

BEHAVIOR OF YOUNG CHILDREN UNDER CONDITIONS SIMULATING ENTRAPMENT IN REFRIGERATORS

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EACH year a number of young children perish as a result of entrapment in iceboxes, refrigerators and freezers. As numbers go, these are few compared with accidental deaths from other causes, but the thought of even a small number of helpless children suffocating needlessly is so appalling as to have created widespread interest in the problem.

Because of increasing public awareness of the fatalities resulting from entrapment of young children in refrigerators during a period of several years preceding 1956, manufacturers, engineers, governmental bodies and others became interested in methods for alleviating this hazard. Congressional hearings on proposed legislation resulted, in 1955, in a request that the National Bureau of Standards (NBS) work with the refrigerator manufacturing industry represented by the National Electrical Manufacturers Association (NEMA) to develop performance criteria for evaluating safety release devices. Considerable progress was made toward this objective by mid-1956, at which time Congress passed an Act* which required "certain safety devices on household refrigerators shipped in interstate commerce" that would allow the doors of such refrigerators to be opened easily from the inside. It further required the development of standards for such release devices. Such standards were published in the Federal Register of August 1, 1957. They require that all devices meet at least one of three specified performance re-

* Public Law 930, Second Session of the 84th Congress, signed by President Eisenhower on August 2, 1956.

quirements, and specify in some detail tests for the purpose of determining compliance with these requirements.

Consideration of the problem by NBS and NEMA made clear that it was not only an engineering problem, but also a problem in child behavior and so the aid of the Children's Bureau was enlisted.

In developing performance criteria for release devices, it was necessary to correlate the mechanical forces required to keep refrigerator doors securely closed against their gaskets and the forces young children are able to exert when seeking to escape from entrapment. Because no data were available on this point, late in 1955 the Children's Bureau and the NBS conducted tests on children in nursery schools in an attempt to gain this information. In this preliminary experiment, some 60 children between the ages of 2 and 5 years were tested in an experimental enclosure, which simulated a refrigerator only with respect to inside dimensions. The enclosure was camouflaged to represent a gay red "Santa Claus chimney," with a window and door. The children were urged to use, and were rewarded for using, their utmost strength in competitive pushing against the door, from both sitting and standing positions. These tests indicated that a significant proportion of the young children tested failed to exert forces in excess of 10 pounds. However, practical manufacturing considerations make it hard to design for assembly-line production a release device which will respond to a direct push of this magnitude on a refrigerator door and which, at the same time, will permit the refrigerator door

(Accepted April 1, 1958; submitted January 27.)

ADDRESS: (K.B.) Washington 25, D.C.

PEDIATRICS, October 1958

to seal so as to allow the refrigerator to perform satisfactorily its primary function—food preservation.

A further investigation was therefore undertaken during the summer of 1956 to provide additional information on the force efforts of children, as well as information on child behavior in general with respect to release devices currently obtainable, the experiment being carried out under conditions simulating actual entrapment as closely as possible. No studies had previously been made under such conditions, insofar as could be determined.

From death certificates and newspaper accounts of refrigerator deaths, a few facts are known and some assumptions can be made. The age range, for all practical purposes, is 2 through 9 years, with the peak between 3 and 6. Males far outnumber females. Children enter refrigerators singly or in groups. In one instance four, and in another case five, children died together, while a number of situations are recorded in which two children were fatally entrapped together. Some of the refrigerators are abandoned in dumps but many are in homes, only temporarily in disuse (as in empty apartments), or are in the process of defrosting. Some children probably get into refrigerators as into a playhouse, some probably are hiding from companions, a few are shut in by playmates.

PART I. BEHAVIOR STUDY

In designing an experiment to simulate as closely as possible the real situation precautions had to be taken to protect the experimental subjects. If a real refrigerator were used or the nature of the experiment disclosed, children's interest in exploring refrigerators might be aroused. But more important still, entrapment in an enclosed dark space is a fear-provoking experience. If it had not been for the dearth of information and the important use to be made of the results, the originators of the plan would not even have considered subjecting children to fear-provoking conditions.

In an effort to make the entrapment bear-

able, not only by the children but by the experimenters, a time limit was proposed. On the advice of consultants to the experiment—a child psychiatrist, child psychologists and pediatricians—a time limit of 3 minutes was set as the maximum time that a child might safely and excusably be allowed to cry.

Especially care was taken to see that both before- and after-test experiences were pleasant and that the children left in a cheerful, relaxed frame of mind.

Setting for the Tests

The ideal environment for such an experiment, it seemed clear, would approach what children are used to in the home or at play. However, practical problems and the time schedule agreed on for the study precluded the possibility of conducting the experiment in children's homes or at nursery schools. These considerations dictated the choice finally made—that of a former residence on an estate now a part of the NBS grounds. Trees, shrubs and spreading lawns, together with a large terrace, contributed much to the environment. Two very large first-floor rooms, with the adjoining tiled terrace, were used for an office, reception quarters and testing space.

In the office-reception room, toys, crayons, coloring books and puzzles were provided for the children, also magazines for parents to read while their children were taking part in the tests.

Test Equipment and Facilities

TEST ENCLOSURE AND RECORDING EQUIPMENT: The plywood test enclosure resembled a child's playhouse, with door, roof and chimney (Fig. 1). The inside dimensions (40 × 18 × 25 in.) were based on the measurements of a number of currently available household refrigerators of 8 to 11 ft³ capacity, and represent, approximately, the maximum inside dimensions excluding the space occupied by the freezing unit. A safety-glass panel formed the ceiling of the enclosure so that motion pictures of the child could be taken from above. A 16 mm motion-picture camera and illumination equipment designed for infrared photog-

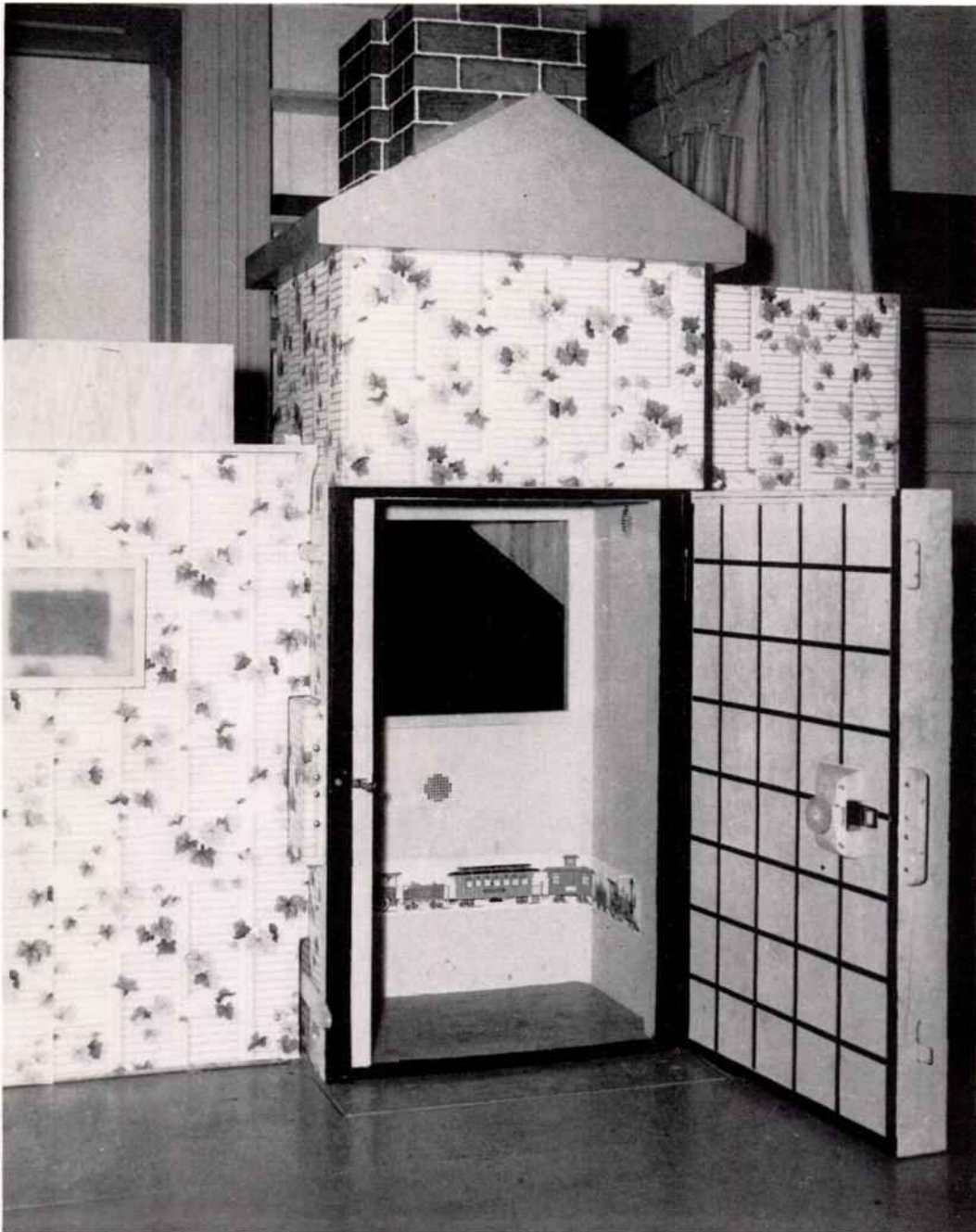


FIG. 1. "Playhouse" test enclosure.

raphy were housed under the roof (Fig. 2). Forced ventilation provided for the child's comfort while in the enclosure.

Several identical doors were constructed into which different release devices were inserted, thus saving time when changing from one release mechanism to another. A snooperscope,

which replaces an infrared image with one of ordinary visible light, was used behind the enclosure for observing the children. Under the low intensity of infrared illumination used, the children were in what seemed to them total darkness. Microphones and tape recorders picked up sounds the children made, comments

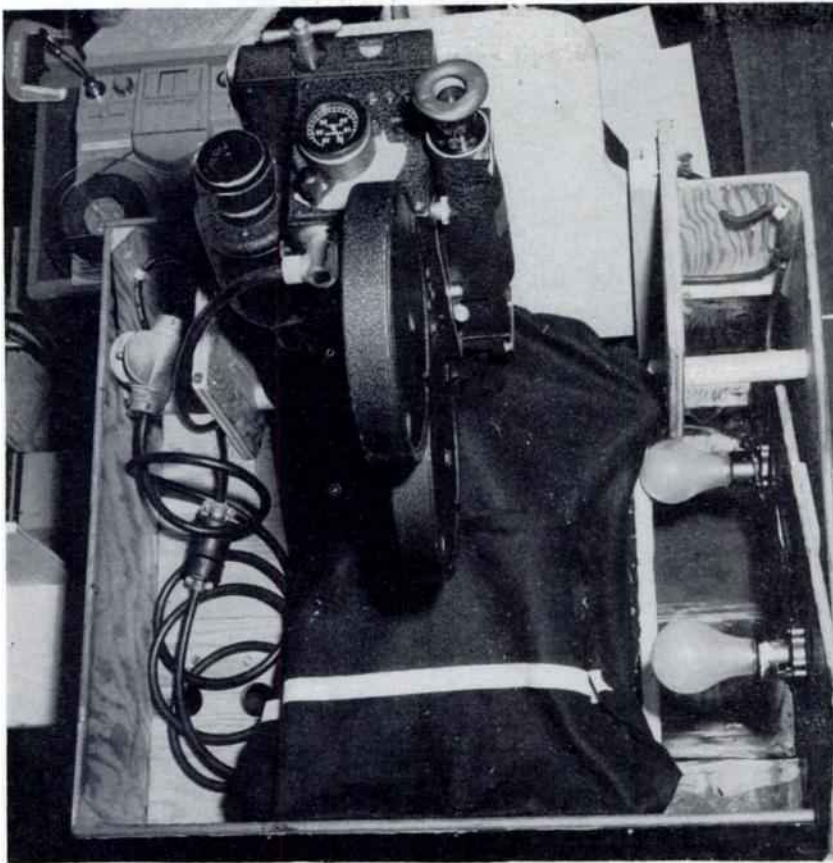


FIG. 2. Motion picture camera and lighting equipment used for obtaining infrared pictures of children in test enclosure.

of the observer, and time and force readings during the tests.

CONVENTIONAL RELEASE DEVICES: The release devices furnished by the household refrigerator manufacturing industry were of two broad classes of construction. One general type included devices which responded to the application of a force to the inside of the door panel, the most effective area being near the latch edge of the door (D 1, D 2). The second general type included devices which responded to manipulation by hand (D 3). Obviously escape by means of the latter type of device depended not only on a child's finding and having the strength to use a releasing mechanism that covered a limited area, but also on his familiarity with operating similar mechanisms.

SPECIALLY DESIGNED ESCAPE DEVICES: Observations of the children's exploratory search of the interior of the playhouse led to the investigators' hunch that what the children were seeking might be a doorknob—something fa-

miliar to most of them and one of the things they are eager to manipulate and conquer as soon as they can walk.

To test this possibility, a doorknob linked to the latching mechanism was made (D 4). In order to help children find it in the dark, a circular plastic rim containing luminescent material was attached. This knob triggered the door's latching mechanism if turned slightly in either clockwise or counter clockwise direction or if it was pushed in or pulled out.

When it became obvious—early in the test program—that some children were going to remain very quiet and move about very little, another experimental device was engineered (D 5). A push-open door linked with a floor panel riding on ball bearings enabled a child to release himself with as little as one-half the effort required without the movable floor panel. This door could be opened by a very slight forward, backward, or sideways movement of the floor panel such as would result if

the child pushed on the door or on any wall of the enclosure. A child weighing between 30 and 50 pounds would not have to push very strenuously to produce the small force (6 to 12 pounds, depending on point of application) that would open the door for him.

Device D 6 was very similar to device D 5 except that it was designed to indicate the maximum force efforts of the child and to permit his release only at the discretion of the observer.

Test Plan

TEST SUBJECTS: Tests were set up for ages 2, 3, 4, and 5 years, with equal numbers of children at each age, and of each sex. Insofar as practicable each of two experiments handled equal numbers of children of each age. Most of the test subjects were obtained as the result of a letter distributed among the NBS staff, broadly describing the nature of the study and inviting their co-operation. The response was immediate and generous. Personal acquaintances and neighbors brought in a scattering of other subjects of the required ages.

The 201 children tested came from 157 families.

RECORDS: A record card was kept on each child. Parents filled in their own names, years spent in school and occupation, as well as the children's names, sex and birth dates. Each child's height, weight, date of test, and his reactions before and after the test were recorded.

Sounds made by a child while in the test enclosure, comments on his behavior made by the observer, also time and force readings spoken into microphones during the testing were recorded on tape and later transferred to record forms.

A moving-picture record of each test had been planned. Unfortunately, the required infrared film was not obtainable in sufficient quantity and, in consequence, the test behavior of only the first 42 and last 48 subjects was recorded on film.

Test Procedure

A feature of the original plan that was adhered to in practically all cases was that each child should be accompanied to the test by one or both of his parents, or by a close relative. In a few instances where this rule was not observed, children were brought to the test

by their nursery-school teacher, a substitute mother figure with whom they felt comfortably at home.

After greeting the parent and child, the experimenter who was to handle the child during the test made friends with the child. Once children's attention was diverted to the toys, most of them played happily until it was time for them to go with the experimenter to play ball on the terrace. Parents remained in the office while each child was taken individually to the test room.

Separation of a child from his parents sometimes required finesse, especially in the case of younger children. Once the child was left in the hands of the experimenter, she could almost invariably establish an easy relationship, and get him to go willingly with her to the terrace and from there to the test room. In only three cases were children so unco-operative that attempts to test them had to be abandoned.

After playing on the terrace, the experimenter weighed and measured the child in the test room, and then led him gradually down the room toward the test enclosure. Older children were often curious about the enclosure from the time they entered the room, but the attention of the younger children usually had to be drawn to it. When the experimenter considered the time was right, she signalled the engineer behind the scene to start the color cartoon which lured the children into the "playhouse."

The sound track with its music and Donald Duck chatter drew most of the children into the playhouse. In some cases the experimenter bent down to look at the movie and told the child what was going on in order to interest him in going inside.

As soon as a child became absorbed in the movie, the experimenter told him she was going back to the office, or otherwise tried to convey to him the idea that he was being left alone. At this point an observer, who could see the child from behind the playhouse in a mirror placed high on the wall, closed the door of the enclosure. Simultaneously the cartoon stopped, the playhouse became dark, a shutter closed the screen, sound- and force-recording equipment began to function, and the overhead camera began taking infrared pictures. Now that the child was shut into an enclosure from which most outside sound was excluded,

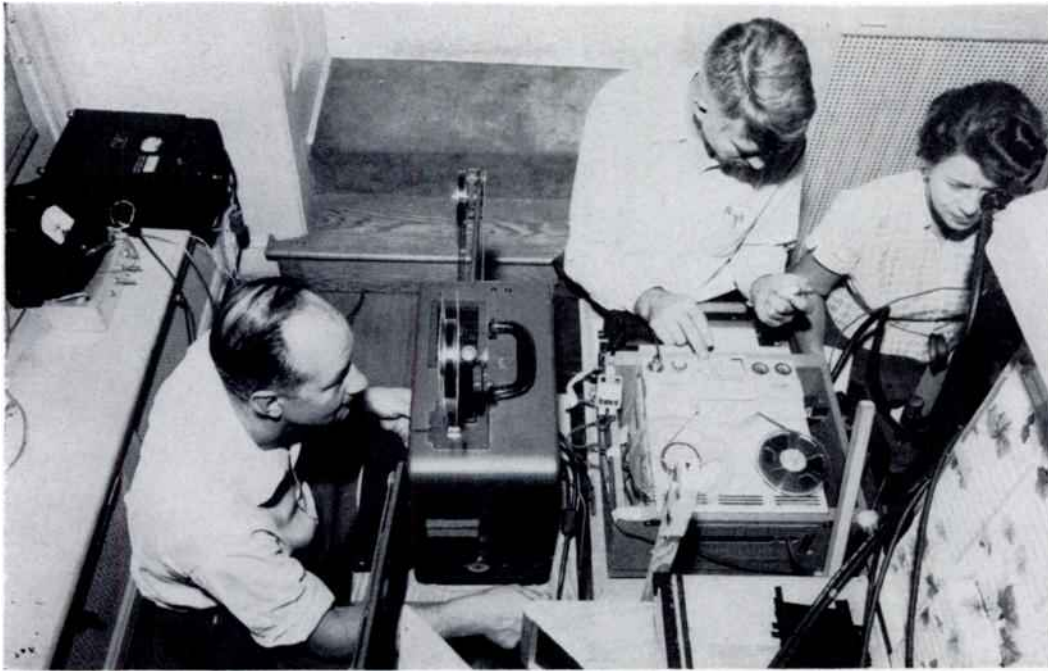


FIG. 3. Test team behind the scenes during a test.

the observer and engineers in charge of observing and recording behind the booth could speak all pertinent information into microphones, to be preserved on tape (Fig. 3). This information included comments on the child's behavior, as seen through the snooperscope, time readings at 10-second intervals, and, in one series of tests, the force output as registered on a gage and observed through a telescope. The child's vocalizations were also recorded on tape.

If a child did not release himself, the observer determined from his behavior when to let him out. This determination was formed on the basis of the amount of effort he was exerting and the degree to which he appeared to be disturbed.

Outside, the experimenter, who had started away or given that impression when the child entered, was there to comfort him the moment he emerged (Fig. 4). The cartoon was at once continued on the outside screen and the child was invited to watch it or to fetch his parents to watch it with him and to see the playhouse. This proved to be an effective way to calm him, take his mind off his experience in the playhouse, and help him carry away a happy impression of his visit.

FINDINGS

Success in Escaping

A child's success in escaping depended on at least three factors: the device with which he was dealing, his age and size, and his behavior. Greatest success was achieved with device D 2, which required a releasing force of 12 pounds directed against the door panel near the latch edge (or more, if applied elsewhere), device D 4 equipped with a knob to be turned, pushed or pulled, and device D 5 with a movable floor panel. Two-thirds to three-fourths of the children taking part in tests making use of these devices let themselves out (Table I). In tests in which device D 6 was used, the child could not escape, but he was considered successful if he exerted a maximum force in excess of 15 pounds. Success with each of the six devices was affected by age and height and weight (Tables II, III, IV). Boys and girls got out with equal ease (Table V). Other factors* not determined in these tests

* One 5-year-old boy, it turned out when follow-up interviews with mothers were held, merely



FIG. 4. The experimenter, ready to comfort this child after the test, finds reassurance unnecessary.

may have influenced success, such as the child's intelligence or the socio-economic status for the 15 minutes he was allowed to stay in the enclosure, because he had somehow gained the impression before he left home that the test he was brought for would take half an hour.

group from which he came. The only measure of the latter factor obtained in the study was the combined years of education of the parents. A higher rate of success was associated with fewer years of education of the parents.

TABLE I
OUTCOME IN TEST, BY TYPE OF DEVICE
(Number and Per Cent of Children)

	Device													
	D 1		D 2		D 3		D 4		D 5		D 6		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Success	9	29.0	21	65.6	7	17.1	34	68.0	12	75.0	14	45.2	97	48.3
Failure	22	71.0	11	34.4	34	82.9	16	32.0	4	25.0	17	54.8	104	51.7
Total	31	100.0	32	100.0	41	100.0	50	100.0	16	100.0	31	100.0	201	100.0

TABLE II
OUTCOME IN TEST, BY AGE
(Number and Per Cent of Children)

	Age (years)									
	2		3		4		5		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Success	10	19.6	26	44.8	27	64.3	34	68.0	97	48.3
Failure	41	80.4	32	55.2	15	35.7	16	32.0	104	51.7
Total	51	100.0	58	100.0	42	100.0	50	100.0	201	100.0

TABLE III
OUTCOME IN TEST, BY HEIGHT
(Number and Per Cent of Children)

	Height (inches)											
	30-35		36-40		41-45		46-50		51-55		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Success	6	18.7	26	38.8	50	63.3	14	63.6	1	100.0	97	48.3
Failure	26	81.3	41	61.2	29	36.7	8	36.4	0	—	104	51.7
Total	32	100.0	67	100.0	79	100.0	22	100.0	1	100.0	201	100.0

Behavior in the Test Enclosure—General Response to Entrapment

Particularly striking was the wide range in behavior shown by the children in response to the entrapment situation, varying from complete inactivity to violent panic.

Three major behavior patterns were observed (Table VI):

1. Inaction, with no effort to escape or only slight effort (24%).

These were the children who stood or sat patiently, apparently waiting to be let

TABLE IV
OUTCOME IN TEST, BY WEIGHT
(Number and Per Cent of Children)

	Weight (pounds)									
	20-30		31-40		41-50		51-60		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
Success	13	24.1	55	54.5	23	59.0	6	85.7	97	48.3
Failure	41	75.9	46	45.5	16	41.0	1	14.3	104	51.7
Total	54	100.0	101	100.0	39	100.0	7	100.0	201	100.0

out or for the movie to come on (Fig. 5). Some made slight exploratory movements, gently touching the door or walls. A few knocked politely, saying "Please let me out" or "I'm ready to come out now." A few were almost motionless. Some cried gently, others made no sound and apparently were unconcerned. More than one child sat quietly for 15 minutes. Age was not a factor in determining which children would show this passive behavior. A few more girls than boys were in this group.

2. Purposeful effort to escape, without violence (39%).

These children went to work, usually immediately, to find a way out—pushing, feeling, or trying to manipulate a knob or device, if present (Fig. 6). Some were quiet, others cried or called out, but at the same time made direct efforts to let themselves out. This kind of behavior, equally characteristic of boys and girls, increased with age.

TABLE V
OUTCOME IN TEST, BY SEX
(Number and Per Cent of Children)

	Boys		Girls		Total	
	No.	%	No.	%	No.	%
Success	49	48.5	48	48.0	97	48.3
Failure	52	51.5	52	52.0	104	51.7
Total	101	100.0	100	100.0	201	100.0

3. Violent action, with or without purposeful effort to escape (37%).

These were the children who kicked, banged, jumped up and down, threw themselves against the door, or exhibited anger. Many of these directed their violence toward escape, but some panicked to the degree that no purposeful effort was apparent. This type of behavior decreased with age and was somewhat more characteristic of boys.

This marked variation in behavior obviously influenced success in getting out. The four passive children who escaped did so because the slight shift of their weight on the movable floor (device D 5) opened the door for them.

Greatest success (86% of Group 2 above) was achieved by those who went about the job purposefully, but most of these were also the older children. Panic, anger and violence interfered with success, so that the group with this type of behavior (Group 3 above) most of whom were also younger, achieved success in only 32% of the cases.

Behavior in the Enclosure—Specific Acts

In early consideration of the problem of release devices it had been presumed that children would push, yet not all did so. Considering only the four devices (D 1, D 2, D 5, and D 6) in connection with which pushing was appropriate and when no release gadget was present to attract the child's attention, 67 (61%) of the 110 children pushed to some degree. About the

TABLE VI
TYPE OF BEHAVIOR IN ENCLOSURE
(Number and Per Cent of Children)

Item	Inaction		Purposeful Movement		Violent Action		Total	
	No.	%	No.	%	No.	%	No.	%
Sex	47	23.7	78	39.4	73	36.9*	198	100.0
Boys	20	20.0	39	39.0	41	41.0	100	100.0
Girls	27	27.5	39	39.8	32	32.7	98	100.0
Age								
2 years	13	25.5	5	9.8	33	64.7	51	100.0
3 years	16	28.1	17	29.8	24	42.1	57	100.0
4 years	8	19.0	24	57.2	10	23.8	42	100.0
5 years	10	20.8	32	66.7	6	12.5	48	100.0
Escape								
Success	4	8.5	67	85.9	23	31.5	94	47.5
Failure	43	91.5	11	14.1	50	68.5	104	52.5
Total	47	100.0	78	100.0	73	100.0	198	100.0

* Three children were not classified because their movement was too rapid to be recorded or observed.

same number knocked (Fig. 7), banged, slapped or kicked the door or walls (Table VII). When confronted with a gadget which could be grasped (D 3 and D 4), 18% pulled it; 9% pushed it; and 40% made turning motions (Table VII, Fig. 8).

Hand movements of some of the children were particularly noticeable. About one-fourth of the children put their hands to their mouths or faces. A small number made curious twisting, twining and picking movements of the fingers or clenching and clasping of the hands (Fig. 9). Very few

sucked the thumb or fingers and none masturbated. Wringing the hands, as an adult does, was observed in several children.

With sound recordings available on all children it was possible to determine the vocal response they made to entrapment (Table VIII). Some children were silent, with a range from only 6% of the 2-year-olds to 50% of the 5-year-olds. About a quarter of the children screamed, the younger children more often showing this behavior than the older ones. Many of the children called for help.

Although as they entered the playhouse they had been told the experimenter was

TABLE VII
TYPE OF EFFORT
(Number and Per Cent of Children)

	Number Tested	Number	Per Cent
Pushes	110*	67	60.9
Kicks, knocks, bangs, or slaps	110*	61	55.5
Pulls knob	91†	16	17.6
Pushes knob	91†	8	8.8
Turns knob	91†	36	39.6

* Devices D1, D2, D5 and D6.

† Devices D3 and D4.

TABLE VIII
VOCALIZATION IN THE ENCLOSURE
(Number and Per Cent of Children)

Age (years)	Number Tested	Silent		Screams	
		No.	%	No.	%
2	51	3	5.9	20	39.2
3	58	16	27.6	16	27.6
4	42	13	31.0	9	21.4
5	50	25	50.0	6	12.0
Total	201	57	28.4	51	25.4



FIG. 5. Boy has withdrawn to corner (4 years).

leaving, some called to her to be let out. But most of the children called "Mommy" or "Mother" even though she was well out of earshot (Table IX). Only six children called "Father" or "Daddy" (5 girls and 1 boy) although about one-third of the children who called for help had been accompanied to the test by father alone or by both parents.

Duration of Test

Time in the enclosure was short for most children (Table X). One-fourth got out by themselves or were released in less than 10 seconds and three-fourths either got out by themselves or were released in less than 3 minutes. One-half of those who released themselves did so in less than 10 seconds. If a child became panicky and seemed much upset, he was immediately released. If his disturbance seemed mild or moder-



FIG. 6a. Girl pushes on door from squatting position (3 years).

TABLE IX
CALLS FOR HELP
(Number of Children)

Brought to Test by	Cries or Calls	Person Called	
		Mother Mommy	Father Daddy
Mother	84	38	1
Father	19	4	4
Both	36	9	1
Other	6	1	
Total	145	52	6

ate the limit of 3 minutes agreed upon through psychiatric and psychologic consultation was adhered to. A few inactive children remained in the enclosure for relatively long periods, six in this group staying over 10 minutes.

Behavior on Entering and on Leaving the Enclosure

There was little resistance to the test situation (Tables XI and XII) but the small number reluctant to leave their parents (17%) or resistant to entering the playhouse (13%) contributed more heavily to the group characterized by violent action in the playhouse than did the co-operative children.

Upon escape or release the experimenter was right there to comfort the child if necessary and to show the movie on the outside screen for the child's entertainment.



FIG. 6b. Girl makes a firm two-arm push on door (2 years).



FIG. 7a. With clenched fist, boy completes knock on door (5 years).

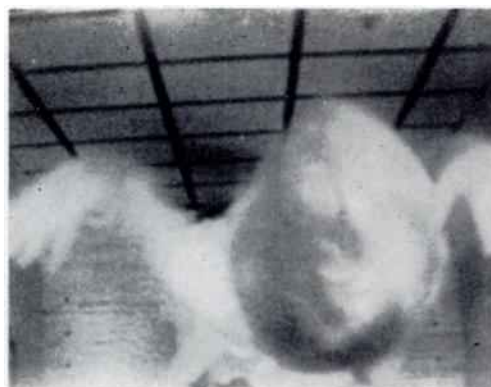


FIG. 7b. Kneeling, girl raises hands shoulder high to slap door (4 years).

TABLE X
TIME IN THE ENCLOSURE

Time Interval	Number and Per Cent of Children Escaping or Released		
	Number	Per Cent	Cumulative Per Cent
Less than 10 sec	49	24.4	—
10 to 59 sec	29	14.4	38.8
1 min to less than 2 min	44	21.9	60.7
2 min to less than 3 min	36	17.9	78.6
3 min to less than 5 min	24	11.9	90.5
5 min to less than 10 min	13	6.4	97.0
10 min and over	6	3.0	100.0
Total	201	100.0	

TABLE XI
BEHAVIOR ON LEAVING PARENT AND DURING TEST
(Number and Per Cent of Children)

Behavior in Enclosure	Total	Willing to Leave Parent		Reluctant or Resistant	
		No.	%	No.	%
Inactive	47	41	87.2	6	12.8
Purposeful movement	78	70	89.7	8	10.3
Violent	73	53	72.6	20	27.4
Total	198	164	82.8	34	17.2



FIG. 8a. Boy approaches knob with left hand after squatting in corner (3 years).



FIG. 8b. Same boy later grasps doorknob in both hands, turns it clockwise to release himself (3 years).



FIG. 9. Boy, distraught, makes many hand-to-face movements, intermittently clasping and unclasping fingers (3 years).

One-third of the children emerged unruffled (Table XIII); about half were upset but could be comforted or distracted by the movie; and a small group (11%) emerged from the enclosure upset. These were the younger children and also those who had shown a violent reaction in the playhouse.

Force Exerted by the Children

Device D 6, designed to indicate the horizontal force exerted by children (Table XIV) no matter where the force was applied, was used to test 31 children. This force was found to range up to a maximum of 29 pounds. The average by age group ranged from 10.4 pounds for 3-year-olds to 20.6 pounds for 5-year-olds. The average for 2-year-olds was 12.8 pounds. A study of the data did not reveal why the 3-year-olds

TABLE XII
BEHAVIOR ON ENTERING ENCLOSURE AND DURING TEST
(Number and Per Cent of Children)

Behavior in Enclosure	Total	Willing to Enter Enclosure		Reluctant or Resistant to Enter	
		No.	%	No.	%
Inactive	47	44	93.6	3	6.4
Purposeful movement	78	69	88.5	9	11.5
Violent	73	60	82.2	13	17.8
Total	198	173	87.4	25	12.6

exerted less force, on the average, than did the 2-year-olds.

Though direct measurements of forces exerted with other devices were not made, the fact that some children released themselves with devices set at specific thresholds indicated the minimum force they exerted at the moment release occurred. Device D 1 required a force of at least 18 pounds to effect release, and D 2 a force of at least 12 pounds. Using the results for children who released themselves in tests using these devices, and combining these results with those for children exerting various forces measured by D 6, Figure 10 is derived.*

* There are at least three possible sources of error in the observed force values for device D 6. First, friction, weight, weight distribution on the floor panel, and direction of applied force may have affected the directly observed force values.

TABLE XIII
REACTION ON LEAVING THE ENCLOSURE AND DURING TEST
(Number and Per Cent of Children)

Behavior	Total	Unruffled		Can Be Comforted		Upset		Unknown	
		No.	%	No.	%	No.	%	No.	%
Inactive	47	17	36.2	27	57.4	3	6.4		
Purposeful	78	51	65.4	25	32.0	2	2.6		
Violent	73	1	1.4	51	69.7	16	21.9	5	6.8
Total	198	69	34.9	103	52.0	21	10.6	5	2.5

TABLE XIV
MAXIMUM HORIZONTAL FORCES EXERTED BY CHILDREN
(ACCORDING TO AGE) ON DEVICE D6*

2 Years	3 Years	4 Years	5 Years
(lb)	(lb)	(lb)	(lb)
14.5	12.3	17.3	16.7
14.5	6.8	23.4	19.0
19.0	9.0	11.2	16.7
16.7	14.5	15.6	22.3
14.5	16.7	10.0	29.0
0.0	5.6	12.3	10.0
10.0	7.9	19.0	22.3
13.4		10.5	29.0
Av. 12.8	10.4	14.9	20.6

* Designed to measure horizontal force without permitting self release.

From this it can be seen that 25 to 30% of the children taking part in tests in which horizontal force was an appropriate effort exerted in excess of 18 pounds and 65% exerted in excess of 12 pounds.

DISCUSSION

No experiment could be designed to reproduce all the conditions actually present in a naturally occurring entrapment. The kind of child who gets entrapped in a re-

Second, the person who observed the force gage probably was unable to read with great precision the values indicated by the sometimes-fluctuating needle. Third, the calibrated accuracy of the force gage affected the results.

Computations based on the calibration data taken for device D 6, loaded centrally with a weight of 34 pounds on the floor panel, showed that the maximum deviation of applied force from that indicated by the calibration curve used in the preparation of Figure 10 and Table XIV was - 1.7 and + 1.5 pounds for rearwardly directed forces (as in the case of a child pushing on the door) and sidewardly directed forces, respectively. The corresponding average deviation was - 1.2 and + 0.4 pounds. Available information indicated that the calibrated accuracy of the force gages used in the calibration of device D 6 and in the tests was within ± 0.2 pound. It is estimated that the person who watched the force gage while children were in the enclosure was able to read the maximum forces indicated by the fluctuating needle within ± 0.5 pound.

frigerator is unknown. Is he bold and aggressive and may he therefore be expected to be active in releasing himself? Or does he often seek solitude? What kind of child is lured in, or shut in, by companions? The best the experimenters could do was to take from a volunteer population a sample chosen with the aid of competent statistical advice and containing children of ages known to be susceptible to this type of tragedy. Obviously no test would have been considered that involved depriving a child of oxygen, so it is possible only to speculate as to a child's activity in an atmosphere in which oxygen depletion was taking place.

Probably the greatest differences between the experimental situation and real life lay in the fact that the children knew people were not far off, and in the protection provided against psychologic trauma. The experimenters who handled the children were warm, friendly people, fond of and widely experienced with children, who first developed rapport with each child to be tested. Having got a child's confidence they were unable to bear his fear reaction long (in contrast to the observer who, having developed no such relationship, could be more objective). His cries brought a quick appeal by the experimenter for his release. How a child would ultimately have solved his problem was therefore often not determined. Left in the enclosure longer some children might have quieted down and released themselves. Success, therefore, is possibly underestimated.

The wide range of behavior of the children was especially interesting in light of the purpose of these experiments—to provide data for the development of performance standards for release devices. If one assumes that behavior of these children was generally typical of those entrapped by chance, then a significant number will probably not release themselves by the use of any currently practical device requiring purposeful physical effort. A device utilizing their purposeless movements would increase the escapes. The movable floor panel device was developed for this purpose, and

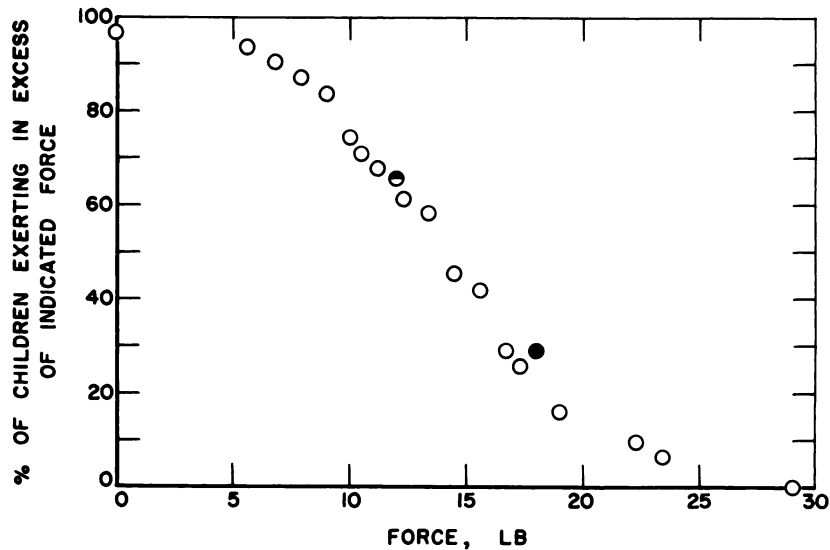


FIG. 10. Horizontal components of forces exerted by children, ages 2 through 5 years.

<i>Device</i>	<i>Number Tested</i>	<i>Number Who Released Themselves</i>	<i>Symbol</i>
1	31	9	●
2	32	21	◐
6	31*	0	○

* All released by observer.

showed some promise in this connection in the few tests in which it was used. However, problems in its manufacture and sanitary care, and the impracticability of making its releasing features accessible from all spaces in which a child might become entrapped, appear to place serious limitations on it. In addition, were it sensitive enough to be effective for passive children, it might interfere with normal use of the refrigerator.

The association of lower education level of parents with degree of success might possibly be explained on the grounds that parents with no more than grade or high school education may give their children more opportunity to play independently than parents with college or advanced degrees.

The turning movements made by many children when taking part in tests utilizing

a device that could be grasped, suggested that the household doorknob was familiar enough to all children to be useful. This proved a valid assumption.

Fundamental to the establishment of performance requirements relating to devices that release by pushing was knowledge of children's pushing behavior. Would a child push? Where? With how much force? Not all children pushed; some directed their efforts to walls rather than to the door, some to the hinge rather than the latch side of the door. Others let themselves out accidentally when they leaned against the door or when in their violent activity they bumped against it. The size of the space, the size of the child and chance all played a part here.

PART II. FOLLOW-UP STUDY

Though the experiment produced data which can be expected to save lives, the in-

investigators would still have been uncertain of their justification if the subjects had been harmed. The complacency with which most of the children took the testing, and the ease with which those who became upset could be comforted, reassured the directors of the experiment that it was permissible and justifiable. Nevertheless, more objective data on the aftereffects, if any, seemed desirable to round out the experiment. Deep-seated anxieties in the children could not be uncovered without extensive psychologic testing, and even if such deviations were found their relation to the experiments could not be determined, since previous personality studies of the children had not been done. The only type of study which seemed practical was interviews with the mothers, who were in a position to observe any evidence of changes in behavior following the tests. Also, the mothers were able to give a first-hand account of how the child reacted after the test, how much he talked about it, and what residual effect was apparent on the surface.

INTERVIEW METHODS

About 8 months after the test, follow-up interviews were held with the mothers of 96 of the children who had been test subjects. This sample, of almost half the children originally tested, was drawn so that it consisted of equal numbers of boys and girls of each age from 2 through 5 years, with an equal number handled by each of the two experimenters.

In order to avoid the suggestion that harm might have been done the children, the approach to the parents was made on the grounds that when the tests were held in the summer of 1956, time did not permit getting background material on the children's health, personality and daily routines, such as eating and sleeping.

Mothers without exception responded cordially to the request. The interviews which were conducted in the homes by one interviewer, a member of the original staff, lasted from 30 to 45 minutes. Times of day were chosen to suit the mothers' convenience, often at children's nap-time or when they were in kindergarten or nursery school. Only 34 of the children were present during the interview,

the others being in the room only momentarily or not at all.

Studies of young children who have undergone traumatic experiences—bombing, separation from parents, and operative procedures,¹⁻³ have shown that regressive behavior in patterns of sleeping, eating and toileting is not unusual. The interview started in relatively structured fashion with questions about appetite, taking the bottle, sleeping, thumb sucking and wetting. The questions were phrased to describe his behavior, any change in recent months, and if any change, the approximate date. Thus any behavior changes in these areas could be related to the time of the tests without asking directly for such information or implying that there might be an association.

The interview then moved more freely into a discussion of the child's usual emotional reactions, i.e., was he easy-going, fearful, etc. This line of inquiry, though of no practical value in answering the questions of the study, led easily into comments by the mother on how the child seemed to feel about the test, did he remember it, had he talked about it, had he seemed upset. Other possible upsetting experiences and their timing were also sought, such as hospitalization, new sibling, moves, or separation from parents.

The first part of the interview, then, yielded data on regressive behavior, the second part some impressions of effect of the tests as noted by the mothers.

FINDINGS

No child went back to taking a bottle after the test, although several had a history of reversion briefly before the test by trying out a new sibling's juice or milk bottle.

No unfavorable change in the sleeping behavior of any children, such as restlessness or crying out, was reported for a period of 4 months after the test, with the exception of one child whose family moved from an apartment to the country soon after the test, and who then began ("rarely") to cry out in his sleep because, he said, he feared animals in the country. He wanted his door open and his light on.

Of the 37 children who sucked their thumbs or fingers or, more rarely, a blanket, all had done so since babyhood. Their age

distribution was: 10, 2 years; 13, 3 years; 8, 4 years; 6, 5 years.

Of the children who were bedwetters none reverted to this behavior anywhere near the time of the test with the possible exception of one 5-year-old whose mother could not recall just when it began.

Many of the 2-year-olds were not yet talking at the time they took the test. Only four of them ever talked about it later, two of them indicating they did not like the dark room. The other 20 never mentioned the experience, as far as the mother knew.

Children 3, 4, and 5 years old were for the most part quite voluble about their experience, their comments reflecting their pride in success, their enjoyment of the attention they got from the experimenters who played with them, or their puzzlement over *why* they were shut in.

The attitudes of the children, as recalled by their mothers, 8 months after the test, ranged through more or less casual acceptance, remarks about not liking "that kind of playhouse," thinking it was "a lark, and bragging about it," showing great pride in having earned money (\$5 a child was given to recompense parents for transportation expenses, baby sitting, etc.), curiosity about the whole thing, and resentment at "a dirty trick." A good many children thought they got out by themselves when actually they did not; their believed success made them feel exultant.

Illustrative Case Reports

CASE 76: A 2-year-old girl (3 years at time of interview) frequently refers to the test, though the parents have never brought up the subject, her last mention of it being to her grandparents whom she visited recently. This mother did not realize what the test would entail, that is, being locked in, and would not do it again. She thinks, however, it did not prove to be a bad experience for the child because she had opportunity to watch her mother being locked in and getting out.

CASE 41: A 4-year-old boy, the youngest of his family, who was very hard to separate from his mother, did not make a very great physical

effort to get out of the enclosure, but did a great deal of calling to "Woman!" (seven times) to let him out. He seemed somewhat disturbed for a few days afterward, but accepted his mother's explanation of the test. Recently, while on the NBS grounds he said, "I don't want to see the movie again," although no one had mentioned the experiment. This is a family which has been having a struggle to meet the expenses of the mother's illness. The boy showed no other overt evidence of being disturbed, no changes in routine behavior patterns save a "wolf dream" approximately 6 months later.

CASE 125: A 4-year-old boy whose mother reported he "came home with a happy expression as if he'd been to a party" had been taken to the test with his younger sister by his father. He is next to the youngest in a family of five children; neither he nor his 3-year-old sister showed ill effects, the little girl's only reaction being that "something was put over on her." The family background is serene, the parents appearing to be stable, mature people.

CASE 19: A boy who was 3 years of age (summer, 1956) is described by his mother as being somewhat dominated by his 5-year-old sister. At the time of the test he went into the test house readily, but made no effort to get out beyond calling "Mommy" a great many times. He was released because of crying at 3 minutes, 20 seconds. While the experimenter was cheering him up, she found a tiny baby rabbit in the tall grass, and this so entranced him that it seems to be all he recalls. His mother speaks of his having "enjoyed the whole experience."

CASE 20: The sister of Case 19, 5 years of age, who went into the house quickly because she thought it was a dollhouse, got out by herself in 2 minutes, 19 seconds, showing little or no concern. She has made no mention of the experience in recent months. The parents have never brought up the subject.

DISCUSSION

In designing the experiment the staff was deeply concerned to avoid exposing the children to a damaging experience. They took great care that no child should become too upset and that all children should have a pleasant experience after the test. Apparently the precautions taken were ade-

quate, for the children in the sample followed up 8 months later showed no reversion in behavior, and the parents, when given an opportunity to discuss reactions, produced no evidence of trauma or concern over aftereffects.

Other factors may also have contributed to the apparently low level of anxiety.

The fact that almost all the parents tried out being shut into the enclosure seemed, as was intended, to absorb some of the children's concern. To have father or mother double up and squeeze into the small space was a source of merriment.

A number of mothers reported that their children talked the test over among themselves. This kind of "shared experience," the opportunity to talk freely with others who had been through the same thing, was reported in "Operation Schoolhouse"⁴ to help sufferers to integrate the disaster, because their feelings did not have to be repressed. Under incomparably milder stress, quite a number of children in this experiment demonstrated what may be similar tension-relieving behavior: three children in one family (2, 3, and 5 years old) talked about their experience in terms of the toys they had played with; a 4-year-old boy and his 3-year-old sister talked about the test, and he told his playmates about it.

An interesting aspect of the experiment, which seemed to be reflected in the children's behavior, was that a child's parents were not involved in his "trouble," and so did not become excited and upset. In many real-life experiences in which a child is hurt or hospitalized, the parents are much distressed, something a child may sense even though the parents try to conceal their feelings.

In the present experiment the parents did not come on the scene until the child had recovered his equilibrium or was on the way to doing so, and they were invariably calm and unalarmed. In the Vicksburg⁵ study it was remarked that "much of a child's later behavior around the topic of the tornado was almost wholly parent-determined." Our impression is that the us-

ually nonchalant behavior of the parents of the children in the NBS study may well have been related to the casual way in which the children seem to have reacted to the experience.

SUMMARY

Behavior of young children in a situation simulating entrapment in refrigerators was studied in order to develop standards for inside releasing devices, in accordance with Public Law 930 of the 84th Congress.

Using a specially designed enclosure, 201 children 2 to 5 years of age took part in tests in which six devices were used, including two developed in the course of this experiment as the result of observation of behavior.

Success in escaping was dependent on the device, a child's age and size and his behavior. It was also influenced by the educational level of the parents, a higher rate of success being associated with fewer years of education attained by mother and father combined. Three major types of behavior were observed: (1) inaction, with no effort or only slight effort to get out (24%); (2) purposeful effort to escape (39%); (3) violent action both directed toward escape and undirected (37%).

Some of the children made no outcry (6% of the 2-year-olds and 50% of the 5-year-olds). Not all children pushed. When tested with devices where pushing was appropriate, 61% used this technique. Some children had curious twisting and twining movements of the fingers or clenching of the hands. When presented with a gadget that could be grasped, some (18%) pulled, a few (9%) pushed, but 40% tried to turn it like a doorknob.

Time of confinement in the enclosure was short for most children. Three-fourths released themselves or were released in less than 3 minutes; one-fourth in less than 10 seconds. Of those who let themselves out, one-half did so in less than 10 seconds. One-third of the children emerged unruffled, about half were upset but could be comforted easily, and a small group (11%) re-

quired some help to become calm.

Forces exerted in any horizontal direction by the children for whom such records were obtained ranged up to 29 pounds. The average was about 10 pounds for 3-year-olds and about 21 pounds for 5-year-olds. For reasons not known, the 2-year-old group exerted a slightly greater average force than did the 3-year-old group.

More than one-fourth of the children exerted in excess of 18 pounds and almost two-thirds in excess of 12 pounds.

Data from these experiments proved valuable in developing standards for release devices (as required by Public Law 930), which are expected to be effective for self-release by a large percentage of, but not all, entrapped children. An important result of the behavior study was the finding that, when entrapped, children most often try to escape either by pushing on the door through which they entered the enclosure, or by manipulating a knob release as they would a doorknob. Relatively few children pushed against the back, sides or ceiling of the enclosure.

A follow-up study of 96 test subjects, 8 months after the tests, by interviews with the mothers showed very little obvious residual effect. Reversion to infantile behavior was not found. A number of children still talked about the tests, some with pleasure, a few with resentment. Mothers were not aware of more than ephemeral emotional upset in any of the children.

Reasons for the low level of anxiety engendered by the tests may lie in the precautions taken and in factors inherent in the situation; the parents were not involved in the incident, which enabled them to be calm and casual with the children.

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SUMMARIO IN INTERLINGUA

Le Comportamento De Juvene Infantes Sub Conditiones Simulante Le Intrapamento In Un Refrigerator

Anno post anno un numero de juvene infantes mori de suffocation resultante del intrapamento in un refrigerator. Pro disveloppar standards pro le construction de dispositivos de dislocation al interior de refrigeratores, le comportamento de juvene infantes esseva studiate in un situation que simulava le conditiones de intrappamento.

Esseva construite un cabina, simile in apparenzia a un casa de ludo, con le dimensiones interior del typic refrigerator de menage, e equipate con un apparatusa pro mesurar le fortia usate per le infante in su effortio de liberar se, pro obtener un documentation cinematographic a lumine infra-rubie e un documentation acustic a banda magnetic de omne detalios del comportamento del infante durante su inclusion in le obscuritate del cabina, e pro permittre le obtention de un reporto corrente per un observator utilisante illumination infra-rubie. Quando un infante, non succedente a liberar se, se inquietava promptemente, le observator aperiva le porta.

Duo centos e un infantes de etates de inter 2 e 5 annos participava in le tests in que sex dispositivos de dislocation esseva usate, incluse duo disveloppate in le curso del experimentos e como resultato de observationes facite con respecto al comportamento del infantes.

Le successo del infantes de liberar se dependeva del typo de dispositivo dislocatori,

del etate e del grandor del infante, e del comportamento characteristic de ille. Le successo del infantes de liberar se esseva etiam influentiate per le nivello del education del parentes: Un plus alte grado de successo esseva associate con un plus basse numero de annos de education formal in le vita de patre e matre combinate. Tres typos principal de comportamento esseva observate: (1) Inaction, con nulle o solmente leve effortios a liberar se (24%); (2) effortio appropriate a liberar se (39%); e (3) action violente, tanto visante al liberation como etiam sin direction (37%).

Certes del infantes non clamava (6% de illes de duo annos de etate e 50% de illes de cinque annos). Non omne le infantes pulsava. In le tests con dispositivos de disblockation requirente un pulso, 61% del infantes usava iste technica. In le tests con dispositivos que poteva esser apprehendite per le mano, 18% tirava, 9% pulsava, sed 40% tentava tornar lo como un button de porta.

Le tempore que le infantes passava intra le cabina esseva breve in le majoritate del casos. Inter illes qui se liberava per se mesme, un medietate lo faceva in minus que 10 secundas. Un tertio del infantes emergeva imperturbate; circa un medietate esseva disturbate sed poteva facilmente esser reconfortate; e un micre gruppo (11%) requireva un certe assistentia pro calmar se.

Le fortias applicate in direction horizontal per le infantes pro qui iste factor esseva mesu-

rate variava usque a un maximo de 29 libras. Le fortia medie esseva circa 10 libras pro infantes de 3 annos de etate e circa 21 libras pro illes de 5 annos de etate. Le fortia medie applicate per le gruppo de 2 annos de etate esseva levemente plus grande que illo applicate per le gruppo de 3 annos.

Plus que un quarto del infantes applicava un fortia de plus que 18 libras e quasi duo tertios applicava plus que 12 libras.

Datos ab iste experimentos esseva de valor in le disveloppamento de standards pro le construction de dispositivos de disblockation efficace in le auto-liberation de un grande procentage (ben que non le totalitate) de infantes intrapate.

Un studio subsequente de 96 subjectos del test, effectuate post un intervallo de 8 menses in le forma de interviews con le matres, revelava pauchissime obvie effectos residue. Reversion a comportamento infantil non esseva constatate. Un numero del infantes continuava parlar del tests, certes con placer, alicunes con ressentimento. Le matres non habeva notate plus que un ephemere disturbance emotional in ulle del subjectos.

Le ration pro le basse nivello de anxietate inspirate per le tests es possibilmente a trovar in le precauciones prendite e in factores inherente in le situation, per exemplo le non-participation del parentes e lor consequente capacitate de esser calme e equanime con lor infantes.

CHEMICAL DETECTION OF FOLIC ACID DEFICIENCY IN MAN

Two papers by H. Tabor *et al.* (J. Clin. Investigation, 37:824, 829, June, 1958) describe a method and its application which promise to be useful in clinical investigation of the metabolism of folic acid and detection of its deficiency. The method is based on the determination of formiminoglutamic acid in urine. This compound is an intermediate in the metabolism of histidine that has been found to accumulate in the urine of folic acid-deficient rats. Excretion of this compound in the urine is also increased during the administration of folic acid antagonists. An active form of folic acid, tetrahydrofolic acid, is required for the metabolism of formiminoglutamic acid. The method in the present paper is based on enzymatic reactions, recently described by the authors, combined with a sensitive spectrophotometric measurement. Although the method does not appear to be simple, it is probably within the scope of the laboratories of many institutions. It is applicable to specimens of urine containing less than 0.1 micromole of formiminoglutamic acid. The method appears to have a high order of specificity. The application is illustrated by studies with subjects receiving folic acid antagonists. No data are given concerning the use of the method in detection of simple deficiency of folic acid in human subjects.

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