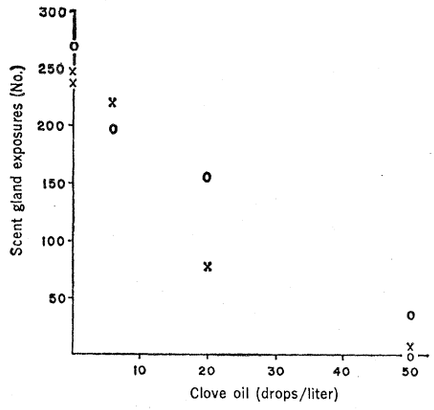

Fig. 5. Data obtained from preliminary experiments testing the effect of the amount of scent in the food on the incidence of Nassanoff gland exposure (days 18 through 22). Station No. 1 (○) had 50, 6, 0, 20, and 50 drops of oil of clove per liter of solution; and station No. 3 (×) had 0, 20, 50, 6, and 0 drops per liter, respectively, on the 5 days of odor variation.

landed only reluctantly at the control station. According to Kalmus (*13*), this is due to a lack of adequate visual and olfactory stimuli generated by the flight activity and odors of foraging bees. To prevent bees from inspecting and rejecting the middle station because of the lack of a necessary "landing factor," we lowered an insect net over the reluctant recruits as they hovered near the dish. This prevented them from arriving at the control station and proceeding upwind to one of the experimental sites (usually No. 1). However, most recruits landed at the dish, attracted in part by the visual stimulus of bee-sized pieces of cellulose sponges placed around the inside circumference of the dish. Care used in transferring bees to the alcohol bottle prevented the release of alarm odor (*14*).

Our results (Table 1) support the olfaction hypothesis and contradict the dance language hypothesis (Table 1 and Fig. 3). Recruits came to the site marked by the food odor but not necessarily to the sites presumably indicated in the hive by the dance maneuvers of returning foragers. This was true, even when the odor had not been used since the previous day. Other experiments with a different hive in another location, in which experimental and control sites were at different distances (370 and 150 m, respectively), yielded comparable results (*15*).

Our results also support the odor accumulation hypothesis. The linear increase in recruitment per unit time occurred when scent was used at the experimental sites (Fig. 4), but did not occur at the control site when foragers collected unscented sucrose at the experimental sites (Fig. 3).

Neither the odor of feeding bees nor the odor from the scent gland provided the problems anticipated (*10*). No site had odor in the food on days 4, 9, and 14; and recruitment of bees was lowest on each of these days. This indicates that searching bees had to be very close to feeding and landing bees before they could use either the odor or the visual pattern of flying or feeding bees. Apparently, the attraction afforded by foraging bees (*13*) was used only after the recruits had chemotactically oriented to the food odor (or distinctive location odor) at that site.

The degree of exposure of the scent gland varied inversely with recruitment (Table 1), and it appeared that the use of unscented sucrose solution contributed to a high rate of gland exposure. To determine whether there is a relation between amount of odor in the food and rate of gland exposure, we varied the amount of odor in the solution at the two experimental sites during a 5-day period after our 17-day sequence. The results (Fig. 5) indicate that the level of exposure of the scent gland can be adjusted by altering the amount of odor in the food. This may also explain why bees do not expose their scent glands when visiting natural food sources such as flowers (*16*).

Three concepts have been examined in the above experiments: odor accumulation in the hive, attractiveness of Nassanoff secretion, and the usefulness of the olfaction hypothesis in predicting the field distribution of recruited bees. Our results show that, although elements of the dance maneuver in the hive do correlate with the distance and direction traveled by regular foragers in the field, the presence of this information in the hive does not appear to contribute to the ecology of foraging or recruitment (*3*).

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Pan-Cultural Elements in Facial Displays of Emotion

Abstract. *Observers in both literate and preliterate cultures chose the predicted emotion for photographs of the face, although agreement was higher in the literate samples. These findings suggest that the pan-cultural element in facial displays of emotion is the association between facial muscular movements and discrete primary emotions, although cultures may still differ in what evokes an emotion, in rules for controlling the display of emotion, and in behavioral consequences.*

In studies in New Guinea, Borneo, the United States, Brazil, and Japan we found evidence of pan-cultural elements in facial displays of affect. Observers in these cultures recognize some of the same emotions when they are shown a standard set of facial photographs. This finding contradicts (i) the theory (*1*) that

facial displays of emotion are socially learned and therefore culturally variable; and (ii) the findings from studies within a single culture that observers of the face alone do not achieve either accuracy or high agreement in recognizing different emotional states (*2*).

Bruner and Taguiri (*3*) said: "The best evidence available [from 30 years of research] seems to indicate that there is no invariable pattern (or at least no innate invariable pattern of expression) accompanying specific emotions." In contrast, our findings support Darwin's (*4*) suggestion that facial expressions of emotion are similar among humans, regardless of culture, because of their evolutionary origin.

Our study was based in part on Tomkins' (*5*) theory of personality, which emphasized the importance of affect and which postulated innate subcortical programs linking certain evokers to distinguishable, universal facial displays for each of the primary affects—interest, joy, surprise, fear, anger, distress, disgust-contempt, and shame. Ekman and Friesen (*6*) reasoned that past impressions of cultural differences in facial displays of affect may represent a failure to distinguish what is pan-cultural (the association of facial muscular movements with each primary affect) from what is culturally variable (learned affect evokers, behavioral consequences of an affect display, and the operation of display rules).

Display rules were defined as procedures learned early in life for the management of affect displays and include deintensifying, intensifying, neutralizing, or masking an affect display. These rules prescribe what to do about the display of each affect in different social settings; they vary with the social role and demographic characteristics, and should vary across cultures.

To uncover the pan-cultural elements in facial displays of affect, the investigator must obtain samples (photographs) of facial expression that are free of cultural differences because of learned evokers, display rules, and consequences. We attempted to select such photographs and to prove that observers from different cultures recognize the same affect from the same photograph. Because similarities in the recognition of emotion among literate cultures might be attributed to learning their own or each other's facial affect cues from a shared visual source (television, movies, or magazines), it was necessary to obtain data also from visually isolated cultures, preferably preliterate cultures.

Photographs were selected from over 3000 pictures to obtain those which showed only the pure display of a single affect. The selection was guided by a study in which Ekman, Friesen, and Tomkins (*7*) developed a procedure for scoring facial affects that was based on a compilation of lists of cues particular to each primary affect. The scoring procedure had not been completed when the photographs were selected for this cross-cultural study, but the partial lists provided the basis for choosing pictures which contained cues distinctive for happiness, surprise, fear, anger, disgust-contempt, and sadness. This list of affects includes all of Tomkins' primary affect categories except for interest and shame; it also includes almost all of the affect states, discriminable within any one culture.

The most common reasons for rejecting photographs were that they showed the influence of display rules or blends of the cues of one affect with those of one or more other affects rather than single-affect pictures. Thirty photographs met our criteria; they showed male and female Caucasians, adults and children, professional and amateur actors, and mental patients. The stimuli were reproduced as 35-mm slides and photographs (13 by 18 cm) cropped to include only the face and neck.

The observers' task was to select a word from a list of six affects for each picture. In the United States, Brazil, and Japan, slides were projected one at a time for 20 seconds each to groups of freshmen college students from whom the foreign-born had been eliminated. The photographic prints (13 by 18 cm) were shown one at a time to each observer in New Guinea and Borneo. The affect words were translated into the locally understood languages (Japanese, Portuguese, Neo-Melanesian Pidgin, Fore, and Bidayuh). There were no Neo-Melanesian Pidgin equivalents for disgust-contempt or surprise, and in these cases a phrase was submitted (looking at something which stinks, looking at something new).

For our isolated, non-Western preliterate samples we attempted to find those least affected by the modern technological, commercial, and ideological currents. The New Guinea sample was the Fore linguistic-cultural group (*8*) who until 12 years ago were an isolated Neolithic material culture. We studied the Fore most influenced by contacts with Westerners (government, missionaries, and others) as well as those least influenced by these recent contacts who have preferred to remain in their isolated hamlets in the mountains.

We report in detail only on the most Westernized Fore; we summarize the results on the less Westernized Fore, whose unfamiliarity with certain tasks required development of specialized

Table 1. Rates of recognition of six affects among samples from the United States, Brazil, Japan, New Guinea, and Borneo.

Affect category	United States	Brazil	Japan	New Guinea*		Borneo*
				Pidgin responses	Fore responses	
Happy (H)	97 H	97 H	87 H	99 H	82 H	92 H
Fear (F)	88 F	77 F	71 F	46 F	54 F	40 F
			26 Su	31 A	25 A	33 Su
Disgust-contempt (D)	82 D	86 D	82 D	29 D	44 D	26 Sa
				23 A	30 A	23 H
Anger (A)	69 A	82 A	63 A	56 A	50 A	64 A
	29 D		14 D	22 F	25 F	
Surprise (SU)	91 Su	82 Su	87 Su	38 Su	45 F	36 Su
				30 F	19 A	23 F
Sadness (SA)	73 Sa	82 Sa	74 Sa	55 Sa	56 A	52 Sa
				23 A		
Number of observers						
	99	40	29	18	14	15
Number of stimuli for which most frequent response was predicted response						
	30/30	30/30	29/30	11/24	12/24	18/23
Number of stimuli for which 70 percent of the observers agreed						
	25/30	26/30	23/30	7/24	6/24	6/23
Chi-square†						
	10,393	3818	2347	532	261	427
Chi-square excluding happy stimuli†						
	5718	2119	1241	188	92	211

* A few photographs, mostly happy pictures, were eliminated in work with preliterate observers in order to make the task shorter. † All chi-squares were significant beyond $P=.01$.

judgment procedures and conducting a number of additional experiments. There were two subsamples in the most Westernized Fore; one subsample performed the judgment task by using Pidgin translations of the affect terms, and the other subsample used the affect terms of their own Fore language.

The Borneo sample was the Sadong, a Bidayuh-speaking group of Hill Dyaks in southwest Sarawak. These people still lived in their traditional long houses and maintained their traditional agrarian way of life. Only one man spoke English, most men spoke some Malay, and many had seen a few movies in a commercial center located about a day's walk from their village.

The distribution of six responses to each category (affect) of photographs was tallied, and the most frequent judgment response for each affect category was converted into a percentage of the total responses to the stimuli which represented that category (Table 1). The data from the three literate samples support our contention of a pan-cultural element in facial affect display. Agreement and accuracy were far higher in each group than had been reported for recognition of emotions within cultures, and the same affect term was the most frequent response in the United States and Brazil for all of the stimuli and for 29 out of the 30 stimuli when Japan is compared. Three literate cultures are not a sufficient sample to proclaim universality; however, Izard (*9*), who worked independently at the same time as we, but with his own set of facial photographs obtained results for eight other literate cultures that are substantially the same as ours.

When exposure to common visual input is controlled (to answer the argument that such similarities among literate cultures only reflect learned recognitions from mass media) the agreement and accuracy were lower in the preliterate cultures than in the literate ones. We believe that this is because of the enormous obstacles imposed by language barriers and task unfamiliarity in preliterate cultures (even with the more Westernized observers). Despite such handicaps, there were similar recognitions of happiness, anger, and fear in all samples, and for disgust, surprise, and sadness in two out of three samples (Table 1). An affect category was never misidentified by the majority of observers in more than one of the preliterate samples. Our studies of other much less Westernized Fore observers yielded similar results, with the exception of the sadness category, and we also obtained additional support in studies in progress on how these affects are expressed in the Fore. The possibility that the data on the preliterate samples might have been biased by the use of Caucasoid faces as stimuli was negated by additional studies in which Melanesian (South Fore) faces were shown to the South Fore observers and results similar to those reported here were obtained. The proposition that there are pan-cultural elements in human affect displays appears to be largely supported, both in the literate cultures that we and Izard have studied, and for the most part in the preliterate cultures that we have investigated. Those who deem it important to have maximum control for shared visual input to limit the opportunity to learn common affect recognitions might still want the further evidence on the less Westernized samples of Fore to be reported later.

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Retrograde Amnesia in Free Recall

Abstract. *Supervention of high-priority events in a series of events constituting a free-recall task interferes with postexposure processing of mnemonic information about immediately preceding events, with the result that recall of these preceding events is impaired. Recall of immediately following events is not affected. This retrograde interference is time dependent.*

Retrograde amnesia refers to selective impairment of memory for events preceding a critical "amnestic" event. The magnitude or the extent of such impairment varies directly with the temporal proximity between the amnestic event and the events whose retention is measured. Known and putative amnestic events or treatments include concussion, electroconvulsive shock, local brain stimulation, anesthesia, anoxia, and administration of various drugs (*1*). The action of amnestic events is usually interpreted in terms of the disruption of consolidation of the engrams or memory traces of events preceding the amnestic event, but alternative interpretations have also been offered (*2*).

Understandng of retrograde amnesia is of considerable theoretical importance. The advancement of such understanding depends on availability of appropriate methods for the production of retrograde amnesia under the laboratory conditions and for accurate specification of its characteristics. I describe here two experiments with use of a new method of demonstrating a phenomenon that resembles retrograde amnesia. The method has certain advantages over the existing ones (*3*), although its applicability is limited to human subjects.

In the experiments, the events to be remembered were common words presented to the subjects sequentially, one word at a time, with the instructions to remember as many of the words in a given list as possible and to recall them