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Infant perception of a manual pick-up event

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Manual pick-up of an object is a simple causal event frequently observed by infants. A habituation-recovery of looking technique with filmed stimuli is used in experiments which seek to investigate aspects of the perception and encoding of such events in infants. In the first study with 28-week-olds, it is found that 'lateral mirror-image' pick-ups are hardly discriminable, while a change in the contact relation of hand and object is readily discriminable. In the second, again with 28-week-olds, the discriminability of the contact relation appears to be specific to a dynamic context involving a hand (rather than another inanimate object). The results of a further experiment make it appear unlikely that the previous results were simply due to the partial occlusion of the picked-up object produced by the grasping. The implications of these results for infant perception of causality are briefly considered.

One of the commonest events infants of any age must witness is that of a hand picking up an object. Whether performed by others in the vicinity or, increasingly with development, by the infant himself, this is probably among the most ubiquitous of simple causal interactions in the infant's environment. Although actions performed by hands play an important role in Piaget's (1955) classic account of the origins of causality, little or nothing is known about how an infant might perceive pick-up events. This paper reports some experiments that are intended to address aspects of this question.

Piaget traces the origins of causality to the emergence of prehensile skills in Stage 3 of sensori-motor development. It is argued that the infant is to a large extent unable to take account of the spatio-temporal relations involved in causal interactions. A basic distinction is drawn between those events constituted by, or involved in, the infant's own activity and those events which take place independently. The latter sort of event is termed 'objective'. Development proceeds by way of the infant first coming to recognize the necessity of spatial contacts *within* the sphere of his own activity. Only later, around the end of the first year, does the infant begin to objectify sources of causal power—recognizing causes independent of his own activity and attending to their spatio-temporal characteristics.

Leslie (1982) suggested that Piaget might have underestimated the infant's ability to take note of spatio-temporal relations in objective events. In a habituation-test experiment, infants of 4½ and 7½ months were habituated to a film of a hand which approached, picked up and then carried off a toy doll. After an interval of one minute, one group was tested on a film in which the original orientation of the hand to doll was changed from left to right. Effectively these two films were 'lateral mirror-images' of each other. Another group was tested on a film in which the left orientation of the hand to doll remained the same, but this time the hand did not actually make contact with the doll, remaining instead approximately 15 mm from its nearest edge. In this way the hand appeared to pick up and carry off the doll as if 'by magic'. It was found that this latter group produced significantly greater recovery of looking than the first.

Leslie suggested that the lower discriminability of the lateral mirror-image pick-ups might reflect something akin to 'perceptual similarity' phenomena found by other workers using static pattern stimuli (e.g. Bornstein *et al.*, 1978). By contrast, the film pair differing in spatial contiguity of hand to doll during pick-up was easily discriminated by the infants. Both the younger and the older infants appeared to respond in essentially the same way.

It could be hypothesized, then, that even quite young infants are able to take notice of the contact relation between a hand and object in pick-up. Furthermore, the perceptual similarity of the mirror-image pick-ups may indicate that the infant's perception of these events operates at a relatively abstract level inasmuch as a left-right orientation change presumably involves greater 'sensory' differences than a small change in contiguity does.

If this were so, it could have important implications since the ability to perceive spatial continuities/discontinuities between a hand and an object in pick-up is likely to be an important component of a system that comes to organize its observations of such events according to causal-like principles.

The first study reported here replicates and extends the above experiment. A control group is added so that recovery to orientation change alone may be assessed, as well as a group in which both orientation and contact are changed simultaneously. The experiment also includes an additional control regarding the visibility to the mother of the test film. It was hypothesized that contact change would lead to significant recovery of looking in the test trial, while right-left orientation change would not.

Experiment 1

Method

Stimuli. The stimuli were looped 16mm colour films of a hand picking up a brightly coloured Russian-type doll from a shiny brown table top (illustrated in Fig. 1). There were four films in all. In the first (contact left) a hand enters from off-screen at the left-hand side and proceeds to grasp the doll. After a stationary period of about 0.5 s the hand picks up the doll and retreats back off-screen with it. In the second film (contact right), everything happens as before except that the hand enters and leaves at the right-hand side of the screen. In the third film (no-contact left), the hand enters from the left side and approaches the doll as before, but instead of actually making contact with the doll by grasping it, the hands stops short with an (approximate) 15 mm gap between fingertips and nearest edge of the doll. After a stationary period the hand 'picks up' the doll (without touching it) and both hand and doll retreat off-screen, the doll following the hand at a constant distance as if 'by magic'. In the final film (no-contact right) everything happens as in the latter film, except the hand enters and leaves at the right side of the screen.

Design. There were four groups of subjects (see Table 1). Group I were allocated the film pair 'contact left-no-contact right'. Half the subjects started with the contact left film in the habituation phase and went on to the no-contact right film in the recovery-test phase. The other half received the reverse order. Infants in this group saw a pair of films that contrasted in terms of both a change in the contact relation and a change in the orientation relation between hand and doll.

Group II were allocated the film pair 'contact left-no-contact left', half the infants habituating to contact left then proceeding to no-contact left, and half receiving the reverse order. This group saw a film pair contrasting only in terms of contact/no-contact. Half the subjects in Group III saw the pair 'contact left-contact right', while the other half saw 'no contact-left-no-contact right', thus contrasting only the right-left orientation of hand to doll. Finally, Group IV acted as controls, half seeing contact left in both habituation and recovery phases and half seeing no-contact left in both phases. (For ease of exposition, Groups I and III have been represented above as always starting with a 'left' film; in fact, the order as regards left-right was counterbalanced within these groups.) There was an interval of approximately one minute between the end of habituation phase and the beginning of the recovery test trial.

To help control for accidental differences between films (e.g. scratches, etc.) both sequences illustrated in Fig. 1 were filmed twice. When a 'right' version of a film was required its 'twin' was projected from the reverse side, giving a mirror image. Similarly, in the control group, the film was changed during the interval to its partner version.

The infants sat on their mother's lap throughout the experiment. To control for possible differential maternal influence on their infant's looking during recovery phase, mothers were required to close their eyes before the test trial and to open them again only after presentation had ended. Mothers were not informed beforehand of the purpose of the experiment nor of the films they would see.

All sessions were videotaped for later checking of in-session scoring by an independent judge who was blind as to which film pair any particular infant was viewing. Complete agreement was found on 92 per cent of trials; in the remaining trials disagreement was within the rounding error, i.e. never exceeded 1 s (see below).

Subjects. There were 20 male and 20 female infants aged between 25 and 33 weeks (mean age 28.6 weeks, SD =1.86 weeks) randomly assigned 10 to each group with an equal number of males and females in each group. To reach $n = 40$, 61 subjects were seen. Of the 21 rejections, two fell asleep, three were inadvertently distracted by their mothers, three were rejected due to experimenter error, one due to mechanical breakdown, nine for

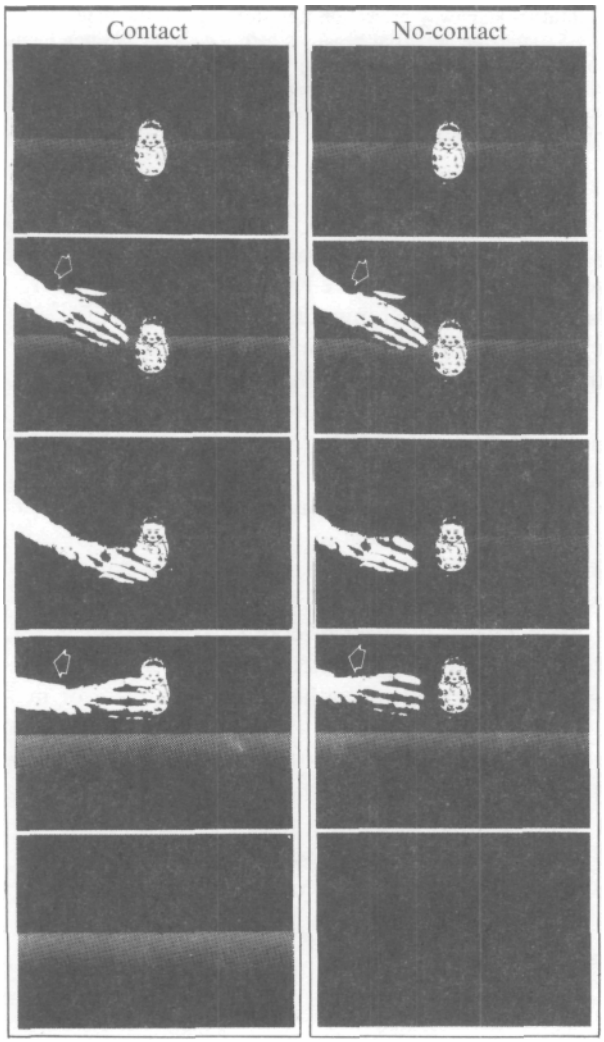


Figure 1. The films were made on 16mm High Speed Ektachrome VNF and formed into loops for continuous projection at 24 frames s^{-1}. Each film lasted approximately *4½* s before repeating, including an eight-frame blank between start and finish. The doll was moved by means of black wire moving against a black background such that it was completely invisible on the finished film. Overall projected picture size was 30 x 39 cm. The doll was (approx.) 9 cm high and the hand was (approx.) 6cm high and 12cm long.

Table 1. Experiment 1 Design

	Orientation change	No orientation change
Contact change	Group I	Group II
No-contact change	Group III	Group IV

persistent fussing, one was inattentive from the start, and two failed to reach criterion within 18 trials. Rejections per group were roughly equal (five, four, six and six respectively).

Procedure. The procedure followed was essentially the same as Leslie (1982). The films were presented in a dimly lit room, with all potentially distracting surfaces shrouded. Each trial consisted of a single continuous look in the direction of the film. The infants sat on their mother's lap facing a back-projection screen approximately 1.2m away. An infra-red video system provided a frontal head and chest view of the infant which was displayed on a TV monitor.

Each trial began with the experimenter flashing on and off a pair of small lights stationed just in front of the screen, until the infant appeared to look in their direction. Lights were then extinguished and the film projected onto the screen. Projection continued until the infant appeared to look away from the film. The length of the

look towards the film was timed. As soon as the infant looked away projection was stopped and the time recorded to the nearest half second. Approximately 5 s later the next trial began as before with the flashing lights. An infant was deemed to have habituated when on each of three consecutive trials (s)he produced looks whose length was less than the mean of the first three trials. Each infant thus had a minimum of six trials. Having satisfied this criterion, the 1 min interval ensued during which the film was changed. A recovery trial was then administered in the same way with a new film. Infants were rejected if they failed to reach criterion within 18 trials; two subjects were rejected for this reason.

Results

Habituation was assessed by comparing first habituation trial looking with last habituation trial looking. Preliminary analysis showed no significant main effects of sex or film order (contact first vs. no-contact first) and these factors were eliminated from subsequent analysis. Analysis of variance with factors contact change (2) x orientation change (2) x trials (2) with repeated measures on the last factor shows a significant main effect of trials (F=21-298, d.f. = 1,36, $P<0.0001$). No other main effects or interactions proved significant. This indicates that looking declined from the first to the last habituation trials, and that the decline was uniform across groups.

Recovery of looking was assessed by an analysis of variance on last habituation trial vs. test trial. Preliminary analysis again indicated no main effects of sex or film order. Analysis of variance on the last habituation trial vs. test trial with factors contact change (2) x orientation change (2) x trials (2) showed a significant main effect of trials ($F=$ 18.008, d.f. = 1,36, $P<0.001$). There was also a significant main effect of contact change (F=4.711, d.f. = 1,36, $P = 0.037$) and a significant contact change x trials interaction (F=6.4237, d.f. = 1,36, $P=0.016$). Orientation change was not significant either as a main effect or in interaction.

The trials main effect and the contact change main effect are attributable to the contact change x trials interaction in the light of the previous analysis. The significant contact change x trials interaction indicates that looking times rose more sharply on the test trial for those groups receiving film pairs differing in contact. The absence of orientation change effects indicates that this did not significantly influence recovery. These results are illustrated in Fig. 2.

Discussion

The results suggest that the infants habituated to the cinematic stimuli in an essentially uniform manner across groups. There were no significant differences in looking levels between groups on either the first or last habituation trials, while within groups looking declined significantly from first to last trial. Looking rose again on the test trial in all groups suggesting perhaps a small degree of 'spontaneous' recovery. The significant contact change x trials interaction indicates, however, that this rise was greater in Groups I and II who saw a film pair contrasting contact between hand and doll than in Groups III and IV who did not. Recovery in the orientation change only group (Group III) was not significantly different from that in the control group (Group IV).

These results with 28-week-old infants confirm Leslie's (1982) initial findings. Infants appear to discriminate a change in the contact relation between a hand and object during a pick-up event but not a right-left orientation change. A change in the contact relation between hand and doll produced greater apparent novelty for infants after an interval of about 1 min than a change in the right-left orientation of the pick-up.

Although it seems reasonably clear that the infants in the present study could attend to the hand-doll configuration and remember enough about it to dishabituate to a change in contiguity about 1 min later it is not clear whether this reflects an ability simply to discriminate spacing in a pattern that is essentially *meaningless* for them or whether it

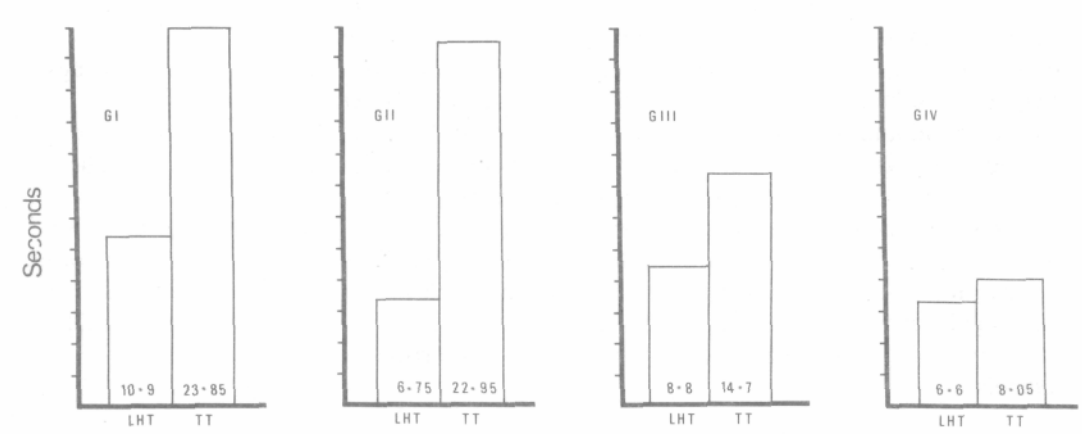


Figure 2. Experiment 1: Mean looking time by groups on last habituation trial (LHT) and test trial (TT). Group I viewed a film pair contrasting both the contact relation and orientation to the doll; Group II a film pair contrasting only the contact relation; Group III contrasting only orientation; while Group IV acted as controls.

indexes something more specific to the perception of a pick-up event. For example, it might be the case that even young infants can have at least a primitive causal perception of a hand as an active entity that produces effects. The structure of such a percept and its consequent encoding might involve the spatial contiguity relation between hand and object as an important parameter.

A first step towards answering this sort of question would be to investigate whether the contiguity relation is equally discriminable when a hand does not pick up an object as when it does. Thus one could present infants with the first part of the pick-up sequence in which the hand approaches the object and takes up a stationary position relative to it either grasping it or not quite grasping it. Another group of infants could be shown the second half, where the hand proceeds from the stationary position to picking up and carrying off the object—again either in contact or out of contact.

Furthermore, one could contrast the discriminability of the contiguity relation in a context involving a hand with a sequence in which an inanimate object substitutes for the hand and performs analogous movements. If attention to the contiguity relation depends upon the perception of a hand as an active entity that produces effects, then the substitution of an inanimate object that is not perceived in this way should lead to a reduction in the salience of the contiguity relation.

Thus, discrimination of contact/no-contact would indicate that infants can attend to the contiguity between hand and object in a normal pick-up. Discrimination of contiguity *selectively* in hand pick-up would be suggestive of a special role for contiguity in this context. This in turn would be at least suggestive of the infant construing manual pick-up as in some sense causal.

Experiment 2

The next experiment reported attempts to test these hypotheses. One group of infants views films involving a hand as before while another group sees films where an inanimate object is substituted for the hand and performs analogous movements. In addition, the action used in the previous films is split such that one group views films depicting only the approach and stationary phases, while another group views films depicting only the stationary and pick-up phases. Thus there are four experimental groups: the first sees a hand pick up the doll; the second sees the hand approach and grasp the doll; the third

sees an inanimate object 'pick up' the doll; while the fourth sees the inanimate object approach and make contact with the doll. Having habituated to these films, these groups then go on to be tested on equivalent films that lack the element of contact (either between hand and doll or between other object and doll). In addition, four control groups appropriate to each of the previous groups are incorporated in the experiment. For the control groups the contact relation remains unchanged in the test trial.

It was hypothesized that contact change would be most readily discriminated by those infants viewing the film pair showing the hand picking up the doll than in any of the other groups. In particular, it was expected that the hand pick-up experimental group would show significantly more recovery of looking than its control group, and that this would not be true of the other experimental groups when compared with their respective controls.

Method

Design. There were four experimental groups who each saw a film pair contrasting a contact relation (see Table 2). Group 1 saw the hand and doll start from the stationary position and then move off-screen together. Group 2 saw the hand entering the screen and moving into the stationary position. Group 3 saw a sequence analogous to Group 1 but with a white oblong in place of the hand, while Group 4 saw a sequence analogous to Group 2 with the oblong substituting for the hand. In addition, there were four control groups who saw the same films as the experimentals respectively but without a contact change on the test trial.

Within each experimental group the order of presentation of the contact/no-contact films was counterbalanced, half the subjects habituating to a contact version and being tested on a no-contact version, and half habituating to no-contact and being tested on contact. In the control groups half the subjects saw a contact version in both habituation and test phases while half received a no-contact version in both phases. The same method of using twin versions of each film in the control groups was followed as in Expt 1 to help control for accidental differences between contact and no-contact versions.

Table 2. Experiment 2 : Design

		Pick-up	No pick-up
Contact change (experimentals)	Hand	Group 1	Group 2
	Oblong	Group 3	Group 4
No-contact change (controls)	Hand	Group 5	Group 6
	Oblong	Group 7	Group 8

In-session scoring was checked from videotape at the end of each session. In addition, a randomly selected one-third of all sessions was checked by an independent judge blind as to which film pair was being used; again agreement with experimenter scoring was high (94 per cent of all trials).

In summary, there were eight groups. Groups 1 and 5 (control) saw hand pick-up films; Groups 2 and 6 (control) saw hand no-pick-up films; Groups 3 and 7 (control) saw non-hand pick-up films; and Groups 4 and 8 (control) saw non-hand no-pick-up films.

Procedure. The procedure followed was the same in all respects as that followed in Expt 1.

Stimuli. The films were made by the same method as before and are graphically illustrated in Fig. 3.

Subjects. Ninety-six fresh subjects, 48 males and 48 females, were randomly assigned to eight groups, 12 infants per group with an even balance of males and females in each group. Ages ranged from 24 to 33 weeks (mean age = 28.46 weeks, SD = 2.4 weeks). To reach $n = 96$, 125 subjects were seen. Of the 29 who were rejected, one fell asleep, one was inadvertently distracted by mother, four were subject to experimenter error, three through mechanical breakdown, three were inattentive from the start, twelve were rejected for fussing, and five failed to reach criterion within 18 trials.

Results

Habituation was again assessed by comparing looking on the first habituation trial with the last habituation trial in a 2 (contact change vs. no-contact change) x 2 (hand vs. non-hand) x 2 (pick-up vs. no pick-up) x 2 (trials) analysis of variance with repeated measures on the last factor. A significant main effect of trials was found ($F = 34.46$, d.f. = 1,88, $P<0.0001$). No other main effects or interactions proved significant. This

indicates that looking times on first and last habituation trials did not differ significantly between groups but that there was a decline in looking times within groups.

Figure 4 shows the mean looking times on last habituation and test trials by groups. Table 3 shows the results of the planned comparisons on test trial looking scores and recovery scores (calculated as the difference between test trial and last habituation trial). As hypothesized, only the hand pick-up contact change group showed significantly greater test trial looking (and recovery) than its control.

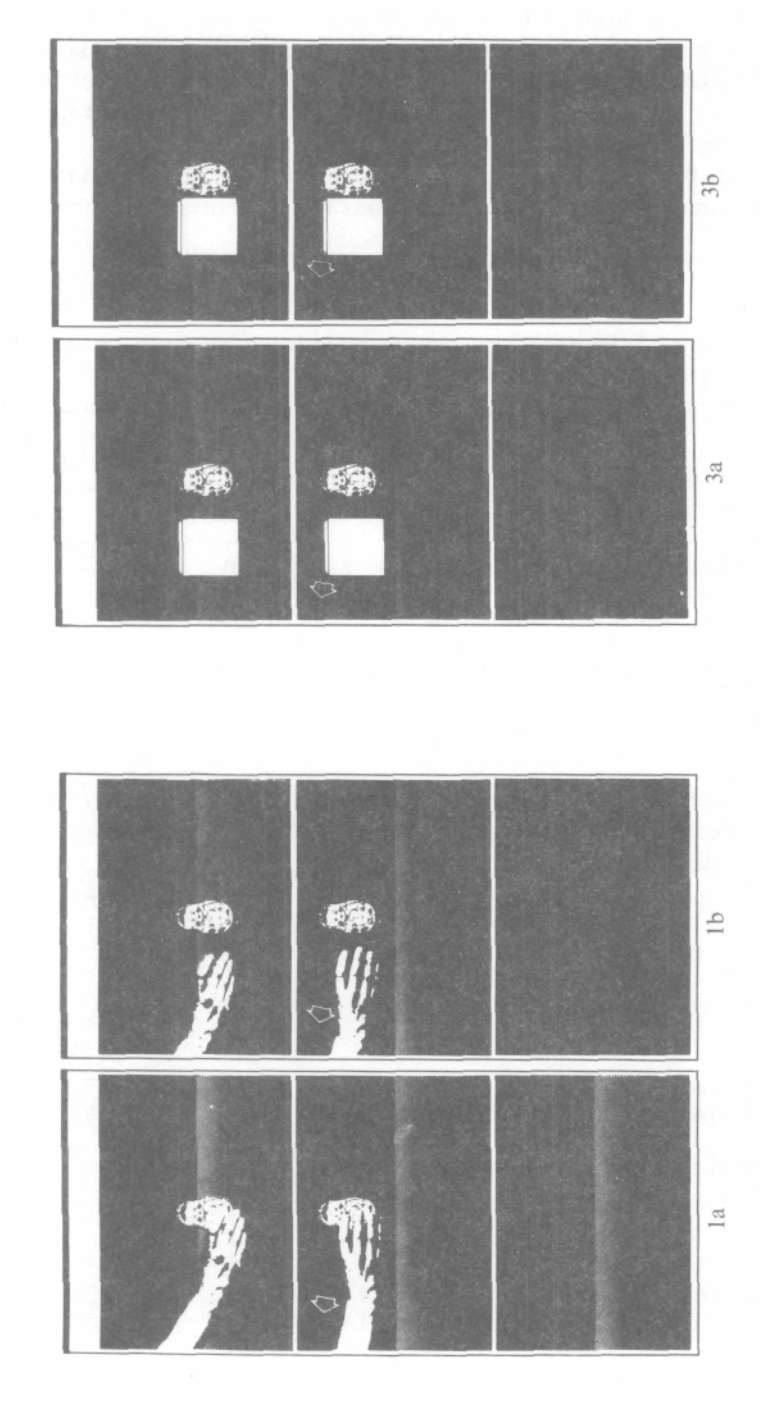
Recovery was further assessed by analysis of variance on last habituation trial vs. test trial with the same factors as above. The results of this analysis are summarized in Table 4.

Table 3. Experiment 2 : Planned comparisons by independent *t* test on test trial scores and recovery scores (test trial-last habituation trial)

	Test trial (looking scores)		Recovery scores (test trial-last habit)	
	t (d.f. = 22)	*P*	*t* (d.f. = 22)	*P*
Hand pick-up (Group 1) vs. control (Group 5)	3.101	0.003 (one-tail)	3.583	0.0008 (one-tail)
Hand no pick-up (Group 2) vs. control (Group 6)	-0.03	n.s.	0.296	n.s.
Non-hand pick-up (Group 3) vs. control (Group 7)	0.149	n.s.	0.867	n.s.
Non-hand no pick-up (Group 4) vs. control (Group 8)	-0.914	n.s.	0.21	n.s.

Table 4. Experiment 2: Last habituation vs. test trial ANOVA summary table contact change (vs. no-contact change) x hand (vs. non-hand) x pick-up (vs. no pick-up) x trials (last habit vs. test trial)

Source	Sum of squares	d.f.	Mean square	*F*	*P*
Between subjects	*2537.54*	*95*			
Contact change		1	4.533		
Hand		1	6.939		
Pick-up		1	324.22	14.135	<0.001
Contact change x hand		1	86.001	3.749	0.056
Contact change x pick-up		1	67.095	2.925	0.091
Hand x pick-up		1	8.543		
Contact change x hand x pick-up		1	1.668		
Error between		88	22.938		
Within subjects	*1970.38*	*96*			
Trials		1	492.481	46.592	<0.001
Contact change x trials		1	98.47	9.316	0.003
Hand x trials		1	111.78	10.576	0.002
Pick-up x trials		1	132.50	12.536	<0.001
Contact change x hand x trials		1	40.793	3.859	0.053
Contact change x pick-up x trials		1	76.887	7.274	0.008
Hand x pick-up x trials		1	46.512	4.4	0.039
Contact change x hand x pick-up x trials		1	40.793	3.859	0.053
Error within		88	10.57		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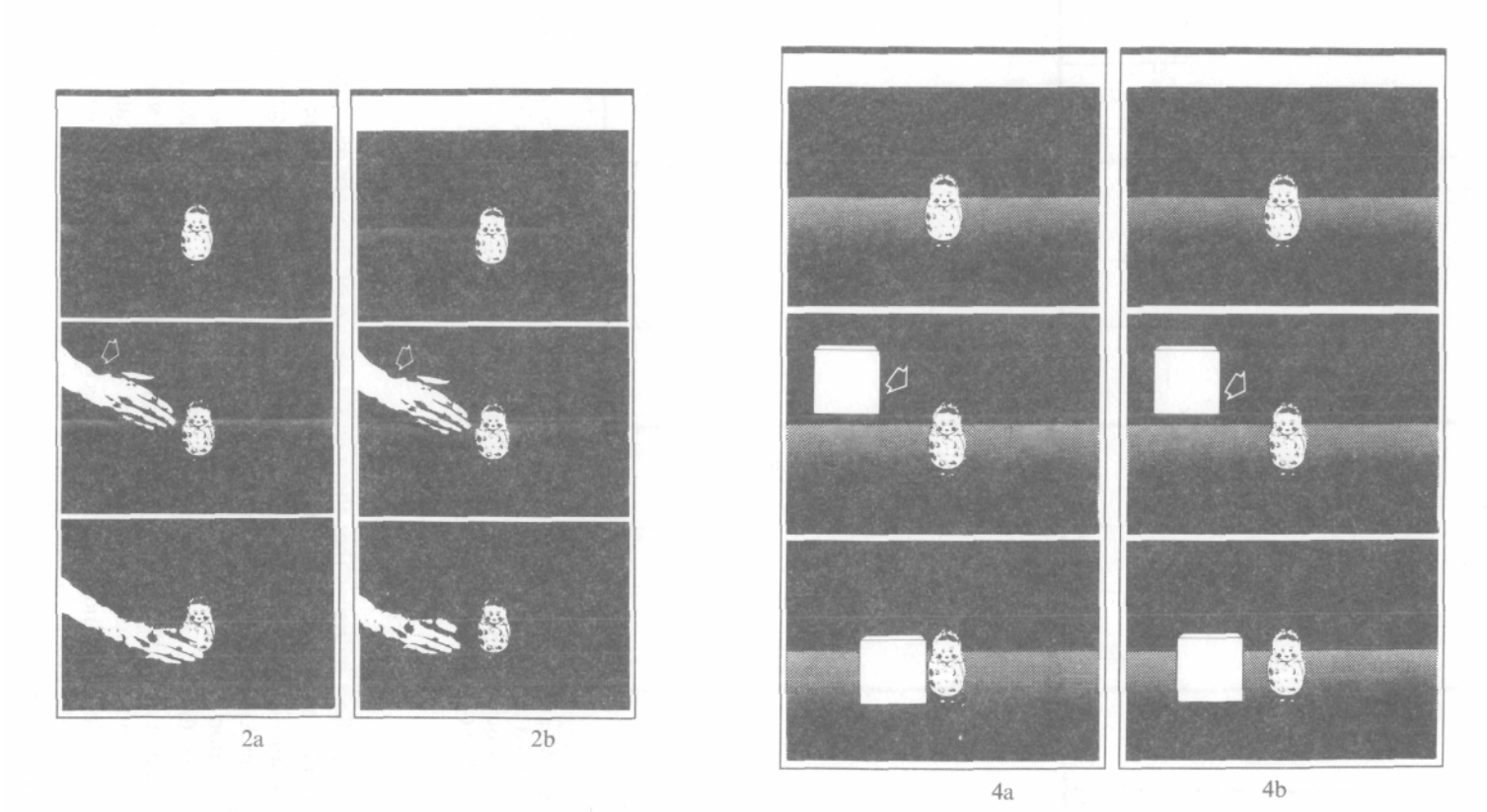

Figure 3. The films were again shot on 16mm Ektachrome VNF and formed into loops for projection at 24 frames s^{-1}. Each film lasted approximately 3 s before repeating, including an eight-frame blank. The projected dimensions were approximately the same as in Expt 1. The oblong was (approx.) 7.5cm high and 12cm long. Film la = hand pick-up contact;lb = hand pick-up no contact; 2a = hand no pick-up contact; 2b = hand no pick-up no contact; 3a = oblong pickup contact; 3b = oblong pick-up no contact; 4a = oblong no pick-up contact; 4b = oblong no pick-up no contact.

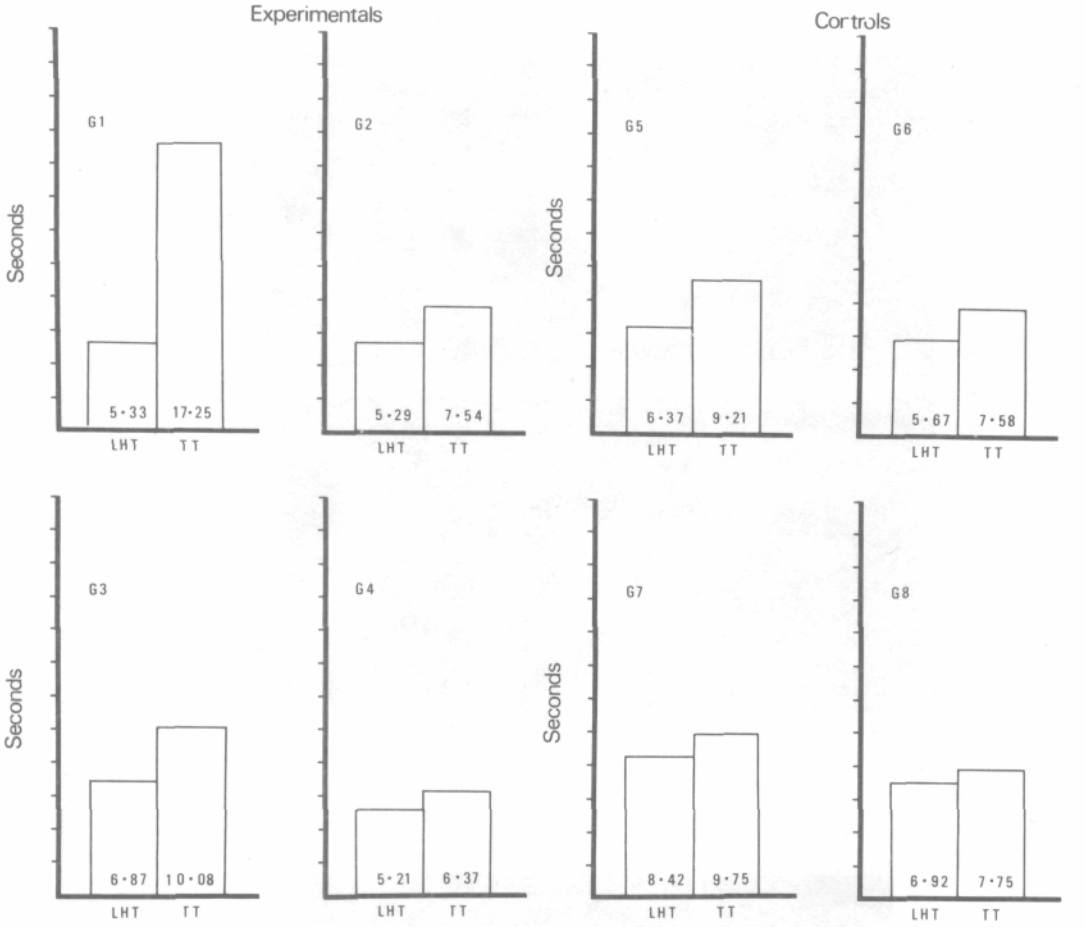

Figure 4. Experiment 2: Mean looking time by groups on last habituation trial (LHT) and test trial (TT). Groups 1 to 4 viewed films contrasting contact. Group 1 saw hand pick-up films; Group 2 hand no pick-up films; Group 3 oblong pick-up films; and Group 4 oblong no pick-up films. Groups 5 to 8 were their respective controls with no contrast in contact.

The large trials main effect indicates that there was a degree of recovery over the interval common to all groups, although it is likely that this main effect has been inflated by interactions at various levels. The pick-up main effect and the contact change x hand and contact change x pick-up interactions are probably accounted for by the pick-up x trials interaction and by higher order interactions, since these were not significant factors in the first vs. last habituation trials analysis above. The contact change x trials interaction appears to reflect higher looking in the experimental groups on the test trial than their control counterparts. The hand x trials interaction indicates that those infants who were viewing hand-involving films recovered interest on the test trial more than those viewing the oblong-involving films. The pick-up x trials interaction indicates that pick-up films produced more recovery than no-pick-up films on the test trial.

Inspection of the relevant means indicates that the significant contact change x pick-up x trials interaction was due to greater dishabituation to contact change in those infants viewing a pick-up film. The hand x pick-up x trials interaction indicates that infants recovered interest more when a hand was involved in pick-up than when an

oblong was involved. There was a trend which fell just short of significance for a contact change x hand x trials interaction, reflecting a tendency for the infants to dishabituate more to a contact change when the hand was involved than when the oblong was involved. Finally, the quadruple interaction of contact change x hand x pick-up x trials also came close to being significant at $P = 0.053$. This reflected a tendency for infants to dishabituate more to a contact change when the hand picks up than when the oblong picks up.

These data were further examined by a set of individual comparisons on group recovery scores using the Newman-Keuls method. The results of this show Group 1 recovery scores to be significantly higher than all other groups ($P < 0.01$). No other comparisons proved significant at even the 10 per cent level. These results indicate that probably all the main effects and interactions found in the preceding analysis of variance were driven by the Group 1 scores. Thus it is probably the case that only the four-way interaction needs to be taken seriously.

In summary, groups did not differ significantly on either the first or last habituation trials and the decline in looking was uniform across groups. The planned comparisons showed that only in the hand pick-up group did a change in the contact relation lead to recovery after the interval that was significantly greater than its control. ANOVA on last habituation vs. test trial showed a complex pattern of interaction. Individual comparisons by the Newman-Keuls method, however, indicated that this pattern was due to the Group 1 scores, suggesting that in the previous analysis a quadruple interaction of contact change x hand x pick-up x trials was driving lower order effects.

Discussion

The individual comparisons showed that a change in the contiguity relation led to dishabituation only in the case of the hand pick-up. Where there was no pick-up or where an inanimate oblong substituted for the hand, the contiguity relation appears not to have been noticed or at least did not lead to dishabituation. This supports the hypothesis that contact would have different 'value' for the infant in a hand pick-up than in the other contexts. The ANOVA suggested a complex pattern of interacting factors. Contact change, hand and pick-up all appeared to determine recovery both individually and in interaction. The *post hoc* comparisons, however, showed that the results on recovery were in fact much simpler than this might at first suggest. The only significant differences in recovery between groups were associated in every case with Group 1. It may be somewhat hazardous to compare the no-pick-up and pick-up groups directly on recovery to contact change. After all, in the pick-up films the contact (or no-contact) relation was 'there' throughout the film, whereas in the no-pick-up films it was 'there' only after the hand or oblong had got into position. Nevertheless, it might have been the case that the position taken up by the hand (or oblong or both) relative to the doll would have been 'important' enough to the infants to attend to and remember it. Or it might have been 'important' to them only when the hand was involved and not the oblong. As it was, it seemed to make no difference whether it was the hand or the oblong and in both cases there was no evidence that contact change produced dishabituation. In the case of pick-up films, however, the involvement of the hand did appear to make a difference: it led to dishabituation to contact change.

It is probably true that in general discrimination experiments never provide unambiguous evidence regarding the 'meaningfulness' of stimuli (cf. Bower, 1972); that at best they provide evidence that is only suggestive of meaningfulness. In the present case, it is suggestive that contact change, hand and pick-up appeared to interact in determining recovery. It is as if the pick-up leads the infant to attend more closely to the hand and as if the hand pick-up then leads the infant into noticing the contact relation. It is perhaps tempting to suppose that this might reflect a tendency on the infant's part to see relationships between these different aspects of the event.

Why was the contact change not discriminated in the case of the oblong pick-up? After all the contact relation was 'there' throughout just as it was in the hand pick-up. From one point of view then it must have been just as 'visible'. It should be pointed out, however, that when the hand was in contact with the doll the fingers lightly grasped one of its edges. Thus part of the doll was occluded. But when the oblong was in contact with the doll it merely butted up to this edge without occluding any part of the doll. The contact/no-contact relation in the hand case presented a partial occlusion/no-occlusion contrast. Perhaps the contact change discrimination simply focused upon this appearance of the doll. If partial occlusion of the doll was alone responsible for the greater discriminability of contact change in the hand pick-up group, then one should expect to find an increased recovery in an oblong pick-up group where the oblong also partially occludes the doll when in contact.

To test this possibility a new pair of films was prepared. This time the oblong was modified by removing a portion of its rear leading surface. When in contact with the doll, the doll nestled in this space leaving a lip in the front leading surface of the oblong protruding over part of the doll. The area of the doll thus obscured was at least as great as that which had previously been occluded by the fingers of the hand. Sixteen fresh infants (mean age = 27.9 weeks, SD = 2.3 weeks) were presented with this new pair of films using the same procedure as before. Eight infants saw the contact film first and were tested on the no-contact film, while eight received the reverse order.

The results from this new group were compared with the results from Group 3 (oblong pick-up contact change) of the previous experiment. Analysis of variance on first vs. last habituation trials showed only a significant effect of trials ($F = 15.52$, d.f. = 1,26, $P < 0.001$). The F ratios for groups and groups x trials were less than 1.0 in both cases. This indicates that the present group did not differ on either first or last habituation trials with Group 3 of the previous experiment. The present group scored a mean of 6.69 s on the last habituation trial and a mean of 10.03 s on the test trial. Analysis of these scores in comparison with Group 3 showed a significant effect of trials ($F = 18.13$, d.f. = 1,26, $P < 0.001$). Again there was no significant effect of groups and no interaction ($F < 1.0$ in both cases). This indicates that the rise in looking from last habituation to test trial was uniform across the two groups.

Having the oblong partly occlude the doll when in contact did not lead to increased recovery of looking. This would seem to contradict the possibility that partial occlusion *per se* is responsible for the greater discriminability of contact change in the hand pick-up film. It is still possible, of course, that partial occlusion by the fingers (i.e. grasping) plays an important role in the infant's perception of manual pick-up. Future research could look at this question.

Thus there is no evidence in these results that the infants will dishabituate to contact change in the case of oblong pick-up. One must be cautious, however, in concluding from this that the infants were literally incapable of discriminating the change. As Kagan *et al.* (1979) have argued discrimination may be a necessary condition of dishabituation, but it is not clear that it is a sufficient condition. Kagan *et al.* present evidence that a contrast may lead to dishabituation in one context but not in another. They propose a 'curvilinear discrepancy hypothesis' which predicts that dishabituation will not occur if the two stimuli are either very similar (but not identical) or very dissimilar so that the infant fails to relate the two stimuli via a common 'schema'. Thus it is even possible that in the present case the infants approached the contact and no-contact versions of oblong pick-up in entirely different ways.

One possibility that might be considered in this light is that the no-contact version of oblong pick-up was an 'ambiguous' stimulus for the infants. It seems reasonable to

suppose that in the contact version the infants would perceive the adjacent doll and oblong as a single object—an oblong-doll amalgam. Indeed it would perhaps be more surprising if they had seen this configuration as two distinct objects. In the case of the no-contact version the separation of the objects might then suggest distinct objects while their 'common fate' of movement might suggest a single amalgam, giving rise to a certain 'ambiguity'.* If such speculations were along the right lines, an explanation might be suggested for the different value the contact relation may have had for the infants depending upon its context. Thus, in the case of oblong pick-up the contact relation functions to specify the object *composition* of the event, while in the hand pick-up the contact relation has a function related to the *dynamics* of the event.

General discussion

The first experiment was interpreted as showing that lateral mirror-image pick-ups are perceptually similar for infants. This seems more plausible in this case than saying that the infants fail to relate left and right pick-ups via a common 'schema'. It is not known, however, to what extent this similarity depends specifically upon a lateral mirror-image. It is possible, for example, that any orientation change (or some orientation changes that are not lateral mirror-images) would not be readily discriminable either. Such a finding would suggest that infants recognize a class of pick-up events that is abstract with respect to orientation a sort of 'event constancy'. This would be an interesting line for future research. For the present it can be argued that infants disregard at least some orientation changes. The relatively greater salience of a contact change between hand and object may indicate that this is a more important dimension in the infant's perception of pick-up.

The second experiment was interpreted as showing that the contact relation between two objects can have different 'values' for the infant in different contexts. It can be assumed that a contact hand pick-up is a familiar event in the infant's environment, whereas the no-contact version is not. Nevertheless, the point remains that even if familiarity played a role in this experiment, the basis for judging the familiarity of the normal hand pick-up was the contiguity relation. In Piagetian terms, this relation is 'objective' by virtue of obtaining outside the infant's *own* activity. The infants in this study (who would be in Stage 3 of sensori-motor development) should only just be taking account of spatial contiguity relations within the sphere of their own activity and not yet be able to apply themselves to these relations in 'objective' events. Leslie (1982) found that 4½-month-olds dishabituated to a contact change in a hand pick-up. Infants of this age have just begun to reach for and pick up objects themselves. In a pilot study partially replicating the present Expt 2, the author has some evidence suggesting a similar pattern of dishabituation in 13-week-olds. The 13-week-old has had only the most limited reaching experience (Bower, 1972; Bruner & Koslowski, 1972; Trevarthen, 1975, 1978) and can be expected to have had little or no experience of active pick-up. Although these results need to be investigated

* This speculation receives a degree of support from analysis of the total looking times each film attracted during habituation. Analysis on looking time to habituation showed a significant interaction of hand x pick-up x contact ($F=8.37$, d.f. = l,88, $P = 0.005$). Further analysis (Newman-Keuls method) showed that total looking to the oblong pick-up no-contact film was significantly higher ($P<0.05$) than to all other films with the exception of the hand pick-up contact film. In the oblong pick-up group with partial occlusion, the no-contact film was again found to have attracted longer total looking during habituation than the contact version ($P < 0.05$, one-tailed). In neither of the relevant groups, however, was there a difference in recovery times dependent upon presentation order. This seems to be due to the fact that longer total looking resulted mainly from a larger number of trials to criterion. The longer time to habituation with the oblong pick-up no-contact film may indicate that this film entailed a greater workload during the encoding process than the contact version. One possible explanation of this would be that oblong pick-up no-contact was 'ambiguous'. In contrast, time to habituation did not differ for the hand versions of these films, where one might expect the infants to have no difficulty construing the hand as a distinct object in both contact and no-contact versions.

further, taken together they begin to suggest that some aspects of the capacity to understand objective events do not have to be gradually constructed through the exercise of motor skills, but may result from natural structures of observational intelligence.

Gelman & Spelke (1981) have recommended that the infant's differential perception of events involving animates and inanimates be investigated. The present studies could be viewed in this light. One idea worthy of further examination is that hands are seen from an early age as agents of change —as active entities that produce effects under certain spatio-temporal constraints. In this way pick-up may be an early established or natural category of event. In the no-contact pick-up films used here, because the objects were not physically yoked to one another, some very small independent movements of the doll were possible and indeed occurred as it trailed behind the hand or oblong. Perhaps these small spatio-temporal discontinuities cued a lack of contact for the infant. It is possible that in the appropriate context the infant's parsing of events is highly sensitive to such spatiotemporal discontinuities.

Even if the infant in some sense sees a (normal) hand pick-up event as causal, a number of important questions remain concerning how the no-contact version is perceived. Is it seen as entirely non-causal, involving simply a hand moving in unison with another object such that the simultaneity and spatial correlation of the movements is fortuitous? Or is the infant *compelled* to see hands as agents, so that a no-contact pick-up is seen as an anomalous event —a magical violation of causal principles? Or has such a principle yet to develop, so that the infant sees this as just a stylistic variation on a normal pick-up? Answers to these questions should provide us with important insights into the development of causality.

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