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SHAKE YOUR RATTLE DOWN TO THE  
GROUND: INFANTS' EXPLORATION OF  
OBJECTS RELATIVE TO SURFACE

A Thesis Presented

by

JAMES D. MORGANTE

Submitted to the Graduate School of the  
University of Massachusetts Amherst in partial fulfillment  
of the requirements for the degree of

MASTER OF SCIENCE

September 2006

Psychology

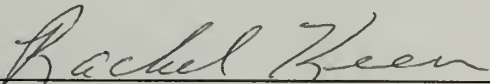
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Rachel Keen, Chair



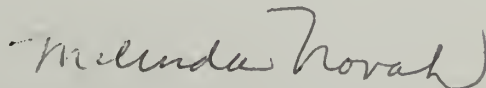
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ABSTRACT

SHAKE YOUR RATTLE DOWN TO THE  
GROUND: INFANTS' EXPLORATION OF  
OBJECTS RELATIVE TO SURFACE

SEPTEMBER 2006

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The role of visual feedback on object and surface exploration was examined in 8-month-old infants. Infants were presented with two objects varying in sound potential on two distinct flooring surfaces. Exploratory behaviors were observed in both normal illumination and in the dark. By varying the illumination, surface, and sounding property of the object, it could be determined whether the combination of both vision and audition, or audition alone, influenced infants' exploration and exploitation of the various object affordances. Results suggest that observation of the visual consequences of a self-produced action increases 8-month-old infants' manual exploration of the object.



# CONTENTS

	Page
ABSTRACT.....	iii
LIST OF TABLES.....	v
LIST OF FIGURES.....	vi
CHAPTER	
1. VISION, TOUCH, AND ENVIRONMENT.....	1
Introduction.....	1
Method.....	6
Participants.....	6
Stimuli.....	6
Procedure.....	7
Coding.....	8
Results.....	9
Discussion.....	11
REFERENCES.....	25

## LIST OF TABLES

Table	Page
1. Counterbalanced Orders.....	15
2. Means and Standard Deviations for Each Exploratory Behavior.....	16

## LIST OF FIGURES

Figure	Page
1. Mean object-directed behaviors for shaking as a function of sound potential.....	17
2. Mean object-directed behaviors for mouthing as a function of sound potential.....	18
3. Mean exploration behaviors as a function of illumination.....	19
4. Mean surface-directed behaviors.....	20
5. Scatterplot of shaking rates as a function of trial length for trials conducted in the light.....	21
6. Scatterplot of shaking rates as a function of trial length for trials conducted in the dark.....	22
7. Scatterplot of banging rates as a function of trial length for trials conducted in the light.....	23
8. Scatterplot of banging rates as a function of trial length for trials conducted in the dark.....	24



## Chapter 1

### VISION, TOUCH, AND ENVIRONMENT

#### Introduction

Infants live in a world of discovery. Through purposeful perception and active exploration, infants develop an understanding of the physical world and functionally coordinate their actions with respect to the structure of their environment (Gibson, 1988; Gibson & Spelke, 1983). During the first year of life, infants learn fundamental behaviors (e.g., reaching and grasping) that will be applied to the environment to solve problems and engage in more complex activities such as the manipulation and purposeful use of objects. Even young infants (e.g., newborns) have been shown to act in discriminating and meaningful ways (Rochat, 1987).

An “affordance” has been defined as the fit between an animal’s capabilities and the environmental supports and opportunities that make a given activity possible (Gibson & Pick, 2000). When the affordance of an object is discovered and understood, infants are able to explore and manipulate by means of employing strategies that are both intentional and specific to the properties of a given object. In a study with 6-, 9-, and 12-month-old infants, Palmer (1989) investigated infants’ discriminatory exploration behaviors on a range of toys varying in properties such as rigidity, weight, texture, and noise. Palmer found that infants waved a bell with a clapper more than a bell without. In addition, infants differentially mouthed these two objects (i.e., more mouthing of the bell without a clapper) across the three age groups. The differentiation of action strategy

(e.g., direction of waving and mouthing) presumes that infants perceptually discriminated the affordances (i.e., sound potential) of these objects.

Bushnell and Boudreau (1991, 1993) have provided a useful timetable for the development of haptic perception based on several object properties. The properties illustrated in their timetable for the development of haptic perception include size (volume), temperature, hardness, texture, weight, and configurational shape. Findings from investigations on hardness and texture indicate that from about 6 months of age on, infants are able to haptically perceive both of these object properties (Gibson & Walker, 1984; Lockman & McHale, 1989; McCall, 1974; Palmer, 1989; Ruff, 1984; Steele & Pederson, 1977). While studies of object exploration and responsiveness to specific properties of objects during the first year of life are not new to the field, the empirical literature reveals gaps in regard to infants' haptic sensitivity to properties of objects. Specifically, most of the research on infants' knowledge of affordances has involved either cross-modal or bimodal stimulus presentations rather than strictly haptic perception.

When considering the hardness of an object, infants ranging in age from 6 to 12 months have been shown to squeeze spongy objects and bang hard ones when these objects were presented in a lighted environment (Lockman and Wright, 1988; Palmer, 1989). Likewise, Gibson and Walker (1984) observed that 12-month-old infants' exploration of either a rigid or flexible cylinder involved the same squeezing and striking behaviors when observed in the dark, indicating that haptic properties without vision would elicit similar behaviors. Recently, Bourgeois, Khawar, Neal, and Lockman (2005) have extended the findings on infants' sensitivity to the affordance of rigidity by showing

that 6-, 8-, and 10-month-old infants explore objects and surfaces interactively, tailoring their manual actions to material properties of both the object and various surfaces.

Bourgeois and colleagues observed that infants bang hard objects more often on hard and taunt surfaces as compared to liquid or spongy surfaces.

While 12-month-olds have demonstrated sensitivity to both compressible and rigid objects without vision, the reported behavior of younger infants has only been observed in studies when vision is available. Given these findings, it is difficult to interpret whether or not younger infants can perceive the hardness of an object without the use of vision or if the exploratory behaviors are a result of the ability to see the consequences of their executed manipulation strategies. Needham, Barrett, and Peterman (2002) have suggested that as early as 3 months, when engaging with objects through use of sticky mittens, infants' visual engagement may be a result of their realization that they are in control of an object's movements. Thus, it is possible that self-produced action may enhance infants' visual attention to the action as well as to the object and its affordances involved in the action. The question remains as to whether an infant who watches its own exploration of an object is reinforced through observing the action(s), discriminating the affordance(s) haptically, or both.

Studies conducted in the absence of visual feedback on reaching and search have shown that infants can execute appropriate sequential behaviors and actions necessary to achieve a particular goal. When reaching for objects in the dark, infants as young as 4 months have demonstrated the ability to execute a reach and grasp sound-producing objects (Clifton, Muir, Ashmead, & Clarkson, 1993; Wishart, Bower, & Dunkeld, 1978). In the absence of both visual and auditory input, 6.5-month-old infants have been shown

to accurately search for a given object (Goubet & Clifton, 1998). McCall and Clifton (1999) extended this finding with a means-end task in which 8.5-month-olds successfully uncovered and retrieved objects in the dark with intentional sequential action behaviors comparable to that of retrieval in the light. Collectively, these studies indicate that action sequences are not dependent upon visual feedback from limb and hand movements.

While these studies exploited infants' abilities to execute appropriate exploratory actions in the absence of visual input, the findings do not inform us as to how infants perceive the properties of a given object haptically.

Few reported studies have specifically examined exploratory actions in the dark. When considering visual feedback, findings suggest that certain exploratory behaviors may depend upon illumination. Rochat (1989) compared the object manipulation and exploration behaviors of 3 and 4 to 5-month-old infants in the light and the dark across several exploratory behaviors. Results indicated that fingering was the only behavior to occur with greater frequency in the light than in the dark, suggesting that early fingering of an object is linked to vision and depends on this modality (Rochat, 1989).

The present study was designed to investigate the possible relations between vision, touch, and the environment. We examined the role of visual feedback on 8-month-olds' manipulation behaviors of two objects varying in sound potential when explored individually on two distinct flooring surfaces. In addition, we sought to explore the possibility of young infants being "aurally captured." In other words, could an 8-month-old infants' purposeful perception be drawn specifically to the auditory characteristics of an object resulting in the dilution of attention to its visual properties?



The infants who participated in this study were observed in both normal illumination and in the dark. Assuming that exploratory behaviors are affected by vision, it was predicted that infants would show more object and surface directed behaviors when vision was available (i.e., in the light) as compared to when it was not (i.e., in the dark). The two objects infants had the opportunity to explore and manipulate differed in their sound potential. By varying both the illumination and sounding property of the object, we could determine whether the combination of both vision and audition, or audition alone, influenced the duration and frequencies of exploratory behaviors. If exploration is guided by both the aural properties of an object and visual feedback, shaking of a sounding rattle should occur with greater frequency in the light as compared to the dark. However, if exploration is not affected by visual feedback and the aural features of an object can capture infants' attention, the frequency of shaking in the dark should be equal to or perhaps greater than in the light. This would suggest that infants were attending primarily to the aural property of the object and were little influenced by its visual consequences.

Consistent with previous research on the discrimination of object affordances, infants were expected to mouth the rattle without sound potential more and shake the sounding rattle more. Previous studies on object-surface relations have been conducted with infants being seated at a table or in a high chair (Bourgeois et al., 2005; Gibson & Walker, 1984; Palmer, 1989). Objects used in this study were presented to infants while they were seated on one of two distinct flooring surfaces, hardwood and carpet. This manipulation was added to determine whether or not previous findings could be extended to an additional context in which exploration occurs. Infants were expected to show

more surface-directed banging on the hardwood floor as compared to the carpet.

Through the observation of infants' exploratory behaviors in the presence and absence of vision, the role of visual feedback on exploratory actions executed to exploit the affordance(s) of a given object, both rattle and surface of exploration, could be assessed.

### Method

#### Participants

Participants were 20 healthy, full-term infants (12 girls, 8 boys) ranging in age from 7 months, 12 days, to 8 months, 18 days ( $M = 8$  months (240.25 days),  $SD = 10.18$  days). All of the infants participated in the same experimental condition. Data from ten additional infants were eliminated: eight did not reach for the rattle, and one cried at the onset of the experiment. Data from one infant were excluded because of an environmental distraction (i.e., equipment noise from a neighboring lab).

Several sources, including birth records from local town halls, birth listings in the newspaper, and a commercial source were used to obtain the names of infants. Parents were initially contacted via letter and then with follow-up phone calls. Each infant received a Child Study Center t-shirt as a token of thanks for their participation.

#### Stimuli

Two RhythMix® rattles of different colors were presented to the infant for the purpose of exploration and manipulation. One rattle was modified so that it lacked sound potential (i.e., the beads inside were removed). The rattles were presented on one of two surfaces, either a carpet or hardwood floor, with an area of approximately 11 ¼ sq. ft. The carpet surface was plush with a velvety even-cut pile. The hardwood surface was a



TrafficMaster® 7 ½” Savannah Oak glueless laminate flooring with tongue-and-groove installation. Test trials were videotaped with a camera equipped with both normal and infrared recording.

## Procedure

Eight month olds’ actions were recorded as they explored two rattles varying in sound potential. The study used a 2 x 2 x 2 design in which exploration of both rattles was compared across illumination (e.g., light or dark) and flooring surfaces (e.g., carpet or hardwood). All infants had the opportunity to explore each rattle on the two distinct flooring surfaces, and in both normal illumination and in the dark.

During a 3-minute warm-up period, infants were given the opportunity to explore (e.g., crawl on) both the carpet and hardwood floor surfaces. After the warm-up, infants were seated on the center of the surface with their back facing their parent. Parents sat directly behind their infant to provide both physical (i.e., postural) and emotional (e.g., closeness during dark trials) support. When providing necessary postural support, parents were asked to position their hands around the infant’s lower waist so that movement of the arms and torso was not restrained. During the 8 test trials, parents were asked not to reinforce their infant’s actions through gesture or speech. To control for order effects, trials were counterbalanced across subjects for illumination, surface, and object. More specifically, of the eight possible counterbalanced conditions for each trial, four were selected and distributed equally often across participants. Five infants were assigned to each order (see Table 1). In an effort to reduce infant discomfort, illumination trials were presented consecutively, so that the first four trials were in the

light and the last four in the dark, or vice versa. For dark trials, the room lighting was slowly transitioned from light to total darkness, then back to light for the inter-trial interval by means of a rheostat.

All infants were presented with one trial for each combination of object, illumination, and surface. Each test trial lasted for a maximum of 30 seconds. When the rattle was released from grasp (e.g., thrown or dropped) prior to 15 seconds of trial duration, it was picked up by the experimenter and reintroduced to the infant up to three times. Test trials ended after the full 30 seconds of exploration or when the rattle was released after the minimum 15 seconds of exploration. There was a brief interval between each trial, lasting about 30 seconds.

At the start of each trial, the experimenter placed the rattle between his index and middle finger and oscillated the rattle back and forth. The purpose of this action was to reveal the sound potential of the rattle without modeling an action (i.e., shaking) that might be imitated by the infant during the test trial. Both the sounding and non-sounding rattle were introduced with this action. After the infant was familiarized with the sound potential of the rattle, it was presented within reach, centered with respect to the infant's chest. The experimenter removed his hand from the rattle after the infant had established a firm grasp and could hold it by him or herself.

### Coding

For each second of the test trial, the position and action of the infant's hands with respect to the object was scored in accordance with pre-established manipulation behaviors. The selected behaviors were chosen based on the physical properties of the

objects, surfaces, and their potential interrelations. Scoring was limited to manipulation behaviors that appropriately exploited properties of the materials used in this study. These behaviors included: mouthing, shaking, banging, and two-handed exploration. Mouthing and two-handed exploration occurrences were measured in terms of duration to the nearest second. The position of the infant's hand(s) with respect to the object was scored at one second trial intervals. Shaking and banging were measured in terms of frequency of occurrence.

Infants were scored as mouthing the rattle if it touched the lips or tongue (e.g., licking), or was inserted into the oral cavity. Two-handed exploration occurred when infants manipulated the object with both hands. Shaking was defined as a vigorous up and down or side-to-side movement of the rattle. Each discrete movement of the rattle was scored as one shake. In other words, if the infant waved the rattle to the left then waved it back to the right, observers coded this motion as two shakes. Likewise, an upward movement followed by a downward movement was scored as two shakes. Banging was defined as a rapid striking action of the object toward the surface from a raised vertical or horizontal position.

The same initial observer scored all four manipulation behaviors for the entire sample and a second observer conducted reliability on 50% of the trials. Percent agreement for mouthing, two-handed exploration, shaking, and banging, were 99%, 99%, 83%, and 87%, respectively.

### Results

Because the infant's behavior with the object could end a trial prior to the maximum 30-second duration, trial length was analyzed by means of a 3-factor analysis

of variance (ANOVA) to assess potential differences in trial length as a result of illumination (light vs. dark), surface (hardwood vs. carpet), and/or object (sounding vs. non-sounding). Analysis of trial length revealed a significant main effect of illumination  $F(1,19) = 8.06, p = .01$ . Trials conducted in the light ( $M = 29.2, SD = 1.26$ ) were 1.66 seconds longer than trials conducted in the dark ( $M = 27.54, SD = 2.34$ ). Average test trial duration ranged from 26.50 to 30 seconds in the light and 23 to 30 seconds in the dark. Proportion of trials exceeding 25 seconds for both the light and dark was 93.75% and 80%, respectively.

Exploratory behaviors (i.e., mouthing, shaking, two-handed exploration, and banging) were analyzed by means of analysis of variance (ANOVA) to assess differences across illumination (light vs. dark), surface (hardwood vs. carpet), and object (sounding vs. non-sounding). Each exploratory behavior was analyzed with a 3-factor ANOVA. Means for the aforementioned exploratory behaviors are reported in Table 2. The sounding object elicited more shaking  $F(1,19) = 25.35, p < .001$  (see Figure 1), whereas the non-sounding object elicited more mouthing  $F(1, 19) = 8.71, p < .01$  (see Figure 2). Objects presented in the light elicited more shaking  $F(1,19) = 5.73, p = .027$ , and more banging  $F(1,19) = 10.63, p = .004$  (see Figure 3). To control for potential effects of trial length for light and dark trials, these frequency measures were converted to rates (i.e., frequency divided by trial length). Again, more shaking  $F(1,19) = 4.59, p = .045$  and banging  $F(1,19) = 7.47, p = .013$  occurred when objects were presented in the light. To further confirm that longer length of light trials did not contribute to the illumination effect for shaking or banging, correlations were run between rate of shaking and rate of banging and length of trial (see Figures 5 and 6). These analyses did not reveal any

significant correlations (all  $p$ 's  $> .25$ ). Finally, the hardwood floor elicited more banging as compared to the carpet  $F(1,19) = 8.17, p = .01$  (see Figure 4). No differences were found in regards to two-handed exploration.

### Discussion

The purpose of this study was to investigate the role of visual feedback during an exploratory experience that varied in illumination, object, and surface with 8-month-old infants. Previous studies with infants between the ages of six and twelve months of age, in which object manipulation was the focus, have been conducted while objects were under visual control (i.e., in the light). Rochat (1989) reported the early exploratory behaviors of infants ranging from 3 to 5 months of age in which there was no visual control over exploration. However, it is not until 6 months of age and older that there is an increase in the number of manipulation strategies (e.g., shaking, banging, and fingering) that are contingent upon the affordance(s) of an object (Ruff, 1984; Palmer, 1989). In the present study, object and surface affordances were varied to determine if observing self-produced actions on an object would enhance manual exploration in 8-month-old infants.

Consistent with prior research on the affordances of objects, the infants who participated in this study discriminated the properties of both the objects and surfaces with the appropriate exploratory actions. In agreement with prior research, the sounding rattle elicited more shaking, whereas the non-sounding rattle elicited more mouthing. Extending surface exploration beyond the tabletop to the floor revealed that infants successfully discriminated surface properties in a context other than the traditional exploration paradigm. Infants banged objects more on the hardwood floor compared to



the carpet, suggesting that they utilized the surface as a tool for exploiting the particular affordances (i.e., hardness) of the given object.

It is important to note that surface-directed behavior was not modeled for the infant, nor was it an essential strategy for the exploration of the given objects. Banging on a surface was just one of the many strategies infants could have executed on our objects. The various affordances of our objects enabled infants to shake, mouth, and manipulate with one hand or both. It was not necessary for them to utilize the available surface to exploit the properties of either object, and in fact they had to engage in more complex motor behavior to bang the object on the floor than if they were seated with a tabletop. A motor coordination of trunk bending and extended reach directed toward the surface was necessary to execute surface-directed banging. Infants' discriminating use of surface as a tool during exploration, even when it was not as readily available, not only demonstrated their knowledge of affordances, but also the coordinated action sequence involving agent, object, and environment.

Illumination results indicated that certain exploratory behaviors may not be associated with visual feedback or seeing the consequences of self-produced actions. The absence of visual feedback did not result in longer durations of oral or two-handed contact with the object. It is not surprising that oral exploration does not appear to be contingent upon visual control because this activity cannot be viewed by the infant. In contrast, two-handed exploration has the potential to guide and engage infants visually in the action. As demonstrated with studies which observed infants' ability to reach for objects in the absence of visual control, grasping is not contingent upon visual guidance (Clifton, Rochat, Litovsky, & Perris, 1991).



In the absence of vision, previous research has suggested the possibility of infants being “captured” by an object property that could potentially exert greater control over exploration so that lack of feedback from visual properties does not reduce exploration (Bushnell, Shaw, & Strauss, 1985). In other words, certain object properties (e.g., auditory or tactile) could result in more exploratory behaviors in the dark. To explore this idea, we chose objects that differed in sound potential. If infants could be captured by the varying sounding potential of our objects, results would have revealed an interaction of illumination and object whereby more shaking and banging behaviors would have been observed in the dark with the appropriate rattle. However, infants in this study were not aurally captured by our objects in the dark. In fact, more banging and shaking occurred in the light as compared to the dark regardless of the object’s sound potential. Neither of these behaviors increased to compensate for the absence of visual access to the objects (e.g., more banging of the non-sounding rattle on the hardwood surface or more shaking of the sounding rattle) during the trials conducted in the dark. Instead, more activity occurred when infants could see what they were doing with their hands irrespective of object.

It is possible that during observation of self-produced actions under visual control, infants are sensitive to the motion of an object in addition to sight of the hand(s). If this is the case, when exploring objects without a motion component (e.g., textured surfaces), infants could be captured in a sensory domain other than the visual. However, in a study with 3- to 5-month-olds, an elastic rubber object with various textures at each of its extremities did not result in more fingering behaviors in the dark as compared to the light (Rochat, 1989). This finding suggests that exploratory actions (i.e., fine motor

manipulation strategies) are coordinated with vision even in the absence of motion from an object.

Overall, this research suggests that self-produced action enhances infants' attention to an action as well as to the object, and its affordances, involved in the action. When 8-month-olds explore the affordance(s) of an object they do so in a discriminatory manner haptically, and are reinforced visually through the produced action(s). It appears that the ability to discriminate the affordances of objects and the employment of object-specific action strategies is enhanced through purposeful perception in addition to active exploration.

Table 1

## Counterbalanced Orders

Order Combinations	Trial Number							
	1	2	3	4	5	6	7	8
A	LCN	LCS	LWN	LWS	DCN	DCS	DWN	DWS
B	LWS	LCS	LWN	LCN	DWS	DCS	DWN	DCN
C	DCN	DWN	DCS	DWS	LCN	LWN	LCS	LWS
D	DWS	DWN	DCS	DCN	LWS	LWN	LCS	LCN

*Note.* Each of the variables has been abbreviated as follows: L = light, D = dark, C = carpet, W = hardwood, S = sounding, and N = non-sounding.

Table 2

## Means and Standard Deviations for Each Exploratory Behavior

Variable	Light	Dark	Hardwood	Carpet	Non-Sounding	Sounding
<b>Banging</b>						
M	3.54	.95	3.34	1.15	2.86	1.63
SD	3.98	1.40	3.66	2.00	3.55	2.30
<b>Mouthing</b>						
M	9.46	8.71	8.41	9.76	10.10	8.08
SD	7.50	6.43	6.78	6.59	6.61	6.55
<b>Shaking</b>						
M	14.25	8.55	11.60	11.20	6.70	16.10
SD	10.17	6.04	7.26	7.16	5.41	9.42
<b>Two-Handed</b>						
M	9.24	6.69	7.84	8.09	7.79	8.14
SD	4.09	4.92	4.22	4.30	4.47	4.11

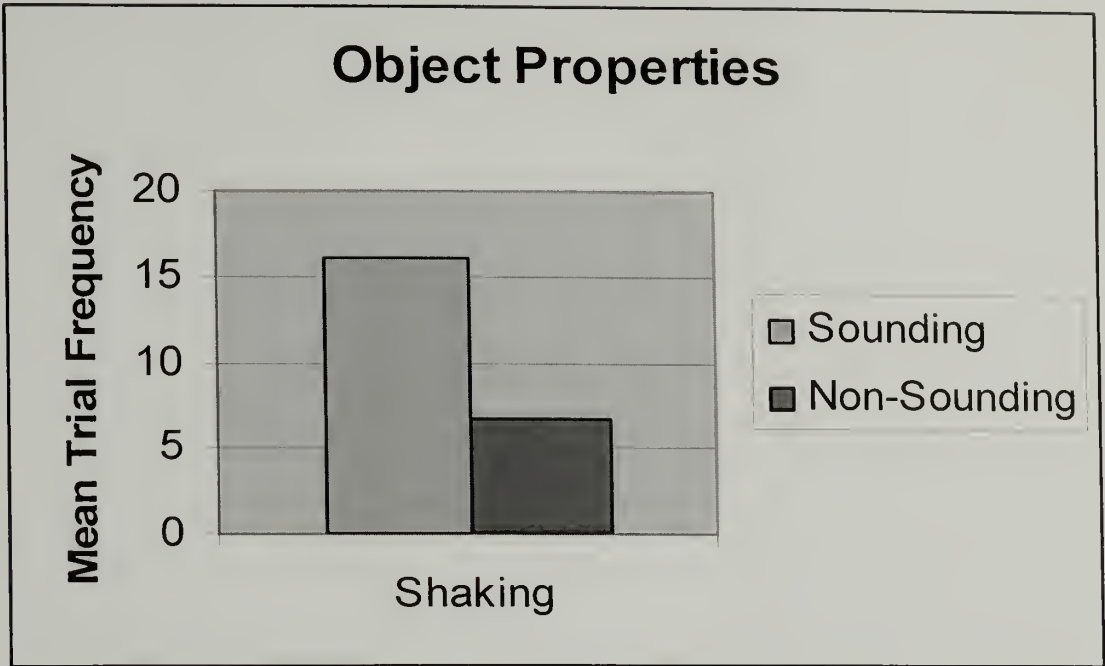


Figure 1: Mean object-directed behaviors for shaking as a function of sound potential.

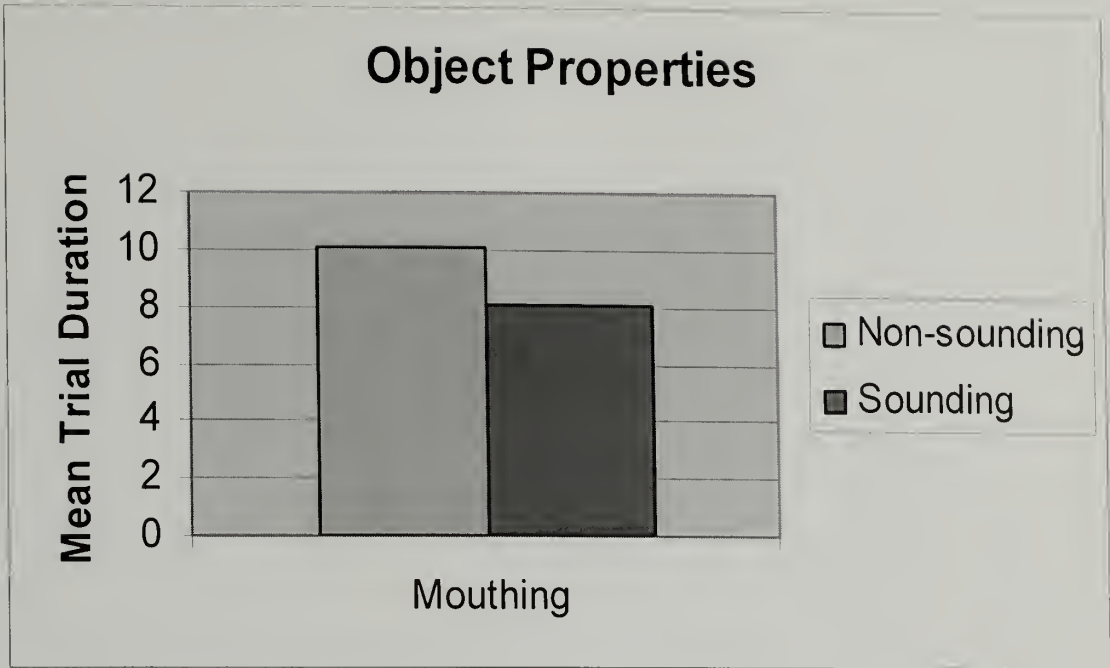


Figure 2: Mean object-directed behaviors for mouthing as a function of sound potential.



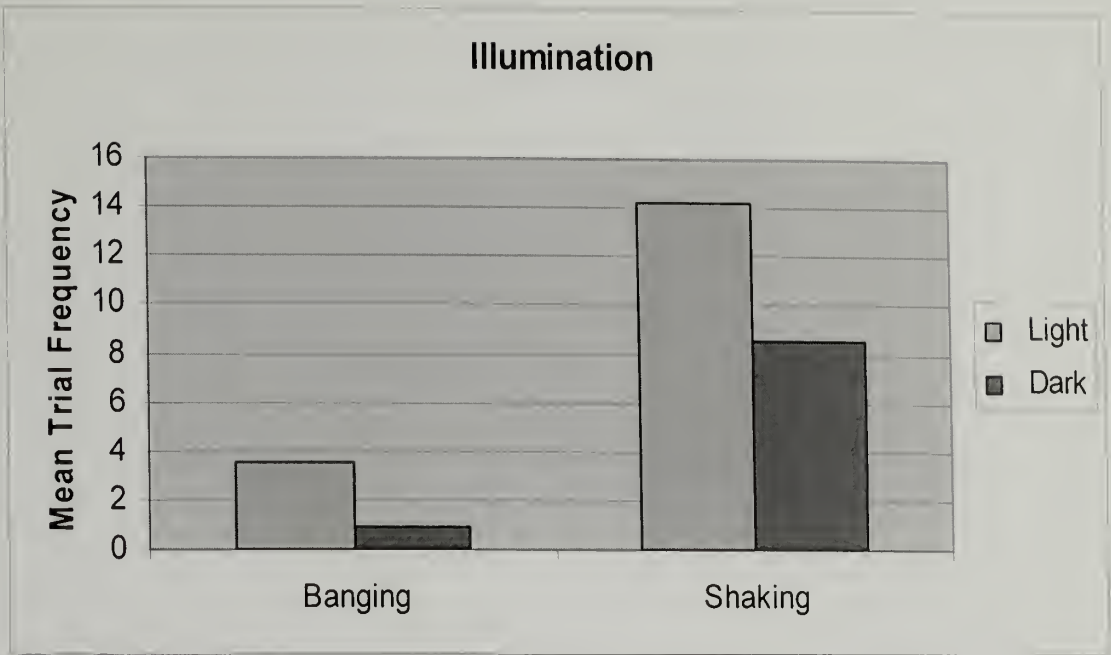


Figure 3: Mean exploration behaviors as a function of illumination.

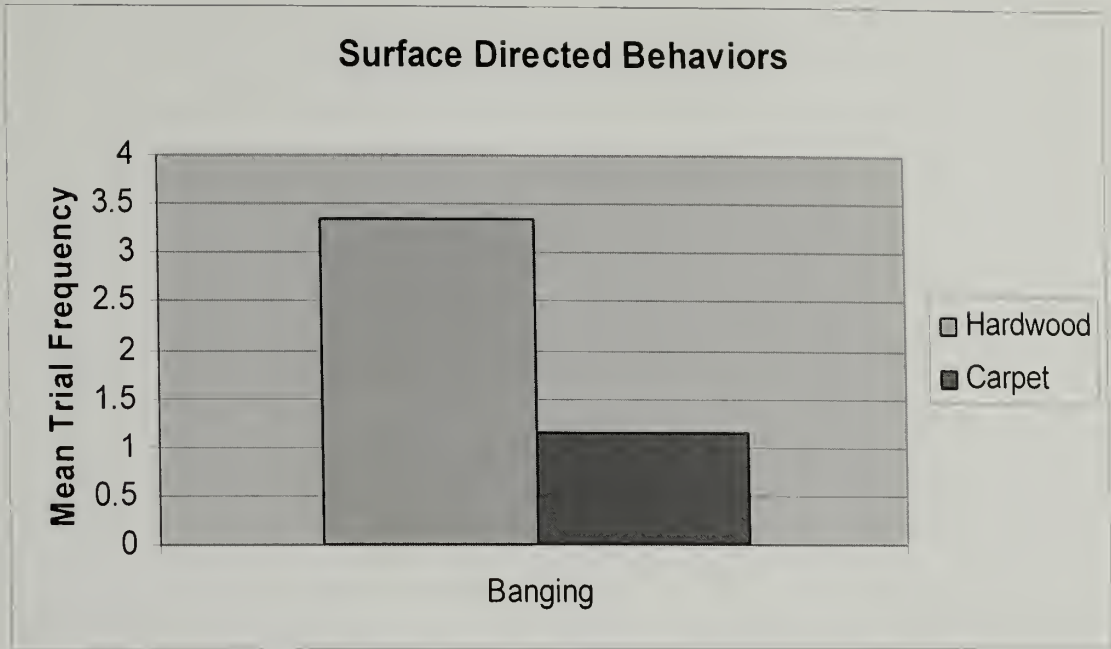


Figure 4: Mean surface-directed behaviors.

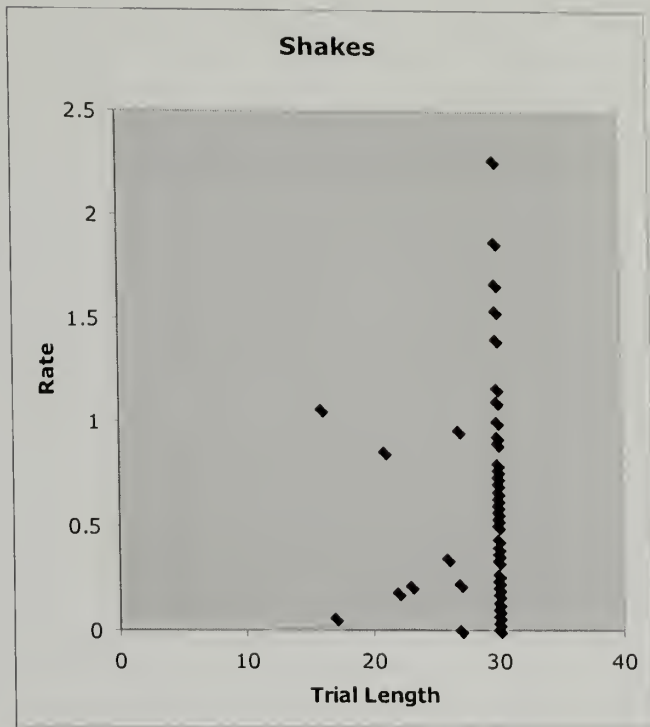


Figure 5: Scatterplot of shaking rates as a function of trial length for trials conducted in the light.

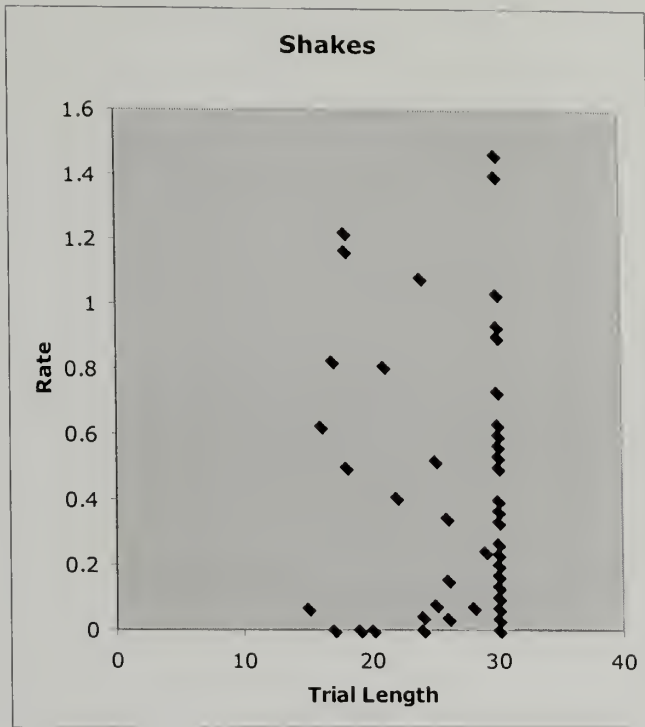


Figure 6: Scatterplot of shaking rates as a function of trial length for trials conducted in the dark.

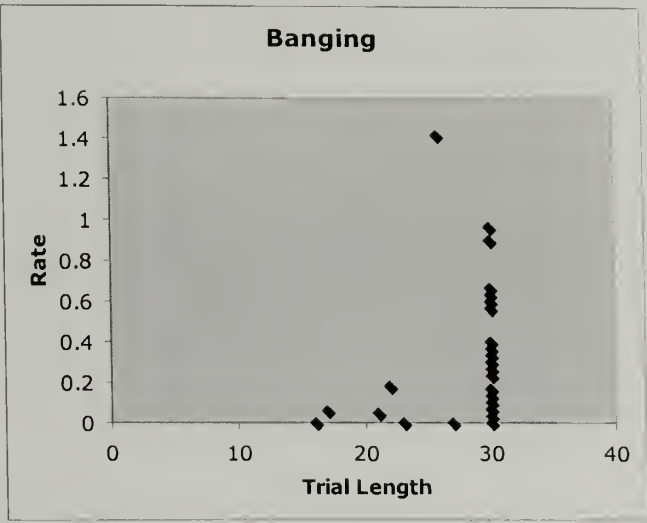


Figure 7: Scatterplot of banging rates as a function of trial length for trials conducted in the light.

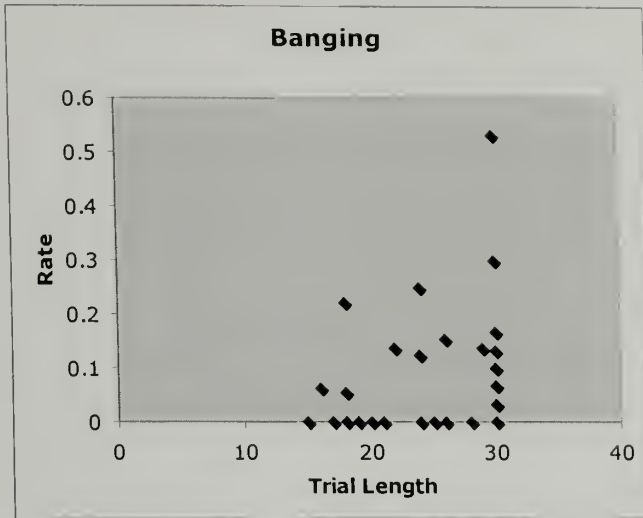


Figure 8: Scatterplot of banging rates as a function of trial length for trials conducted in the dark.



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