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ABSTRACT

This study focused on two questions: (1) is there a difference between social and mechanical non-social causality in infancy? and (2) do infants use information about contact between objects in inanimate, mechanical causal sequences more than they use it in situations where a social event is to be caused? Forty-eight 10- to 10.9-month-old infants and their mothers participated in the study. Infants were given the opportunity to produce three events selected to present a continuum from inanimate and mechanical to animate and social. The events were (a) the appearance of a picture in a window: (b) the movement of a mechanical dog: and (c) social responses from a female experimenter. The events were activated by operating a manipulandum (a knob). Two conditions were employed: 24 of the infants could trigger each event by moving the knob toward the event, thereby creating contact with it, while the other 24 could activate each event by moving the knob away from the event. Mothers demonstrated to their children how to use the knob. Infants were given a five minute period in which they could use the knob to trigger the events. Each session was videotaped from one camera located behind a one-way mirror and a second camera located in the room. After each toy session the mother and one other observer rated the infant's level of understanding of the cause-effect relationship between moving the knob and the occurrence of the event. An analysis of variance performed on the number of pushes of the knob toward and away from the events and on the two qualitative ratings of the infant's understanding revealed that infants most frequently used the knob to produce pictures in the window, and that they understood that event best. The results indicate that infants use different causal strategies in social and non-social situations. The role of contact between cause and effect is discussed. (Author/MP)

Differences between Social and Mechanical Causality in Infancy

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Running head: Social and Mechanical Causality in Infancy

Abstract

Forty-eight infants, 10.0 to 10.9 months of age, were observed interacting with three mechanical toys. An event could be produced on each toy by pushing a manipulandum. The events represented a continuum from an inanimate, mechanical event to an animate, social event. The events were: a) the appearance of a picture in a window, b) the movement of a mechanical dog, and c) social responses from a female experimenter. Two conditions were employed. Half the infants could activate each event by pushing a knob toward the event, making contact with it. The other half activated each event by pushing the knob away from each event. Mothers demonstrated the condition appropriate response. Analyses of variance on pushes of the knob toward and away from the events and on two qualitative ratings of understanding revealed that infants used the knob most to produce pictures in the window, $p < .001$, and understood that toy the best, $p < .05$. The results indicate that infants use different causal strategies in social and non-social situatic s. The role of contact between cause and effect is discussed.

Differences between Social and Mechanical Causality in Infancy

Baldwin (1901) outlined the task of the psychological as opposed to the philosophical study of causality. "The psychologist has to determine the elements which have actually entered into the conception or perception of causal connection in the various stages and phases of mental development...He has to inquire how the belief in uniform recurrence arises, and through what stages it passes." (p. 163) The major psychological theory on the development of causality in infancy is that of Piaget (1927, 1954, 1974). He stressed the importance of this aspect of cognitive development stating that "Causality must definitely be conceived as intelligence itself to the extent that the latter is applied to temporal relations and organizes a lasting universe." (Piaget 1954, p. 357) Piaget's (1952, 1954) earlier work on the sensorimotor period described the processes through which infants develop knowledge about space, object-permanence, time and means-end relationship, all of which are relevant to understanding causality, especially mechanical causality. Piaget (1927, 1954), also addressed infant causality directly outlining a progression from a lack of differentiation between cause and effect through a period of egocentricity during which infants have an overextended view of their own causal powers, to an objective, more realistic sense of causality. In the latter part of the sensorimotor period infants appear to be aware that there are causal agents in the world other than themselves and that causality is relative to the situation. Uzgiris and Hunt (1975) standardized Piaget's observations of infant causality to produce an ordinal scale of sensorimotor development. Their studies supported Piaget's theoretical outline of the progression toward externalized, spatialized, and objectified causality. Although Piaget and Uzgiris and Hunt described infants' attempts to recreate both mechanical and social effects they made no systematic attempt to describe the differences in strategies infants apply to these two very different types of causal knowledge. Although social and mechanical causality both share common cognitive elements (i.e., awareness of contingency, the experience of efficacy, and appreciation of regular reoccurrence of events due to one's own behavior), there are important distinctions in the strategies that must be used to create inanimate effects and human, social effects which can be created through communication and from a distance. By studying the mechanical and social domains separately, we can more clearly describe the causal structures and strategies relevant to each domain.

In many ways Piaget's, Uzgiris, and Hunt's studies of infant causality have been focused most on elaborating the cognitive structures relevant to mechanical causal sequences those which require knowledge of physical laws, inertia, relative speeds, force and spatial relations, including the role of contact between objects in mechanical causal sequences. Michotte's (1963) studies of adult perception of causality also revealed the importance of these issues. He presented adults with animated sequences in which one square approached a second square and the second one moved away. Michotte found that the set of event characteristics which produced the strongest causal impression was the same set that would apply to a real event involving two such objects. Central to the strong causal perception was the presence of contact between the objects. Michotte labeled such a sequence an "exposed causal relationship." Piaget and Lambercier (1958) used the Michotte technique with children and found that they too judged contact between objects as a necessary part of a causal sequence.

Understanding social causality involves some of these physical factors plus communication, that is, vocal and gestural signals that operate at a distance, and roletaking, the ability to predict and understand another human's thinking and perception. he relationship between infant causal understanding and social events has been the focus of research in recent years, although not by the name of social causality. Watson (1966) reported infants as young as eight weeks smiled and cooed vigorously as they learned they had contingent control of a mobile suspended over their cribs, and as they played interactive games with parents who were providing contingent feedback. Similarly, Lamb (in press) suggests that in the first quarter year infants develop expectations that adults will respond predictably. He and others (Emde, Gaensbauer & Harmon 1976) contend that in the third quarter of the first year infants <u>intentionally</u> emit social behaviors to elicit adult responses.

In the ethological attachment literature, a central tenet is that infant-adult attachments arise from interaction (Ainsworth, Blehar, Waters & Wall 1978; Sroufe & Waters 1977). Through interaction infants learn that there is order in the social world and that they have some control over the significant others in that world. Maternal behaviors during the first few months of infant life which were found to correlate with high quality infant attachment at one year included maternal sensitivity to infant signals, cooperation versus interference, availability, and responsiveness (Ainsworth, et al. 1978). All of these maternal behaviors serve to reinforce the infant's experience of causal power in the interaction. Sroufe (1977), Goulet (1974), and Zaslow (Note 1), have employed social causal principles in explaining stranger wariness which occurs in the third quarter of the first year and beyond. They suggest that the wariness is due in part to the infants' awareness that a stranger's behavior can have consequences for infants who are unsure of how to control a new adult's behavior. Infants have been shown to respond more positively and with less fear when they have control over the responses of new people (Bretherton 1978) and mechanical toys (Gunnar 1978, 1980).

Social causality is also relevant to another major social domain, communication. Bates, Begnini, Bretherton, Camaioni and Volterra (1979) have demonstrated a relationship between the development of gestural and vocal communication and the development of the cognitive ability to understand means-end relationships. As precursors of intentional speech, Harding and Golinkoff (1979) found two causal abilities: the ability to recognize ordered causal sequences and the willingness to use an adult as a tool in achieving goals.

The present study focused on two questions: Is there a difference between social and non-social, or mechanical, causality in infancy? And, do infants use information about contact between objects in inanimate, mechanical causal sequences more than they use it in situations where a social event is to be caused? Infants were given the opportunity to produce three events selected to represent a continuum from inanimate and mechanical to animate and social characteristics. The events were activated by operating a manipulandum. The most inanimate and least social event was the appearance of a picture in a window. An intermediate event was the activation of a mechanical dog. The most social and animate event was a social response from a female experimenter. Half the infants could trigger these events by moving a manipulandum toward the event, thereby creating contact with it. The other half created the effects by moving the manipulandum away from the event. The age of ten months was selected because research has indicated that in the fourth quarter of the first year intentional acts are performed to produce social responses (Emde, Gaensbauer & Harmon 1976) and to communicate (Bates, et al. 1979; Bretherton, McNew & Beeghly-Smith 1980). A pragmatic reason for selecting ten months is that Millar and Schaffer (1972, 1973), Millar (1976), and Carlson (Note 2) have demonstrated that even nine-month-olds can learn to control a manipulandum to produce visual and/or auditory feedback.

Two hypotheses were offered. First, greater use of the manipulandum was predicted for the inanimate window event than for the animate and social human event. An intermediate level of manipulandum use was predicted for the dog toy. By ten months of age infants have probably learned that to move things requires direct physical action, while animate social events can be operated from a distance (Watson 1966; Bates, et al. 1975; Harding & Golinkoff 1979). Second, infants were predicted to move the manipulandum toward the inanimate window event, making contact with it, more than they pushed the manipulandum away from the event, even in the condition where a push away would trigger the event. This would indicate that in addition to seeing the manipulandum as relevant to causing the action in the inanimate event, the infants appreciate the role of contact in physical causality.

Method

Subjects

Participants in the study were 24 male and 24 female middle-class infants in the Boulder area, ranging in age from 10.0 to 10.9 months of age (mean = 10.3 months) whose birthweights exceeded 2500 grams. Parents of 52 infants agreed to participate after receiving a letter and a telephone call. The data from four infants were not included, two due to fussiness during taping and two due to video tape failure.

Materials

Three large mechanical toys were constructed (see Figure 1), each with a large backboard (76 cm x 63 cm). Two of the toys had a base platform (76 cm x 19 cm). Each toy had an event object (window, dog, human) which could be activated by moving a wooden knob mounted in a slot adjacent to the event object. Each knob (2.5 cm in diameter x 1.5 cm) had a resting position 7 cm from the object and could easily be slid 7 cm toward the object, creating contact with it, or 7 cm away from the object. An unseen pulley device returned the knobs to the central position after they had been moved. The toys were adjusted so that the events were activated by a full knob movement in only one direction, either toward or away from the object.

Insert Figure 1 about here

The three events that could be produced were: a) a 3-second appearance of one of four brightly colored pictures in a plexiglas window (10 cm in diameter); b) the barking and tail-wagging of a small commercial mechanical dog; and c) a social response from the female experimenter who was seated at the right side of the backboard with her hand placed on the platform to provide a point of contact with the knob. The contingent event in this human event toy included eye contact, smiles, and the vocalization of "hi" or "hello (baby's name)," and a wave-like hand motion on the platform.

Procedure

Each infant was given approximately ten minutes of free play in the laboratory to become accustomed to the testing situation. At that time the experimenter instructed the mother to always push the knob either toward or away from the event object on all three toys, depending on random condition assignment. She was told to aim for a rate of demonstration that would maintain the infant's attention throughout a five-minute session, yet allow enough time for the infant's own exploration.

The infant was then placed on a large table next to a one-way mirror. At the back of the table one of the toys was firmly clamped to the edge of the table. The mother sat in a chair behind the infant. Taping began and the mother demonstrated how the toy operated. After five minutes the infant was returned to the floor to play and the next toy was put in place. During this break the mother rated how well she felt her child had understood the cause-effect relationship between moving the knob and the occurrence of the event. The two other toys were then presented to the baby in the same manner. Order of toy presentation was randomized. The infant played with each toy for five minutes and each session was videotaped from behind a one-way mirror and a second camera located in the room. Signals from the two cameras were combined by means of a special effects generator to insure against losing data during the infants' active exploration.

Scoring and qualitative ratings

Two trained raters counted from the video tapes four behaviors performed by the infants and the number of demonstrations performed by the mothers. Infant behaviors included: a) a full push toward the event which made contact with the event object, b) a push part of the distance toward the object, c) a full push away from the event, and d) a partial push away from the event. The maternal behavior counted was a full knob push in the condition appropriate direction. Reliability for these ratings ranged between 85% and 95% agreement.

Two qualitative scales of infant understanding were used. The first was the mother's rating. After each toy session the mother rated her baby's level of understanding on a three-point scale: 0 = The baby has no understanding of how the toy works; 1 = The baby is aware that the knob is involved in producing the result, but is not sure about what to do; 2 = The baby understands that it is the movement of the knob in one direction which produces the event. An expanded, five-point scale was filled out by a third video tape observer. The scale included infants' use of the knob, their attention to the task and emotional indices of understanding (see Appendix A). A recent paper by Cicchetti and Pogge-Hesse (in press) emphasizes the value of using emotional responses as indices of cognitive functioning. The observer's ratings were based in part on such emotional indicators of understanding as smiles, laughter and excitement upon successful activation of the toys. Reliability on this scale was 60% for 19 pilot toy sessions. An additional 16% of the ratings were within one scale step of agreement. Disagreements were resolved by discussion.

Results and Discussion

Table 1 gives the means of the infant behaviors and maternal demonstrations in the two conditions.

Insert Table 1 about here

Relationship between maternal demonstration and infant behavior

The maternal demonstration means given in Table 1 indicate that the most demonstrations were provided for the dog toy and the least were given for the window toy. Pearson *r* correlations were computed to determine whether the mothers demonstrated the toys at generally similar rates. The demonstration rates were highly correlated ($p < .001$), *r* = .56 for window with human event, *r* = .52 for window with dog, and $r = .65$ for human event with dog. In addition, Pearson r correlations were computed between infant behaviors and maternal demonstration rates in order to determine the degree to which infant action was a function of what the mothers did on each toy, and to see if mother demonstrations had cumulative effects from one toy to the next. Out of 36 possible correlations computed, only one was significant. These correlations show that the infants' behavior was not simply a reflection of maternal behavior.

Analysis of infant knob pushing scores, the combined score of all full and partial pushes in both directions

In order to test the first hypothesis, that infants would use the manipulandum more on the inanimate window toy than on the human event toy, a 2 (condition) x 2 (sex) x 3 (toy) x 5 (minutes) ANOVA was conducted on the combined variable of all full and partial pushes in both directions added together. The analysis yielded a significant main effect of toy, $F(2,88)=7.62$, $p < .001$. Post hoc analyses revealed that the infants directed more knob pushing activity to the window toy than to the other toys. All post hoc analyses were Duncan Multiple Range tests, $p < .05$. These results substantiated the hypothesis that the infants would use the physical manipulation of a knob more on the inanimate toy than on the other toys, indicating that the physical action of using the manipulandum was more meaningful in the inanimate context. The ANOVA on all pushes also produced a main effect of minutes, $F(4,176)=2.87$ $p < .001$, and a toy by minute interaction, $F(3,352)=4.86$, $p < .001$. The infants' knob-related activity decreased across the five minutes of the sessions for the window and the human toy while it remained consistently low for the dog toy. By the fifth minute knob pushing activity scores on all three toys were not significantly different from one another.

The decrease in knob activity over time appears to be simply a boredom or fatigue curve. However, knob pushing on the dog toy did not follow this pattern.

In this and other ways, infants' response to the dog toy was different from their response to other toys. Many infants in pilot research had shown fear and startle responses, often crying when the dog was activated. The dog's "bark" and movements were substantially attenuated for the study. Infants in the study did not cry when the dog went off, although many seemed wary of it. At the same time it was clear that the infants enjoyed touching the dog. Most touching went on when the dog was not in motion. The highest knob use on the dog, reached in the third minute, was equivalent to the lowest levels of knob use on the other toys. It is reasonable to assume that this difference was due in large part to the wariness of the dog toy that the infants displayed.

Analysis of full pushes toward the events and full pushes away from the events

To test the second hypothesis, that infants would not only use the knob on the window toy more, but would have a preference for pushing it toward the window rather than away from it, two 2(condition) x 2(sex) x 3(toy) x 5(minute) ANOVAS were conducted on (a) full pushes toward the event which produced contact between the knob and event object; and (b) full pushes away from the event objects. Totals used in these analyses had been corrected for the overall differences in knob use described above by dividing the total of toward or away pushes by the total of all pushes, full toward, partial toward, full away and partial away, for each minute.

The ANOVA on the full toward push scores yielded only a main effect of toy, $F(2,88)=7.89$, $p<.001$. The infants pushed the knob toward the window event more than to the other toys regardless of whether the assigned condition was toward or away. The finding is evidence that the infants were not just performing an arbitrary operant to create an effect, but were bringing to the learning situation their understanding of the role of contact in mechanical causal situations.

The four-way ANOVA on the dependent variable of full pushes away from the event yielded two significant effects, a condition by toy interaction, F (2,88)= 3.20, $p < .05$, and a toy by minute interaction, F (8,352)=2.42, $p < .05$. The condition by toy interaction was due to a condition effect for only the dog toy. Away condition infants pushed the knob away from the event more than toward condition infants did. This effect may indicate that infants were capable of exploring the knob's relationship to the dog activity, but they did so only when they could activate the dog by pushing the knob away from the noises and movements that were frightening to them. The toy by minute interaction reflected patterns of away pushing in the human event and the dog toy that were mirror images of each other. Away pushes increased over time for the dog toy but decreased for the human event toy. The infants were warming up to the dog and getting bored with the knob aspects of the human toy. Away pushing levels remained constant across minutes on the window toy.

Analyses of quantitative measures of successful learning

Another way to evaluate social versus mechanical differences in the use of a manipulandum is to look at rates of successful learning in the conditions which used a toward or away response to produce the effects. A 2(condition) x 2(sex) x 3(toy) x 5(minute) ANOVA was computed on the dependent variable, number of successful activations. "Success" was defined as a full push in the condition-appropriate direction. As in the other analyses, success totals were divided by activity level scores to control for the differences in knob related activity in this analysis.

The ANOVA on success scores produced one significant effect, a condition by toy interaction, F (2,88)=4.15, $p < .05$. Post hoc analyses revealed infants in the toward group succeeded in activating the window toy more than the infants in the away group. The conditions made no difference in the infant behavior directed toward the human event. The away condition proved to be significantly more effective for the dog toy than the toward condition. The window and human toy condition results had been predicted in the study's hypotheses. The condition effects on the dog toy can be explained in large part by the infants' emotional response to the toy. The advantage in the away condition on the dog had not been predicted and the fact that it occurred gives reason to conduct further research with other operationalizations of social and mechanical events.

Analyses of qualitative measures of successful learning

Mother and observer ratings of the infant's understanding of the knob-event relationship were correlated at the $p < .05$ level; .65 on the window toy, .37 on the human event toy, and .73 on the dog toy. For both sets of ratings there were no significant within-child correlations, so the mothers and the trained observer were not simply making judgments based on general impressions of the infants but on performances related to the specific toys.

The two sets of qualitiative ratings served as dependent variables in two 2(condition) x 2(sex) x 3(toy) ANOVAS. The ANOVA on the observer's ratings resulted in a significant main effect of toy, $F(2,88)=4.06$, $p < .05$. The ratings on the dog toy were significantly lower than the ratings for the window and human toys. There was also a condition by toy interaction $F(2,88)=4.92$, $p < .01$. This effect was not the result of a condition difference within the same toy. It resulted instead from two extreme cell means. The babies in the toward condition for the window toy had significantly higher ratings than all the other groups and the infants in the toward condition on the dog toy had significantly lower scores than all the other groups, findings consistent with the results of the quantitative analyses. The ANOVA on the mothers' ratings produced essentially the same results, a main effect of toy, $F(2,88)=2.95$, $p < .056$, and a condition by toy interaction, $F(2,88)=4.36$, $p < .05$. The infants in the toward condition for the window toy were given higher ratings than the away condition infants for that toy. Condition did not make a difference for the dog or human toys.

The qualitative analyses provide converging evidence that contact is more relevant to and supports learning in a mechanical causal sequence than in a social one. Whereas the analyses on the knob pushing scores of the infants had indicated they had more success pushing the knob away to activate the dog, that finding was not supported in the qualitative ratings. The dog toy was qualitatively rated as the least well understood, even in the away condition, a finding that supports the argument that the dog was qualitatively different from the other toys due more to emotional than cognitive factors.

Summary and Conclusions

The study addressed two questions and provided preliminary answers to both. As predicted the infants used the knob more on the window toy than on the human event toy, apparently indicating a mechanical means is more appropriate for creating an inanimate effect than a social one. Even when difference in overall knob use levels were controlled, there was a preference for pushing the knob toward the window, rather than away from it. This direction preference occurred even in the condition where mothers demonstrated that the way to make the toy work was to push the knob away from the event. As predicted, there was no such direction of knob pushing preference on the human toy. In ten months of experiencing social stimulation that occurred spontaneously or as the result of behavior at a distance, the infants would not be prepared to expect manipulandum pushes to produce social response. When faced with such an artificial situation, a knob push in one direction would be just as sensible a response as a knob push in the other direction. The quantitative analyses of infant behvaior and qualitative ratings made by mothers and the observer both confirmed that the best learning took place in the situation in which a toward push created the action on the window toy. These findings are consistent with Michotte's (1963) theory that the physical elements of a sequence of mechanical movements can support the perception of causality. He stated that those elements must bear a close approximation to the real world parameters of physical causality, including an observable flow of motion from the first object to the second and the presence of contact between the objects. The infants in this study apparently used these cues in the toward condition on the window toy to achieve high success rates, while the same cues present in the toward condition for the human event did not support high success rates. It was clear that the infants were bringing to this new learning situation their expectations about how one activates human versus physical, mechanical events. The infants used the knob on the window toy more than on the other two toys, yet the mothers demonstrated most on the dog toy and least on the window toy. While this seemed paradoxical it can be explained in part by the fact that from the start the infants had their own procedures to operate the toys, and their behavior was not a mere reflection of what their mothers did. In addition mother demonstrations seemed to be employed more frequently when the children's interest was waning, as a means of drawing attention back to the task at hand.

The infants' behavior directed to the dog toy, requires other explanations than those presented for the results on the other two toys. The dog toy results are most likely due to the interfering emotional reactions that may have masked the causal understanding the infants had about this toy. Gunnar (1978,1980) and Harlow and Zimmerman (1959) used furry mechanical toys as fear-eliciting stimuli.

The dog toy induced fear and wariness in the present study despite extensive attempts to electronically reduce the frightening aspects of the toy. It is possible that a dog with animate features which behaves in a mechanical way is an anomaly, and fear arises out of the uncertainty of not knowing which way to approach it, as an animate or an inaminate object. Kagan (1974) has suggested that from seven to eight months of age babies are developing an ability "to actively retrieve cognitive structures--hypotheses--in the service of interpreting discrepant events." (p. 240) Assuming that ten-month-olds are capable of forming hypotheses and of reacting to disconfirmation of these expectations as Kagan suggests, it is possible that mechanical action from an animate looking creature is an example of such a disconfirmed expectation, a qualitatively different event and not an intermediate point on a continuum ranging from social animate events to mechanical ones as was the assumption in this design.

The findings in this study are consistent with the theoretical developments in the learning literature including the theoretical constructs of belongingness (Thorndike 1911), preparedness (Seligman 1970, Testa 1974) and biological constraints of learning (Hinde & Stevenson-Hinde 1972; Seligman & Hagar 1972; and Shettleworth 1972). These constructs have been offered to account for the discovery of an increasing number of phenomena which can not be explained through general laws of learning. General laws of learning have been questioned for a long time. Researchers are now taking into account constraints on learning including the causal aspects relevant to response-reinforcement relationships. There are parallels between the preparedness and constraints on learning research and the present study. For a human infant, a mechanical act like moving a knob to create mechanical motion in an adjacent window can be seen as a "prepared" response, one that can be readily influenced by intensive training. Moving a knob to create motion and smiles in a human being may be anomaly, an "unprepared" or even "counterprepared" response. There are few similar situations in the infants' experience. At this time we cannot argue that the differences described here are biologically prepared, but it is clear that they are at least experientially prepared through ten months of interaction with objects which must be physically moved as opposed to humans who can be made to respond from a distance.

To fully establish the robustness of infant discrimination between social and mechanical causality, additional work is needed concerning four aspects of the results produced by this study: infant causal behaviors, the role of contact between cause and effect, the strength and generalizability of the social versus mechanical differences in causal behavior, and the age range across which social and mechanical causal knowledge develops. First, additional studies are needed to describe more behaviors infants employ to cause social and mechanical events. In future work infant's social means, like vocal and gestural communicative acts, affective responses and facial behaviors, should be employed as means to recreate social and mechanical events to give us the complement of what this study has provided. Second, the importance of contact in infants' understanding of mechanical causality has been implied in this study, yet further studies are needed to prove the point. The way the present study was designed we cannot be sure whether it was the infants' understanding of contact itself, that produced the preference for toward pushing in the window toy or whether merely pushing the knob in the direction of the desired effect was enough. Contact and direction of pushing could be teased apart by testing infants in several conditions in which a mechanical effect is produced by pushing a knob to one of several points located at varying distances from the event, as well as a condition where contact is required. If the contact condition were superior and if, in addition, infants pushed the knob to make contact even when it wasn't necessary for the toy's activation, the argument for infant appreciation of contact in mechanical causal sequences would be much more convincing. Third, future studies need to employ additional types of social and non-social effects. The results of the present study indicate that there are social and mechanical causalities that are different even in infancy. If we are to know that these are substantial differences and not just response preferences related to three specific toys, additional cause-effect sequences must be tested. Fourth, it is necessary to conduct the present study plus the three types of expansion mentioned above with infants across a broader age range, from ten months to two years. Continued research as outlined above can provide us with a refined view of sensorimotor causality which maps the two parallel developments of social and mechanical causality.

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Footnote

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Table 1.

Mean frequencies of Infant and maternal behaviors as a function of infant-mother pairs' assignment to toward and away condition during five minute interaction with each toy.

	Window Toy	Dog Toy	Human-event Toy
Toward Condition			
Infant behavior			
Full push toward	5.88	1	2.42
Partial push toward	8.83	3.13	7.46
Full+partial push toward	14.7	4.13	9.92
Full push away	5.25	.54	2.54
Partial push away	9.17	4.88	6.13
Full+partial push away	14.42	5.42	8.67
Total knob pushes, both directions	29.08	9.54	18.58
Successes (full pushes toward)	5.88	1	2.42
Maternal Demonstration	11.42	18.21	13.83
Away Condition			
Infant behavior			
Full push toward	5.12	.38	1.58
Partial push toward	8.54	1.58	5.13
Full+partial pushes away	13.71	1.96	6.7

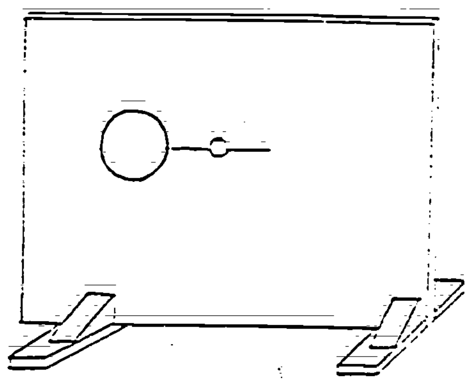
continued on page 25

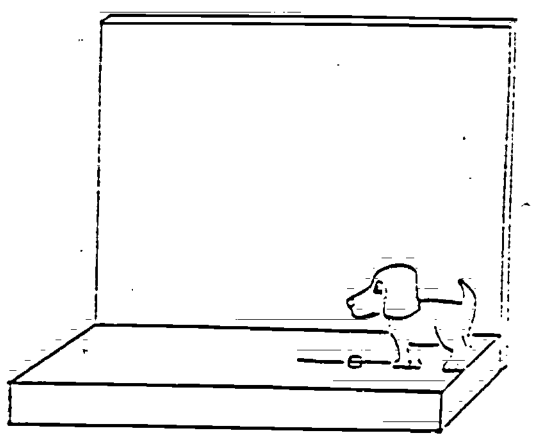
Table 1. (continued)

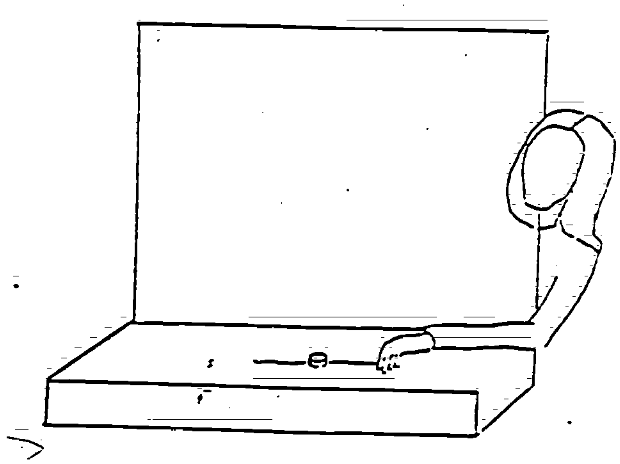
	Window Toy	Dog Toy	Human-event Toy
Away Condition (cont.)			
Infant behavior (cont.)			
Full push away	2.75	3.21	2.71
Partial push away	10.63	6.38	7.83
Full+partial pushes away	13.38	9.58	10.54
Total knob pushes, both directions	27.08	4.90	17.25
Successes (full pushes away)	2.75	3.21	2.71
Maternal Demonstrations	16.31	24.38	16.88

Figure Caption

Figure 1. The three mechanical toys: the window toy, the dog toy and the human event toy.







Appendix A.

OBSERVER'S QUALITIATIVE RATING SCALE

0 = No understanding of the causal relationships between knob and event

- Solely knob directed or solely event directed activity.

.5 = Brief indications of understanding and accidents

- One manipulation of the knob plus looking at the event.
- One accidental success which is not followed up by further attempts. Sometimes there is a surprised look when the event caused by the accident occurs.
- Repeated moves of the knob in the wrong direction with no looks toward the event.
- Simultaneous touching of event and knob.
- Bangs and slaps at the knob without looks to the event, immediately following mother demonstrations.

1 = Stronger indications that the knob is related to the event

- An accidental success that is followed by more deliberate attempts.
- Repeated partial pushes of the knob in the correct direction while not looking at the event.
- Repeated contacts to the knob while looking at the event (often immediately following a demonstration).
- Repeated wrong direction pushes plus looking at the event.

1.5 = Indications that there is a connection between using the knob and the occurence of event plus some understanding about the correct direction of pushing

- Repeated partial pushes in the correct direction plus some looks to the event.

Appendix A cont.

- Repeated full pushes of the knob in both directions, plus some looks to the event during the pushing.
- One full push of the knob in the correct direction (activating the event), while looking at the event.

2 = Strong indications that the infant understands that pushing the knob in the condition appropriate direction produces the event

- Repeated pushes of the knob in the correct direction while looking at the event.
- Repeated successes while looking back and forth between the event and the knob.
- Repeated successes plus looking coupled with strong facial and vocal indications of delight (sometimes it verges on awe). Whereas the baby may have smiled or chortled throughout some of the mother's demonstrations, upon the first and then subsequent independent successes the infant pauses a moment still looking at the event in action and then gives a much stronger burst of laughter and smiling. Some turn quickly to smile at their mothers.