Relevant Cues of Sign Components in a Hand Signal Language as Percieved by a Bottle-nosed Dolphin.

by
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Marine Options Project Report
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The Kewalo Basin Marine Mammal Laboratory is conducting on-going research in dolphin language comprehension (Herman, 1980). In this project one of the two dolphins, Akeakamai (or "Ake"), is being taught "words" in the form of hand-and-arm signals. She currently has a vocabulary of approximately 30 signs, including nouns, verbs, and two modifiers. The following is paraphrased from a proposal submitted to and accepted by Dr. Louis M. Herman, director of the project, by one of his graduate students, Melissa R. Shyan.

The language being taught to the dolphin Ake is increasing in complexity. Previously there had been no study made of what parts of the signs may be most important to Ake. We know that she may be paying more attention to motion than to the shape of the hands, for example, since dolphins seem to see movement better than subtle shapes (Dawson, 1980; Madsen and Herman, 1980), but when an error is made we have no way of knowing whether the error was due to Ake's perception of the sign or for some other reason. This affects our understanding of her errors, and limits decisions on what new signs should look like, since we don't know how well Ake can discriminate between signs. What we need to know is what parts of the sign Ake is paying most attention to. What will she do with various partial and changed signs? What are the "critical components" of each sign?

Furthermore, Poizner (1981) found that relevant cues in signs are percieved differently by hearing and deaf people. Ms. Shyan proposed that a comparison be made between the relevant cues in our signs for hearing humans, a deaf human, and Ake, who

like the deaf human, has no verbal language. Would Ake interpret the signs more like a hearing human, a deaf one, or in some unique way?

In September 1981 Ms. Shyan and Ms. Susan Swartz began presenting normal and modified signs to human trainers familiar with Ake's language and to the dolphin. Preliminary comparison of the results shows that the priorities for choice of one action over another were similar. In both humans and dolphin, gross motor motion was most important, followed by handshape, then direction and location which were related. However, in the dolphin the results are much more tentative at this time, since she has not yet been shown all the modified signs, and her variability of response is greater.

METHODS

Sign Analysis

The first step was to analyze Ake's signs into their component parts, as seen by humans. This was done by videotaping a good signer giving all the signs from a "dolphin's eye view," i.e., from inside the tank looking up at the trainer. Then, using a check-list based on Stokoe (1972), each signal was divided into location (in reference to body), hand shape, hand orientation, and movement components (see Appendix A). This analysis was done by Ms. Shyan, Ms. Swartz, and Ms. Daisy Slagle, a deaf native user and instructor of American Sign Language. The beginning, middle, and ending components of signs were compared with those of other similar signs. Similarities and differences were noted between nouns, between nouns and modifiers, and bet-

ween verbs. (Since verbs are signed with one hand and nouns and modifiers with two, it was not considered necessary to compare verbs with either nouns or modifiers.)

Test Signs

Components to be used in test trials with Ake were chosen on the basis of similarities with other signs, and modifications of whole signs were chosen based on which would give the most information about Ake's perception, no matter what her response was. The changes were made in either location, hand shape, or movement components, and were designed to establish how fine Ake's discrimination is.

Human Sign Interpretation

Then each test sign was embedded in a videotaped sequence of normal signs, and shown to trainers at the Lab. The trainers were asked in a forced choice recognition task to decide which sign each fragment or altered sign was, and to indicate how confident they were of their response on a scale of one to five (Appendix B). Note that trainers were forced to make a choice between possible responses, whereas Ake had the option of not responding.

Dolphin Sign Interpretation

Finally these components were (and are being) presented to Ake in the course of normal training sessions, once per week, with only one or two fragments or altered signs presented in each session to aviod accidental re-training. Ake was reinforced based on a correct category of sign response for each test trial.

In other words, she got a fish and social reinforcement if her response corresponded to one of the signs which use or overlap the component presented. If she gave no response, she was given only a fish after 10 seconds. Her response was considered an error if the sign for the response she gave had no similarity to the sign presented. If the keyboard operator was in doubt about a particular response, Ake would recieve only a fish, again after a 10 second pause. This was to avoid reinforcing Ake for the doubtful response but to preclude emotionality. A screen was used to hide Ake's trainer from her as the trainer got into position for each trial. This included non-test trials, so that Ake would not know which trials were test trials. Other controls consisted of two "blind observers" writing down what they thought the sentence was; one from the sign only, the other from Ake's response only. Each sign part, and Ake's response to it, was videotaped for later analysis. Each test trial will eventually be given four times to allow Ake to choose a different response if she isn't sure. Her variability in response is likely to roughly approximate the confidence scale given to the trainers. The data consisted of the human's and Ake's responses to the components and modified signs presented. The data from Ake will be compared to the trainer's responses to the test signs for a common response to a component which is part of several signs, in order to see differences and similarities in perception between the humans and the dolphin.

RESULTS

The results consist of the breakdown of signs into component parts by deaf and hearing observers, the responses of trainers to the modified signs in a forced-choice situation, and Ake's responses to the same modified signs given during training sessions. The analysis of the signs by the deaf observer, Ms. Slagle, was more detailed than that of the hearing observers, but all analyses were constrained by the check list.

Human Data

The human data seems to correlate our hypothesis that gross motor movement (movement of the whole arm as opposed to movement of only the hand or fingers) would be most important, followed by handshape. Direction of movement and location on the body were related, and were less important than the other components. For example, the signs "toss" and "mouth" have a common beginning gross motor component which starts at shoulder level and moves out from the body (see Appendix A). In toss the hand then rotates and moves leftward, whereas in mouth the movement is simply reversed. The hand shape is closed, with thumb extended up for toss, and closed for mouth. When we used the beginning gross motor movement with the toss handshape, in "toss stop," 82% of the trainers responded with mouth, and only 18% with toss; indicating that the gross motor movement, which is the critical component for mouth, took priority over the handshape presented. However, the 18% toss response shows that the handshape had some relevance, since when the same gross motor movement was presented with the mouth handshape, the response was mouth 100% of the

time, as compared to only 82% with the toss handshape (see Table 1).

Figure 1 shows the correspondence between the amount of change in the sign and the average confidence level of the trainers. The proportion of change from the model is based on the original analyses of the signs as compared to the analysis of the modified signs. The number of components changed divided by the original number of components gave us this figure. As expected, the greater the change in a sign, the lower the confidence of the humans. Also, the greater the change in the sign, the greater the variability in response (see Table 1). For example, "mouth stop" had a proportion of change of .58 from mouth, and mouth was the only response given by the trainers, with a confidence level of 4.62. On the other hand, trainers gave three different responses to "toss stat.," which involves no movement at all, simply handshape and location. The proportions of change from the models were .92 from mouth, and .91 from toss and over. The confidence levels for this sign were 2.50, 3.38, and 1.00, respectively.

Dolphin Data

Akeakamai's responses have been similar to those of the humans as of this writing. However, she has not yet been shown all the signs enough times to be able to evaluate her responses more than tentatively. She used her option to do nothing three times, twice on "toss stat." which has no movement and a high proportion of change from any model (.91 change from toss and over, .92 change from mouth). The other no response was on

"mirror modified toss," which also has fairly high proportions of change (.65, .75, and .55, from over, tail-touch, and toss). On two signs Ake's response was one the humans had not given, and both of these consisted of fine motor movement only ("Mouth close stat." and "spit open stat."). Her response was toss to both of these, which seems to have no connection with the presented sign, and could have been in frustration, rather than a real choice. Ake's priorities for choice seem tentatively to be the same as the humans: gross motor movement takes first priority, fine motor movement second, and then direction of movement and location on the body, which are related.

DISCUSSION

This study has shown that when known signs are modified in a controlled manner, human trainers, when forced to choose which normal sign the modified sign resembles, are less confident of their response the greater the modification of the sign. However, modifying some components of the sign produced more variable responses and lower confidence levels than modifying other components. For human beings, the gross movement of the arm seems to be the most important factor in a sign, followed by fine motor movement, as in finger movement and handshape. The absolute direction of the movement and the relation to the body seem to be less important, and are related to each other. In this study, a deaf signer paid more attention to details in the signs than either hearing signers or the dolphin, but these results are tentative. Also tentatively, the dolphin Ake seems to have the same priorities of sign components as her human

trainers, but we do not know if she is unable to distinguish the smaller changes in signs. She has been encouraged to generalize in her training, since no two signers give the signs exactly the same way.

I participated in all phases of this project, and learned the design and execution of experiments, the uses of control techniques, data analysis, proposal and report writing, and personnel management and supervision. I also learned techniques of shaping behaviors using reinforcement, dolphin husbandry, and dolphin physiology. The study will be continued to learn more about Ake's perception of her signs.

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TABLE 1

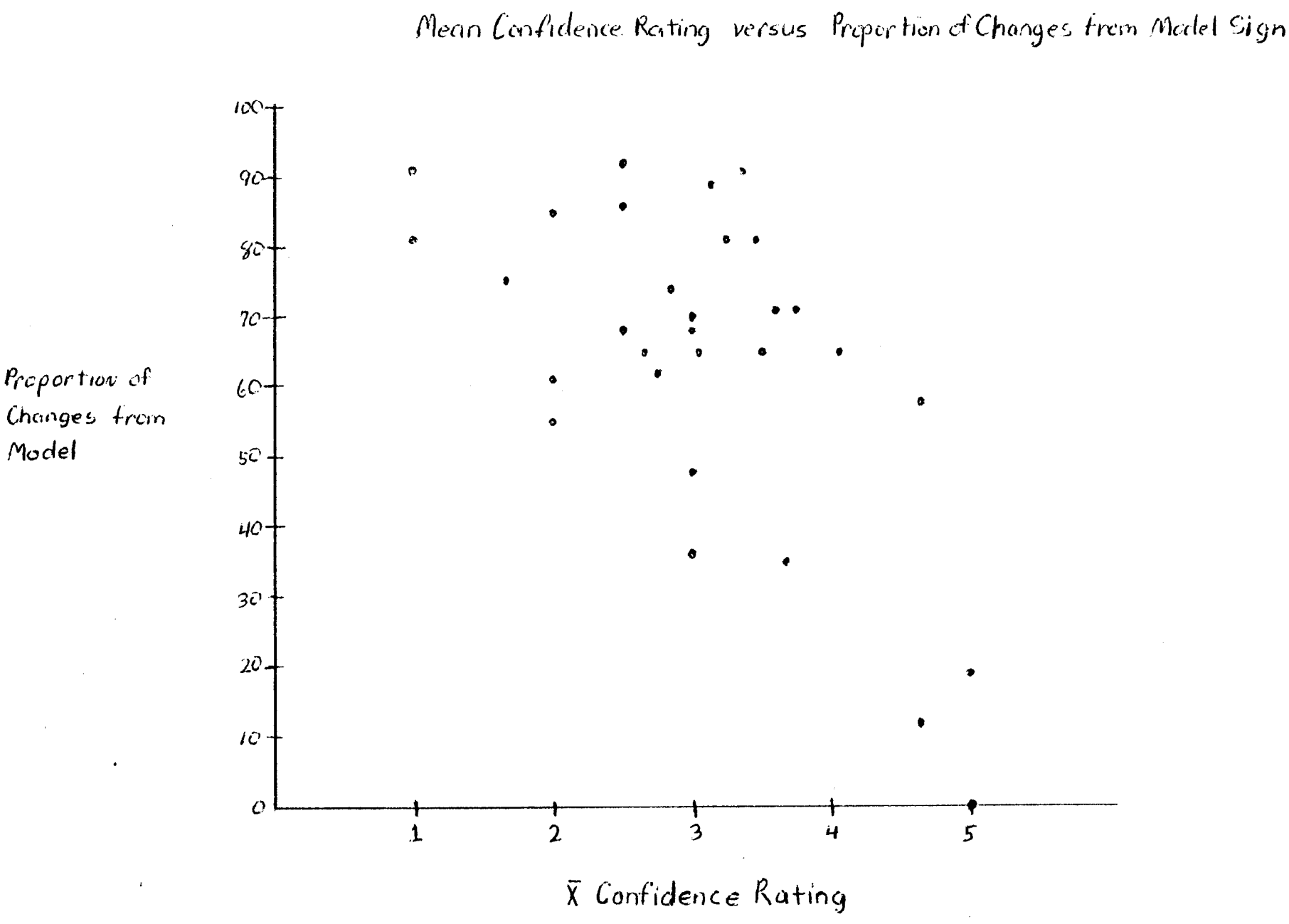
Human and Dolphin Responses to Modified Signs

Sign	Prop. Change	Human Responses	% Tot.Human Responses (Confidence)	Ake's Responses	Times Responded/ No. Given(%)
OVER	.0	OVER	100(5.00)		
MIRROR OVER	.12	OVER	100(4.62)	OVER	3/3(100%)
MODIFIED	.68	OVER	44(3.00)		
TOSS	.70	TAIL-TOUCH	31(3.00)		
	.48	TOSS	25(3.00)	TOSS	1/1 (100%)
MIRROR	.65	OVER	43(2.67)		
MODIFIED	.75	TAIL-TOUCH	30(1.67)		
TOSS	.55	TOSS	27(2.00)	NOTHING	1/1 (100%)
MOUTH	.81	MOUTH	94(3.47)		
STAT.	.86	SPIT	6(2.50)	SPIT	1/1 (100%)
SPIT	.85	MOUTH	9(2.00)		
STAT.	.89	SPIT	91(3.13)	SPIT	1/1 (100%)
TOSS	.92	MOUTH	6(2.50)		
STAT.	.91	TOSS	91(3.38)		
	.91	OVER	3(1.00)	NOTHING	2/2(100%)
MOUTH STOP	.58	MOUTH	100(4.62)	MOUTH	1/1(100%)
SPIT	.65	MOUTH	85(3.04)	MOUTH	1/3(33.3%)
STOP	.68	SPIT	12(2.50)	SPIT	2/3(66.6%)
	.81	TOSS	3(1.00)		
TOSS	.81	MOUTH	82(3.25)	MOUTH	1/1(100%)
STOP	.74	TOSS	18(2.83)		
MOUTH HAND SAME	.19	MOUTH	100(5.00)	MOUTH	1/1(100%)
SPIT	.35	MOUTH	91(3.69)	MOUTH	1/2(50%)
HAND	.36	SPIT	9(3.00)	SPIT	1/2(50%)
SAME					
TOSS	.65	MOUTH	94(4.07)	MOUTH	1/1(100%)
HAND	.61	TOSS	6(2.00)		
SAME					
MOUTH	.62	MOUTH	12(2.75)		
CLOSE	.71	SPIT	88(3.75)	TOSS	1/1(100%)

STAT.					
SPIT	.65	MOUTH	12(2.75)		
OPEN	.71	SPIT	94(3.60)	TOSS	1/1(100%)
STAT.					

Note: stat. = stationary (no movement). Mirror = with left hand. Stop = first portion of sign given. Hand same = no change in handshape within sign. Close = hand closing is only movement. Open = hand opening is only movement.

FIGURE 1


Mean Confidence Rating versus Proportion of Changes from Model Sign
Proportion of Changes from Model
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
X̄ Confidence Rating

Description of Hand Signal Abbreviations

APPENDIX A

Location (Tab)

Location looks at where the sign takes place in reference to the trainer's body and the tankside wall. Each portion of the sign should be located, as well as an overall impression given as to the total sign location.

Ø	in front of body	◡	lower head (mouth)
∩	top of head	)	side of head
Ab	above body	π	neck region
⊔	mid-face (eyes, nose)	Sb	side of body
○	in front of head	Bw	below wall
[]	whole trunk region		

Hand Shape (Dez)

Hand shape looks at the actual formation of the hand for each portion of the sign. This has been labled according to ALS finger spelling and numbers.

B	open hand	5	fingers spread
A	closed hand thumb to side	S	closed hand thumb front

Hand Orientation

HO looks at the orientation of the hand relative to the water and to the dolphin. It is not movement, but rather the plane of the hand, and location of the palm, relative to the water and the dolphin.

H	horizontal to water	Pt	palm toward dolphin
V	vertical to water	Ps	palm sideways to dolphin
D	diagonal to water	Pu	palm up
		PB	palm toward trainer

Movement (Sig)

Movement describes the motion of the hand and arm for each portion of the sign. It is to be used to determine discrete parts of each sign. Each change of motion constitutes a new part. This provides the columns 1 through 7 in the Check List. The Check List also contains descriptiove categories for these motions. Each motion may contain a single aspect from this category list, or combinations thereof. This section deals with the shape of the motion, the angle of the motion, and repetition of motion. Various combinations of these may be needed for a complete description of a sign.

∧	vertical up	
∨	vertical down	vertical action
∿	up and down	
>	rightward	
<	leftward	sideways action
≷	side to side	
⧹	diagonal up	diagonal action
⧸	diagonal down	
⊤	toward signer	
⊥	away from signer	horizontal action
I	to and fro movement	
↺	rotate to palm up	
↻	rotate to palm down	rotary action
⟲	circular action	
)(	hands converge	
X	hands touch	
÷	hands diverge	interaction
"	hands interchange	
+	hands cross	

□ opening action

closing action

Rp repetition of movement

// hands parallel

\/ hands move differently

∩ hand nodding

⊃ curving motion

Comments

Comments are for any relevant observations that are not covered by the Check List. For example, transition motions should be described in the Comments section if not adequately covered. Other important observations, such as motion hesitation or intermediate hand shapes, should also be described here, though an attempt must be made to categorize them using the check list first. Comments is not to be used in place of the check list for any sign, but rather to provide additional information as necessary.

Check List for Hand Signals

Sign: TOSS

Discreet Movements:		1	2	3	4	5	6	7
Location	Ø	✓	✓	✓	✓			
	⌒							
	Ao							
	⊔							
	○							
	[]	✓	✓	✓	✓			
	∪							
	3							
	π							
	Sb		✓	✓				
	Bw							
Hand Shape	B				✓			
	A	✓	✓	✓				
	5							
	S							
HO	H							
	V							
	D	✓	✓	✓	✓			
	Pc	✓						
	Ps		✓		TB			
Movement	^	✓						
	v							
	//							
	>							
	<			✓				
	≥							

	1	2	3	4	5	6	7
Du							
Dd				✓			
T				✓			
⊥		✓					
I							
a			✓				
D							
◎							
⟩(							
X							
÷							
‘’							
∓							
□				✓			
#	✓						
Rp			2 ✓				
ll							
1/							
∩							
⊃			✓				

Comments:

APPENDIX B

sign number	SP	PP	PT	ST	MT	TS	UN	LT	TT	FZ	SB	PH	WT	OV	RT	HP	BK	guessing 1 2 unsure 3 4 positive 5
1																		1 2 3 4 5
2																		1 2 3 4 5
3																		1 2 3 4 5
4																		1 2 3 4 5
5																		1 2 3 4 5
6																		1 2 3 4 5
7																		1 2 3 4 5
8																		1 2 3 4 5
9																		1 2 3 4 5
10																		1 2 3 4 5
11																		1 2 3 4 5
12																		1 2 3 4 5
13																		1 2 3 4 5
14																		1 2 3 4 5
15																		1 2 3 4 5
16																		1 2 3 4 5
17																		1 2 3 4 5
18																		1 2 3 4 5