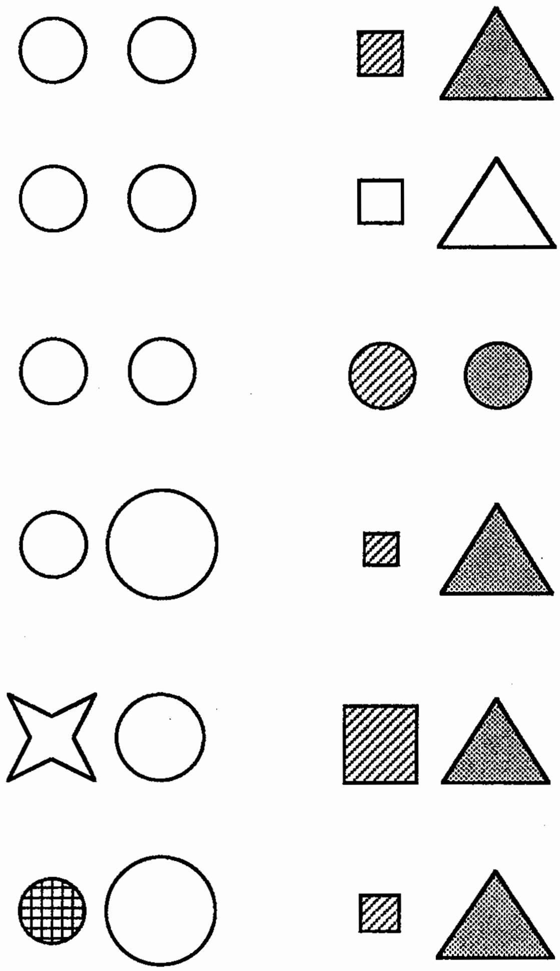
Figure Captions

Figure 1. A proposed hierarchy of sameness-difference tasks.

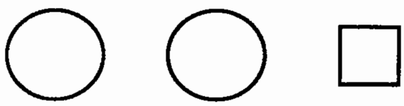
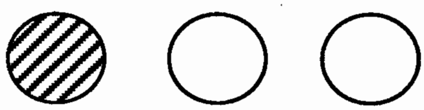
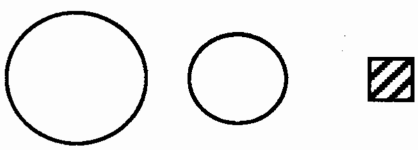
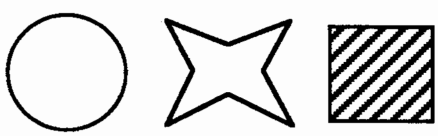
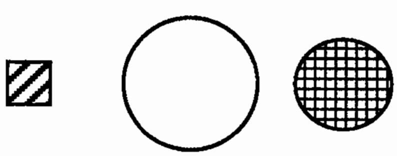
Figure 2. A proposed hierarchy of oddity tasks.

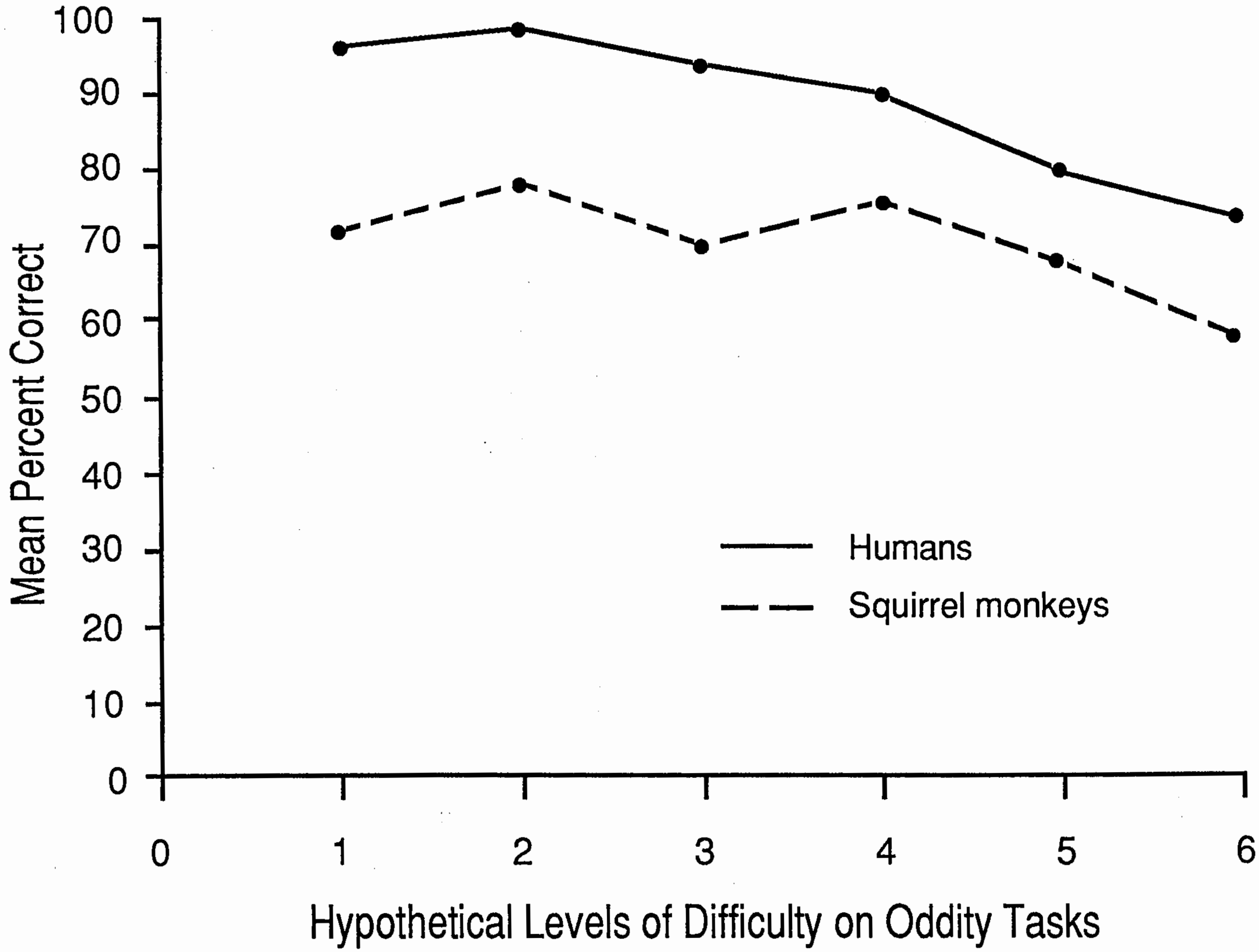
Figure 3. Percentages correct by humans and squirrel monkeys as a function of the hypothetical levels of difficulty in a series of oddity tasks.

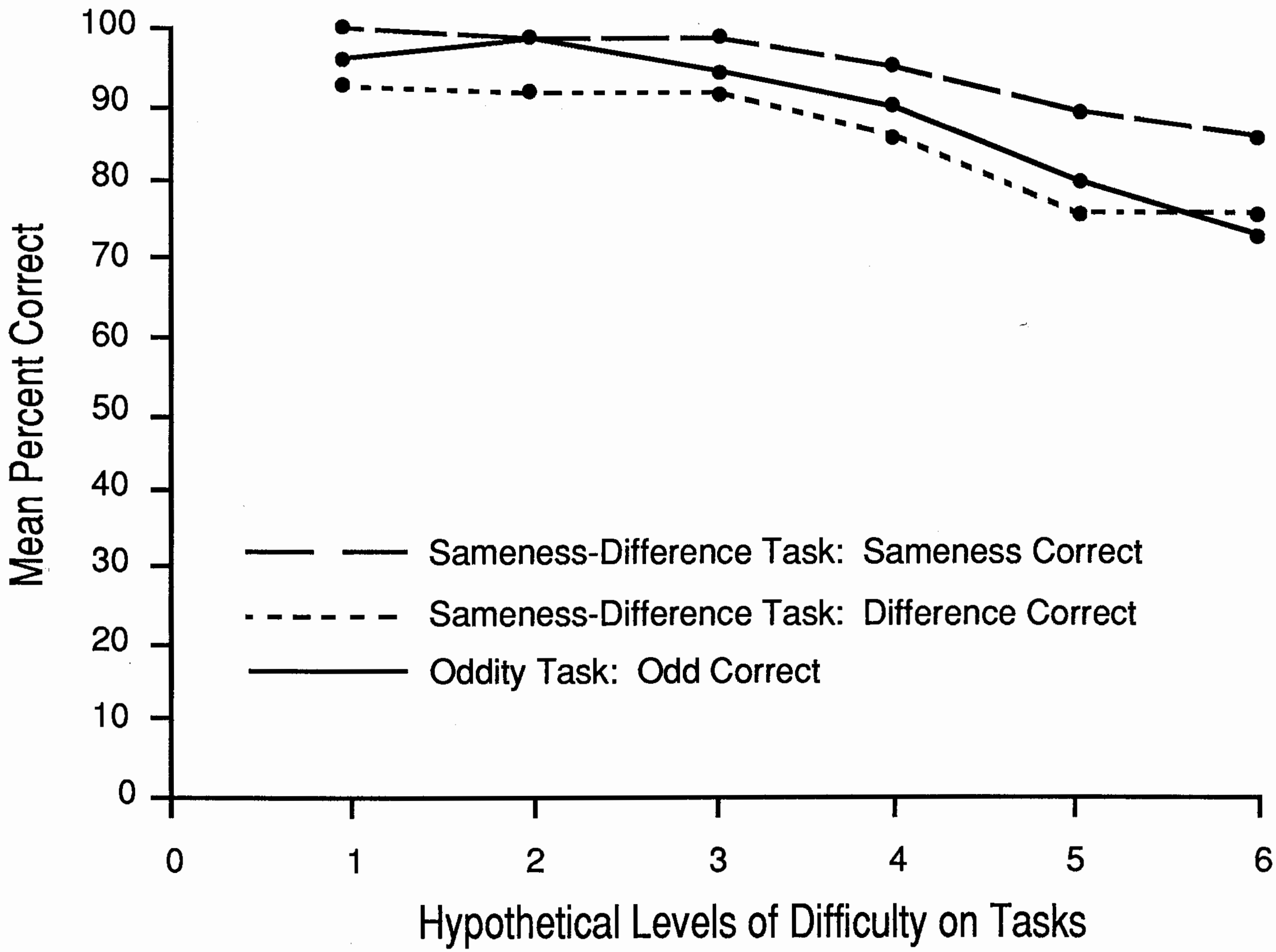
Figure 4. Percentages correct by humans as a function of the hypothetical levels of difficulty in a series of oddity tasks and a series of sameness-difference tasks. In the sameness-difference tasks, half the subjects were reinforced for responding to sameness correct and half for difference correct.



SAMENESS	DIFFERENCE	TASKS	EXAMPLE SHOWN
		3R-0C-0A	Color, Form, and Size Relevant
		2R-1C-0A	Form and Size Relevant Color Constant
		1R-2C-0A	Color Relevant Form and Size Constant
		2R-0C-1A	Color and Form Relevant Size Ambiguous
		1R-1C-1A	Color Relevant Size Constant Form Ambiguous
		1R-0C-2A	Form Relevant Color and Size Ambiguous

ODDITY	TASKS	EXAMPLE SHOWN
	3R - 0C - 0A	Color, Form, and Size Relevant
	2R - 1C - 0A	Form and Size Relevant Color Constant
	1R - 2C - 0A	Color Relevant Form and Size Constant
	2R - 0C - 1A	Color and Form Relevant Size Ambiguous
	1R - 1C - 1A	Color Relevant Size Constant Form Ambiguous
	1R - 0C - 2A	Form Relevant Color and Size Ambiguous


100
90
80
70
60
50
40
30
20
10
0
Mean Percent Correct
Humans
Squirrel monkeys
0
1
2
3
4
5
6
Hypothetical Levels of Difficulty on Oddity Tasks



100
90
80
70
60
50
40
30
20
10
0
Mean Percent Correct
0
1
2
3
4
5
6
Hypothetical Levels of Difficulty on Tasks
Sameness-Difference Task: Sameness Correct
Sameness-Difference Task: Difference Correct
Oddity Task: Odd Correct