Free Choice and Cognitive Dissonance Revisited: Choosing "Lesser Evils" Versus "Greater Goods"

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Free Choice and Cognitive Dissonance Revisited: Choosing "Lesser Evils" Versus "Greater Goods"

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Traditional dissonance theory predicts a spreading apart of chosen and rejected alternatives following a decision. More recent constraint satisfaction models of this classic free-choice paradigm suggest that these effects may vary with the overall attractiveness of the choice options. This prediction was tested with 13-year-olds choosing among posters. As in prior computer simulations, a difficult choice between generally less desirable alternatives produced a large increase in participants' evaluations of the chosen alternative, whereas a difficult choice between generally more desirable alternatives produced a large decrease in evaluations of the rejected alternative. The results were discussed in terms of the relative amounts of dissonance created in the various conditions. The utility of the consonance constraint satisfaction model that generated these novel predictions was stressed.

There's small choice in rotten apples.
—William Shakespeare (*The Taming of the Shrew*)

For more than four decades, it has been known that people tend to rationalize the choices they make—increasing their evaluations of chosen alternatives and decreasing their evaluations of rejected alternatives. Indeed, demonstrations of such reevaluation effects following free choices have comprised one of the major paradigms of Festinger's (1957, 1964) theory of cognitive dissonance.

More recently, however, Shultz and Lepper (1992, 1996) have presented a computational, constraint satisfaction model of these and other cognitive dissonance phenomena. In addition to replicating the results of previous studies, simulations generated by this consonance model suggest a number of new and more precise predictions about the consequences of decisions. In particular, these simulations predict differences in the specific form of dissonance reduction as a function of the general level of attractiveness of the choice options—whether a person is choosing, for example, between two highly tempting desserts or two overcooked and unttractive green vegetables. Such predictions not only constitute a highly rigorous test of the consonance model but also illustrate how this model can be useful for guiding contemporary psychological research. This article, therefore, reports new psychological data directly testing these specific predictions.

THE FREE-CHOICE PARADIGM

In the traditional free-choice paradigm (Brehm, 1956; Festinger, 1957), choosing between alternatives creates cognitive dissonance because the chosen alternative is never perfect, and the rejected alternative often has desirable aspects that are necessarily foregone as soon as an irreversible choice is made. Once a choice has been made, however, dissonance can be reduced by increasing one's evaluation of the chosen alternative and/or decreasing one's evaluation of the rejected alter-

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native. Such dissonance reduction serves to further separate the choice alternatives in terms of their desirability.

Theoretically, the amount of dissonance is greater the closer the alternatives are in desirability before the choice is made. The closer the alternatives are in their initial desirability, the more difficult is an exclusive choice between them. Note, however, that there would be no dissonance if the two alternatives were identical except in magnitude as, for example, in a choice between two amounts of money. This is because dissonance depends on the presence of qualitative differences between the alternative choices. With such qualitative differences between the alternative choices, the more dissonance created by the choice, the greater the increase in separation between the alternatives should be after the choice has been made.

In the classic free-choice experiment, female university students were requested to rate eight different small household appliances (Brehm, 1956). The participants were then given either a difficult choice (i.e., between two alternatives that had both been rated high) or an easy choice (i.e., between one alternative that had been rated high and another alternative that had been rated low) of which of two appliances to take home as payment for their participation. After participants had made a decision, they were asked to rate the eight appliances again. The amount of separation or "spreading apart" of the alternatives was measured by subtracting the first rating from the second rating for each of the two choice alternatives. Even though cognitive dissonance theory had predicted only a greater separation with a difficult choice than with an easy choice, most of the actual separation proved to be due to a relatively large decrease in the value of the rejected alternative in the difficult choice condition. These data are plotted in Figure 1 in terms of mean changes in evaluations.

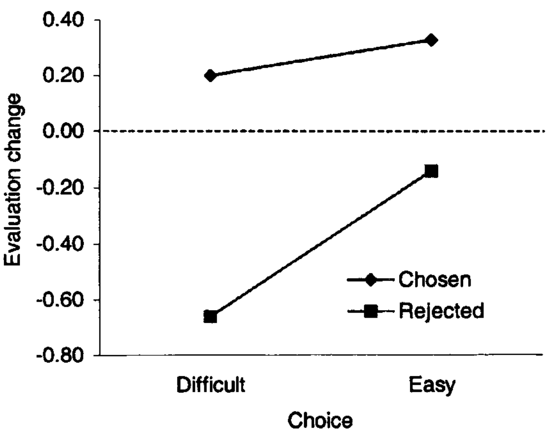

Figure 1 Mean change in the evaluation of chosen and rejected objects.
SOURCE: Adapted from Brehm (1956).

CONSTRAINT SATISFACTION NETWORKS

Recently, Shultz and Lepper (1992, 1996) simulated these and other cognitive dissonance phenomena using a constraint satisfaction connectionist network model known as the consonance model. Such artificial neural networks are inspired by some of the basic computational properties of the human brain. Brain neurons can be characterized by an average rate of firing, which is represented in artificial neurons (known as units) as an activity level implemented as a real number. The activity of brain neurons is known to be modulated by their input from other neurons. Such input is a function of both the activity of sending neurons and the synaptic connections between the sending and receiving neurons. Many brain neurons sum their inputs, which can be excitatory or inhibitory, and use this net input to modulate their current level of activity. In artificial neural networks, synapses are represented by real numbers, which can be positive (representing excitatory synapses) or negative (representing inhibitory synapses). Inputs to an artificial neuronal unit are computed as the product of the activity of a sending unit and the connection weight between the two units. Each input is either excitatory or inhibitory, depending on whether the product is positive or negative, respectively. The inputs are summed across the sending units and then used to modulate the current activity of the receiving unit. Positive net inputs increase the activity of the receiving unit, and negative net inputs decrease this activity. Generally, units have floor and ceiling levels of activation, so the function that converts input into a revised activation level is effectively nonlinear, giving rise to many interesting computational properties.

Computer simulations suggest that constraint satisfaction principles may underlie a wide range of psychological phenomena, including memory retrieval, revision of beliefs, explanation, comprehension, schema completion, analogical retrieval and mapping, person perception, attitude change, and cognitive balance (e.g., Holyoak & Thagard, 1989; Kintsch, 1988; Kunda & Thagard, 1996; Read & Miller, 1993, 1994, 1998; Rumelhart, Smolensky, McClelland, & Hinton, 1986; Sloman, 1990; Spellman & Holyoak, 1992; Spellman, Ullman, & Holyoak, 1993; Thagard, 1989). Thus, there may be considerably more continuity between cognitive dissonance and other psychological phenomena than had been previously realized (Shultz & Lepper, 1996, 1998). Good introductory treatments of constraint satisfaction networks can be found in Rumelhart et al. (1986) and Anderson (1995, ch. 12).

THE CONSONANCE MODEL

The consonance model is based on the idea that reduction of cognitive dissonance can be interpreted as a constraint satisfaction problem. The motivation to increase cognitive consistency that is postulated by dissonance theory and other consistency theories can be viewed as imposing constraints on the beliefs and attitudes that a person holds simultaneously (Abelson et al., 1968; Abelson & Rosenberg, 1958; Feldman, 1966). Such problems can be solved mathematically by satisfying a number of soft constraints that can vary in their relative importance. In this context, soft constraints are those that are desirable but not essential to satisfy.

In this model, consonance networks correspond to a person's representation of the situations created in the conditions of a cognitive dissonance experiment. There are two components to these networks: units that represent cognitive elements and connection weights that represent relations between units. Units in a network can be variously active, representing the direction and strength of the person's beliefs and attitudes. Each cognition is represented by a pair of negatively connected units. In each such pair, one unit represents the positive pole of the cognition, and the other unit represents the negative pole of the cognition. Activity on the positive unit indicates that something represented by the pair is believed to be true or is positively evaluated; activity on the negative end indicates that something is believed to be false or is negatively evaluated. In either case, the higher the activation, the stronger the belief or evaluation. The negative relation between the units in each pair reflects the natural tension between truth and falsity or between like and dislike. The net value of the cognition is computed as activation on the positive unit minus activation on the negative unit. This representation scheme allows for some degree of ambivalence in cognitions, but the tendency is for any such ambivalence to be resolved as activity in one unit dampens activity of the other unit in the pair.

Pairs of units may also differ in how resistant they are to change, reflecting differences in the extent to which the cognitions they represent are strongly anchored in reality or are supported by other cognitions. Resistance to change is implemented in the consonance model as a multiplier that scales the amount of change produced by net input. Beliefs (e.g., I just said that I like x) are more resistant to change than attitudes (e.g., I like x), reflecting the fact that beliefs in dissonance experiments are generally anchored in reality, often reflect what just happened to the person, and are typically designed to be difficult to undo or distort. In contrast, participants in dissonance experiments may be quite uncertain about how they feel about some novel evaluation that they are asked to make.

In a consonance network, connection weights between cognitions represent psychological implications among these belief and attitude units. Connection weights between any two units can be excitatory, inhibitory, or nonexistent, corresponding, respectively, to the three basic relationships between cognitions—consonant, dissonant, and irrelevant—postulated by dissonance theory. Unit activations and connection weights can vary across the different conditions of a single experiment as a function of relevant procedural manipulations. Consonance is essentially the degree to which similarly evaluated units are connected by excitatory (positive) weights and oppositely valued units are connected by inhibitory (negative) weights. These are cognitive states that are locally consistent. As the simulation runs, unit activations change over time cycles to increase consonance while satisfying the various constraints imposed by current unit activations and connection weights. At each time cycle, some number of units are randomly selected to have their activation updated. Eventually, the network typically saturates, meaning that it becomes as consonant as it can be under the circumstances.

CONSONANCE MODEL PREDICTIONS FOR THE FREE-CHOICE PARADIGM

In our consonance model simulations of the Brehm (1956) experiment, the difficult choice condition was referred to as *difficult/high* because both alternatives had relatively high initial evaluations (Shultz & Lepper, 1996). These simulations also included a *difficult/low* choice condition, however, which had not been used in previous free-choice experiments. This condition featured two alternatives relatively low but close to one another in initial evaluations. Network specifications for these free-choice simulations are shown in Figure 2. There were three cognitions, two of which are evaluations of the alternative objects and one the decision itself. The decision cognition had an initially high value, and the initial evaluations of the alternative objects depended on condition. There was a positive relation between the decision and the chosen object, reflecting the fact that the most positive evaluation led to the decision, and a negative relation between the two alternative objects, reflecting the fact that they were competing for an exclusive choice.

Following Brehm (1956), we computed evaluation differences as final evaluation minus initial evaluation for each alternative. Mean difference scores for the chosen and rejected alternatives (i.e., reevaluation—initial evaluation) after the networks had saturated are

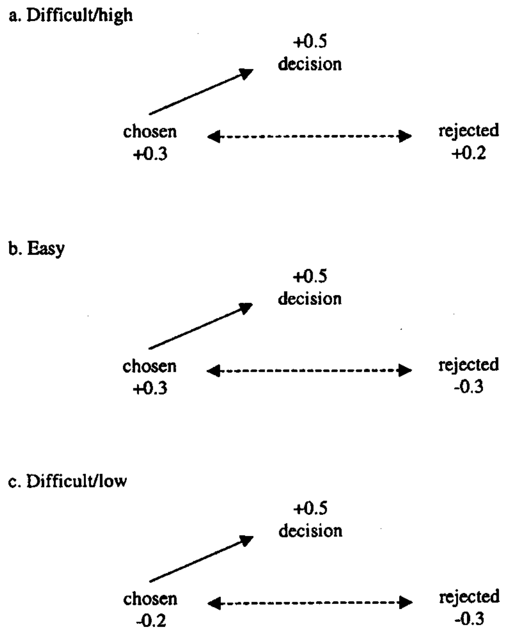

Figure 2 Network specifications for simulation of three conditions of a free-choice experiment.
SOURCE: Shultz and Lepper (1996).
NOTE: In each condition, there are three cognitions: the decision, evaluation of the chosen alternative, and evaluation of the rejected alternative. Initial net activations of these three cognitions are indicated by real numbers placed next to the name of the cognition. Positive implications between cognitions are indicated by solid arrows; negative implications are indicated by dashed arrows. Direction of the arrows indicates assumed cause-to-effect implications. Actual networks are more complicated than these schematic diagrams because each cognition is implemented by a pair of negatively connected units and because connection weights between units are bi-directional.

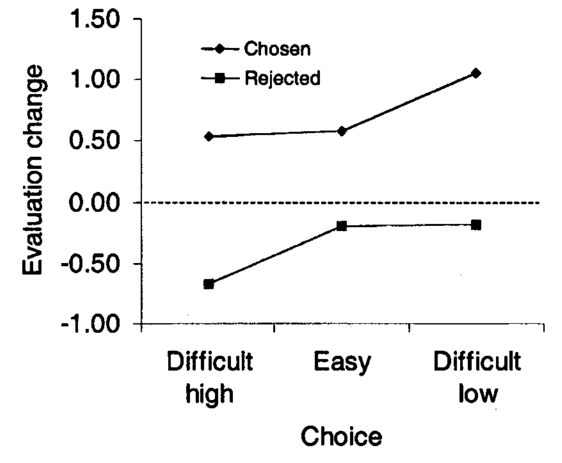

Figure 3 Mean change in the evaluation of chosen and rejected objects in a simulation by the consonance model.
SOURCE: Shultz and Lepper (1996).

plotted in Figure 3.[1] The evaluation difference scores were subjected to ANOVAs in which the nature of the choice served as a between-network factor, and choice alternative served as a within-network factor. The findings yielded a strong interaction between alternative and choice condition, $F(2, 57) = 21.44$, $p < .001$. When dissonance reduction in the simulations reached asymptote, evaluation of the chosen object had increased, but more so in the difficult/low condition, and evaluation of the rejected object had decreased, but more so in the difficult/high condition. As Figure 3 reveals, most of the action was produced by a decrease in evaluation of the rejected alternative in the difficult/high choice condition and an increase in evaluation of the chosen alternative in the difficult/low choice condition.

It is apparent that these simulation findings match Brehm's (1956) human data in Figure 1 quite precisely. Considering only the difficult/high and the easy choice conditions that were used in Brehm's experiment, the largest effects in both the simulation and the human data were due to the decrease in evaluation of the rejected alternative. Thus, these simulation results fit Brehm's (1956) human data more precisely than did cognitive dissonance theory. Dissonance theory merely predicted a larger separation of the alternatives following a difficult choice than following an easy choice but not the particularly large decrease in liking of the rejected alternative.[2]

In addition, use of the new difficult/low choice condition in the simulation provided some new predictions from the consonance model. In this new condition, the largest effect was created by the rise in evaluation of the chosen alternative. Moreover, the rise in evaluation of the chosen alternative in this difficult/low choice condition was greater than the fall in evaluation of the rejected alternative in the difficult/high choice condition. This difference was assessed by a two-tailed, unpaired t test comparing the absolute values of the difficult/high rejected alternative scores to those of the difficult/low chosen alternative scores, $t(38) = 6.70$, $p < .001$.

The purpose of the present study was to test these simulation predictions with people by adding a difficult/low choice to the original Brehm (1956) design. The experiment involved 13-year-olds choosing among posters. Each participant rated eight commercially available posters, made a choice between two of them, and then rated the posters again. Choice conditions included difficult/high, easy, and difficult/low. In the control condition, participants rated the posters twice but without any intervening choice. The no-choice control condition was included to control for regression-to-the-mean effects, that is, the tendency for both high and low scores to move toward the mean when reassessed under conditions of substantial measurement error.

METHOD

Participants

The participants were 107 French-speaking 13-year-old school children enrolled in a summer day camp in Montreal. There were 68 females and 39 males. Each child received a poster for participating. There were 19 girls and 8 boys in the difficult/high choice condition, 16 girls and 10 boys in the easy choice condition, and 16 girls and 9 boys in the difficult/low choice condition. In the control conditions, there were 17 girls and 12 boys.

Objects of Choice

Alternative objects to be rated and chosen were 11 posters that were judged to be somewhat appealing to both genders. Three were used in a practice session, and 8 were used for the actual ratings and choices. Four were paintings (by Dali, Klimt, Renoir, and Van Gogh), and 7 were photographs (of a couple sitting on a car, a baby seal, a sports car, city buildings, Marilyn Monroe, a crying baby, and a tail of a whale emerging from the ocean). Each poster was displayed on a sheet of cardboard.

Procedure

The experiment was described as a study of how people choose among alternatives. Each participant was tested individually in a quiet room by a female experimenter. There was a practice session, initial ratings, choice, and final ratings.

Practice session. Participants were first asked if they already owned any of the 11 posters. If so, those posters were relegated to the owner's practice session. The participant was asked to look at the 11 posters and to imagine how they might look in his or her own home. This was done to ensure that the participant would be involved and that the forthcoming evaluations would be genuine. For each of the three practice posters, participants wrote down a number between –7 and +7 to represent their liking for the poster, with higher numbers indicating greater liking. Then, the three practice posters were evaluated again using a rating system that would be used throughout the initial and final ratings of the other eight posters. Here, the participant placed a check mark on one of a series of 14 rectangles of increasing size. A relatively large number of scale points enabled plenty of room for ratings to change. The rating scale had labels ranging from strongly dislike ("Me déplaît beaucoup") to strongly like ("Me plaît beaucoup"), with midway labels on each side—dislike moderately ("Me déplaît modérément") and like moderately ("Me plaît modérément"). The experimenter examined the two evaluations to determine whether there were any large discrepancies between the two ratings of each object. Any such discrepancies were discussed, stressing the importance of accuracy in the ratings.

First ratings. Each participant was randomly assigned to one of four conditions: difficult/high choice, difficult/low choice, easy choice, or control. The experimenter presented the eight posters in a random order, and the participant rated liking for each one using the 14 rectangles just described. The experimenter emphasized the importance of honesty, accuracy, and spreading the ratings throughout the entire scale.

Choice. After completing the first set of ratings, the participant wrote answers to some written questions that were not directly relevant to the study, for example, "What is your birth date?" and "What are your hobbies?" During this filler interval of about 90 seconds, the experimenter selected the choice objects to fit the randomly assigned condition. For participants in the difficult/high choice condition, she eliminated objects with ratings of +6 or +7 and then selected the two next highest rated objects. For the easy choice condition, she eliminated objects with ratings of +6, +7, –6, and –7 and selected the next highest and next lowest rated objects, respectively. For participants in the difficult/low choice condition, she eliminated objects with ratings of –6 or –7 and then selected the two next lowest rated objects. This procedure allowed sufficient room for change on the final ratings.

The experimenter explained that participants could keep the posters they chose. Participants were encouraged to take as much time as required to choose and were told that their choices were irreversible. The time it took to make the choice was recorded as a check on the manipulation of choice difficulty. If the choices were selected properly, one might expect that difficult choices would take more time than easy choices. For participants in the control condition, this choice took place after rather than before the final ratings.

Final ratings. The participant then rated the eight posters again using the same 14-rectangle procedure as in the first ratings. It was stressed that the participant was free to change his or her mind about any poster. To minimize memory effects, the posters were presented in a different random order than in the first ratings. Although all eight posters were rated, we concentrated in data analysis only on rating changes for the two posters involved in the choice. For both the chosen and the rejected poster, change scores were computed as the difference between final ratings and first ratings.

Control condition. Because the control-condition participants did not make their choices until after the final ratings, we could examine their rating changes on each of the three choice types. They could then serve simultaneously as controls for all three experimental groups.

Debriefing. When the study was finished, participants were each given a written description of the purpose of the study, and the experimenter answered any questions and distributed the chosen posters.

RESULTS

Manipulation Checks

Choice times in seconds for the experimental conditions were subjected to an ANOVA in which type of choice served as a between-subjects factor. In this analysis, there was a significant main effect of choice, $F(2, 76) = 3.52$, $p < .05$. Mean choice times were 16.6 s for the difficult/high condition, 6.8 s for the easy condition, and 13.0 s for the difficult/low condition. To test the specific hypothesis that difficult choices took longer to make than did easy choices, a contrast regression F was tested with weights of +1 for the difficult conditions and –2 for the easy condition.[3] This contrast proved to be significant, $F(1, 76) = 6.21$, $p < .025$, and the residual was not significant, $F(1, 76) = 0.83$, indicating as predicted that most of the between-group variance in choice times (88%) was due to difficult choices taking longer than easy choices.

Experimental Conditions

The results were analyzed separately for the experimental and control conditions because choice was manipulated in the former but not in the latter conditions. Results for the experimental conditions in terms of mean evaluation changes are presented in Figure 4. A Choice × Object ANOVA, with the three levels of choice (difficult/high, easy, difficult/low) as a between-subjects factor and the two levels of object (chosen and rejected) as a within-subjects factor, revealed main effects of both choice, $F(2, 75) = 10.74$, $p < .001$, and object, $F(1, 75) = 40.01$, $p < .001$, as well as an interaction between the two, $F(2, 75) = 3.35$, $p < .05$.

To provide a more precise test of the predictions generated by the consonance model, a contrast regression F test, designed to reflect the interaction pattern predicted by the simulations shown in Figure 3, was computed using weights of –1 for the easy and difficult/low rejected cells, –3 for the difficult/high rejected cell, +1 for the difficult/high and easy chosen cells, and +3 for the difficult/low chosen cell. These weights were derived from the pattern of simulation means, the +1 cells being slightly above the no-change mark of 0, the –1 means being slightly below 0, the +3 cell being far above 0, and the –3 cell being far below 0. This predicted contrast proved highly significant, $F(1, 75) = 57.88$, $p < .001$. The residual was not significant, $F(4, 75) = 2.19$, indicating that the pattern of results predicted by our simulation indeed captured most (90%) of the systematic variation in the data.

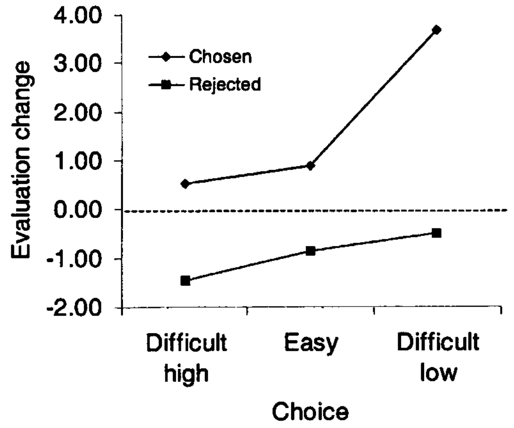

Figure 4 Mean change in the evaluation of chosen and rejected objects in the experimental choice conditions.

To determine whether the predicted interactions held for both the difficult/high and difficult/low choice conditions, we also performed separate contrasts for each of the difficult conditions in comparison to the easy condition. In one of these contrasts, difficult/high versus easy, weights were +2 for the difficult/high and easy chosen cells, –3 for the difficult/high rejected cell, –1 for the easy rejected cell, and 0 for the difficult/low cells, $F(1, 75) = 14.38$, $p < .001$. In the other contrast, difficult/low versus easy, weights were +1 for the easy chosen cell, +3 for the difficult/low chosen cell, –2 for the easy and difficult/low rejected cells, and 0 for the difficult/high cells, $F(1, 75) = 44.28$, $p < .001$. Again, these weights were chosen to mirror the predictions provided by the simulation means. Thus, the simulation predictions were confirmed for both the difficult/high choice and difficult/low choice conditions.

Yet another way to examine these data, consistent with Brehm's (1956) original analysis, is to determine which of the six means differ significantly from the theoretical mean of 0, which represents no change in evaluation. Dunnett's (1955) technique for comparing a number of treatment means against a control mean was modified

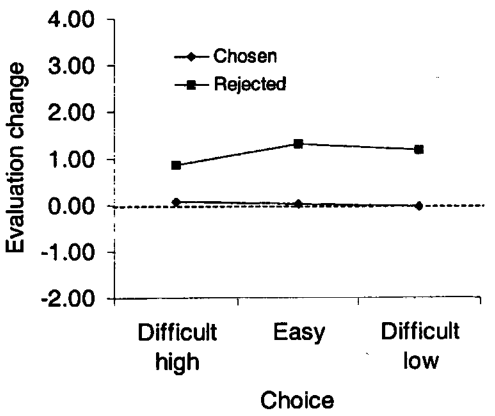

Figure 5 **Mean change in the evaluation of objects to be chosen or rejected in the control conditions.**

for use with a theoretical control mean, in this case a mean of 0. Application of this technique revealed that only the means for the rejected object in the difficult/high choice and the chosen object in the difficult/low choice conditions differed from 0, $p < .01$. None of the other four means in Figure 4 differed significantly from 0, $p > .05$.

Finally, as with our prior simulations (Shultz & Lepper, 1996), in absolute values the difficult/high choice rejected object difference scores proved lower than the difficult/low choice chosen object difference scores, $t(50) = 2.97$, $p < .01$. That is, the decrease in evaluation of the rejected alternative in the difficult/high choice condition was less than the increase in evaluation of the chosen alternative in the difficult/low choice condition.

Control Condition

Comparable results for the control condition, once again in terms of mean evaluation changes, are presented in Figure 5. An ANOVA, with both object and choice as repeated measures, yielded only a main effect of object, $F(1, 28) = 8.89$, $p < .01$. Unlike the experimental conditions, evaluations of the rejected object increased more than did evaluations of the chosen object. Although this finding is meaningless in isolation because control participants did not make their choice until after the final ratings, it does indicate that the results for the experimental conditions could not be due merely to regression-to-the-mean effects. The results for control participants are quite different than those predicted by the simulations and found for the experimental conditions.

DISCUSSION

Thus, the present study confirmed the predictions from the consonance constraint satisfaction model of the differences in locus of spreading apart effects in the free-choice paradigm as a function of the general desirability of the choice alternatives (Shultz & Lepper, 1996). The subtleties of the obtained interaction are not explained by classical dissonance theory, which only predicts more separation of the evaluations of the chosen and the rejected alternatives for difficult choices than for easy choices.

The more precise interaction obtained between choice condition and alternative in both the simulations and the present psychological data can be viewed, in part, in terms of greater changes in the evaluation of the alternative that has the most room to change in a given direction. For the chosen alternative, the direction of evaluative change is upward, and there is more room to move up in the difficult/low choice condition, where the chosen alternative is not highly evaluated to begin with, than in the other two conditions, where it begins with relatively high evaluations. For the rejected alternative, the direction of change is downward, and there is more room to move in that direction in the difficult/high choice condition, where the rejected alternative starts with a relatively high evaluation, than in the other two conditions, where it starts with relatively low evaluations. Although this interpretation may seem obvious once it has been pointed out, it has not to our knowledge ever appeared in print, nor has the precise data pattern even been acknowledged in the literature.

Actually, the data pattern in both simulation and present experiment is even more subtle than that. As noted, evaluation of the chosen alternative in the difficult/low choice condition rose more than evaluation of the rejected alternative in the difficult/high choice condition declined. This finding seems immune to an explanation based on differential room to move. Later, we explain this finding in terms of differential dissonance levels.

It is also important to note that these results are not due to the statistical phenomenon known as regression to the mean. Such a possible interpretation is eliminated by results obtained in the control condition, in which participants merely rated the posters twice before making a choice. An explanation based on regression to the mean would predict that the mean change scores in the control condition would resemble those found in the experimental choice conditions. That is, there should be a large increase in evaluation of the better alternative in the difficult/low choice condition and a large decrease in evaluation of the lesser alternative in the difficult/high choice condition. But mean evaluation change scores for the control conditions were nothing like those in the choice conditions. Instead, they revealed only a relatively constant increase in evaluation of the rejected object across comparisons, as shown in Figure 5. Thus, the predicted interaction shown in Figure 3 could not be due merely to regression-to-the-mean effects.

In the simulations using the consonance constraint satisfaction model (Shultz & Lepper, 1996), it was possible to plot dissonance reduction over time cycles.[4] Dissonance was defined as the negative of total consonance divided by r, the number of nonzero (i.e., dissonant plus consonant) intercognition relations in the network:

$$dissonance = \frac{-consonance}{r}. \qquad (1)$$

Consonance, in turn, was defined as the sum of triple products of sending unit activations, receiving unit activations, and the weights connecting them

$$consonance = \sum \sum w_{ij} a_i a_j. \qquad (2)$$

Where w_{ij} is the weight between units i and j, a_i is the activation of the receiving unit i, and a_j is the activation of the sending unit j. Basically, consonance is high when positive connection weights link highly active sending and receiving units and when negative connection weights link units that have opposite levels of activation (one unit having positive activation and the other unit having negative activation).

This definition of dissonance goes beyond the original definition given by Festinger (1957). Not only is it formalized, but it also assesses the amount of dissonance in each intercognition relation, includes within-cognition ambivalence, and can vary even when all relations are dissonant or all relations are consonant. In our simulations, initial dissonance was greater in the difficult/low choice condition than in the difficult/high choice condition, which in turn showed more initial dissonance than the easy choice condition. Over time cycles, dissonance decreased to about equal levels in all three conditions.

Classical dissonance theory would have predicted the finding of more initial dissonance for a difficult/high choice than for an easy choice, but simulations with the consonance model suggested that there may be even more initial dissonance in the difficult/low choice condition. Apparently, being forced to choose between less attractive alternatives is especially dissonance arousing.[5] Classical dissonance theory would appear to have no particular prediction to make about the relative amounts of dissonance in difficult/low versus difficult/high choices unless perhaps dissonance theory could be stretched to predict more dissonance in the difficult/high choice than in the difficult/low choice condition because the initial low evaluations of the alternatives in the former condition might decrease the importance of the choice. The actual simulation finding of greater dissonance in the difficult/low choice condition than the difficult/high choice condition, however, can be used to explain why evaluation of the chosen alternative in the difficult/low choice condition increased more than evaluation of the rejected alternative in the difficult/high choice condition decreased. Such an explanation would stress that greater dissonance produces more evaluation change.

Psychologically, the higher dissonance in the difficult/low condition than in the difficult/high condition might stem from the knowledge that even a good decision does not yield a very favorable outcome when the alternatives are poor. We can be more precise about the source of this effect in networks. It is due to much lower triple products contributing to consonance in Equation 2 for the difficult/low condition than for the difficult/high condition. More particularly, these triple products are lower in the difficult/low condition because the initial value of the chosen object is so low on account of the relative undesirability of that object. Because dissonance as defined in Equation 1 is essentially the negative of consonance, there is then considerably more dissonance in the difficult/low condition than in the difficult/high condition. Again, having to choose something relatively undesirable arouses considerable dissonance. This underscores the benefits of making the processes of dissonance arousal and reduction computationally explicit.

Although dissonance theory has been fairly thoroughly studied over the many years of its existence, our recent constraint satisfaction modeling appears to have uncovered some new and useful predictions. In addition to the free-choice phenomena focused on here, it might be worthwhile to exploit the ability of the consonance model to generate predictions for more complex situations involving many cognitions instead of the mere three or four cognitions dealt with in typical verbal formulations of classical dissonance theory.

In presenting the current findings, we are sometimes asked to provide examples of difficult/low choices, apparently because it is assumed that people are more likely to seek out choices among relatively well-liked items than among items that they do not particularly like. People trying to economize by choosing among lower cost and lower quality consumer items might be one common example. In such cases, the present model would predict sharp increases in evaluation of chosen alternatives, all other considerations being equal.

Another common example of a difficult/low choice might be political elections, in which voters are often forced to choose among candidates, none of whom attract great popular support. It would be interesting to investigate changes in the evaluations of elected candidates that could be predicted by dissonance reduction. For example, different effects might be predicted as a function of the specific locus of reevaluation of alternatives for election campaigns in which "winners" continue as candidates, whereas "losers" do not.

Returning to the Shakespearean quotation with which we began, there may not be an attractive alternative among rotten apples, but the process of choosing one of them can have important repercussions. Choosing between relatively unattractive, qualitatively distinct objects is difficult to do, is particularly dissonance arousing, and can yield large increases in the value of the chosen alternative.

NOTES

1. The results in Figure 2 represent a low level of parameter randomization. As parameter randomization increased, the interaction weakened statistically, but the pattern of evaluation change remained fairly constant. See Shultz and Lepper (1996) for details.

2. In fact, dissonance theory should actually predict a greater increase in the evaluation of the chosen alternative in the difficult than in the easy choice condition. The obtained lack of difference could be rationalized, however, if the chosen alternative in the difficult choice condition were more inherently resistant to change or if ceiling effects precluded higher evaluations.

3. The sum of such contrast weights must be 0. See Rosenthal and Rosnow (1985) for further details.

4. Although it is not yet clear how time cycles in a network relate to the time taken by psychological processes such as dissonance reduction, we assume that dissonance reduction in people is not instantaneous but rather must occur in real time just as other psychological processes do.

5. It should be noted that, although the two alternatives in the difficult/low condition were clearly less desirable than those in the difficult/high condition, these choices were not in absolute terms disliked. If the alternatives were actively noxious or unpleasant, some additional inducing pressure would be needed to force a choice, and the paradigm would become one of forced compliance (Brehm & Cohen, 1962).

REFERENCES

Abelson, R. P., Aronson, E., McGuire, W. J., Newcomb, T. M., Rosenberg, M. J., & Tannenbaum, P. H. (Eds.). (1968). *Theories of cognitive consistency: A sourcebook.* Chicago: Rand McNally.

Abelson, R. P., & Rosenberg, M. J. (1958). Symbolic psycho-logic: A model of attitudinal cognition. *Behavioral Science, 3,* 1-13.

Anderson, J. A. (1995). *An introduction to neural networks.* Cambridge, MA: MIT Press.

Brehm, J. W. (1956). Post-decision changes in the desirability of choice alternatives. *Journal of Abnormal and Social Psychology, 52,* 384-389.

Brehm, J. W., & Cohen, A. R. (1962). *Explorations in cognitive dissonance.* New York: John Wiley.

Dunnett, C. W. (1955). A multiple comparison procedure for comparing several treatments with a control. *Journal of the American Statistical Association, 50,* 1096-1121.

Feldman, S. (Ed.) (1966). *Cognitive consistency.* New York: Academic Press.

Festinger, L. (1957). *A theory of cognitive dissonance.* Evanston, IL: Row, Peterson.

Festinger, L. (1964). *Conflict, decision, and dissonance.* Stanford, CA.: Stanford University Press.

Holyoak, K. J., & Thagard, P. (1989). Analogical mapping by constraint satisfaction. *Cognitive Science, 13,* 295-355.

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction-integration model. *Psychological Review, 95,* 163-182.

Kunda, Z., & Thagard, P. (1996). Forming impressions from stereotypes, traits, and behaviors: A parallel-constraint satisfaction theory. *Psychological Review, 103,* 284-308.

Read, S. J., & Miller, L. C. (1993). Rapist or "regular guy"?: Explanatory coherence in the construction of mental models of others. *Personality and Social Psychology Bulletin, 19,* 526-541.

Read, S. J., & Miller, L. C. (1994). Dissonance and balance in belief systems: The promise of parallel constraint satisfaction processes and connectionist modeling approaches. In R. C. Schank & E. Langer (Eds.), *Beliefs, reasoning, and decision making: Psycho-logic in honor of Bob Abelson* (pp. 209-235). Hillsdale, NJ: Lawrence Erlbaum.

Read, S. J., & Miller, L. C. (Eds.). (1998). *Connectionist models of social reasoning and social behavior.* Hillsdale, NJ: Lawrence Erlbaum.

Rosenthal, R., & Rosnow, R. L. (1985). *Contrast analysis: Focused comparisons in the analysis of variance.* New York: Cambridge University Press.

Rumelhart, D. E., Smolensky, P., McClelland, J. L., & Hinton, G. (1986). Schemata and sequential thought processes in PDP models. In D. E. Rumelhart & J. L. McClelland (Eds.), *Parallel distributed processing: Explorations in the microstructure of cognition* (Vol. 2, pp. 7-57). Cambridge, MA: MIT Press.

Shultz, T., & Lepper, M. R. (1992). A constraint satisfaction model of cognitive dissonance phenomena. In *Proceedings of the Fourteenth Annual Conference of the Cognitive Science Society* (pp. 462-467). Hillsdale, NJ: Lawrence Erlbaum.

Shultz, T. R., & Lepper, M. R. (1996). Cognitive dissonance reduction as constraint satisfaction. *Psychological Review, 103,* 219-240.

Shultz, T. R., & Lepper, M. R. (1998). The consonance model of dissonance reduction. In S. J. Read & L. C. Miller (Eds.), *Connectionist models of social reasoning and social behavior* (pp. 211-244). Hillsdale, NJ: Lawrence Erlbaum.

Sloman, S. (1990). *Persistence in memory and judgment: Part-set inhibition and primacy.* Unpublished doctoral dissertation, Stanford University, Stanford, CA.

Spellman, B. A., & Holyoak, K. J. (1992). If Saddam is Hitler, then who is George Bush? Analogical mapping between systems of social roles. *Journal of Personality and Social Psychology, 62,* 913-933.

Spellman, B. A., Ullman, J. B., & Holyoak, K. J. (1993). A coherence model of cognitive consistency: Dynamics of attitude change during the Persian Gulf war. *Journal of Social Issues, 49,* 147-165.

Thagard, P. (1989). Explanatory coherence. *Behavioral and Brain Sciences, 12,* 435-502.

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