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ABSTRACT

This study examined the development of children's decisionmaking abilities and the effects of age and gender differences on their use of probability, gain, and loss information about risky alternatives. Subjects were 158 children of 7-13 years of age who were observed during a task in which they chose among alternative gambles in a computer game. Two expectations were that: (1) young children would make patterns of choices that reflected editing out of the probability information for the purpose of simplifying the task; and (2) children could use the probability information in determining the relative importance of gains and losses in evaluating risk alternatives. Results showed that older children and boys were more likely than others to use a multiplicative strategy in choosing among gambles. Older children and girls favored choices that would reduce their exposure to large losses, while younger children and boys preferred choices that afforded opportunities for large gains. (Author/SH)

Developmental Change in Decision-Making: Use of Multiplicative Strategies and Sensitivity to Losses[1]

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Abstract. In this study, 158 children ages 7-13 were studied using a decision task in which children chose among alternative gambles in a computer game. Results showed that older children and boys were more likely to use a multiplicative strategy in choosing among gambles. Older children and girls favored choices that would reduce their exposure to large losses, while younger children and boys preferred choices that afforded opportunities for large gains.

There are pressing reasons to study the development of children's decision making abilities. First, our society's cultural definition of childhood and legal definition of minority includes the belief that children are incompetent to make decisions in their own self-interest (Gardner, Scherer, & Tester, 1989; *Parham v. J.R.*, 1979). Second, the primary sources of mortality and morbidity from early adolescence through young adulthood are associated with voluntary risk taking behaviors (Blum, 1987; Gardner, in press). Finally, decision making theory is one of the fundamental intellectual tools used to understand how humans and other animals adapt to their ecological surrounds. It is therefore surprising that, as Rest (1983) noted, children's decision making "has been studied very little and its developmental character is practically unknown." In particular, there is little information about the development of decision making abilities and attitudes toward risk in the period from childhood to the threshold of adolescence (significant studies that contrast pre-adolescents and adolescents are Scherer, in press, and Weithorn & Campbell, 1982; see Furby & Beyth-Marom, in press, for a review of information about adolescent decision making).

This study examined age and gender differences in how children use probability, gain, and loss information about risky alternatives in a decision task. We reasoned that there were two ways that the information might be used. First, as Kahneman and Tversky (1979) have argued for adults, children faced with a complex choice may simplify their task by omitting from consideration one or more dimensions of information about the alternatives.

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In this study, children are given decision tasks in which the probability of obtaining a gain or incurring a loss is the same for each alternative. It was expected that children, and particularly young children, might make patterns of choices that reflect an editing out of the probability information to simplify the task.

Second, children could use the probability information in determining the relative importance of gains and losses in evaluating risk alternatives. When gains are most probable, it is reasonable to weigh information about those gains more heavily than when losses are most probable. If the loss and gain values are multiplied by the probabilities of these outcomes and summed, this is the expected value rule. One need not perform mental arithmetic, however, to make decisions that are roughly consistent with a multiplicative rule. In some decision making tasks, it may suffice for the decision maker to attend primarily to gain information when the chances of winning dominate those of losing, and attend primarily to loss information when the reverse is true. It was of interest, therefore, to look for evidence about whether children can use probability, gain, and loss information in conformity to the multiplicative rule.

This study also examined children's differential sensitivity to the possible costs and benefits pertaining to a choice. Risk averse decision makers prefer alternatives that reduce their exposure to large losses, while risk seeking decision makers are attracted to alternatives affording opportunities for large gains. It is generally thought that adults are on balance risk averse, that is losses loom larger than gains (Tversky & Kahneman, 1979), but there may also be substantial individual differences in preferences for risk versus security (Lopes, 1987). There seems to be no research on the development of these preferences.

In our previous research (Tester, Gardner, & Wilfong, 1987) we found that young adolescent children (11-13 years old) utilized more information about a decision than younger children (7-9 years). The most striking difference between the younger and older children was the greater sensitivity of the latter to the number of points that could be lost. However, because of the design of the study we were unable to determine whether the older children combined probability information with loss or gain information using a multiplicative strategy. This study was designed to investigate whether children can combine these dimensions of information multiplicatively and to obtain further information about how children use gain and loss information.

Methodological issues in identifying children's decision-making strategies

We were impressed by two experimental methodologies that have been used to study how children combine dimensions of information in making judgments. Anderson and his colleagues have conducted many studies of children's abilities to make judgments in tasks where two dimensions of information must be multiplicatively combined (for example, Anderson & Cuneo, 1978). Unfortunately, as Surber (1984) has pointed out, these data are difficult to interpret because children are required to respond using a quantitative scale (Tester *et al.* [1987] also required children to respond using a scale). The change in the patterns of responses generated by children could either be developmental changes in how they make judgments or in how they use the response scale. One of our goals, therefore, was to develop a methodology that did not require children to respond using a numerical scale.

Siegler (1981) also studied children's use of multiplicative and additive rules in judgment tasks, but was able to classify children according to the rule they used based on the pattern of their choices across tasks, thereby avoiding the problems in interpreting children's ratings. These classifications were possible because on the tasks Siegler studied, such as judgments about the torque on a balance beam, children's choices were sufficiently consistent that the rules they used were easily recognizable. Consequently, Siegler had no need for a theory about errors in classification. This makes his technique difficult to apply to children's decision-making, because we have found that children's choices among risky alternatives frequently do not form consistent patterns.[2] One difference between the balance beam task and our risky decision tasks is that the balance beam is deterministic whereas gambles are random. A balance beam returns reliable and highly informative feedback, such that good or bad judgments about the amount and placement of the weight required to balance the beam will succeed or fail consistently. It makes sense that children would have firm intuitions about how the system is expected to behave, except at points of transition from one rule to the next. In risky choices, however, good or bad judgments are much less crisply defined, and even well-reasoned choices will frequently lead to undesired outcomes. Sticking to a consistent decision-making policy in risky settings will require strong belief in that policy, because one will be forced to maintain it in the face of contrary experience. It is not surprising, then, that children's risky choices rarely fall into clean patterns. This lack of consistency forces us to derive new methods for inferring children's decision-making strategies from noisy data.

Method

Subjects

Subjects included 158 children ages 7-13 ($\bar{X} = 10.9$, $SD = 1.7$ years), with 87 boys and 71 girls recruited by letters to their parents. Roughly equal proportions of boys and girls were recruited at each age, so age and gender were nearly uncorrelated ($r = .05$).

Procedure

Spinner task. Children were asked to make choices among alternative gambles presented as layouts of four spinners on the color screen of a microcomputer (Figure 1). A spinner consisted of a disk divided into two sections by a pair of symmetric radii. The upper, dark colored portion of the disk represented the probability of winning and the lower portion the probability of losing. The box of dark balls above the spinner represented the number of points to be won, the box below the possible loss.

Figure 1 about here.

[2]Our interest in 3 dimensions of information (probability, loss and gain) as against only 2 on a balance beam (mass and distance from the fulcrum) also made Siegler's methodology impractical, because it would have required us to administer many more trials than children would be willing to accept.

Procedure. Following several practice trials, each subject participated in 12 randomized trials. At the beginning of the trials, each child was given a stock of 50 points and told that the purpose of the game was to win as many points as possible by choosing the best spinners.[3]

Children were given unlimited time to make choices. They indicated their choice of a spinner in the layout by using a mouse to move the cursor to the circle in the center of the screen in the quadrant of the desired spinner, and clicking. This cleared the four-quadrant layout from the screen and replaced it with a large version of the chosen spinner. A small ball then orbited the probability disc and stopped randomly in the winning or losing portion. The appropriate number of points was then added to or deducted from the child's total.

At the beginning of each of the 12 trials, children were asked to choose the best of the four spinners. After they had made their choice and the gamble was played out, the layout was presented again, but this time with a blank quadrant in place of the chosen spinner (Figure 2). The child was then asked to choose the best spinner from the remaining three. After that gamble, the child chose again from the remaining pair. We took the ordering of the spinners implied by these three choices as a preference ranking of the four spinners.[4]

Figure 2 about here.

Design

The 12 trials represent a within-subject experimental design (Table 1). Within each trial, the spinners had identical probability of winning (and hence of losing). The spinners within trials only differed in the number of points that are gained or lost. Six of the 12 trials were high probability trials, with probabilities of winning $> .5$, while the other 6 were low probability trials, with probabilities of winning $< .5$. The order of presentation of layouts was randomized for each subject, as is the screen position of each spinner within a layout.

Table 1 about here.

Measuring strategy use

Predicted strategies. We measured children's use of three strategies for combining information on this task. For each trial, there was a preference ranking among the spinners that

[3]Children were all praised for their performance on the task. Neither in this task nor in any other study we have done did we find age (or gender) effects on the number of points won. The reason is that the noise in the data contributed by the random outcomes of the gambles washes out any effect of differences in strategies used by children.

[4]It is possible that a child's choices would not reveal his or her preference ranking. The child could simply determine which spinner he or she liked least, decide not to choose it, and then choose randomly among the remaining spinners. Because there is no incentive in this task to pick the favored spinner first, the strategy of avoiding the least favored spinner would win as many points as would picking them in rank order. An incentive to pick the best spinner first could have been provided by making it random whether the child would have the opportunity to make the second or third choices. This design would have confused the children, complicated the data analysis, and increased the number of subjects required. Our sense from piloting and running the experiment was that children enjoyed trying to identify the best spinner and made good faith efforts to do so.

was implied by a strategy to integrate information about the choices. Two strategies, *gain first* and *loss first*, are based on the prediction by Kahneman and Tversky (1979) that when any dimension of information about a choice is invariant across the range of alternatives it will be 'edited out' and ignored in decision making. In this task, probability is always invariant, so the prediction would be that children would base their choices only on the gain and loss information. In *gain first* the child first ranked the spinners based on the number of points that could be won in the gamble, then resolved ties by choosing the spinner with the smaller loss. So for Layout 1 in Table 1, a child using the *gain first* strategy would have ranked the spinners $1 > 3 > 4 > 2$, and for all the other layouts as well. In the *loss first* strategy, spinners are ranked first in order of decreasing loss and ties are resolved by choosing the larger gain, so a child using the *loss first* strategy would have ranked the spinners $3 > 1 > 2 > 4$.[5] The third strategy is *multiply*, where children evaluate spinners by ranking them in an order corresponding to $\phi(p)g + (1 - \phi(p))\ell$, where g is the gain, ℓ is the loss, and $0 < \phi(p) < 1$ is the weight the child applies to the integration of gain and loss when the probability of winning is p. We assume that $\phi(p) < .5$ when $p < .5$ and $\phi(p) > .5$ when $p > .5$. Then whenever $p < .5$, as in Layout 1, the *multiply* rule predicts the ranking $3 > 1 > 2 > 4$, the same as *loss first*, and whenever $p > .5$ it predicts $1 > 3 > 4 > 2$, the same as *gain first*. It follows that if every child consistently followed one of these three strategies, it would be easy to classify them: *gain first* children would always rank the spinners $1 > 3 > 4 > 2$, *loss first* children would always rank them $3 > 1 > 2 > 4$ and *multiplying* children would switch depending on p.

Inferring strategy use from noisy data. Unfortunately, even if children know the strategies described above, it is clear from watching them do the task that they do not always execute them well. For example, they sometimes goof when choosing a circle to click, they seem to shift strategies from choice to choice within a layout depending on the outcomes of gambles, and they doubtlessly make errors when they encode information about the spinners. They may well think about the merits of spinners from more than one strategic perspective and eclectically combine them in generating rankings. What is needed is a way to measure the influence of latent strategic patterns on noisy rankings.

Our measure is based on the idea underlying Kendall's τ statistic. To evaluate how closely an observed ranking corresponds to the predicted ranking, we begin by hypothesizing that a child has a strategy corresponding to a predicted sequence, say $3 > 1 > 2 > 4$, but that in generating the ranking or using the mouse that sequence is contaminated with noise. The effect of the noise is to transpose adjacent spinners within the ranking, so the

[5] We also generated measures of children's use of GAIN and LOSS strategies that ranked spinners according to a single dimension and then broke ties randomly. In this design, however, it is nearly impossible to discriminate a child's use of GAIN and GAINFIRST, because half the time a child using GAIN would be predicted to generate the GAINFIRST ranking on half the trials, and a ranking that differed by only one transposition of spinners in the other half. In the data, our measures of GAINFIRST and GAIN were almost identical ($r = .90$) and similarly for LOSSFIRST and LOSS ($r = .96$). Consequently, the data do not indicate whether, for example gain-oriented children were using GAINFIRST (and two dimensions of information) or GAIN (only one dimension). We did not need this information, because Tester *et al.* (1987) had demonstrated that the ability to use multiple dimensions of information does increase over this age-span.

child might respond 3 > 2 > 1 > 4. However, the more noise and transpositions we need to impute to the observed ranking to recover the predicted ranking, the less plausible it becomes that the child was pursuing the strategy in question.

Using this idea we measure the distance from a predicted ranking to an observed ranking as the minimum number of transposed spinners (the imputed errors) required to generate the predicted from the observed ranking. The imputed errors will be an integer between 0 (the observed ranking is identical to the predicted ranking) and 5. We then measured the influence of a strategy on a child's decisions by summing the number of imputed errors implied by that strategy across the 12 trials (a small sum of imputed errors).[6] To make the measure more easily interpretable, we reversed the scaling so that 5 corresponded to identity of observed and predicted rankings and 0 represented the greatest possible dissimilarity. These numbers were averaged across trials, to produce three measures of strategy use for each subject: MULTIPLY, GAINFIRST, and LOSSFIRST.

GAINFIRST and LOSSFIRST have a high negative correlation ($r = -.89$). This is a desired artifact of the experimental design, which in effect required children to declare whether they sought to obtain large gains or avoid large losses. We therefore computed the difference, LOSSFIRST - GAINFIRST, to measure sensitivity to loss vs. gain. The design of the study made the choice pattern predicted for *multiply* orthogonal to those predicted for *gain first* and *loss first*, so LOSSFIRST - GAINFIRST is nearly uncorrelated with MULTIPLY ($r = .07$).

Results

Strategy use

Table 2 shows that although MULTIPLY is, in a sense, the best fitting strategy, none of the strategies fit the rankings particularly well (a score of 3 differs from the predicted ranking by two transpositions). Nevertheless, the data reveal an orderly pattern of age and gender differences that suggest that these measures are capturing meaningful variation in children's decision making.

We then classified children according to whether their data are best fit by either the *multiply* strategy or one of the non-multiplicative strategies. Children were classified as using a multiplicative strategy if their scores on MULTIPLY were greater than or equal to their scores on either LOSSFIRST or GAINFIRST: 44% of the sample was so classified. We also classified children as more sensitive to losses than gains if LOSSFIRST − GAINFIRST

[6] The formal justification for this measure requires two more assumptions. First, we assumed that errors in responding occurred independently both within and between trials. This is unlikely, but it is not apparent how a violation of the assumption (if, for example, errors were Markov-dependent) would bias the classification algorithm. Second, and more importantly, we assumed that the probability of a transposition error occurring would be the same whichever strategy the subject used. This assumption is probably false because one would expect more errors to occur when the *multiply* strategy is used. With *gain first* or *loss first*, one need consider only one dimension of information at a time while ranking the spinners, whereas *multiply* requires attending to all of them. Hence we may be under counting the number of subjects who use the *multiply* strategy. Based on these assumptions the total of imputed errors across the 12 trials would be binomially distributed and the average imputed errors would be a sufficient statistic.

> 0: 51% of the sample was so classified. We then looked for AGE and GENDER differences in these classifications using probit regression (Aldrich & Nelson, 1984). We also conducted multivariate analyses of MULTIPLY and LOSSFIRST – GAINFIRST as a sensitivity check, because it was possible that the results could depend on the methodological choice to use dichotomous classifications.[7]

Table 2 about here.

Strategy use as a function of age and gender

Multiplicative strategy. Children whose data were best fit by the *multiply* strategy ($\bar{X}$ = 11.2 years) were .5 years older on average than children best fit by *gain first* or loss first ($\bar{X}$ = 10.7 years, the difference is significant using probit regression, $t = 2.13$).[8]

Fifty-four percent of boys used the multiplicative strategy as opposed to 32% of girls (significant with $t = 2.86$). The probit estimate for the probability of using a multiplicative strategy at age 7 is .33 for boys and .15 for girls, while at age 13 it is .65 for boys and .42 for girls. The AGE × GENDER interaction did not influence the use of the multiplicative strategy.

Sensitivity to loss vs. gain. Children who were more sensitive to loss information ($\bar{X}$ = 11.5 years) than gain information were on average 1.1 years older than those more sensitive to gain information ($\bar{X}$ = 10.4 years, probit $t = 4.22$). Looked at another way, the similarity of children's ranking to the predicted *loss first* rankings increases with AGE ($r = .42$, $p < .001$) while the similarity to *gain first* rankings decreases ($r = -.37$, $p < .001$). The decreasing trend in GAINFIRST with age is striking because one might have expected all measures of strategy use to increase with age as children's decision making becomes more systematic and less noisy.

Sixty-three percent of girls were more sensitive to the loss information, as opposed to 40% of boys (probit $t = 2.87$). The probit estimate for the probability that a child will be more sensitive to losses than gains at age 7 is .09 for boys and .22 for girls, while at age 13 it is .63 for boys and .83 for girls. The AGE × GENDER interaction did not influence sensitivity to loss vs. gain. There was no association between the use of the multiplicative strategy and sensitivity to loss vs. gain, $X^2(1) = 1.3$.

[7] MULTIPLY and LOSSFIRST – GAINFIRST were regressed on AGE and GENDER. As before, both the use of the multiplicative strategy and sensitivity increased significantly with AGE (Wilks' $\Lambda = .80$, $F(2,154) = 19.7$, $p < .001$). The effect of AGE is also significant in univariate analyses on MULTIPLY ($t(155) = 2.95$, $p < .005$) and LOSSFIRST – GAINFIRST ($t(155) = 5.62$, $p < .001$). GENDER also affected these variables significantly (Wilks' $\Lambda = .91$, $F(2,154) = 7.43$, $p < .001$). Boys had higher scores on MULTIPLY ($\bar{X} = 3.05$ vs. $\bar{X} = 2.85$ for girls; $t(155) = 2.09$, $p < .04$). Girls had higher scores on LOSSFIRST – GAINFIRST ($\bar{X} = .62$ vs. $\bar{X} = -.20$ for boys, $t(155) = 3.22$, $p < .002$). As in the probit and logistic analyses of these data, the AGE × GENDER interaction was non-significant in both multivariate and univariate analyses.

[8] The t statistics for the coefficients of independent variables in probit regression are the ratios of the coefficients in their standard errors. Unlike the coefficients in an ordinary linear regression, the t statistics do not have sampling distributions or degrees of freedom. It is conventional to take $t > 2.0$ as an indication of significance. These regressions were checked by also estimating logistic regressions, which produced nearly identical results.

Discussion

Although these data have a simple pattern, they contain several notable results. First, as in many other tasks (for example, both Anderson & Cuneo, 1978, and Siegler, 1981) older children are more likely to use a multiplicative rule in a task that may involve quantitative reasoning. To make decisions corresponding to the multiplicative rule, you need to examine the probability and at least one other dimension of information about the alternative spinners. Recalling Tester *et al.*'s finding that older children use more information about a decision, what may underlie this age trend is an increase in the capacity to reason with several items of information at once. Younger children may have simplified the task by editing out the probability dimension, as predicted by Kahneman and Tversky (1979). The striking finding may be that older children were aware that losses and gains must be weighted by their probabilities, even when those probabilities do not vary across alternatives. Gender differences in quantitative reasoning are sometimes reported and such differences could explain boys' more frequent use of a multiplicative rule. It is also possible, however, that boys have more experience with some activity more specifically related to reasoning with random quantities, such as board games using dice.

As in our previous study (Tester, *et al.,* 1987), sensitivity to losses increases with age. Given the presumption that adults are, on average, risk averse, the finding that young children are generally risk seeking is striking and poses the question of what induces the shift. We speculate that young children's choices are frequently made in the presence of parents and teachers, who scaffold their decision making in a way that increases the probability of successful outcomes and reduces the probability of losing. Increasing maturity may bring increasing exposure to loss in risky choices, and greater sensitivity to it in this task.

The finding that girls were more risk averse and boys more risk seeking fits well with naturalistic data about gender differences in risk taking behavior during adolescence (see Gardner, in press; Gardner & Herman, 1990) and with data on gender differences in personality characteristics like sensation seeking (Zuckerman, 1979). Our finding is notable, however, because it is obtained on a 'cold cognition' task that does not involve either emotional arousal or physical risk taking that might heighten gender differences. Moreover, even though children shift from a risk seeking to a risk averse stance during the period from 7 to 13 years of age, gender differences in preferences for risk are already pronounced at 7 years of age and appear to change little in later childhood.

Finally, we offer a comment on the descriptive adequacy of the 'strategy' construct as applied to children's decision-making. In developing the method used in this experiment, we looked for evidence of strategies, but anticipated the need to sift through noise to find them. Having completed the study, we now wonder whether the model of *observed choice = strategy + noise* is the right one. On the one hand, the coherent patterns of age and gender differences, including the replication of our previous result about age differences in the use of loss information, convince us that we are measuring significant individual and developmental variation in risky decision-making, at least on this task. On the other hand, the magnitude of the noise that must be sifted through to find the strategies suggest that 'strategy' may be the wrong metaphor to describe children's risky decision-making.

Strategy suggests behavior that is more methodical than is characteristic of most, although not all, of the children who performed this task. Perhaps we should picture children's risky decision-making not as a rule-governed strategy, but as a loosely systematic improvisation, guided by an awareness of what information is most telling in a specific context (Gardner & Rogoff, 1990). If so, the developmental shift in the data represented by, for example, the fit of the *multiply* prediction to the older children's data, is not best described as a replacement of an additive rule by a multiplicative rule. A better description may be that children show increasing awareness that the relevance of gain or loss information to a decision depends on the co-occurring probabilities of each outcome.

References

Aldrich, J., & Nelson, F. (1984). *Linear probability, logit, and probit models.* Beverly Hills: Sage.

Anderson, N., & Cuneo, D. (1978). The height + width rule in children's judgments of quantity. *Journal of Experimental Psychology: General, 107,* 335-378.

Blum, R. (1987). Contemporary threats to adolescent health in the United States. *Journal of the American Medical Association, 257,* 3390-3395.

Furby, L., & Beyth-Marom, R. (in press). Risk taking in adolescence: A decision-making perspective. *Developmental Review.*

Gardner, W. (in press). A life-span theory of risk-taking. To appear in N. Bell (Ed.), *Adolescent and adult risk taking: The eighth Texas Tech Symposium on Interfaces in psychology.* Lubbock, TX: Texas Tech University Press.

Gardner, W., & Herman, J. (1991). Adolescent AIDS risk-taking: a rational choice perspective. In W. Gardner, S. Millstein, & B. Wilcox (Eds.). *Adolescents in the AIDS epidemic.* San Francisco: Jossey-Bass, pp. 17-34.

Gardner, W., & Rogoff, B. (1990). Children's deliberateness of planning according to task circumstances. *Developmental Psychology, 26,* 480-487.

Gardner, W., Scherer, D., & Tester, M. (1989). Asserting scientific authority: Cognitive development and adolescent legal rights. *American Psychologist, 44,* 895-902.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 47,* 263-291.

Lopes, L. (1987). Between hope and fear: The psychology of risk. In L. Berkowitz (Ed.), *Advances in experimental social psychology. Vol. 20* (pp. 255-295). Orlando: Academic Press.

Parham v. J.R., 422 U.S. 584, 603 (1979).

Rest, J. (1983). Moral cognition. In J. Flavell & E. Markman (Eds.), *Cognitive Development.* New York: Wiley.

Scherer, D. (in press). The capacities of minors to exercise voluntariness in medical treatment decisions. *Law and Human Behavior.*

Siegler, R. (1981). Developmental sequences between and within concepts. *Monographs of the Society for Research in Child Development, 46* (Serial No. 189).

Surber, C. (1984). Issues in using quantitative rating scales in developmental research. *Psychological Bulletin, 95,* 226-246.

Tester, M., Gardner, W., & Wilfong, E. (1987). Experimental studies of decision making competence. Presented at the Symposium *Children, decisions, and risks* at the meetings of the American Psychological Association, August, New York.

Weithorn, L., & Campbell, S. (1982). The competency of children to make informed treatment decisions. *Child Development, 53,* 1589-1599.

Zuckerman, M. (1979). *Sensation seeking: beyond the optimal level of arousal.* Hillsdale, NJ: Erlbaum.

Table 1

Spinner layout design

	Spinners					Spinners					Spinners			
	1	2	3	4		1	2	3	4		1	2	3	4
Layout	1				Layout	2				Layout	3			
Probability	.20	.20	.20	.20		.90	.90	.90	.90		.35	.35	.35	.35
Gain	3	1	2	2		5	1	3	3		7	1	4	4
Loss	2	2	1	3		3	3	1	5		4	4	1	7
Layout	4				Layout	5				Layout	6			
Probability	.60	.60	.60	.60		.25	.25	.25	.25		.70	.70	.70	.70
Gain	6	4	5	5		9	5	7	7		9	3	6	6
Loss	5	5	4	6		7	7	5	9		6	6	3	9
Layout	7				Layout	8				Layout	9			
Probability	.80	.80	.80	.80		.10	.10	.10	.10		.65	.65	.65	.65
Gain	3	1	2	2		5	1	3	3		7	1	4	4
Loss	2	2	1	3		3	3	1	5		4	4	1	7
Layout	10				Layout	11				Layout	12			
Probability	.40	.40	.40	.40		.75	.75	.75	.75		.30	.30	.30	.30
Gain	6	4	5	5		9	5	7	7		9	3	6	6
Loss	5	5	4	6		7	7	5	9		6	6	3	9

Table 2

Average Strategy Scores as a Function of Gender

	Gender					
Strategy	Girls		Boys		Total	
MULTIPLY	2.85	(.61)	3.05	(.70)	2.96	(.67)
GAINFIRST	2.20	(.80)	2.61	(.80)	2.43	(.82)
LOSSFIRST	2.66	(1.10)	2.18	(.90)	2.40	(1.02)

Note. Standard deviations are in parentheses.

Figure captions

1. A four-spinner layout.

2. A three-spinner layout, presented to the subject after the choice of the upper-left-hand spinner.

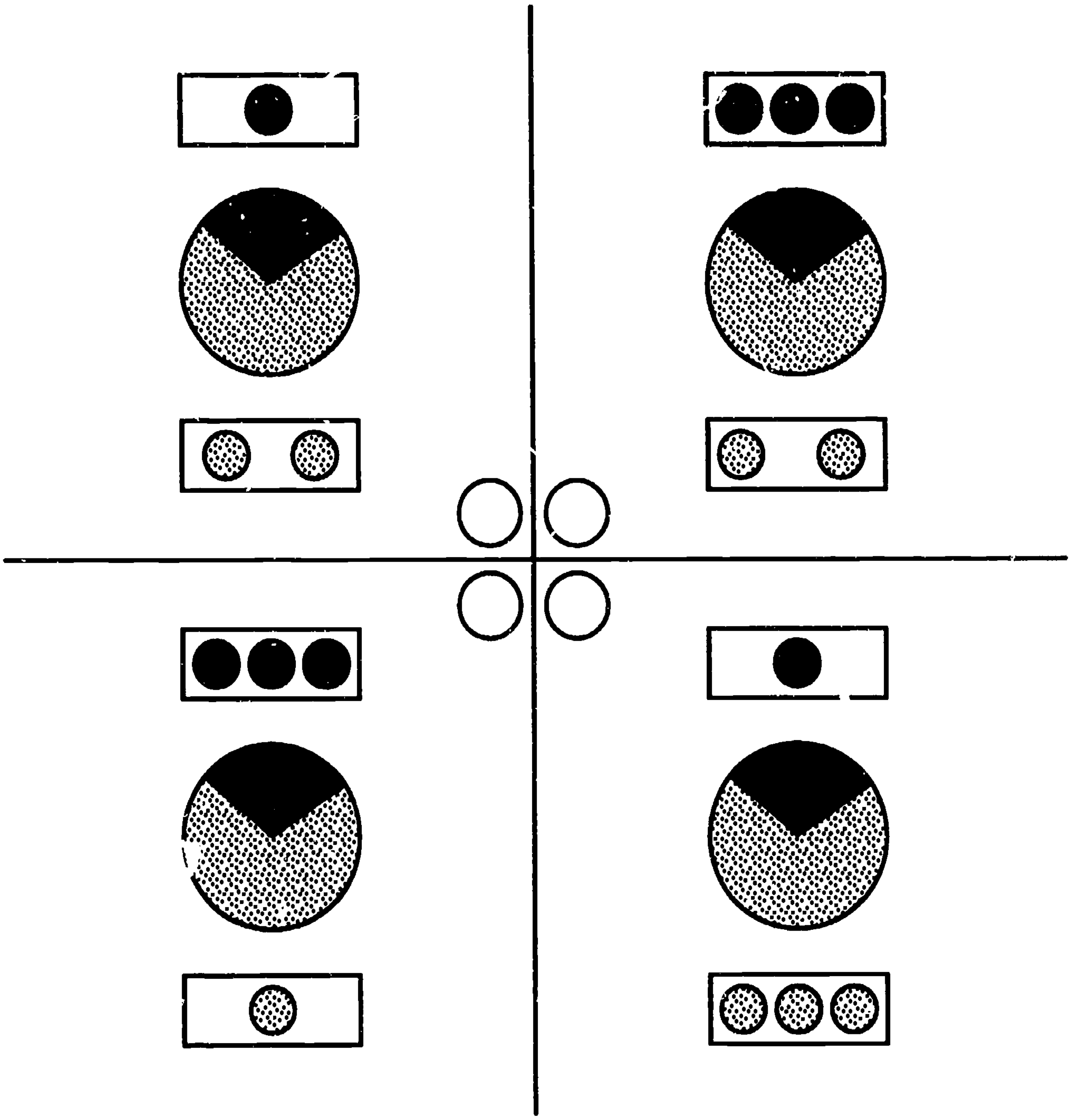

Figure 1.

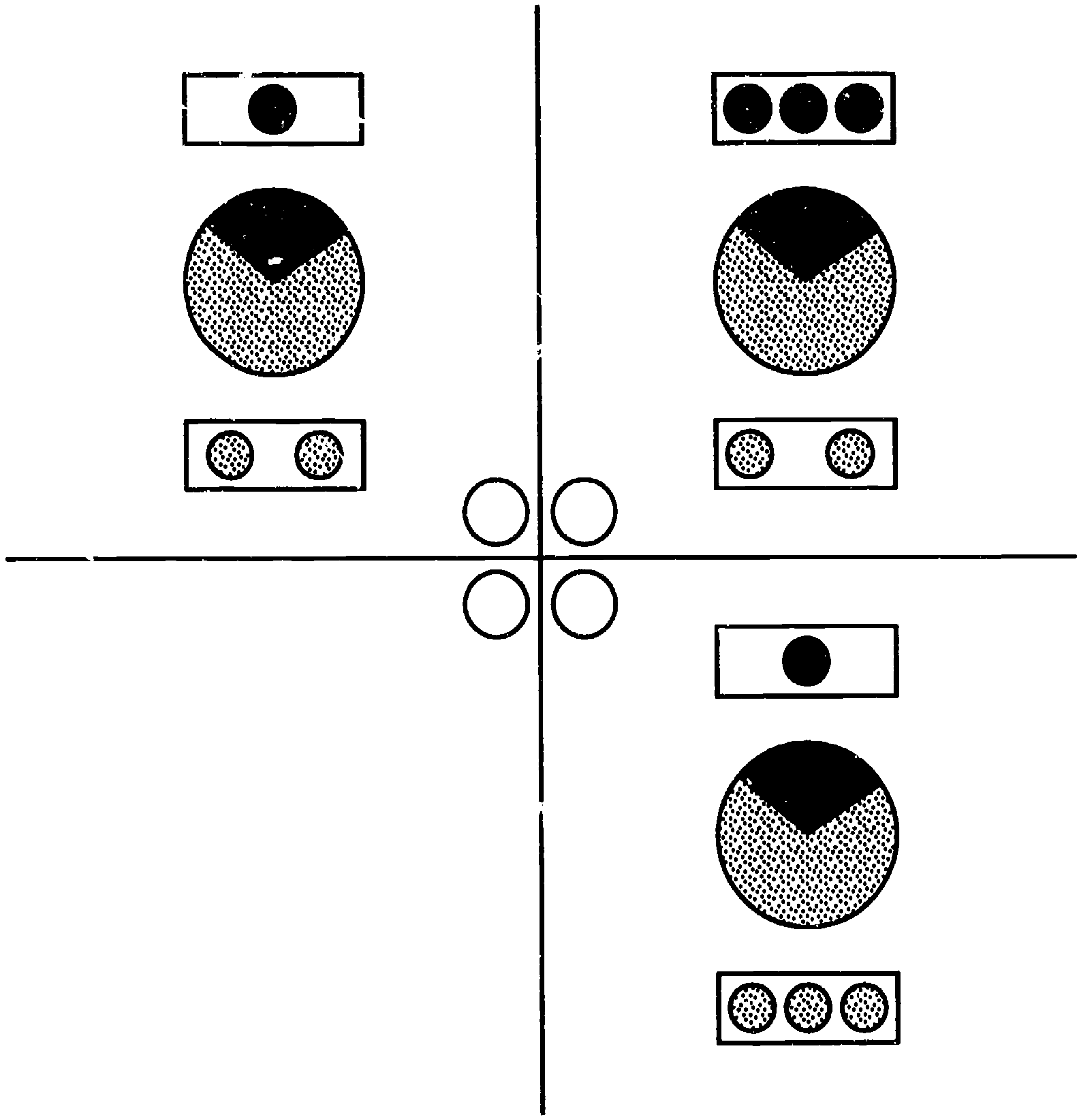

Figure 2.