DOCUMENT RESUME

ED 356 891 PS 021 354

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TITLE Neural Correlates of Emotion Recognition in 7-Month-Old Infants.
PUB DATE Mar 93
NOTE 21p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (60th, New Orleans, LA, March 25-28, 1993).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Emotional Development; *Facial Expressions; Fear; *Infant Behavior; *Infants; *Neurology; *Neuropsychology; Recognition (Psychology)
IDENTIFIERS *Event Related Potentials; Familiarization; Happiness; Neuropsychological Measures; Waveform Analysis

ABSTRACT

Two studies used event-related potentials (ERPs) to examine neural manifestations of emotion recognition in 7-month-old infants. In the first study, 20 infants were presented with 2 alternating achromatic slides of the same female model posing a happy and a fearful expression. Infants' ERPs revealed a prominent positive component to the happy face and baseline activity to the fearful face. In the second study, infants were first presented with flashes of alternating pictures of two different models posing happy faces or fearful faces. A series of test trials followed, 25 percent of which contained 1 of the models seen previously, posing the previously seen, or familiar, expression; another 25 percent contained a previously unseen model posing the familiar expression; the remaining 50 percent portrayed a previously seen or unseen model portraying the previously unseen, or novel, expression (fear, if familiarized to happy; happy, if familiarized to fear). Analysis revealed that infants familiarized to happy evinced positive waveform activity to the happy expression and baseline activity to the fearful expression. In contrast, infants familiarized to fear showed effectively identical responses to both expressions. Results from both studies suggest that during familiarization infants struggle with both identity and expression information, resulting in none of the stimuli being exhaustively processed. Six figures showing ERP responses are included. (MM)

Neural Correlates of Emotion Recognition in 7-Month-Old Infants

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Based on a poster presented at the biennial meetings of the Society for Research in Child Development, 27 March, 1993, New Orleans, LA. For information about this paper, contact the first author in writing at the Institute of Child Development, University of Minnesota, 51 East River Road, Minneapolis, MN 55455, or by electronic mail at CANELSON@VX.CIS.UMN.EDU.

Abstract

Two experiments are reported in which event-related potentials (ERPs) were used to examine the neural manifestation of emotion recognition in 7-month-old infants. In Experiment 1 we conducted the ERP equivalent of a visual preference task; in Experiment 2 we conducted a discrimination task. In both experiments the happy face was found to invoke prominent positive ERP activity, whereas the fearful face did not. The former finding was interpreted to suggest that happy is a more familiar emotion than fear. These results are discussed in the context of previous behavioral studies examining emotion recognition, and ERP studies of memory.

Introduction

The research presented herein represents a recent attempt to examine the electrophysiological correlates of emotion recognition in the infancy period. This work can best be viewed in the context of behavioral research that has preceded it. For example, work conducted in this laboratory has revealed that by 7 months of age infants are able to recognize happy faces despite variations in the identity of the face posing the expression, the gender of the model, or the intensity with which the expressions are displayed.[1-3] However, rather consistently infants this same age have been found to be unable to recognize or categorize fearful faces; these abilities appear to develop after 12 months.[4] These findings provide for the tentative suggestion that our species' young is biologically prepared to recognize certain facial expressions, but that this ability is gradually shaped by experience over the first year or two of life. With regard to the first hypothesis, it is likely that portions of the inferior temporal cortex underlie this ability; with regard to the second hypothesis, experience viewing faces and emotion likely influences the course of development to a great degree.

Our current studies have been built on behavioral studies conducted previously. Here it has been reported that 7-month-old infants are able to categorize happy faces and discriminate happy from fear, although they appear unable to categorize fearful faces, nor discriminate fear from happy if first habituated to fear. One source of this order of presentation effect appears to do with a preference for fearful faces. For example, if infants are simultaneously presented with a happy face paired with a fearful face, they devote more initial attention to fear.[5]

One hypothesis proposed to account for this preference for fear is that the signal value of this expression (and perhaps other negative expressions, such as angry) is greater than for positive expressions, and thus it recruits more attention. If correct, one might expect to find that the neural manifestation of responding to facial expressions would differ for positive vs. negative emotions. This hypothesis was examined by recording ERPs during a preference task and then a discrimination task. Each of these studies shall be discussed in turn.

Preference Task

Methods

Seven-month-old infants (n=20) were presented with two alternating achromatic slides of the same (female) model posing a happy and a fearful expression. These stimuli were presented for 500 msec each, and their probabilities were equal (i.e., 50%/50%). ERPs were recorded from midline electrodes placed over occipital, parietal, central and frontal scalp, and from the left and right temporal regions.

Results

As can be seen in Figure 1, infants' ERPs revealed a prominent positive component (parietal and vertex maxima) to the happy face (thin, solid line), and baseline activity to the fearful face (thick, solid line). These results are in contrast to findings previously obtained by us[6], whereby similarly aged infants (6 month olds) evinced identical patterns of ERP activity when presented with two different models posing neutral expressions. These data can be seen in Figure 2.

Discussion

Based on this latter finding, it seemed reasonable to propose that it was the content of the faces (e.g., arrangement of facial features) in the current study that was responsible for manipulating the obtained ERPs. If this interpretation is correct, how shall we interpret this particular ERP manipulation; that is, a late positive peak to the happy face and essentially a baseline response to the fearful face? The results of our discrimination study may help in this regard.

Discrimination Study

Methods

In this experiment infants were first presented with 500 msec flashes of alternating pictures of two different models (5 trials each) posing happy faces (or fearful faces; the design was counterbalanced). A series of test trials followed, 25% of which contained one of the models seen previously, posing the same (i.e., familiar) expression; another 25% contained a different (previously unseen) model posing the familiar expression. The remaining 50% of the trials portrayed these same two models (i.e., one familiar, one not, each presented on 25% of the trials) portraying the novel expression (i.e., fear, if familiarized to happy, happy, if familiarized to fear).

Results

To simplify our data set, we initially pooled the test trial data over model, thus permitting us to isolate the effect of expression. As can be seen in Figure 3, infants familiarized to happy evinced positive waveform activity to the happy expression (dashed line), and baseline activity to the fearful expression (solid line). This effect was restricted to the temporal leads, particularly at the right temporal lead (T4). In contrast, as can be seen in Figure 4, infants familiarized to fear showed effectively identical responses to both expressions.

Discussion

The most parsimonious conclusions that can be drawn from these data are that infants responded differently to happy and fear when familiarized to happy, and responded the same to these expressions when familiarized to fear. At a very superficial level, these data appear to parallel the behavioral data described earlier. In order to interpret the functional significance of the ERPs themselves, however, it is necessary to put this work into context of other work we've conducted examining the electrophysiological correlates of infant memory.[7-8]

General Discussion

In our ERP studies of memory we typically familiarize infants to one or more unfamiliar stimuli, and then examine the electrophysiological responses to these familiar stimuli compared to novel stimuli. After studying infants ranging in age from birth to one year, we have tentatively derived a taxonomy of infant ERP activity.[7] Two aspects of this taxonomy are relevant to the current data set. First, positive waveform activity that is maximal over central and frontal scalp regions and that occurs with a latency of approximately 1000 to 1500 msec has been taken to reflect the updating of memory for a partially or incompletely encoded stimulus. Second, baseline activity that occurs after approximately 800 msec has been interpreted as the electrophysiological manifestation of a fully encoded stimulus or, in some cases, a stimulus that has undergone no cognitive processing whatsoever.

In the current studies we have consistently shown positive ERP activity invoked by happy faces, and baseline responses to the fearful faces. How can this pattern be interpreted? One possibility may be that when the expression on the model's face is a highly familiar one, such as happy, infants have time to begin processing the identity information in the stimulus, as little effort needs to be expended towards processing the expression information. However, the processing of identity is likely shallow and incomplete, which results in the need to update memory. This, in turn, is expressed by a positive ERP deflection. In contrast, if the expression is an unfamiliar one, such as fear, and the face itself is unfamiliar, the task becomes more difficult. For infants younger than approximately 1 year, neither the identity nor expression information can be processed, and thus the infant's understanding of the stimuli may be superficial. Partial support for this interpretation comes from an examination of the infants' responses to all four classes of test stimuli. For example, when infants were familiarized to happy, they showed prominent positive activity to the familiar, happy face presented by the familiar model and baseline activity to the other three classes of faces (including the happy face posed by the unfamiliar model; see Figure 5). This suggests that infants had struggled to encode this model's face into memory, and were effectively ignoring the other faces. These faces were ignored because a) they portrayed an unfamiliar model, or b) even when the model was familiar, the expression was not. In contrast, when they were familiarized to fear there was little difference to any of the stimuli (see Figure 6). This suggests that during familiarization infants struggled with both the identity and the expression information. Such competition resulted in none of the stimuli being exhaustively processed.

Although the preceding interpretation is more speculative than is desirable, even the most parsimonious interpretation of the data is that infants' ERPs distinguished between happy faces and fearful faces. As had been the case for our previous behavioral studies, some of the variance in this finding has been attributed to infants' experience viewing certain facial expressions. This issue of environmental input has been a haunting problem, and is currently being examined by examining infants' ERP responses to monkey faces [9], and to familiar (e.g., mother) and unfamiliar (e.g., stranger) faces.[10]

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Figure Legends

Figure 1 - Grand average data for the facial preference study. The grand average was computed by averaging data across all subjects (n=20). The data derived from the response to the happy face (solid line) and the fearful face (dashed line) are displayed. The scalp lead nomenclature for figures is as follows: Oz=midline occipital lead, Pz=midline parietal lead, Cz=midline vertex lead, Fz=midline frontal lead, T3=left hemisphere temporal lead, T4=right hemisphere temporal lead.

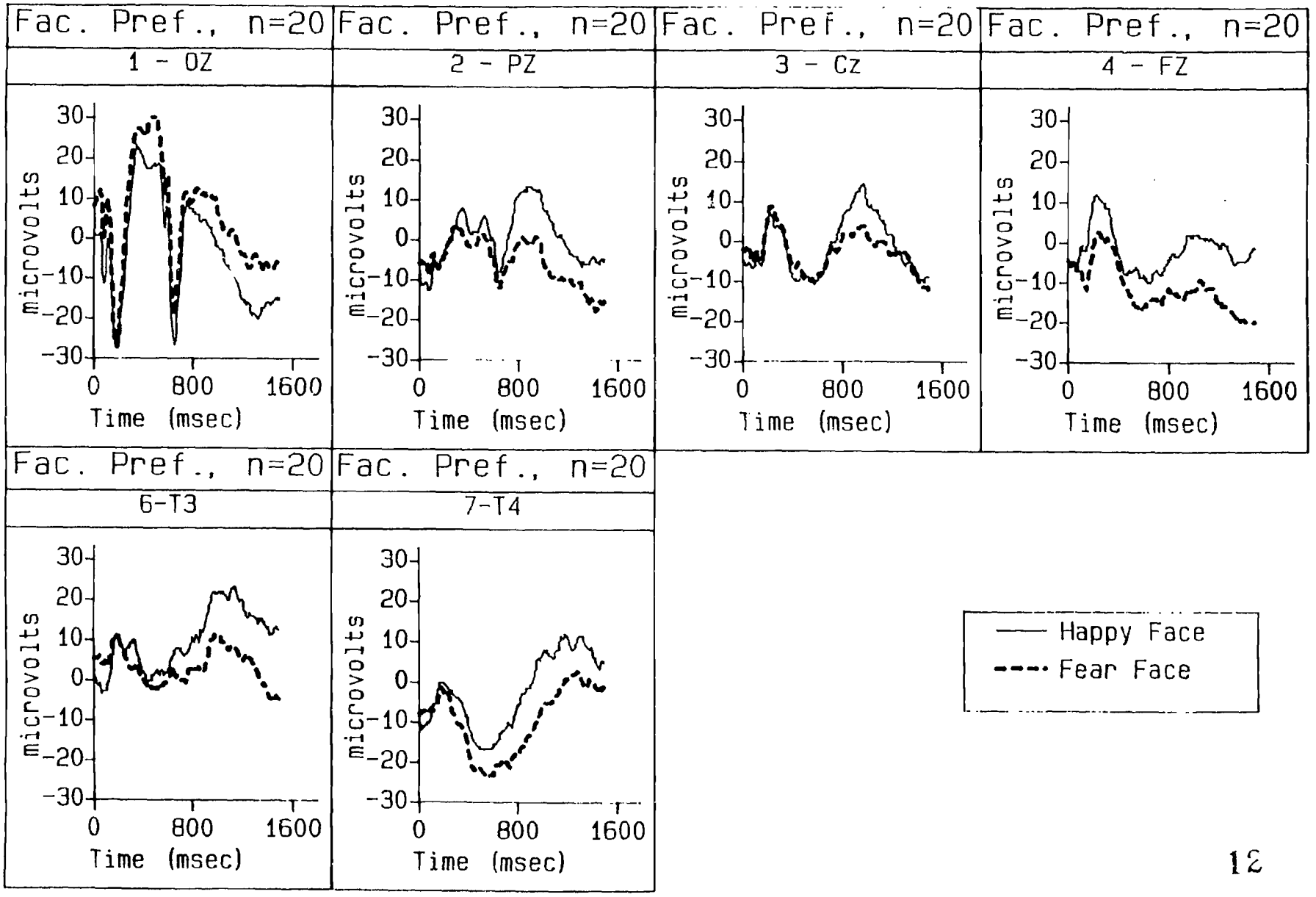
Figure 2 - Grand average data from 6-month-old infants presented with two alternating female faces displaying neutral expressions. The grand average was computed by averaging data across all subjects (n=12). The data derived from the response to "Face A" (thick, solid line) and "Face B" (thin, solid line) are displayed. Positive is up. Reprinted from Nelson & Collins, 1991, with permission.

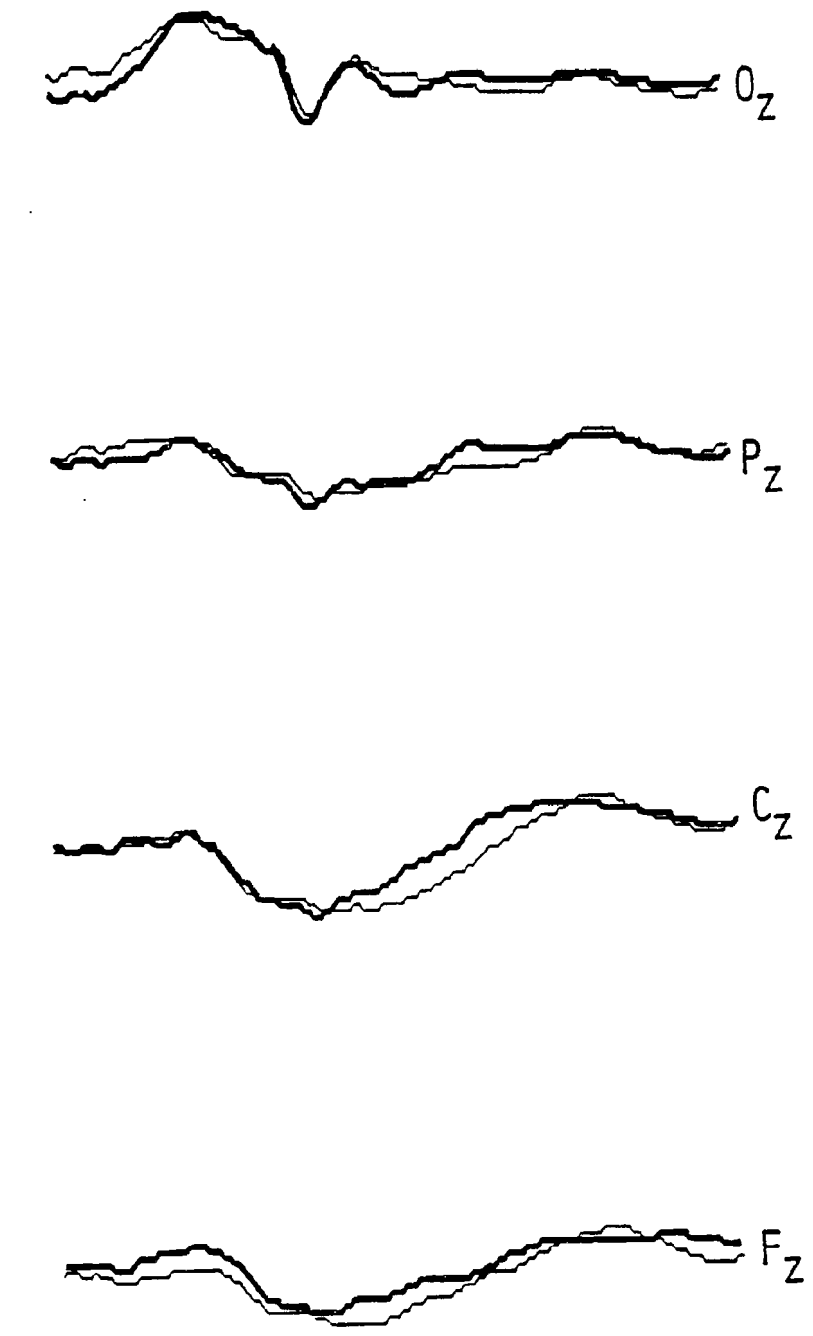
Figure 3 - Grand average data for the discrimination study. The grand average was computed by averaging data across all subjects (n=17). In this condition infants were familiarized to two models posing happy, and then tested on their discrimination of happy vs. fear when posed by both familiar and unfamiliar models. The data derived from infants' responses to the familiar happy expression (collapsing over model; dashed line) and the novel fearful expression (collapsing over model; solid line) are displayed.

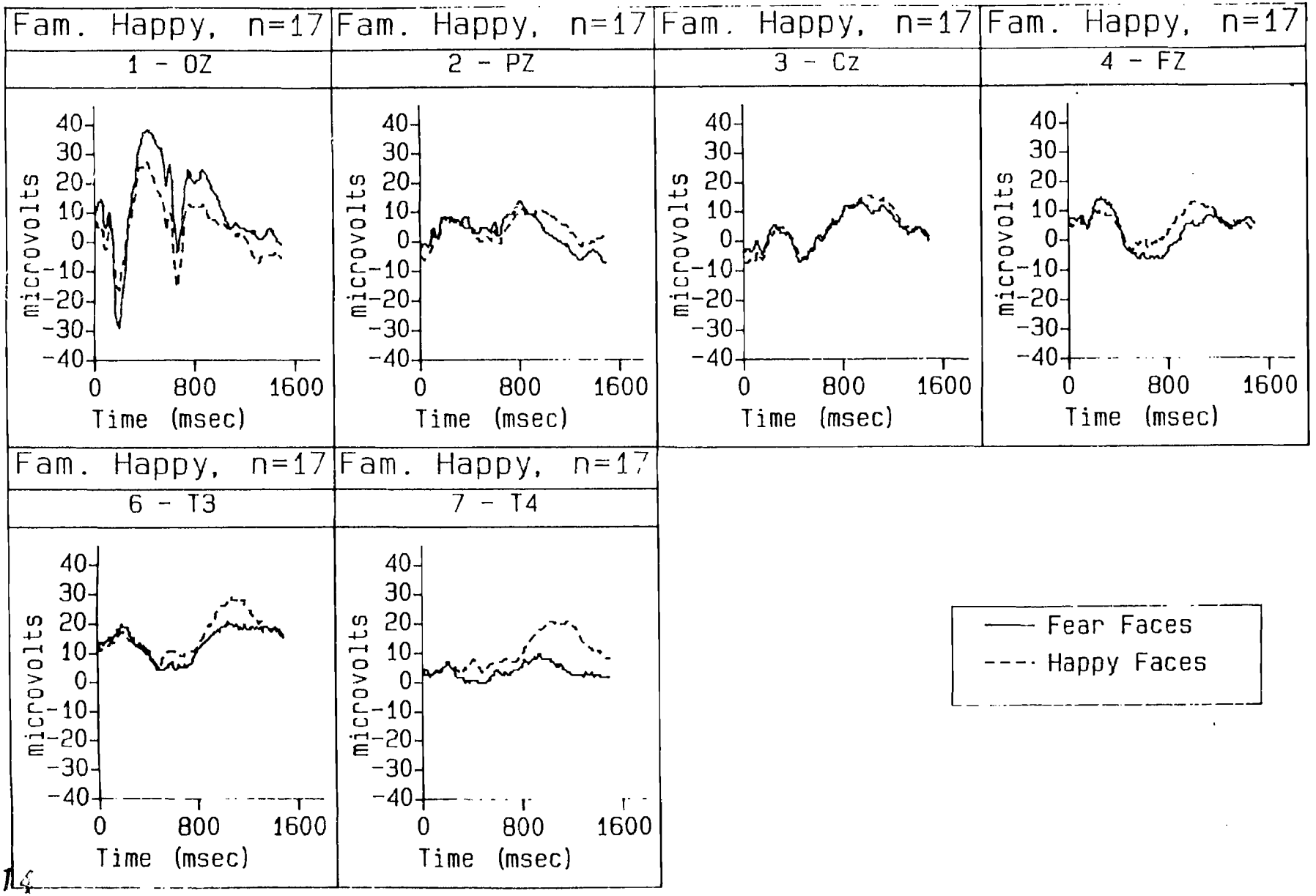
Figure 4 - Grand average data for the discrimination study. The grand average was computed by averaging data across all subjects (n=18). In this condition infants were familiarized to two models posing fear, and then tested on their discrimination of fear vs. happy when posed by both familiar and unfamiliar models. The data derived from infants' responses to the familiar fearful expression (collapsing over model; solid line) and the novel happy expression (collapsing over model; dashed line) are displayed.

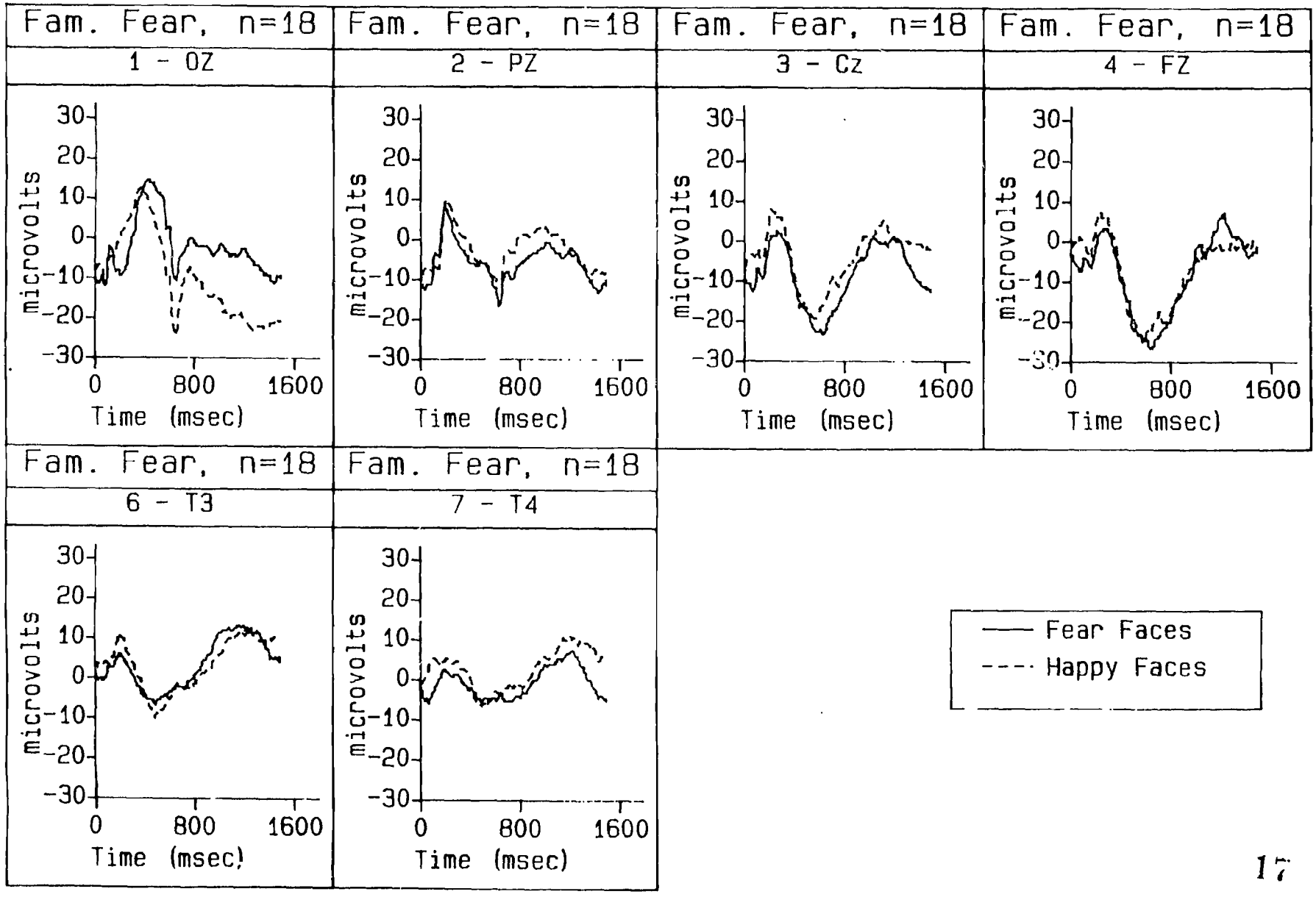
Figure 5 - Grand average data for the discrimination study. The grand average was computed by averaging data across all subjects (n=17). In this condition infants were familiarized to two models posing happy, and then tested on their discrimination of happy vs. fear when posed by both familiar and unfamiliar models. The data derived from infants' responses to the happy expression (thick, solid line - familiar model and thick, dashed line - novel model) and the fearful expression (thin, solid line - familiar model and thin, dashed line - novel model) are displayed.

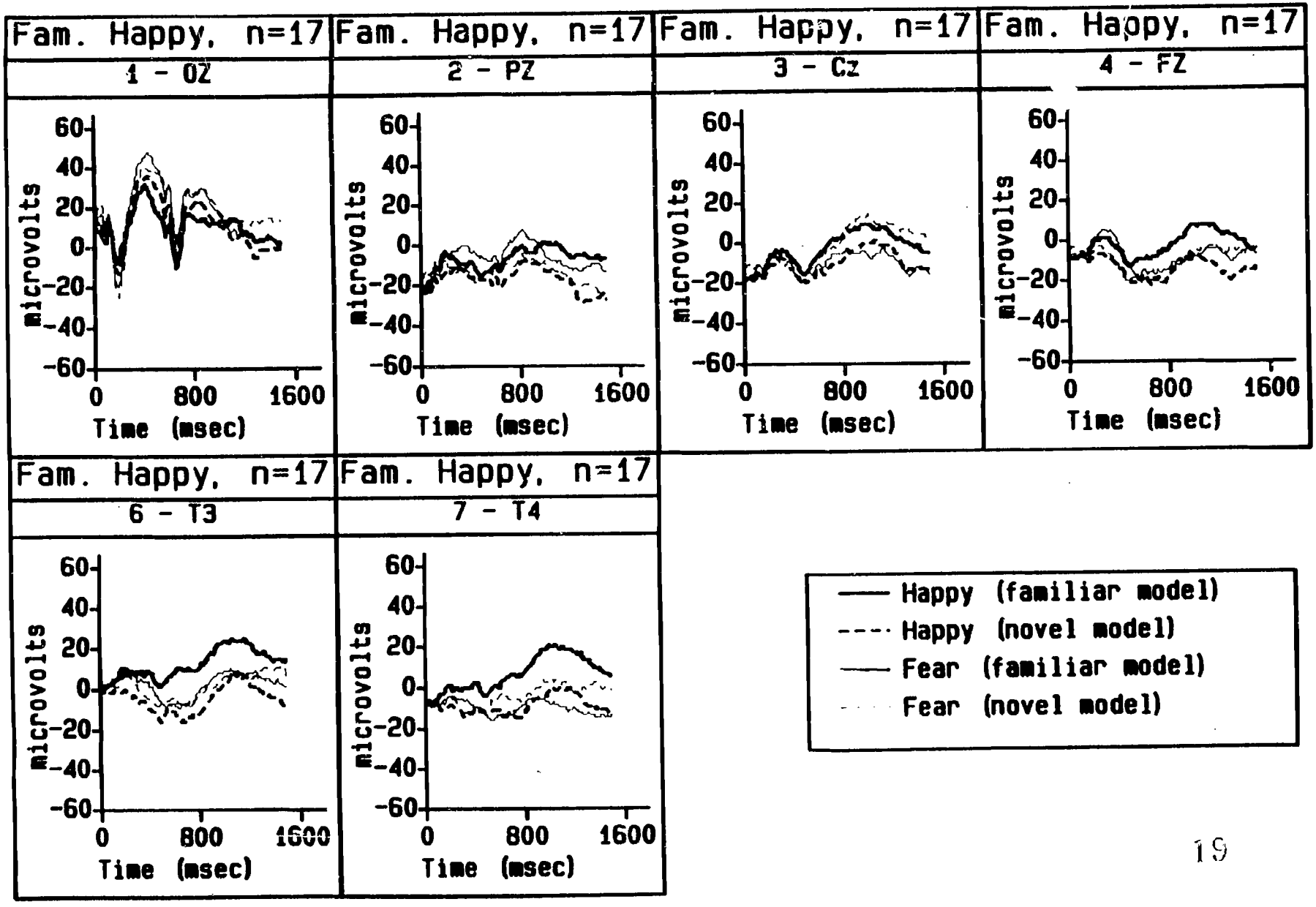
Figure 6 - Grand average data for the discrimination study. The grand average was computed by averaging data across all subjects (n=18). In this condition infants were familiarized to two models posing fear, and then tested on their discrimination of fear vs. happy when posed by both familiar and unfamiliar models. The data derived from infants' responses to the fearful expression (thin, solid line - familiar model and thin, dashed line - novel model) and the happy expression (thick, solid line - familiar model and thick, dashed line - novel model) are displayed.

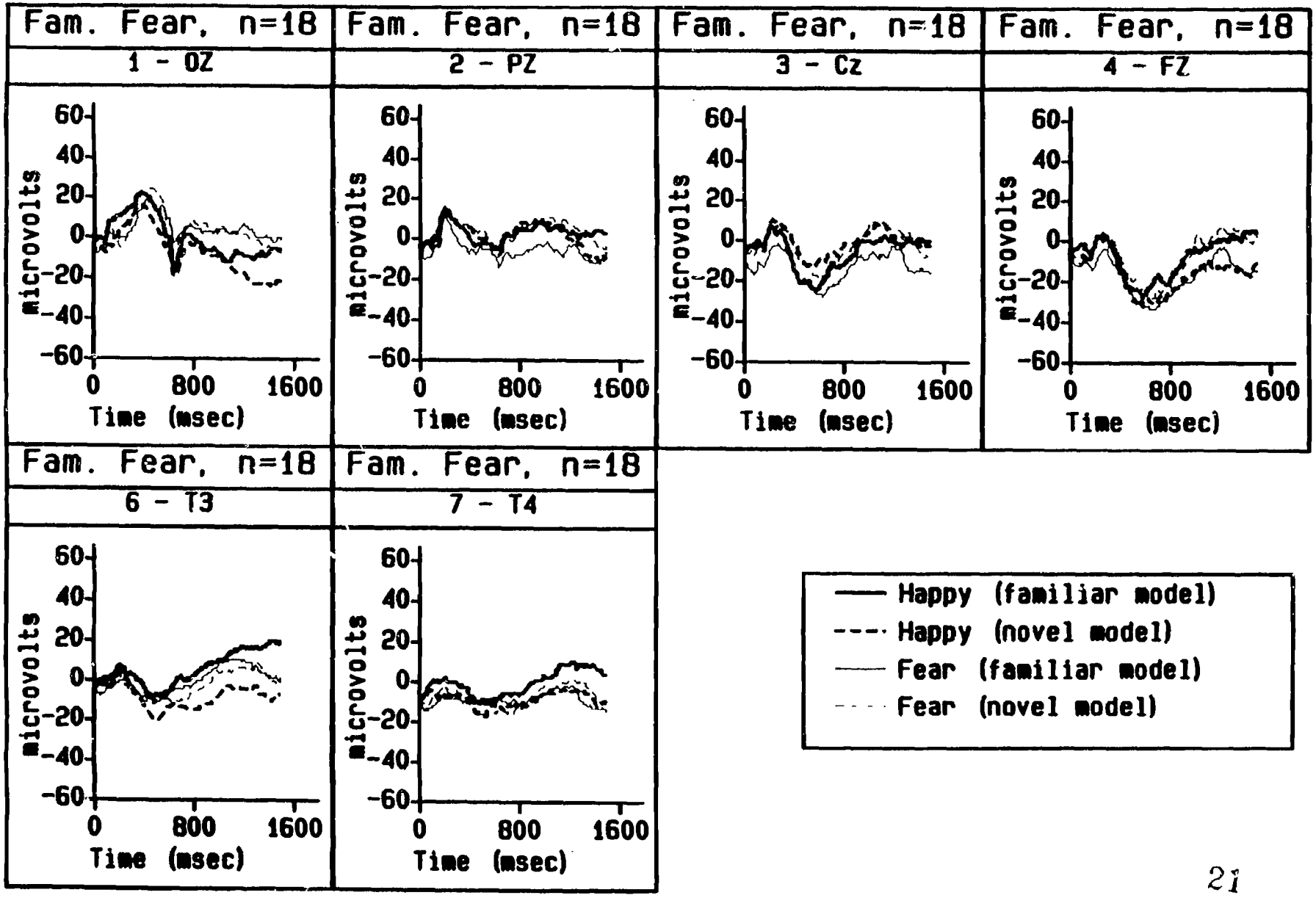

Fac. Pref., n=20
1 - OZ
2 - PZ
3 - Cz
4 - FZ
6-T3
7-T4
microvolts
30
20
10
0
-10
-20
-30
0
800
1600
Time (msec)
Happy Face
Fear Face


O_Z
P_Z
C_Z
F_Z
50
0
-50
0 200 400 600 800 1000 1200 1400 1600 1800
Time (msec)


Fam. Happy, n=17
1 - OZ
2 - PZ
3 - Cz
4 - FZ
6 - T3
7 - T4
microvolts
40
30
20
10
0
-10
-20
-30
-40
0
800
1600
Time (msec)
Fear Faces
Happy Faces


Fam. Fear, n=18
1 - OZ
2 - PZ
3 - Cz
4 - FZ
6 - T3
7 - T4
microvolts
30
20
10
0
-10
-20
-30
0
800
1600
Time (msec)
Fear Faces
Happy Faces


Fam. Happy, n=17
1 - OZ
2 - PZ
3 - Cz
4 - FZ
6 - T3
7 - T4
microvolts
60
40
20
0
-20
-40
-60
0
800
1600
Time (msec)
Happy (familiar model)
Happy (novel model)
Fear (familiar model)
Fear (novel model)


Fam. Fear, n=18
1 - OZ
2 - PZ
3 - Cz
4 - FZ
6 - T3
7 - T4
microvolts
60
40
20
0
-20
-40
-60
0
800
1600
Time (msec)
Happy (familiar model)
Happy (novel model)
Fear (familiar model)
Fear (novel model)