DOCUMENT RESUME

ED 406 066 PS 025 385

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TITLE	Children's Understanding of Biological Inheritance: Nature, Nurture, and Essentialism.
PUB DATE	Apr 97
NOTE	25p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (62nd, Washington, DC, April 3-6, 1997).
PUB TYPE	Speeches/Conference Papers (150) -- Reports - Research/Technical (143)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Animals; Behavior; *Biological Influences; *Children; Cognitive Development; *Heredity; Nature Nurture Controversy; Perinatal Influences; *Physical Characteristics
IDENTIFIERS	Essentialism; Fetal Development

ABSTRACT

This study examining children's understanding of biological inheritance addressed four central questions: (1) are young children able to distinguish between the relative influences of nature and nurture in their understanding of how physical characteristics versus behaviors and preferences develop in animals? (2) does children's understanding of the location of prenatal growth have any impact on their expectations for parent-offspring resemblances? (3) what role is played by psychological essentialism in children's understanding of inheritance? and (4) when do children provide specifically biological explanations that are clearly differentiated from any beliefs they may have about nonbiological causes? A total of 64 kindergarten through third grade children participated, with 16 at each grade level. Individual interviews were used to assess understanding of biological inheritance in the context of illustrated stories about animal offspring born and raised under four conditions, normal biological parentage and rearing, adoptive rearing, inter-uterine transplant parentage and rearing with own species, and inter-uterine transplant parentage and rearing with transplant species. Results indicated that children thought it most likely that offspring would resemble their original species, in both physical and behavioral characteristics, under all conditions. There were also some indications that the transplant conditions were perceived by children as having biological implications for inheritance. Patterns of ratings for choices, and the children's explanations, were consistent with a psychological essentialist view of the transmission of characteristics in animal species. (Contains 14 references.) (KDFB)

Children's Understanding of Biological Inheritance : Nature, Nurture, and Essentialism

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Poster presented at the Biennial meeting of the Society for Research in Child Development,

April 3-6, 1997, Washington, DC.

ABSTRACT

Interviews with children in kindergarten through third grade investigated their understanding of biological inheritance in the context of stories, with pictures, about animal offspring born and raised under three conditions: normal biological parentage and rearing; adoptive rearing; inter-uterine transplant parentage and rearing with own species; inter-uterine transplant parentage and rearing with transplant species. Children thought it most likely that offspring would resemble their original species, in both physical and behavioral characteristics, under all conditions. There were also some indications that the transplant conditions were perceived by children as having biological implications for inheritance. Patterns of ratings for choices, and explanations children gave, were consistent with a psychological essentialist view of the transmission of characteristics in animal species.

Children's Understanding of Biological Inheritance :
Nature, Nurture and Essentialism

A current debate concerning children's understanding of biological phenomena centers on the questions of if and when an autonomous cognitive domain of biological understanding is differentiated from intuitive psycho-social causal reasoning. In the sub-domain of biological inheritance it has been suggested that children have a specifically biological, rather than psychological or social, understanding by 4 years of age (e.g., Springer, 1992; 1995; 1996; Springer & Keil, 1989; 1991). Springer (1995) presented a model for a naive biological theory of kinship in which possession of the basic knowledge that babies grow inside their mothers, and that uterine growth is isolated from external influences (including psychological intentions), leads preschool children to inductively infer that kinship resemblances are inherited by means of prenatal "material transfer" from mother to child (Springer & Keil, 1991).

In contrast, Carey (1985) and Solomon, Johnson, Zaitchik & Carey (1996), argue that it is not until around 7 years of age that children show a specifically biological understanding of inheritance that goes beyond a general expectation of family resemblance. They have argued that to be convincing, claims of autonomous biological understanding must demonstrate that young children understand it is the specifically biological act of parentage that underpins inherited characteristics, and distinguish this from any beliefs they may have about psycho-social influences on family resemblances.

In response, Springer (1996) has recently demonstrated that at least some 4-5 year old preschoolers understand that biological parents and their offspring are more likely to share physical characteristics than beliefs or preferences. For the older preschoolers this understanding was supported by the knowledge of where babies grow. Springer argues that awareness of the fact of prenatal growth in the mother's uterus provides children with a biological mechanism to underpin a specifically biological theory of inheritance.

An additional influence on the research reported here was a series of papers documenting the centrality of psychological essentialism in the causal reasoning of young children (e.g., Gelman, 1992; Gelman & Kremer, 1991; Gelman & Medin, 1993; Gelman & Wellman, 1991; Medin, 1989; Medin & Ortony, 1989). Medin (1989, p1476) described essentialism as when "people act as if things (e.g., objects) have essences or underlying natures that make them the thing that they are." In spite of the philosophical arguments against metaphysical essentialism, there is substantial evidence that psychological essentialism pervades adult identification of concepts and categories. Gelman has presented convincing, empirically supported arguments that the causal reasoning and category identifications of children as young as 2-3 years of age are remarkably consistent with the notion of some implicit, underlying awareness of essence guiding their choices. If young children are guided by psychological essentialism in their thinking about the transmission of physical characteristics from one generation to another, then they do not necessarily need to understand the specific biological mechanisms underpinning this process. They could instead draw on the understanding that parents and offspring have a "natural commonality" (Hirschfeld, 1994) which gives rise to, among other things, some shared physical resemblances. The study reported here was thus designed to offer further insight into children's understanding of parent-offspring resemblances, with a particular focus on the following.

Central Questions of the Study

(1) Are young children able to distinguish between the relative influences of "nature and nurture" in their understanding of how physical characteristics vs behaviors and preferences develop in animals ?

(2) Does children's understanding of the location of prenatal growth have any impact on their expectations for parent-offspring resemblances ?

(3) What role is played by psychological essentialism in children's understanding of inheritance ?

(4) When do children provide specifically biological explanations (even if incorrect) that are clearly differentiated from any beliefs they may have about non-biological causes ?

METHOD

Subjects

A total of 64 kindergarten through third grade children participated in the study, with 16 at each grade level. In the kindergarten, first, second, and third grade groups, respectively, there were 6 girls and 10 boys (M age = 6 years 2 months), 7 girls and 9 boys (M age = 7 years 1 month), 6 girls and 10 boys (M age = 7 years 11 months), 8 girls and 8 boys (M age = 8 years 11 months).

Procedures

Children's understanding of inheritance was examined by asking them to rate their predictions for various offspring characteristics under four conditions : (1) Control: Animal offspring born of own species and raised with own species; (2) Adoption: Offspring born of own species but adopted and raised by a different species; (3) Transplant-Raised Own: Offspring transplanted in utero from one species to another, born from the other species, but then returned to own species for rearing; Transplant-Raised Other: Offspring transplanted in-utero from one species to another, born from the other species, and retained with other species for rearing.

Drawings of domestic animals (horses, sheep, pigs, and cows) and corresponding physical features (e.g., ears, tail, coloration) and behavioral characteristics (e.g., preferred activities, food preferences) were used to portray the following four resemblance outcomes : (1) Original: Like the originating animal species; (2) Other: Like the adoptive or transplant species; (3) Mix: A "blend" of original and other (adoptive or transplant) species;
(4) Different: Unlike either of the parent species (original or other) represented on that trial.

The offspring under consideration on each trial were never actually shown to the children, even in the Transplant condition it was a "generic" fetus that was physically moved from one animal uterus to another. Nor were the offspring referred to by category name, instead the researcher would talk about "the baby that was born from this mother cow" or "the baby that was transplanted from this mother sheep to the mother horse". The offspring characteristics (physical ones such as ears and tail, or behavioral ones such as food preferences and preferred activities) were shown on small picture cards which could be handled by the children. Choices among the four options (Original, Other, Mix, Different) were made by assigning ratings for each one on a 3-point scale (Yes, Maybe, No). This entailed physically placing on the rating scale the small picture cards that represented the four offspring characteristics for each trial.

Each condition (Control, Adoption, Transplant-own, Transplant-Other) was presented as a set of four cards, with the four animal species balanced across sets. For the kindergarten and first grade children, the trials were administered over three sessions with the Control set given on the initial visit, along with some training in how to use the rating scale. The Adoption condition was presented in a second session and the Transplant-Own, Transplant-Other sets were administered (counterbalanced) in a third session. For second and third grade children it was possible to condense this into two visits: the Control and Adoption sets (in this order) at the first visit and the Transplant sets (counterbalanced) in a second visit.

After each trial, following the assignment of ratings, children were asked to explain their choices. All sessions were videotaped and children's explanations were subsequently transcribed from the tapes and coded by two independent observers. Additionally, on each trial of the Adoption and Transplant sets, children were asked the following "essentialist" questions concerning the offspring under consideration : What kind of animal do you think this is really going to be when it grows up ? Why do you think so ?

RESULTS and DISCUSSION

Question (1)

The average rating scores (0-2) that children at each grade assigned to offspring characteristics like those of their Original species vs the Other (Adoption or Transplant) species, in the four conditions, are shown in Table 1. The predominant pattern, at all ages and under all conditions, was to assign a higher rating to the characteristics resembling the offspring's Original parent species in comparison with the Other species. The main selections of interest for the purpose of this report were children's expectations concerning the Original vs Other species outcomes. These were analyzed separately for the physical and behavioral characteristics by means of two 4 (grades: KG, 1st, 2nd, 3rd) X 3 (conditions: adoption, transplant-raised own, transplant-raised other) X 2 (species: original, other) multivariate analyses of variance (MANOVA). Grade was a between-subjects factor and the other two were within-subjects factors. The MANOVAs revealed significant main effects for the higher ratings on Original species than Other, for both the physical characteristics ($F[1,60] = 40.11$, $p < .0001$,) and behavioral ($F[1,60] = 14.54$, $p < .0001$). Thus with regard to question (1) of the introduction, children in this study demonstrated an understanding that animal offspring resemble their parents only on the basis of the biological relationship between them, and their ratings for "species matching" characteristics were consistently higher for their own biological species than for the adoptive or "surrogate" (inter-uterine transplant) resemblance options.

Question (2)

If, as Springer (1995, 1996) has argued, young children's early understanding of inheritance and kinship resemblances is predicated on knowing some basic facts about pregnancy and birth in mammals, then the transplant conditions should present them with a dilemma. Knowing that babies grow inside their mothers, and using this to infer parent-offspring resemblance, might lead children to assume that transplanted offspring will share resemblance with both species in which they have experienced prenatal growth. The Mix of species characteristics were thus of particular interest with regard to the Transplant conditions. The average ratings assigned to the Mix of species option for physical and behavioral characteristics are shown in Table 2. Note that in Table 2 there are also average ratings on the Mix of species condition shown for the Control condition. Even though the Control condition presented only one parent species, the same four option outcomes were available as in the other three conditions and some children did assign ratings greater than zero (between a 0 for no and a 1 for maybe) for the Mix option even without another animal species involved. The most likely explanation for this is that children do assume there may be naturally occurring variations in some animal characteristics such as ears, coloration, food preferences, preferred activities, etc.

The comparisons of interest for the Mix choices were thus between the ratings assigned in the Control condition and those assigned in the other three conditions (Adoption, Transplant-Own, and Transplant-Other). If children do assume uterine growth provides a biological mechanism for the cross-generational transmission of physical features, then there should be higher ratings for the Mix option under the Transplant conditions but not the Adoption condition. And if their theories about inheritance are specifically biological, then the Mix ratings should be higher only for physical features in the Transplant-Raised Own condition (since there is uterine proximity but no shared rearing environment with the other species) but could be higher for both physical and behavioral features in the Transplant-Raised Other condition (where there is both uterine proximity and shared rearing environment).

The pattern of results in Table 2 indicates that there is some support for this expectation among the 1st-3rd grade children, whose ratings for the Mix outcome are generally higher under the Transplant conditions than the Control condition. However, for the kindergarten children, this is not the case; in fact, their average ratings for physical characteristics that are a Mix of species are lower under the Transplant than Control condition. Likewise the evidence is somewhat contradictory under the Adoption condition where the Mix ratings are also slightly higher for adopted offspring than for control offspring.

Three separate MANOVAS were carried out, one for each of the three conditions (Adoption, Transplant-Own, Transplant-Other) to analyze the ratings assigned for the Mix of species outcome, with 4 (grades: KG, 1st, 2nd, 3rd) X 2 (conditions: [adoption or transplant-raised own or transplant-raised other], control) X 2 (characteristics: physical, behavioral). There were no significant effects for the Adoption or Transplant-Raised Other MANOVAS, but there was a significant grade X conditions effect for the Transplant-Raised Own model, $F(3,60) = 3.032$, $p < .036$. Unfortunately, such an interaction is somewhat difficult to interpret since related samples t-tests revealed that 2nd grade children assigned significantly higher ratings to the Mix outcome in the Transplant-Raised Own condition compared to the Control condition for physical characteristics (t [15] = 3.656, p = .002) while third graders assigned significantly higher ratings to the Mix outcome for behavioral characteristics (t [15] = 2.978, p = .009).

This pattern is inconsistent with the predictions made earlier if the distinction between physical and behavioral features in this study is assumed to reflect a difference between characteristics than can be biologically inherited (physical) and those that cannot (behavioral). However, such a distinction may not be tenable in the present study given that all the questions referred to animals and it could be argued that the kinds of behavioral characteristics presented (i.e., what animals like to eat and do) are just as inheritable as their physical features (i.e., form of specific body parts such as ears, tail, and hide coloration). The behavioral characteristics of animals, as represented in this study, differ from human behaviors and preferences in that there is not much "choice" involved. Hence the behavioral characteristics in this study might be just as highly associated with a particular species as the physical features and, in this sense, part of their immutable essential nature that is unlikely to change.

Question (3)

If children are psychological essentialists, and regard the characteristics of species as immutable (even without knowledge of any specific biological mechanisms), then surrogate parentage as exemplified by the Adoption and Transplant conditions would not be expected to impact their matching of parent-offspring characteristics. The offspring would be categorized as whatever species it originated from since this provides its "essence".

Figures 1 through 3 illustrate the similarity of patterning for ratings assigned (with physical and behavioral characteristics combined) under the Adoption and Transplant conditions. The highest ratings are always given, at all grades, to the characteristics that match the Original parent species. Ratings for the Mix and Adoptive, Transplant-Own, Transplant-Other species characteristics are consistently lower across all grades, with the Mix of species choice tending to be a little higher than the Adoption or Transplant outcomes among older children. The patterns illustrated in Figures 1 through 3 are clearly consistent with an essentialist perspective where children seem to be selecting choices consonant with an implicit awareness that the characteristics of animal species are relatively fixed, no matter what animal species raises them, or even what other animal uterus (aside from their original mother) they might spend time in.

Question (4)

To explore the issue of when children are able to provide specifically biological explanations for cross-generational resemblances, their open-ended explanations for predicted offspring characteristics were transcribed from the videotapes and categorized by two independent raters (with a criterion of 95% reliability and disagreements resolved by discussion). Seven response categories emerged from the exploration of children's explanations (plus the traditional "unclassifiable" category for responses that could not be coded unambiguously) and these are defined, with examples, in Table 3.

The percentage frequencies of the explanation categories, by grades and conditions, are illustrated in Figures 4 - 6. As can be seen clearly from these charts, by far the most frequent explanation type at all grade levels was the one referring to species' essential characteristics, knowledge of which was more pertinent to children's considerations about offspring outcomes than any other factor. A distant second in frequency was explanation types that referred to the original species from which an offspring came. Some of the remaining noteworthy differences in explanation frequencies varied with condition and grade. For example, as might be expected, explanations referring to "family of rearing" were more frequent in the Adoption condition than in the other two conditions at all grade levels. Likewise the frequency of children referring to the location of prenatal growth and species of birth increased dramatically for the Transplant conditions relative to the Adoption scenario. Specifically biological explanations were also much more frequent in the Transplant conditions than in the Adoption condition. Intentional explanations were low in frequency throughout this study, but did occur more often under the Adoption condition.

Separate analyses of the explanations were conducted for the three conditions using each child's average frequency score. A series of 4 (grade) X 7 (explanation type) MANOVAs with repeated measures on the second factor revealed significant main effects for explanation frequencies under each condition: Adoption, $F(6,360) = 4.116$, $p<.001$; Transplant-Own, $F(6,360) = 3.750$, $p<.001$; Transplant-Other, $F(6,360) = 2.956$, $p<.008$). There were also significant grade effects under each condition: Adoption, $F(18,360) = 1.739$, $p<.03$; Transplant-Own, $F(18,360) = 3.050$, $p<.0001$; Transplant-Other, $F(18,360) = 1.727$, $p<.03$). The high frequency of explanations classified as "species essence" or "species of origin" support Gelman's claim that the esentialist stance emerges earlier and is pervasive in children's causal and classificatory thinking. The results of this study suggest that, with regard to understanding biological inheritance (at least among non-human animals), psychological essentialism is a dominant strategy until children begin to acquire specific knowledge about biological mechanisms underpinning inheritance.

Another way in which psychological essentialism could be observed in this study was in our analysis of children's responses to the final question asked after each trial about what each animal offspring really would be, regardless of the characteristics they had predicted it might have. Children were assigned a "1" (essentialist) if they said that the animal was really whatever it's originating species had been, and any other response was scored as a "O" (non-essentialist).

Table 4 shows the percentages of "essentialist" responses to this final question, by grade and condition. An essentialist bias is observable here throughout the age range tested, however it is interesting to note the lower frequency of essentialist responses under the Transplant conditions. This finding is consistent with our observations during the interviews where many children were visibly puzzled when confronted with the Transplant scenario. It was as if implicit assumptions children had taken for granted must now be thought about more carefully and, in the process, some children may have come to question their essentialist stance. For others, the specific biological knowledge that inheritance is connected with the processes of reproduction and birth may have swayed them away from essentialist responding in the Transplant conditions. This finding is consistent with the argument that the initial awareness of biological process underpinning inheritance that Springer has identified (i.e., knowing the location of prenatal growth) may have become more salient for children by actually viewing the physical displacement of the fetus from the uterus of one species to another. Since the precise genetic mechanisms of biological inheritance are unlikely to be understood by children in the age range tested (or even many adults) then it is reasonable that children might believe a change of location for uterine growth could have an impact on basic animal identity.

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Table 1. Average ratings, by grade, for expectation of offspring inheriting physical and behavioral characteristics resembling their "Original" species vs "Other" species under four conditions.

Grades:		KG		1st		2nd		3rd	
Features:		Phy	Beh	Phy	Beh	Phy	Beh	Phy	Beh
CONTROL									
	Original	2.00	1.94	1.94	2.00	1.94	1.94	1.94	1.94
	Other	0.22	0.28	0.16	0.28	0.06	0.16	0.25	0.25
ADOPTION									
	Original	1.63	1.63	1.75	1.88	1.88	1.81	1.88	1.75
	Other	0.75	0.78	0.63	0.47	0.78	0.38	0.59	0.25
TRANSPLANT RAISED OWN									
	Original	1.75	1.63	1.88	1.63	1.75	1.88	1.88	1.88
	Other	0.69	0.94	0.69	0.63	0.69	0.63	0.69	0.69
TRANSPLANT RAISED OTHER									
	Original	1.75	1.50	1.50	1.75	2.00	2.00	1.38	1.75
	Other	0.50	1.00	1.06	0.69	0.50	0.75	0.50	0.44

Rating scale coded as Yes = 2, Maybe = 1, No = 0

Phy = Physical features

Beh = Behavioral characteristics or preferences

Table 2. Average ratings, by grade, for expectation of offspring inheriting physical and behavioral characteristics resembling a "Mix" of their original species and another species with whom they are associated by Adoption or by Inter-Uterine Transplant.

Grades :		KG		1st		2nd		3rd	
	Features:	Phy	Beh	Phy	Beh	Phy	Beh	Phy	Beh
CONTROL									
	Mix	0.53	0.53	0.34	0.53	0.50	0.44	0.66	0.41
ADOPTION									
	Mix	0.59	0.63	0.59	0.56	0.75	0.69	0.84	0.66
TRANSPLANT RAISED OWN									
	Mix	0.31	0.56	0.56	0.63	0.94	0.88	0.81	1.13
TRANSPLANT RAISED OTHER									
	Mix	0.38	0.75	0.88	0.81	0.56	0.56	0.88	0.56

Rating scale coded as Yes = 2, Maybe = 1, No = 0

Phy = Physical features

Beh = Behavioral characteristics or preferences

Table 3. Definitions and examples of explanation types given by children.

SPECIES ESSENCE "It's a horse, that's what horses' tails look like"

Explanations that stated unequivocally that the offspringwas of a particular species, without any explicit reference to parentage or rearing environment.

ORIGINAL SPECIES "It started from a pig so it is going to have pig ears"

Statements that refer to the species from which the offspring originates, but without explicit reference to biological mechanisms or the location of prenatal growth.

PRENATAL PROXIMITY "It grew inside the horse mom so it will like to give rides"

Explanations that mention the fact of offspring being carried inside a particular species, or being physically born from a particular species.

BIOLOGICAL MECHANISM "It grew from sheep genes so it will look like a sheep"

Explanations that refer specifically to some kind of biological mechanism for inheritance (even if incorrect). Responses that referred only to prenatal uterine growth were excluded from this category and counted in the previous one.

FAMILY OF REARING "If it grows up with the pigs then it might learn to roll in the mud"

Responses that make reference to the environmental influences on offspring characteristics, whether behavioral or physical.

CHILD'S EXPERIENCE "Sometimes pigs give rides, I've seen that"

Responses that were not truly explanatory in the causal sense but did explain the child's reason for selection as an inference based on their own experiences.

INTENTION or DESIRE "It will have the mom's color because that will make her happy"

Explanations that referred to psychological justifications for outcomes, such as wants or desires, and sometimes included egocentric reference to the child's own preferences.

OTHER "I'm just guessing it will like to do that best"

Anything that could not reasonably be included in the above categories, many of which were comments that were non-explanations.

Table 4. Percentage of "essentialist" responses, by grade, to the final question concerning what species each offspring would really be, in the Adoption and Transplant Conditions.

	ADOPTION		TRANSPLANT-OWN		TRANSPLANT-OTHER	
Features:	Phy	Beh	Phy	Beh	Phy	Beh
Grades						
KG	81	84	69	62	56	50
1st	72	81	63	63	44	63
2nd	63	78	69	69	75	56
3rd	100	100	75	63	63	56

Phy = Physical features

Beh = Behavioral characteristics or preferences

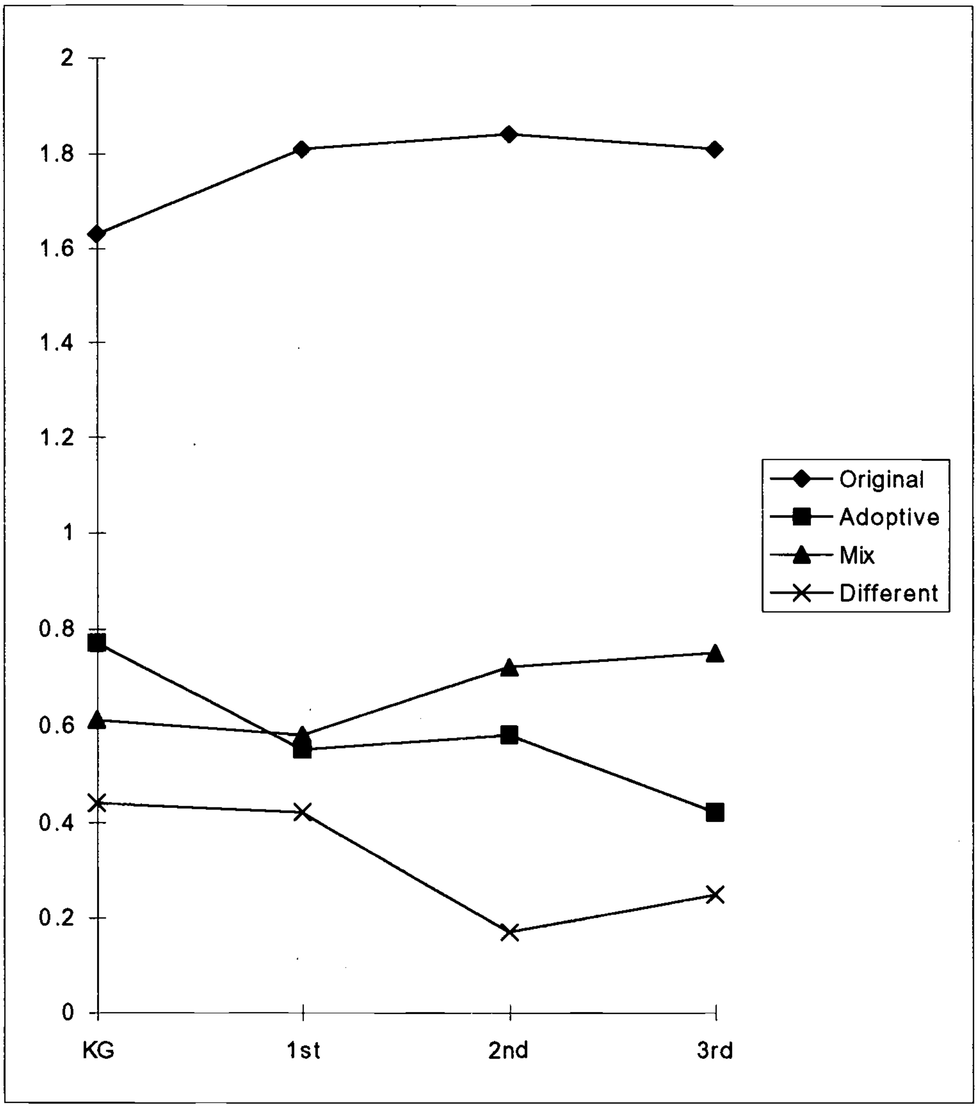


Figure 1. Average ratings, in Adoption condition, for expected offspring resemblance to Original, Adoptive, Mix and Different choices. (2 = yes, 1 = maybe, 0 = no)

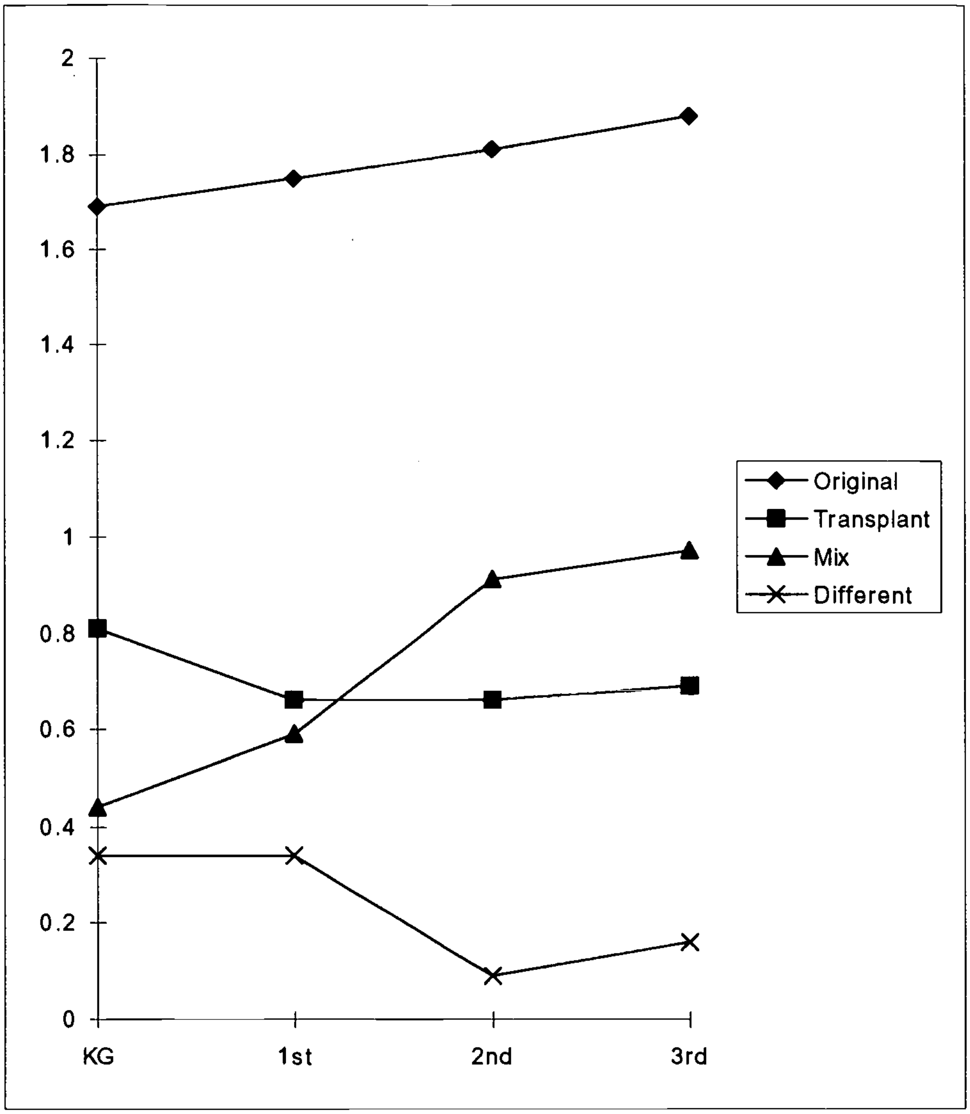
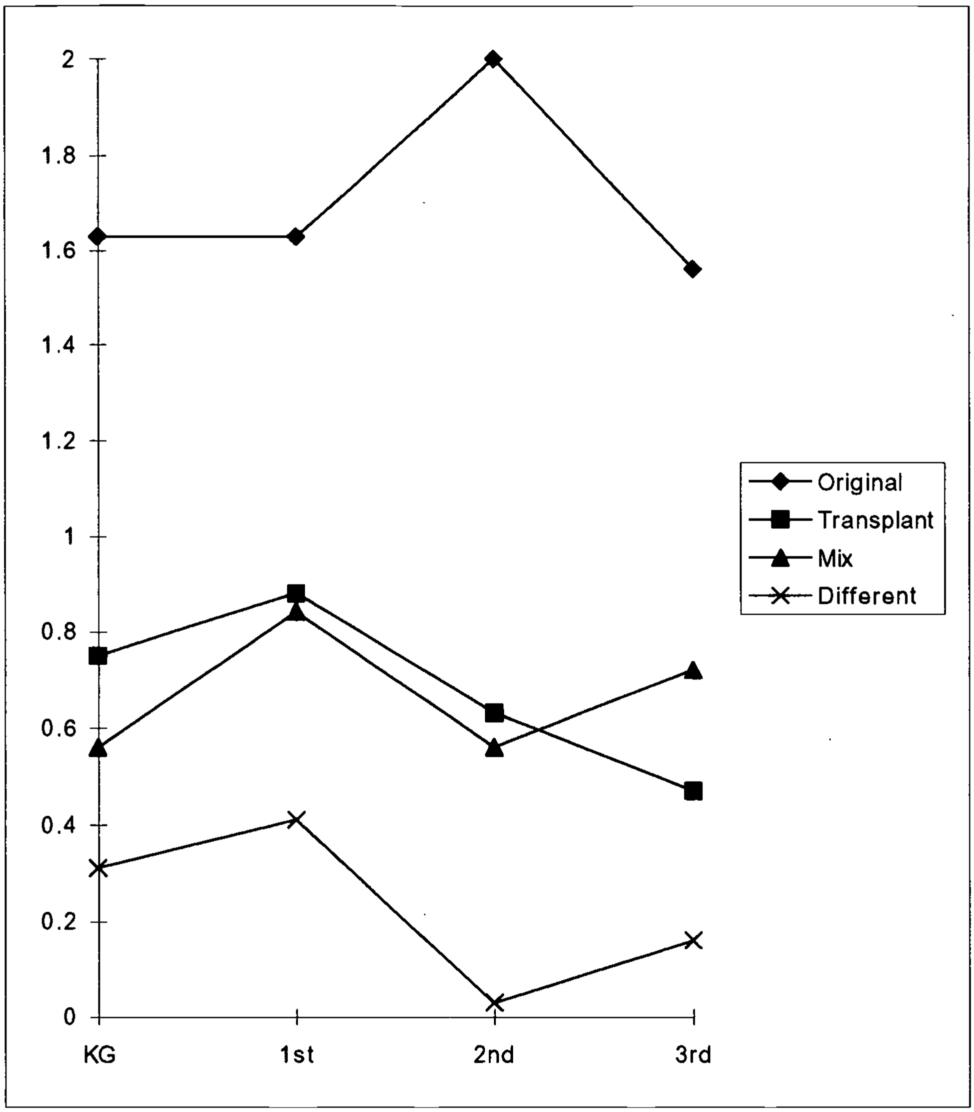


Figure 2. Average ratings, in Transplant-Raised Own condition, for expected offspring resemblance to Original, Transplant, Mix and Different choices. (2 = yes, 1 = maybe, 0 = no)



<u>Figure 3.</u> Average ratings, in Transplant-Raised Other condition, for expected offspring resemblanc to Original, Transplant, Mix and Different choices. (2 = yes, 1 = maybe, 0 = no)

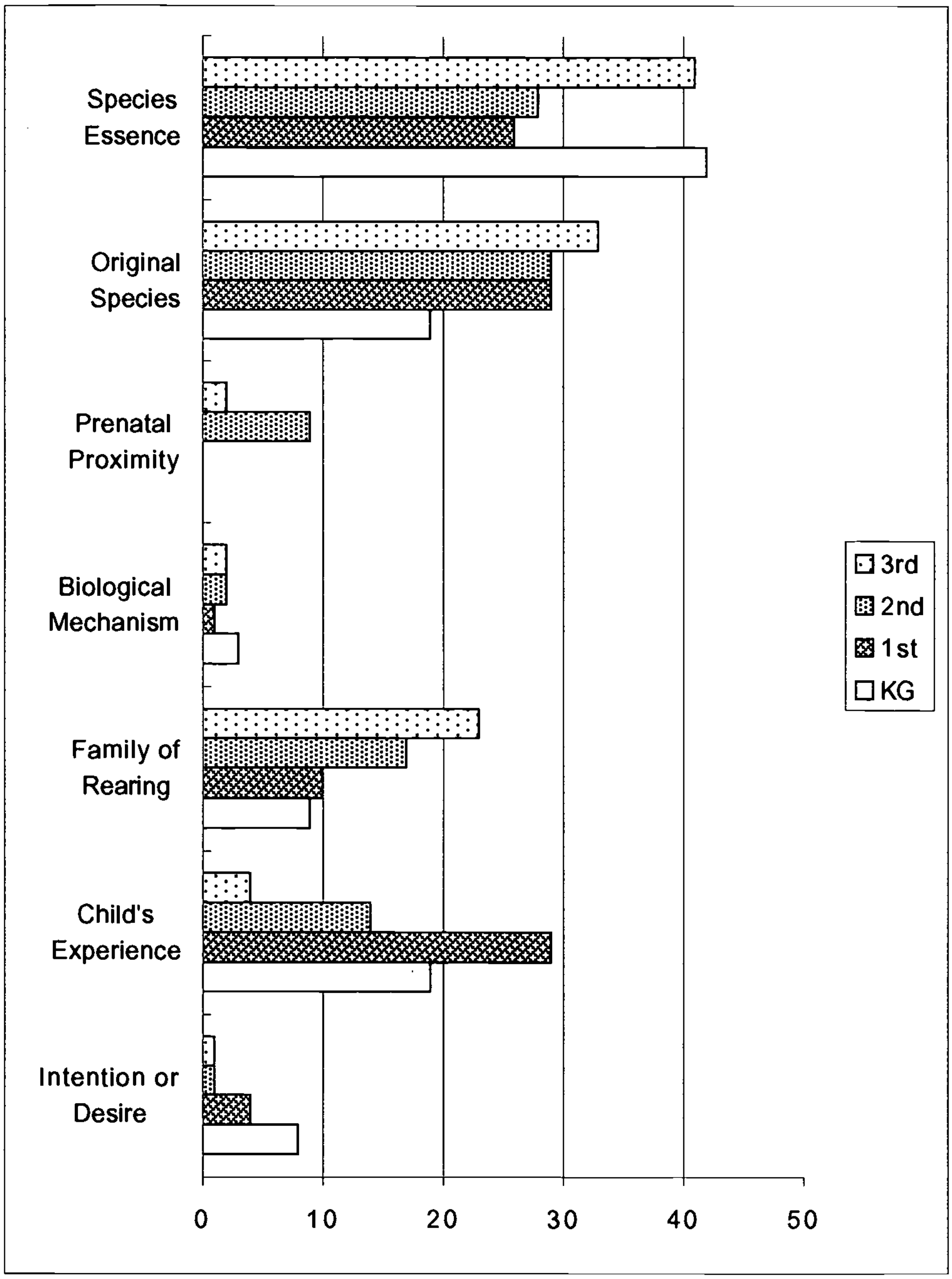


Figure 4. Percentage of each explanation type that children, by grade, gave for predicted offspring characteristics in Adoption by Other Species condition.

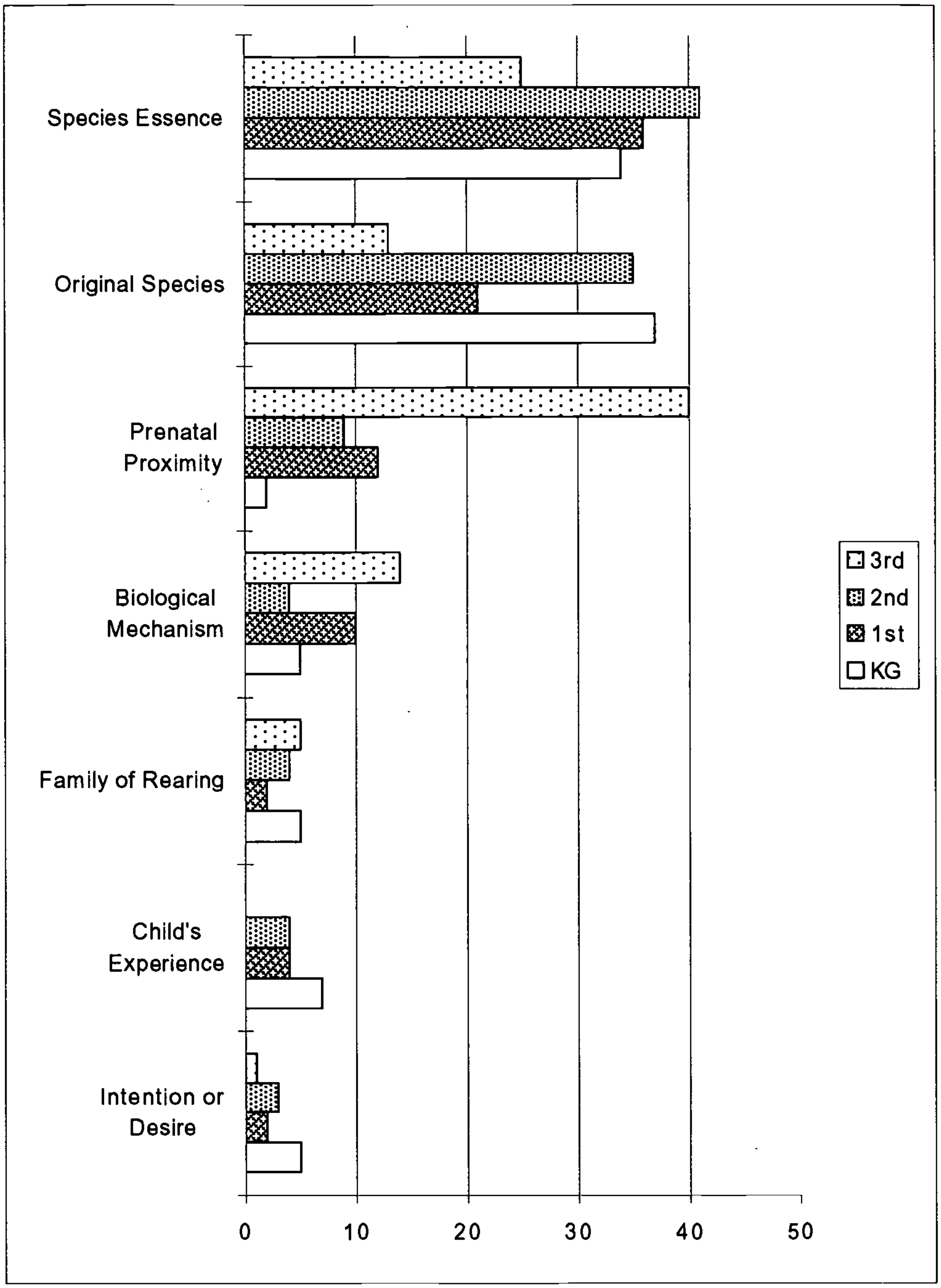


Figure 5. Percentage of each explanation type that children, by grade, gave for predicted offspring characteristics in Transpant-Raised by Own Species condition.

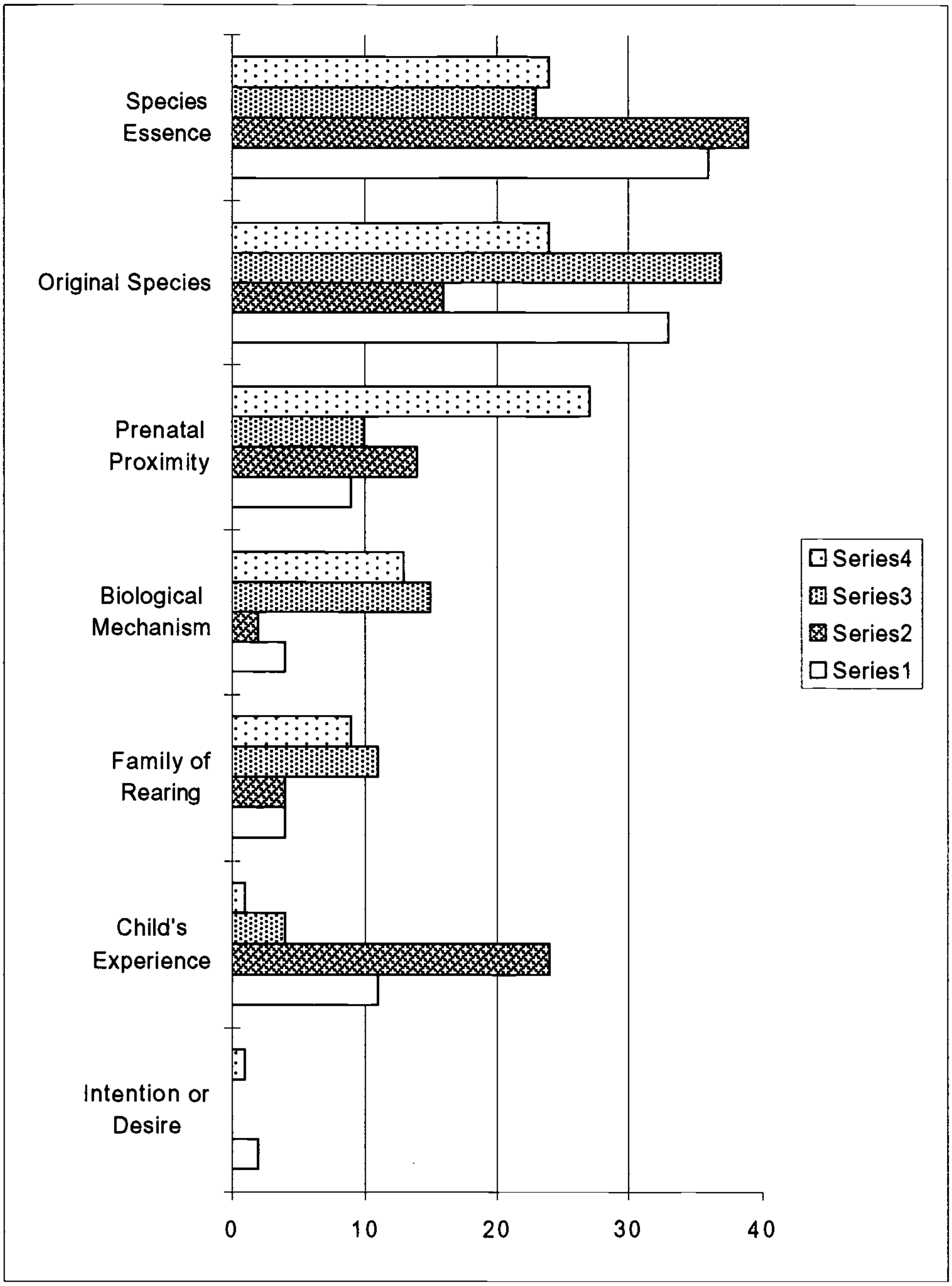


Figure 6. Percentage of each explanation type that children, by grade, gave for predicted offspring characteristics in Transpant-Raised by Other Species condition.

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62nd BIENNIAL MEETING OF THE SOCIETY FOR RESEARCH IN CHILD DEVELOPMENT (April 3-6, 1997, Washington, D.C.)

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