it was reduced below and above this fre-
quency, and at higher frequencies re-
ained at about 20 dB up to the highest
recorded, 3 kHz. The amount of atten-
uation fluctuated, however; conversation at
normal levels outside the animal could often,
but not always, be understood when transmuted from inside. Raised
tones were almost always distinct.

Sounds generated within the ewe her-
self were picked up by the implanted hy-
drophone, amplified, and recorded on
a tape recorder or fed directly to the spec-
trometer analyzer (as the amplifier had two
outputs we were able to listen while ana-
lyzing the sounds). In the most sounds
heard were characteristic and identifi-
able: drinking, eating, swallowing, ra-
mation, and sometimes heavy breathing
could be heard. Ruminations, unex-
pectedly, were rather quiet. A rushing
sound sometimes accompanied move-
ment of the ewe and irregular gargles,probably of digestive origin, occurred
frequently. Periods of quiet were noted
in figure 2. In figure 2 shows mean square
values at peaks taken from spectrum anal-
esis, for different types of internal
sounds. These were of lower frequency,
tailing off above 300 Hz.

Either we heard or attempted to hear
external sounds to be less than in other spe-
cies (4, 6, 7), the loudness peaks and fre-
quencies of internal sounds were less than
to those recorded by others (4, 6, 7).
However, average sound levels were lower
than those previously recorded (4, 6, 7),
especially as we often observed peri-
ods of quiet. In one particular grayorderby
were not able to hear sounds from the maternal cardiovascular system. By holding a hydrophone firmly
against the ewe's skin in the brachial area
we were able to pick up heart

sounds from outside the animal without
being able to hear the reported pulsations
from inside. It is possible, and con-
sistent with spectrum analyses, that
these sounds occur at very low frequen-
cies and, when attenuated, are below
the human threshold for sound.

Our results suggest that sounds avail-
able to the sheep fetus, within its normal
fluid environment, are varied and of
rather low frequency when they are gen-
erated by, or within, the mother. Ex-
ternal sounds are attenuated by about 16
to 37 dB, most attenuation occurring at
frequencies around 1 kHz. In the sheep,
external sounds of above 65 dB at the
body wall should often penetrate to
the uterus.

The existence to which sound signals in-
side the amniotic fluid are heard by the fi-
tus is another question currently being
explored; in precocial mammals, the
auditory system is believed to become functional well before birth, and there is

Of Human Bonding: Newborns Prefer Their Mothers' Voices

Abstract: By sucking on a sonotatic nipple in different ways, a newborn human
could produce either mother's voice or the voice of another female. Infants learned
how to produce the mother's voice and produced it more often than the other voice. The
neonate's preference for the maternal voice suggests that the period shortly after
birth may be important for initiating bonding with the mother.

Human responsiveness to sound begins in the third trimester of life and by
birth reaches sophisticated levels (1, 2), especially with respect to speech (3). Ear-
ly auditory competency probably sub-
erves a variety of developmental fun-
tions such as language acquisition (4, 5)
and mother-infant bonding (6, 7). Mother-infant bonding would best be
served by (and may even require) the
ability of a newborn to discriminate its
mother's voice from that of other fe-
males. However, evidence for differ-
cential sensitivity to or discrimination of
the maternal voice is available only for
other infants for whom the bonding pro-
cess is well advanced (8). Therefore, the
role of maternal voice discrimination in
formation of the mother-infant bond is
unclear. If newborns' sensitivities to

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Fig. 2. Root mean square values at peaks from spectrum analyses for different types of internal
sounds: a, giraffe; d, sheep; c, horse; b, chewing cud; c, rushing noise; w, quiet noise; h, eating noise; o,
drinking noise; m, eating milk.
speech subserves bonding, discrimination of and preference for the maternal voice should be evident near birth. We now report that a newborn infant young-er than 3 days of age can not only dis- criminate its mother’s voice but also will work to produce free voice in preference to the voice of another female. The subjects were ten Caucasian neo-nates (five male and five female) (7). Shortly after delivery we taped-recorded the voices of mothers of infants selected for testing as they read Dr. Seuss’s To Think That I Saw It on Mulberry Street. Recordings were edited to provide 25 minutes of uninterrupted prose, and testing of whether infants would differ- entially produce their mothers’ voices began within 24 hours of recording. Ses-sions began when the infant was to a state of quiet alertness (1). The infant was then placed supine in its bassinet, with the examiner seated on the other end and a non-reflective nipple was placed in its mouth. An assistant held the nipple tightly in place while the examiner was unaware of the experimental condition of the individual infant and could neither hear the tape nor be seen by the infant. The nipple was connected, by way of a pressure trans- ductor, to the solid-state programming and recording equipment. The infants were then allowed 2 minutes to adjust to the situation. Sucking activity was re-
corded during the next 5 minutes, but voices were never presented. This base-line period was used to determine the median interburst interval (IBI) or time elapsing between the end of one burst of sucking and the beginning of the next (9). A burst was defined as a series of indi-
vidual sucks separated by more than 2 seconds by less than 2 seconds. Testing with the voices began after the baseline had been established. For five randomly selected infants, sucking burst terminating IBI’s equal to or greater than the baseline IBI (9) produced only his or her mother’s voice (IBI < 5), and bursts terminating inter-
vals less than the median produced only the voice of another infant’s mother (10). Thus, only one of the voices was pre-
sented. Stroboscopically, with the first suck of a burst and reported on until the burst ended, that is, until 2 seconds elapsed without a suck. For the other five infants, the conditions were re-
versed. Testing lasted 30 minutes. A preference for the maternal voice was indicated if the infant produced it more often than the nonmaternal voice. However, unequal frequencies not in-
dicative of preference for the maternal voice per se could result either because short (or long) IBI’s are less pro-
duced or because the acoustic qualities of a particular voice, such as pitch or in-
tensity, rendered it a more effective form of feedback. The effects of response re-
quirements and voice characteristics were controlled (7) by requiring half the infants to respond after short IBI’s to produce the mother’s voice and half to respond after long ones and (2) by having each maternal voice also serve as the nonmaternal voice for another infant. Preference for the mother’s voice was shown by the increase in the proportion of IBI’s capable of producing her voice; the median IBI’s shifted toward their bot-
tom line values in a direction that produced the maternal voice more than half the time. Eight of the ten medians were shifted in a direction of the maternal value in that the voice was more common (mean = 56 seconds, 0.3 per-
cent increase) (sign test, P = .02), one shifted in the direction that produced the nonmaternal voice more often, and one median did not change from its baseline value (Fig. 3). In these infants were working to gain access to their mother’s voice; reversing the response requirements should result in a reversal of their IBI’s. IBIs were easier to pro-
test two from each condition, who produced their mother’s voice more when in ses-
sion 1 were able to complete a second session 24 hours later, in which the re-
response requirements were reversed (11).

Differential feedback in session 2 began immediately after the 2-minute adjust-
ment period. The criterion time re-
mailed equal to the baseline median of the first session. For all four infants, the median IBI’s shifted toward the new cri-
terion values and away from those which previously produced the maternal voice. The average magnitude of the difference between the medians of the first and re-
versals sessions was 1.93 seconds. Apparently the infant learned to gain access to the mother’s voice. Since spec-
cific temporal properties of sucking were required to produce the maternal voice, we sought evidence for the acquisition of temporally differentiated responding. Temporal discrimination within each condition was ascertained by construct-
1975
controls behavior (15) could provide the means by which limited postnatal experience with the mother results in preference for her voice. The early preference demonstrated here is possible because newborns have auditory competencies adequate for discriminating individual speakers; they are sensitive to rhythm (16), intonation (17), frequency varia-
tion (1, 13), and phonetic components of speech (18). Their general sensory com-
petency may enable other maternal cues, such as her odor (19) and the manner in which she handles her infant (20), to serve as supporting bases for discrimina-
tion and vocal preference. Prenatal (intrauterine) auditory experience may also be a factor. Although the significance and nature of intrauterine auditory experi-
ence in humans is not known, per-
ceptual preferences and proximity-seek-
ing responses of some infant primates are profoundly affected by auditory behavior before birth (21).

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References and Notes

Table 1. Mean and standard deviation (S.D.) of the relative frequency of sucking during a stimulus associated with the maternal voice divided by the relative frequency of sucking during a stimulus associated with the nonmaternal voice. A ratio of 1.0 indicates no preference.

<table>
<thead>
<tr>
<th>Infant group</th>
<th>First third</th>
<th>Last third</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>0.84 ± 0.33</td>
<td>0.73 ± 0.32</td>
</tr>
<tr>
<td>Females</td>
<td>0.81 ± 0.32</td>
<td>0.70 ± 0.31</td>
</tr>
</tbody>
</table>

1. Two infants were not tested a second time, be-
cause we could not gain access to the testing
room, which served as an auxiliary nursery and
as an isolation room. The sessions of two infants
were collapsed because the infants were tested a
second time, but in their first ses-
sion one had shown no preference and the other
had shown only a slight preference for the
non-
maternal voice. Their performances would some-
times produce feedback and sometimes pro-
cede more slowly, and would be terminated in
the middle of a sucking bout. Com-
parable situations were reported by G. A. Capute
et al. (19). Prenatal auditory performances, on the
other hand, were not significantly different.

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