Effect of Naming on Haptic Memory in Children and Adults: Is it Similar to Olfactory Memory?

Trevor C. Cessna (cessnatc@mail.uc.edu)
Department of Psychology, University of Cincinnati, 4150 Edwards I, ML 0376
Cincinnati, OH 45221 USA

Shealan D. McAlister (mcalissd@mail.uc.edu)
Department of Psychology, University of Cincinnati, 4150 Edwards I, ML 0376
Cincinnati, OH 45221 USA

Heidi Kloos (heidi.kloos@uc.edu)
Department of Psychology, University of Cincinnati, 4150 Edwards I, ML 0376
Cincinnati, OH 45221 USA

Robert A. Frank (frank@ohio.edu)
College of Arts and Sciences, Ohio University, Wilson Hall Administrative 203
Athens, OH 45701 USA

Abstract

Recollection of events can be improved with the use of active strategies. In the current study, we examined if naming could serve as a mnemonic device for both children and adults to remember shapes that they explored haptically. Participants either named the shape during the encoding phase (naming condition), or they determined the "likability" of the shape (liking condition). During the retrieval phase, participants had to trace shapes again. Here, the task was to name each shape and to determine whether they remember tracing it previously. Results showed that memory performance was significantly better for adults than for children. More importantly, while there was no difference in memory performance between conditions, naming consistency was found to be the best individual predictor of correct recognition memory performance. Findings are discussed in the context of the developmental similarity and differences between haptic and olfactory memory.

Keywords: Haptic Identification; Haptic Memory; Naming Strategy; Naming Consistency Effect

Introduction

The influence of odor names to aid olfactory recognition has been debated repeatedly, with some researchers demonstrating its memory enhancing effects (Cain & Potts, 1996; Larsson, 1997; Lehrner, Gluck, & Laska, 1999; Rabin & Cain, 1984), while others did not (Engen & Ross, 1973; Lawless & Cain, 1975; Møller, Wulff, & Köster, 2004; Parr, White, & Heatherbell, 2004). These studies varied on how odor names were cued during the encoding (i.e., free naming, forced-choice labeling), and they varied in the time when the odor names were cued (i.e., during encoding, retrieval, or both).

A series of recent studies sought to shed light on such discrepant findings and manipulated the frequency and difficulty of odor naming variables (Frank, Brearton, Rybalsky, Cessna, & Howe, 2011; Frank, Rybalsky, Brearton, & Mannea, 2011). Findings revealed that odor naming enhanced memory only when cued during encoding and retrieval. Specifically, consistently naming the same odor during encoding and retrieval was related to almost perfect recognition, while inconsistently naming an odor was related to poor recognition. The same predictive value of consistently naming on recognition found in adults was also seen in children (Frank, Brearton, et al., 2011). This outcome is surprising given extensive previous literature on how poorly children are at odor naming accuracy (e.g., Lumeng, Zuckerman, Cardinal, & Kaciroti, 2005; Monnery-Patris, Rouby, Nicklaus, & Issanchou, 2009; Stevenson, Mahmut, & Sundqvist, 2007).

The generalizability of consistent naming to predict memory performance found in odors among adults and children have not been fully explored in other sensory domains. The current study tests the relationship between naming and memory by evaluating how children and adults name and remember shapes during haptic exploration.

Among children, previous research has shown that children (ranging from 3 to 8 years old) could label common haptic objects with 75% accuracy (Morrongiello, Humphrey, Timney, Choi, & Rocca, 1994). Furthermore, Bushnell & Baxt (1999) found that 5-year-old children were able to remember 16 familiar and 16 unfamiliar objects averaging 15 correct for the familiar objects and 13.5 for the unfamiliar objects. This study did have one caveat in that the recognition memory task did not have a retention interval between the encoding and retrieval phases as in the previous odor studies. The current study investigates whether a similar experimental design as in the olfactory studies would have the same results among children and adults in terms of the relationship between naming and recognition memory performance.

To summarize, the current study assessed the relation between naming a shape explored haptically and remembering it afterwards. If haptic memory mimics olfactory memory, participants should benefit from providing consistent names during encoding and retrieval. Preschoolers and elementary-school children participated, as well as adults. For control purposes, a condition was added in which naming occurred only during retrieval, not encoding. Furthermore, we manipulated the familiarity of shapes, as a way of exploring the development of haptic memory. Unfamiliar shapes are likely to mimic odors that are very difficult to name.

Method

The study had a 3 x 2 x 2 mixed design, with age group and condition as the independent-group factors, and shape type as the within-group factor. Condition pertained to whether participants had to generate a label for the shapes they encounter during encoding (naming condition) or not (liking condition). Shape type pertained to whether the shape was familiar or unfamiliar.

Participants

Children (*N* = 54) were recruited from public schools serving urban and suburban Midwestern families with lower to higher middle-class status. There were two age groups: 4- to 5-year olds (*N* = 29; *M* = 5.30 years; 20 girls and 9 boys) and 7- to 9-year olds (*N* = 26; *M* = 8.30 years; 9 girls and 17 boys). Adult participants (*N* = 30; *M* = 20.30 years) were recruited either from the general public (2 women and 4 men; ranging in age from 16 to 32) or from the population of college students attending the University of Cincinnati (13 women and 11 men, ranging in age from 18 to 24). Students received partial course credit for participation.

Test Apparatus and Stimuli

Stimuli were balsa-wood shapes (about 3.5 in^2) glued on fitted pieces of mat board (for durability). There were eight familiar shapes (see Figure 1 for examples), and eight unfamiliar shapes (see Figure 2 for examples).

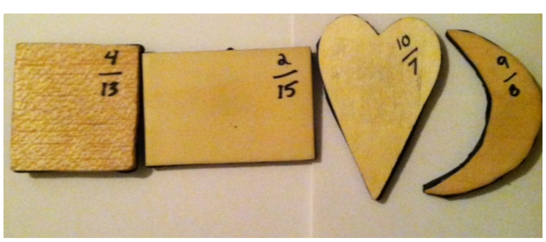

Figure 1: Examples of four familiar shapes (2 geometric and 2 common shapes)

Unfamiliar shapes were created by combining part of one familiar shape with part of another familiar shape. The creation of the unfamiliar shapes was to simulate how some odors are very difficult to name. Table 1 has a list of all familiar and unfamiliar shapes used.

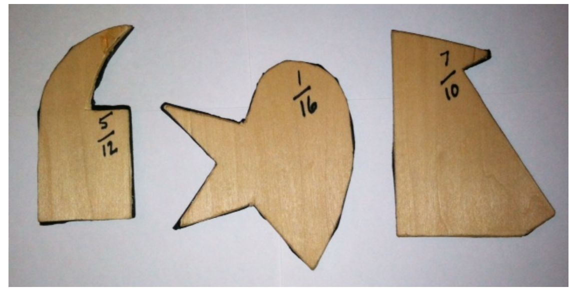

Figure 2: Examples of unfamiliar shapes (from left to right, square–crescent moon, heart-star, and arrow-rectangle).

Table 1: List of Shapes used.

Arrow	Heart-Star
Arrow-Rectangle	Oval
Crescent Moon	Rectangle
Dog Bone	Square
Dog Bone-Crescent Moon	Square-Crescent Moon
Dog Bone-Rectangle	Square-Oval
Heart	Star
Heart-Arrow	Star-Oval

A wooden box (approximately 2 x 2 x 2 ft.) was created to provide participants with a haptic experience of the objects. The box was placed on its side and a 3" x 5" opening was cut into the bottom of the box for an arm to enter. Figure 3 shows the box from the experimenter's point of view. The shapes were attached to its walls and the opening for the child's hand was covered with pieces of felt. A white cloth was draped in the middle of the box to make it impossible for participants to see through the opening. A strip of Velcro was placed in the inside of the box behind the white cloth to hold in place each shape that was being traced.

Figure 3: Testing box from the experimenter's point of view

Procedure

Participants were tested individually with a female experimenter, either in a quiet area of their school or in the lab. The procedure consisted of a familiarization, an encoding phase, and a retrieval phase. Familiarization and encoding differed as a function of condition (liking vs. naming), while retrieval was identical for all participants. Each phase is described in detail below.

Familiarization

A cover story was used that involved "Penny the Poodle", a fictional character who needs help tracing things. Specifically, as a way of practice, the experimenter brought out a circle and demonstrated tracing by dragging two fingers along the edge of the shape. The experimenter then asked the participant to mimic this action too. The participant was then told: "In this game, we are not going to be able to see any of the things that we trace. You are going to trace all of them inside of this box. Penny does not want you to see the things in this game. Try to make sure the curtains are down, and I'll make sure too, and no peeking".

The experimenter put a triangle on the Velcro strip in the middle of the box and asks the participant to place his/her hand inside of the box and trace the shape. After five seconds of tracing the participant is asked to remove his/her hand from the box. In the naming condition, the instructions were: "Can you give a name for the thing you just traced?" Feedback was provided (i.e., in the case of an incorrect response, the experimenter said: "Great name, but for now, we're going to call this a triangle"). The experimenter than explained that some of the shapes are not going to be easy to name. The experimenter showed the participant half of an arrow and said: Some things are hard to name, like this one. What name would you give this?" The participant is told the name can be anything that is a real name. If the participant was hesitant, a prompt was given: "Well, just come up with a name, it can be anything you want to call it. You could call it an arrow, a tree, a stick, anything…just not a person's name like Fred!" The experimenter then showed half of a heart and repeated the process.

For the liking condition, the participant was asked to decide whether Penny likes the traced shape or not. Specifically, the participant was told: "Penny likes things with many corners. Do you think Penny would like the thing you just traced? Be creative! It's up to you to decide if she will like it!" If the participant was hesitant, the experimenter repeated the tracing procedure and pointed out the corners.

Encoding Phase

Participants were told: "Now you are ready to play the game. There are many different things you must trace like we did before, but this time I will not show you any of them. Do your best and try to remember them!" Participants were reminded to not peek. The experimenter placed each shape on the middle Velcro strip, using one of two random orders. Participants' responses were recorded manually (depending on condition, either the name given to the shape, or whether Penny would like the shape). Participants were then given a five-minute break where they could color or look through magazines.

Retrieval Phase

The instructions were: "Okay, now that the break is over, let's trace some more things". In the liking condition, participants are given the same familiarization that was used for naming condition. Then all participants were told: "I want you to give me a name for each shape, and I then want you to tell me if you remember tracing each shape from earlier. Ready? Go!" Responses were recorded again.

Results

Naming accuracy for each shape was determined to be correct if the participant correctly used one of the shape names from Table 1. No partial credit was given for close hits, e.g., calling the "oval" shape as a "circle". Naming consistency was determined as being consistent if the same shape name was used during both encoding and retrieval. Naming consistency could only be determined for the naming condition, given that this is the only condition in which naming occurred twice.

Figure 4 shows memory performance as a function of condition and age group. Proportion memory correct is the sum of both hits and correct rejections. A proportion of 0.5 is chance performance.

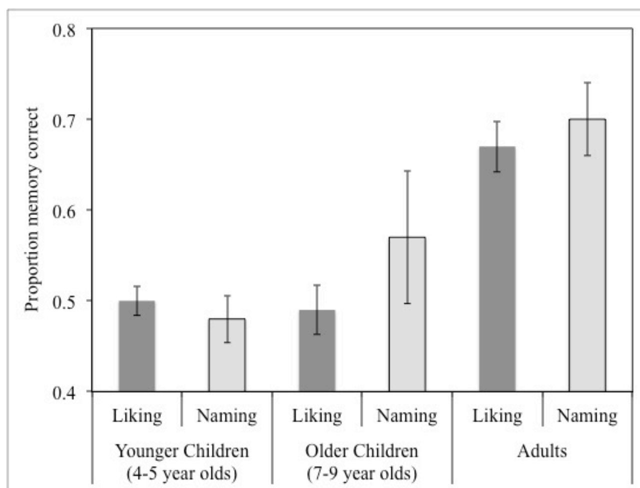

Figure 4: Memory accuracy as a function of condition and age group. The errors bars represent standard errors.

A logistic regression and a generalized linear model were utilized to assess the relationship between consistent naming and naming accuracy to predict recognition (for a detailed explanation into the reasons why these analysis and modeling techniques were chosen over an ANOVA, see Cessna & Frank, 2013; Frank, Brearton, et al., 2011; Frank, Rybalsky, et al., 2011). The generalized estimating equation (GEE) program of SPSS (v.22) was used for the analyses with the exchangeable covariance structure assumed. The different shapes were considered a repeated measure in each model that analyzed each memory response as an individual response. The predictor variables were determined to be significant based on their Wald chi-square values.

First, a GEE analysis was conducted to assess if age group and condition would predict correct recognition. As hypothesized, the analysis revealed that age group has a significant effect on memory performance [Wald χ^2 (2) = 42.25, $p < 0.001$]; however, condition did not [Wald χ^2 (1) = 0.71, p = 0.40]. Post hoc LSD tests showed that adults performed significantly better than both of the children groups (all $p < 0.001$), while the 4- to 5-year olds were not significantly different from the 7- to 9-year olds ($p > 0.05$).

Old Shapes Analyses

To inspect how naming consistency impacted memory performance, the three age groups were each analyzed on correct recognition performance for both consistent and inconsistent shape naming. The results clearly demonstrate that both the adult and older children groups were correct about 9 out of 10 times on memory performance when they were consistent in shape naming. Interestingly, the younger children group was similar in terms of memory performance when they were consistent or inconsistent in shape naming (see Table 2).

Table 2: The relationship between correct recognition and naming consistency across age groups for the *old* shapes in the naming condition.

Age Group	% Memory correct for naming consistency	% Memory correct for naming inconsistency
Younger Children (4-5 year olds)	74	63
Older Children (7-9 year olds)	93	41
Adults	92	42
Mean	87	50

A series of GEE analyses were conducted using the *old* shapes only. The shape stimuli, age group, naming accuracy (during retrieval), and naming consistency were selected as predictors for correct memory performance, and the best models were recorded in Table 3. The best model was chosen based on the minimized corrected quasi-likelihood under independence model criterion (QICC) value. The best model for predicting correct recognition memory performance for *old* stimuli was using both shapes [Wald χ^2 (7) = 23.39, $p < 0.001$] and consistency [Wald χ^2 (1) = 18.14, $p < 0.001$] as predictors. Note: consistency [Wald χ^2 (1) = 28.79, $p < 0.001$] as a predictor by itself was the second best model as its QICC value was only slightly higher (thus inferior) than the best model.

New Shapes Analyses

Prior to any modeling, the three age groups were each analyzed on correct recognition memory performance for both correct and incorrect naming during retrieval instead of naming consistency. Furthermore, since both conditions had the participants name each shape during retrieval, both conditions were also included. The results revealed that correct recognition memory performance improved from the younger children group to the adults in terms of naming accuracy. Furthermore, the data suggests that naming condition may be slightly better than the liking condition (see Table 4).

Table 3: Logistic regression analyses predicting memory for the *old* shapes. R refers to shape naming during retrieval.

	QICC	Wald Chi Square	*df*	Significance
Model 1	863.49			
Shapes		46.40	7	0.00
Model 2	883.76			
Age Group		2.66	2	0.27
Model 3	858.38			
Shapes		44.34	7	0.00
Age Group		3.49	2	0.18
Model 4	857.77			
Shape		25.71	7	0.001
Age Group		3.40	2	0.18
Naming Accuracy (R)		1.38	1	0.24
Model 5	392.79			
Shape		21.29	7	0.003
Age group		3.50	2	0.17
Consistency		15.75	1	0.00
Model 6	385.95			
Shape		23.39	7	0.001
Consistency		18.14	1	0.001
Model 7	392.22			
Consistency		28.79	1	0.00

Table 4: The relationship between correct recognition and naming accuracy across age groups for the *new* shapes in the naming condition.

Age Group	Condition	% Memory correct for correct naming	% Memory correct for incorrect naming
Younger Children (4-5 year olds)	Liking	16	26
	Naming	28	30
Older Children (7-9 year olds)	Liking	25	49
	Naming	59	55
Adults	Liking	80	68
	Naming	85	67
Mean		48	53

A series of GEE analyses were conducted using the *new* shapes only. The shape stimuli, age group, condition, and naming accuracy (during retrieval) were selected as predictors for memory performance, and the best models were recorded in Table 5. The best model for predicting correct recognition memory performance for *new* stimuli was age group [Wald χ^2 (2) = 35.12, p < 0.001] as the only predictor. Note: naming accuracy during retrieval as a predictor was not even close to being the best predictive model (see Table 5). The main reason why naming accuracy was not a bigger factor in predicting memory performance is simply that naming accuracy was almost zero for the unfamiliar shapes (only one participant correctly name a shape) (see Table 6).

Table 5: Logistic regression analyses predicting memory for the *new* shapes. R refers to shape naming during retrieval.

	QICC	Wald Chi Square	*df*	Significance
Model 1	954.06			
Shapes		9.94	7	0.19
Model 2	845.71			
Age Group		35.12	2	0.00
Model 3	854.47			
Shapes		9.82	7	0.20
Age Group		34.51	2	0.00
Model 4	856.40			
Shape		9.77	7	0.20
Age Group		33.76	2	0.00
Naming Accuracy (R)		0.01	1	0.92
Model 5	855.14			
Shape		9.84	7	0.20
Age Group		33.24	2	0.00
Condition		0.98	1	0.32
Naming Accuracy (R)		0.02	1	0.90
Model 6	946.45			
Naming Accuracy (R)		0.01	1	0.95

Table 6: Naming accuracy percentage during encoding (E) and retrieval (R) split by age group, *Old*/*New* shapes, and familiar/unfamiliar shapes

Age Group	*Old*/*New* Shapes	Familiar/ Unfamiliar Shapes	Naming Accuracy (E) %
Younger Children (4-5 year olds)	Old	Familiar	60
		Unfamiliar	0
	New	Familiar	
		Unfamiliar	
Older Children (7-9 year olds)	Old	Familiar	44
		Unfamiliar	0
	New	Familiar	
		Unfamiliar	
Adults	Old	Familiar	65
		Unfamiliar	0
	New	Familiar	
		Unfamiliar	

Discussion

The results of the current study illustrated a strong relation between shape naming consistency and correct recognition, similar to what was seen in previous studies of olfaction (Cessna & Frank, 2013; Frank, Rybalsky, et al., 2011) and flavor (Frank, Brearton, et al., 2011). Interestingly, when comparing the different age groups of the current study to the comparable age groups in Frank, Brearton, and colleagues (2011) flavor research, the effects of naming consistency and correct memory performance is as strong. Again, as reported previously (Cessna & Frank, 2013; Frank, Brearton, et al., 2011; Frank, Rybalsky, et al., 2011), the data suggest that participants utilized a naming strategy in which an "old" recognition memory response was stated when participants had previously named the same shape name during both encoding and retrieval phases of testing and a "new" recognition memory response was used when they had not previously named the shape during the encoding phase. One caveat in the current study is that the younger age group (4-5 year olds) showed weaker evidence that naming consistency predicts correct memory performance than was found previously with flavors (e.g., Frank, Brearton, et al., 2011). In fact, for being consistent or inconsistent, they had a correct memory performance of 74% and 63%, respectively. With memory performance for both consistently and inconsistently named shapes being above chance of 50%, these results may suggest that children from the age of 4-5 years old were not employing the logic that if they named a shape by the same name in encoding and retrieval, then it was sufficient to be an *old* shape on the memory task.

Unlike previous studies where sensory stimuli were used (e.g., Lumeng et al., 2005; Rabin & Cain, 1984), the current study used unfamiliar shapes that were almost impossible to name in comparison to the familiar shapes. These previous studies did show that unfamiliar stimuli were more difficult to name than familiar stimuli; however, the current study assumed that the participants would be able to realize that the unfamiliar shapes were just two familiar shapes cut in half and put together. The data suggested that this assumption was not true and that participants were more likely to name the unfamiliar shape by only one of the half shapes, e.g., naming the Dog Bone-Rectangle shape as just Dog Bone. This outcome could mean that either participants did not have enough time to properly identify this complex haptic stimuli (they could only touch the shape for 5 seconds) or they were more focused to naming the shape as a whole rather than its parts.

The current study demonstrates again the importance of naming consistency to predict recognition when the naming occurred in both the encoding and retrieval phases. Recently, Cessna and Frank (2013) discovered that the relationship between the predictive value of the naming consistency and correct recognition memory performance in odorants were dependent on the temporal placement of the naming task when paired with the recognition memory task. They found that the effects of consistent naming were substantially weakened when memory performance occurred completely separate from the two naming phases. The data suggest that the participants were using the odor names to decide their recognition memory response. Since the effect of naming consistency was found to be as strong as a predictor with haptic stimuli as seen with olfactory stimuli, future research should attempt to completely separate the memory task from the shape naming task to see if the predictive value is also substantially weakened.

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