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Original Article

A Laboratory Simulation of Parental Investment Decisions: The Role of Future Reproductive Opportunities and Quality of Offspring in Determining Levels of Parental Investment

Stefanie L. Turner, Department of Psychology, Knox College, Galesburg, IL, 61401-4999

Francis T. McAndrew, Department of Psychology, Knox College, Galesburg, IL, 61401-4999, Phone: 309-341-7525 FAX: 309-341-7718, Email: fmcandre@knox.edu

Abstract: Hagen's Defection Hypothesis (2002) predicts that a mother's age and the quality of her offspring are critical factors in determining her investment in her newborn. We tested this hypothesis using hamster races in which 113 college student participants received a hamster ("offspring") and 10 poker chips ("resources") to "invest" into the hamster based on information about the quality of the hamster and about the possibility of future races. Subjects invested the most in low quality offspring when they expected to run only one race and the least in low quality offspring when they expected more racing opportunities in the future. Offspring quality affected investment differently depending on the presence or absence of future investment opportunities and the sex of the subject. Overall, the results supported Hagen's model of parental investment and also suggest that parental investment may be explained by conscious as well as unconscious decision-making.

Keywords: Parental Investment, Decision-Making, Parenting

Introduction

In a perfect world, all children would be loved by their parents and all children in each family would be treated equally, with each child receiving as much from the parents as they are able to give. If they are asked about their parenting strategies, most parents would probably report that they work very hard at treating all of their children equally. However, recent work by Hertwig, Davis, and Sulloway (2002) suggests that even parents who diligently pursue equitable treatment of their children may still end up with investment that is biased in favor of some children at the expense of others over the long term. The problem is that first-borns and last-borns are the only children in the family who can ever have exclusive access to the parents' resources; children who are born somewhere in the middle of the family never have the parents to themselves. Thus, different birth order positions will have different handicaps when it comes to extracting resources from the parents. As it turns out, the birth order of the child is only one of many factors that may cause parents to invest differentially in their offspring.

As noble as the goal of equitable treatment for all children may be, parents often must choose between caring for a child and acquiring the resources needed to insure the parents' own reproductive success and they must choose between dividing limited resources between children

who offer them different reproductive payoffs. Natural selection would have operated against parents who could not discriminate between the different potentials of their offspring and then adjusted their parenting accordingly (Low, 2000; Mann, 1992). For their own good, when it will not be possible to raise all of their young successfully to adulthood, parents must selectively invest the most in offspring that have the best chance of surviving and reproducing.

The health of the infant is only one of many factors that determine how much investment it will receive. In fact, investment decisions often have little to do with qualities of the infant *per se*, but rather depend more heavily on parental factors. For example, the fertility, life circumstance, and future reproductive potential of the mother are always critical considerations. The mother must manage her reproductive behavior to make the most out of the hand that has been dealt to her by life (Hrdy, 1999). Young women with many reproductive years ahead of them may be more tempted to give up on a questionable child when her life's circumstances are less than ideal. Indeed, the age of the mother is one of the best predictors of child abuse and infanticide (i.e., the killing of one's children), and the risk is even greater when these young mothers are also unmarried, poor, and lacking in social support (Belsky, 1993; Bugos and McCarthy, 1984; Burgess and Drais, 1999; Daly and Wilson, 1988; Jones, 1997; Lee and George, 1999).

An influential current model of parental investment is Hagen's (1999) Defection Hypothesis. According to this hypothesis, it may be advantageous for parents to invest less in new offspring if there is reason to believe that the costs of rearing the offspring will outweigh the long-term increase in reproductive fitness. Since child-rearing is a very energetically expensive enterprise, investing in a newborn is quite a commitment, and if there is reason to believe that the sacrifice will not pay off in the end, reduced investment in the offspring can be a lucrative strategy. Consistent with Hagen's hypothesis, inadequate social support for the mother, marital problems, and difficult or sickly infants turn out to be associated with a host of low parental investment strategies ranging from postpartum depression to infanticide (Crouch, 1999; Hill and Ball, 1996; Whiffen, 1988).

Hagen's defection hypothesis also suggests that the age of the mother should be an important variable in determining how she responds to the demands of placed upon her by an infant. Specifically, younger women who have plenty of future reproductive opportunities can afford to be choosier when it comes to deciding which offspring will be worth investing in. For older women, it is increasingly likely that the child presents a "last chance," and even a child who might not live to reproduce may seem worth an investment if the mother does not have the option of reserving her resources for a later child. This prediction is consistent with what little data are available on this issue (Hagen, 2002).

The assumptions made by many evolutionary psychologists is that behaviors such as parental investment decisions are largely unconscious, and that the proximate forces guiding responses in this situation are emotional states such as feelings of love (or the lack thereof). Presumably, these emotional responses have been shaped through evolution as a way of insuring that individuals will act in their own long-term reproductive self-interests. Yet, there has been no actual research to document the extent to which parental investment decisions are free from conscious reflection. The difficulties inherent in researching this issue in real-life parenting are obvious. However, we believe that it is possible to simulate parental investment decisions in the laboratory by having individuals make investment decisions when confronted with information that is analogous to that confronting new parents. If the conscious decisions made by individuals in the lab closely parallel what we see in actual parenting situations, we would have further

confirmation that variables such as offspring quality and the age of the mother do indeed operate as predicted. However, such results may throw open the possibility that the decisions made by parents depend upon more than the unconscious investment mechanisms than is commonly assumed. In pursuit of these goals, we gave subjects hamsters, which represented their offspring, and poker chips (representing resources) that they had the option of "investing" in their hamsters or saving for themselves. Also, half of the subjects were (falsely) told that they would have the opportunity to race a different hamster later, at which point they could invest the chips they had saved (in addition to a new batch of chips) toward giving their hamster an advantage in the race. Each subject's hamster raced another subject's hamster; each poker chip invested in the hamster gave it a slight advantage in the race, and the subject believed that only winning hamsters would receive a monetary prize.

Predictions

· We predicted that, just as a younger mother, who expects to produce more offspring in the future, should reserve whatever resources she can spare for her future offspring, subjects would invest less if they expected to run two races than if they expected to run only one. This effect should be especially pronounced among those subjects who believed that they had an untrained hamster (representing a low-quality offspring).

· We also predicted that, because fathers almost always invest less than mothers in new offspring, males would invest less than females in all conditions.

· Finally, as a way of checking the extent to which conscious cognitive processes are mediating the decisions, we predicted that if subjects were asked after the race how they would have invested if circumstances had been different, their responses would align with our expectations for the original investment (with subjects with untrained hamsters who expect to run only one race investing the most, and subjects with trained hamsters who expect to run two races investing the least).

Method

Participants.

One hundred and thirteen undergraduate psychology students at a small Midwestern college participated (40M, 73F). Data were collected from one hundred and eighteen subjects, but the data from five subjects was discarded due to improperly filled-out questionnaires. Subjects were recruited from psychology courses and were paid $3 for their participation.

Materials.

In this study we used Syrian hamsters (*Mesocricetus auratus*) and plastic hamster exercise balls procured from a local pet store.

Design and Procedure.

Subjects arrived at the laboratory in pairs to participate in a study that was "investigating factors that influence gamblers' betting decisions." For ease in instruction-giving, both subjects in each pair were randomly assigned to the same one of four experimental groups:

· High Quality/Last Chance (Hamster is trained and subject will be running only one race: HQ/LC)

· High Quality/Future Opportunity (Hamster is trained and subject will be running two races with two different hamsters: HQ/FO)

· Low Quality/Last Chance (Hamster is untrained and subject will be running only one race: LQ/LC)

· Low Quality/Future Opportunity (Hamster is trained and subject will be running two races with different hamsters: LQ/FO)

An instruction sheet explained that the two subjects' hamsters would race each other, and that the subject whose hamster won the race would receive a reward of $3. It also explained that each subject would receive 10 poker chips, which the subject could either invest in the hamster or keep for him or herself. For each "invested" chip, the hamster would receive a 2 second time advantage in the race and each "kept" chip could be redeemed for additional cash (25 cents per chip), but only if that hamster won the race. Subjects were informed that some hamsters were trained and some were untrained; trained hamsters had spent a few hours running in a plastic exercise ball, while untrained hamsters had never been in an exercise ball before. Following the instructions, each subject received a hamster, which he or she was allowed to name and bond with for 1 - 2 minutes before the race.

Subjects who expected to run two races were told that any chips they "kept" for themselves would roll over to the next race, when they would also receive additional chips to invest in a different hamster. They were told that the quality of the hamster they received in the first race was unrelated to the quality of the hamster they would receive in the second race. Subjects were then privately informed about whether their hamsters were trained or untrained, so that each subject was unaware of the quality of his or her competitor's hamster. To verify that subjects knew whether their hamsters were trained or untrained, they were asked to write the quality of their hamster on the instruction sheet.

Subjects then went into an adjoining room in which a two-lane "track" had been constructed using three pieces of lumber, each 3.05 meters in length. Each subject was given a stopwatch, a questionnaire, and 10 poker chips. Subjects decided how many chips to invest in the hamster (2 second time advantage per chip) and how many to keep (25 cent reward per chip if the hamster won) and wrote their investment decisions in a box at the top of the questionnaire. Subjects were not aware of the investment decision of their opponents.

The hamsters were then placed on the track and each subject timed his or her own hamster using a stopwatch. After the race was over, subjects filled out a questionnaire specific to their group assignment in which they rated the importance of several factors in their investment decisions. Subjects also answered two hypothetical questions that asked how their investment would have changed if circumstances had been different.

The first hypothetical question, "How might your decision have been different if you had known you would only have one hamster to race?" was only answered by subjects who expected to run two races. Subjects answered on a scale of 1-3, indicating whether the subject would have invested less (1), the same (2), more (3), or "I don't know."

The second hypothetical question asked how subjects would have invested differently if their hamster's quality had been different; in other words, subjects with trained hamsters were asked how they would have invested if their hamster had been untrained, and subjects with untrained hamsters were asked how they would have invested if their hamster had been trained. Just as in the first hypothetical question, subjects chose whether they would have invested less, the same, or more, and those responses were assigned values of 1, 2, and 3 respectively. An "I don't know" option was also included.

Subjects were informed that the purpose of the study was to investigate how information about the hamster had affected their investment decisions and each subject, whether their hamster won or lost, received $3. Subjects were asked to refrain from sharing the details of the study with future subjects.

Results

Tests of Predictions about Investment

Investment data were analyzed using a 2 x 2 x 2 factorial analysis of variance (ANOVA) with offspring quality, future reproductive opportunity, and sex of subject as independent variables and the number of chips invested as the dependent variable. The means can be found in Table 1.

Table 1. Investment by expectation of future opportunity (Future Opportunity or Last Chance) and by quality of offspring (High Quality or Low Quality).

Investment	Last Chance	Future Opportunity
High Quality	**Moderate (Mean=4.794)**	**Moderate (Mean=4.804)**
Low Quality	**Highest (Mean=5.128)**	**Lowest (Mean=3.769)**

The first prediction to be tested was that subjects who expected to run in two races would invest less than subjects who expected to run only one. The main effect results were in the predicted direction (LC *Mean*=4.96 vs. FO *Mean*=4.29) but were not quite statistically significant, $F(1,105)=2.42$, $p<.12$, However, an *a priori t* test indicated that subjects who only expected to run one race did in fact invest significantly more in low quality offspring (i.e., untrained hamsters) than did subjects who expected to run two races, $t(55)=2.14$, $p<.04$, *Means*: 5.13 vs. 3.77. The interaction between offspring quality and the presence or absence of a future investment opportunity failed to reach significance, $F(1,105)=2.49$, $p<.12$. There was no support for the prediction that males overall would invest less than females, $F(1,105)=0.00$, *n.s.*.

The final prediction was that when subjects were specifically asked how their investment decisions might have been different if the quality of their hamster or their opportunities for future betting had been different, they would report changes in investment that would parallel the actual investment patterns seen in the subjects who actually experienced these other conditions. The tests of this prediction relied upon the analyses of responses to three questions. The first question asked how important a factor the hamster's expected success was in the subject's investment decision, from 1 (*not at all important*) to 5 (*extremely important*). Most subjects rated the hamster's expected success as very important; the mean response was 3.42, and the

median and mode were both 4.

The hypothetical question, "How might your decision have been different if you had known you would only have one hamster to race?" was only answered by subjects who expected to run two races, and subjects answered on a scale of 1-3, indicating whether the subject would have invested less (1), the same (2), more (3), or "I don't know." Subjects who responded "I don't know" were not included in the analysis. The mean for this question was 2.33, indicating that most subjects who expected to race two hamsters would have invested more if they had known they would only be racing one hamster. In order to determine whether subjects' responses to this hypothetical question were influenced by the quality of the hamsters they were given, a *t-test* comparing the responses of subjects with trained hamsters to those of subjects with untrained hamsters was performed. The results were nearly significant, $t(40)=-0.28$, $p<.07$, suggesting that subjects who had untrained hamsters would have invested more if they had known that they would only be running one race than subjects with trained hamsters would have.

A second hypothetical question asked how subjects would have invested differently if their hamster's quality had been different. Just as in the first hypothetical question, subjects answered on a scale of 1-3, indicating whether the subject would have invested less (1), the same (2), more (3), or "I don't know." We conducted an ANOVA on the responses with offspring quality and future opportunity as independent variables and change in investment as the dependent variable. While main effects of offspring quality ($F(1,104)=1.34$, *n.s.*) and future opportunity ($F(1,104)=0.79$, *n.s.*) were not significant, their interaction did reach significance ($F(1,104)=18.16$, $p<.0001$). For subjects with trained hamsters, a subject who thought that he or she would only be racing one hamster would have invested *more* if the hamster had been untrained, but a subject who expected to race two hamsters would have invested *less* if the hamster had been untrained. For subjects who had untrained hamsters, the trend was reversed: a subject who expected to race only one hamster would have invested *less* if the hamster had been trained, but subjects who expected to race two hamsters would have invested *more* if the hamster had been trained (see Figure 1). *Post-hoc t*-tests were significant in all possible combinations. Thus, our third prediction was confirmed. Subjects consistently expected to change their investment decisions in response to information about the quality of their hamsters/offspring and the possibility of future reproductive/racing opportunities, and they did so in accordance with the investment decisions made by individuals who had been given the appropriate information in the real investment situation.

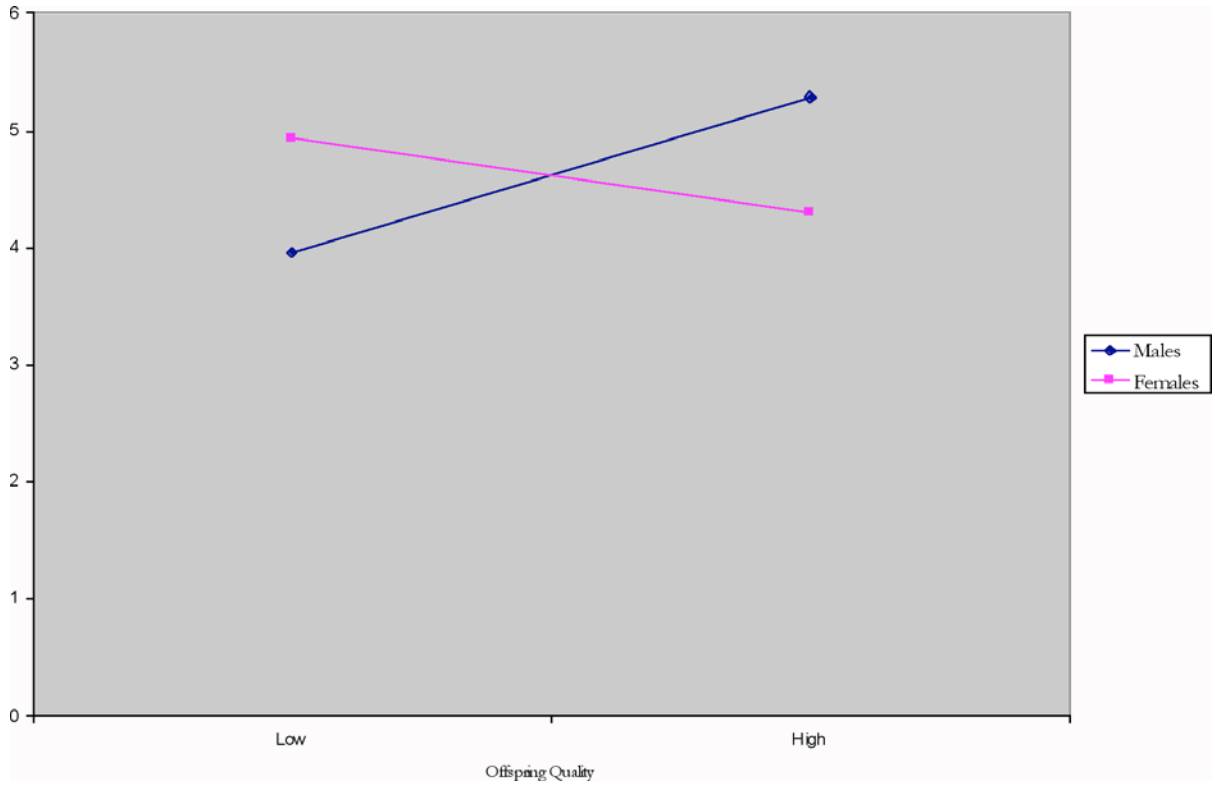
Figure 1. Interaction of Offspring Quality and Future Expectation: Subject responses to hypothetical change in investment.

After conducting this ANOVA, we separated male and female responses for the second hypothetical question, which had shown the strong interaction of offspring quality and future opportunity. After the responses were separated by sex, males showed no main effects for offspring quality ($F(1,34)=0.02$, *n.s.*) or future opportunity ($F(1,34)=0.13$, *n.s.*), and no interaction ($F(1,34)=0.03$, *n.s.*). Females, on the other hand, displayed a main effect of quality, $F(1,66)=6.65$, $p<.01$, as well as a significant interaction with an even higher F value than occurred when males and females were analyzed together ($F(1,66)=35.26$, $p<.0001$).

Significant Exploratory Analyses

The interaction between offspring quality and sex of subject was significant, $F(1,105)=5.09$, $p<.03$, meaning that offspring quality affected investment decisions differently for males and females. More specifically, as demonstrated in Figure 2, males invested less in a low-quality hamster and more in a high-quality hamster, while females invested more in a low-quality hamster and less in a high-quality one.

Figure 2. Interaction of Offspring Quality and Sex of Subject.



Discussion

The results of this experiment were at least partially supportive of Hagen's Defection Hypothesis (1999). Our subjects invested more in low quality "offspring" when they believed that this would be their last investment opportunity than they did when they believed that they would have other opportunities to invest in different offspring in the future. By analogy, this is consistent with younger mothers, who can afford to be choosier, investing less in a child that is unlikely to survive than does an older mother, for whom this child is likely to be a last chance. An additional interesting conclusion suggested by our data is that the age of the mother is only a relevant factor when it comes to investing in low quality offspring. High quality offspring received similar levels of investment from "parents" regardless of their age.

Also of interest was the significant interaction between the sex of the subject and the quality of the hamster. Females invested more in low quality offspring whereas males invested more in high quality offspring. It could be argued that females get a bigger return per unit of investment when investing in LQ offspring. To illustrate how this may be the case, we will rely on an example provided by Edward Hagen (personal communication). Imagine a baby who is ill. It might be a child with outstanding potential, but only if it survives this particular illness. Diligent mothering during the crisis could pay high dividends as long as the problem with the child is "correctable." Males, on the other hand, may profit more by investing in high quality offspring who can take advantage of their investment, since any help that they are able to give to low quality infants may very well be redundant with the mother's investment anyway. It might also be that the sex difference in investment in low quality offspring might be related to other sex differences, possibly sex differences in empathy or related traits, for example.

It is also important to note that the people in our study who were making conscious investment decisions produced a pattern of results that were highly similar to what is seen in real parenting situations. There are two possible interpretations of this. It may be that the unconscious evolved psychological mechanism that influences parental investment decisions is so "rational" that it perfectly mimics the rational choices made by individuals in similar but less emotional experimental situations where the stakes are much lower. An alternative interpretation is that investment decisions made by parents about their own children are more conscious than we may wish to believe. In fact, it may be that humans always use an economic model when investing in anything, regardless of what they are investing in. In either case, the question of the awareness that parents have about their investment decisions becomes an important issue for future researchers to investigate.

The degree to which consciousness may be involved in parental investment decisions may be further complicated by the possibility that these decisions occur differently for males and females. For example, the hypothetical question that asked subjects how they would have invested if their hamster had been differently trained produced exactly the results we expected: People reversed the pattern of their investments. These results imply that the subjects were fully aware of the factors that were influencing their decisions. Yet, when male and female responses to this hypothetical question were separated, males showed no significant interaction between future opportunity and offspring quality at all, while females showed an even stronger interaction than when both sexes were analyzed together. That the size of the interaction increased after substantially reducing the sample size suggests that the effect is so strong for female subjects that it was apparent even with the male subjects diluting the effect. This is potentially because, for males, the "Last Chance" condition is an artificial construction. Unlike females, who spend several years at the end of their lives unable to bear children, males are capable of producing children well into old age. Since males would have never faced a situation in which a child is likely to be a "last chance," males might have found it difficult to correctly predict how they would have invested in that situation. This could potentially be explained if female decisions were being guided by a decision making program that the males did not have access to. Perhaps an interesting avenue of exploration for this issue would be to use older females as subjects who have already become mothers and/or who are nearing the end of their reproductive years. Since real-life investment decisions would have already been primed in these individuals, the results of such a study could potentially add valuable insights to the speculations we are currently engaging in.

While the results of this study are provocative, one must be cautious about drawing too firm conclusions from a laboratory study such as this one, as its methodology has inherent limitations. The obvious issue is whether college students' investments in hamsters can really be the same as a new mother's (or father's) investment in his or her newborn offspring. This will be of particular concern if the assumption is made that parental investment decisions are largely unconscious processes that are completely unlike the conscious decision-making that occurred in the present study. If, however, these are similar processes that lead to similar results, then our laboratory analogy does not seem so far-fetched. Furthermore, since there are a number of studies (e.g., Archer, 1997) that indicate that our interactions with animals, especially pets, trigger many of the same feelings and responses demonstrated by parents toward their children, our simulation makes some sense. Thus, It could be argued that feelings of love, guilt, or obligation by parents simply serve as motivators to induce parents to pursue rational, conscious courses of action that are ultimately in their own best interests; there is no reason to assume that

unconscious motivational factors and conscious decision making cannot work in tandem. The directions for future research suggested by this study have promise for enhancing what we know about parental investment. Hagen's Defection Hypothesis seems to be a good working model for understanding parental investment, and it should continue to serve as the theoretical basis for generating research hypotheses. We believe that phenomena such as parental investment are indeed amenable to experimental research in the laboratory, and we have identified a number of factors that need more attention in the future. Specifically, investigators should pay more attention to the extent to which investment decisions are unconscious as opposed to being within the awareness of the parents making these decisions. It would also appear that teasing out the different criteria that may be involved in parental investment decisions for males as opposed to females might be a worthwhile enterprise.

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