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A Lunar Effect on Fertility

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ABSTRACT: Analysis of 1968 New York City birth records supports folklore that the moon influences human reproduction. Births vary systematically over a period of 29.53 days, the length of the lunar cycle, with peak fertility at third quarter. The effect is small, but is present in four independent time series of births (male, female, black, white) and remains when weekly variation has been removed. A photic explanation is developed which links rhythmic variation in lunar illumination to the timing of ovulation.

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Belief that the moon influences human reproduction is part of the lore of many societies (Eisler, 1968; Harding, 1971). Evidence from some studies has supported these beliefs, typically finding more births around full moon (Menaker and Menaker, 1959; Menaker, 1967; Osley et al., 1973; McDonald, 1966), but others have failed to detect an association (Rippman, 1957; Schnurman, 1949; Abell and Greenspan, 1979). Our analysis provides further evidence that the folklore may be correct.

Individual birth records for 140,000 live births occurring in New York City in 1968 (for more detail on the sample, see Rindfuss et al., 1978) were arranged sequentially by day of occurrence and six time series constructed, one for total births, and one each for five categories of spontaneous births: total, female, male, black, white. Most series are restricted to spontaneous births—those resulting from spontaneous labor—because induced or stimulated labor interferes with the natural timing of childbirth (McDonald, 1966; Abell and Greenspan, 1979). The data are analyzed by Fourier, or spectral, analysis (Brigham, 1974).

A Fourier spectrum was calculated for each time series. The predominant frequencies present in all spectra were 1 cycle/7 days (the weekly cycle), and 1 cycle/3.5 days (the first harmonic of the weekly cycle). Births exhibit a broad flat peak during the week, with a noticeable dropoff on Saturdays and Sundays (see Figure 1). Because the seven-day week does not correspond to known natural cycles, this relation is apparently a cultural one. It is surprising that this pattern remains for spontaneous births; perhaps a disproportionate number of weekday births were induced precisely to avoid a likely weekend birth.

All signals showed small peaks around one cycle per 29.53 days (the lunar period) (Nautical Almanac Office, 1966), but the large amount of random variation in the data produced other spectral peaks of similar strength at various other frequencies. To minimize these effects, cross-amplitude spectra were computed for the two pairs of independent time series: male and female births, and black and white births (see Figure 2).[1]

The results are similar for both pairs of time series. Neglecting the unobservable values at very low frequencies, the three strongest peaks in each spectrum correspond to periods of 7 days, 3.5 days, and 29.53 days (the third period is definitely within five hours of 29.5 days). This find-

[1]The cross-amplitude spectrum is a function of frequency and measures the strength of the sinusoidal components that are common to two signals. Both signals must have a component at a given frequency for it to appear in a cross-spectrum. Cross-spectra tend to reduce the effects of random variations because it is unlikely that random oscillations will appear at the same frequencies in two independent signals.

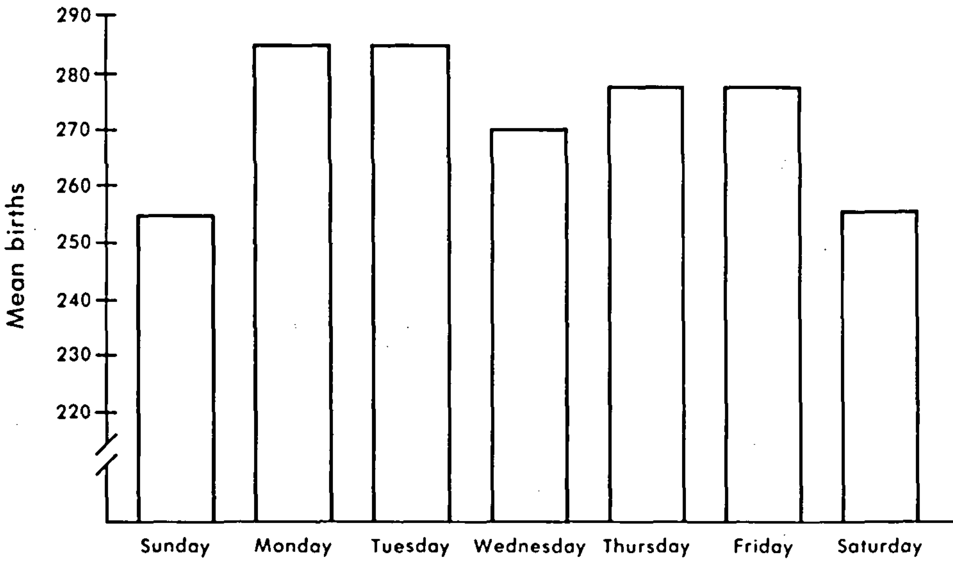

FIG. 1.—Mean spontaneous births by day of week

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ing indicates the existence of a weak cyclic (although not necessarily sinusoidal) pattern the same period as the moon's phases.

Next, another time series was generated: a sine wave at exactly the frequency of the lunar cycle (around 1 cycle/29.53 days). After some preliminary analysis, this sine wave was assigned its maximum value at the time of third quarter[2] (Nautical Almanac Office, 1966). A cross-correlation, a measure of similarity between two time series,[3] was then calculated between this time series and each of the other six time series. Results are presented in Table 1. The cross-correlations for spontaneous births are small—the largest, for total spontaneous births, is 0.19, equivalent to an explained variation of about 4 per cent, but all achieve statistical significance ($p<0.05$).[4] When weekly variations were removed by calculating and subtracting out the average number of births on each day of the week (see Osley et al., 1973) and the cross-correlations again calculated, the magnitude of the correlations increased slightly and statistical significance was maintained. Further, maximum correlations for all time series of spontaneous births showed their largest values at nearly the same time shift, corresponding to maximum births within ± 1 day of third quarter. If the correlations were due to random noise, it is unlikely all would show maximum values at the same

[2]Because the peak births for most time series occurred near the third quarter, for ease of presentation the maximum of the sine wave of the frequency of the lunar cycle was also set at third quarter. The correlation coefficient is not affected by which part of the cycle is designated as the maximum.

[3]The cross-correlation is a measure of how much two signals "look like each other." If two signals are identical, their correlation is 1; if dissimilar, 0. However, two time series can be identical but have a very low mathematical correlation if they are not synchronized, i.e., if the corresponding values of the two signals occur some finite time, T, apart. For example, in Figure 3(a), at $T=0$, the correlation is 1. As T increases, the correlation goes to 0 as the sine waves become 90° out of phase. As T further increases, the correlation goes to nearly -1 as the sine waves become 180° out of phase. When the sine waves become 360° out of phase, they match again and the correlation becomes nearly 1. Successive maxima become smaller because the match between the two finite length signals becomes less complete as they "slide past" each other. The correlation of two signals can be calculated assuming there is some time shift T between them. The cross-correlation function is a measure of how similar two time series appear to be as a function of the assumed time shift, T, used to calculate the correlation.

[4]For greater detail on the procedure used to determine statistical significance, see Blalock, 1979, pp. 419–420.

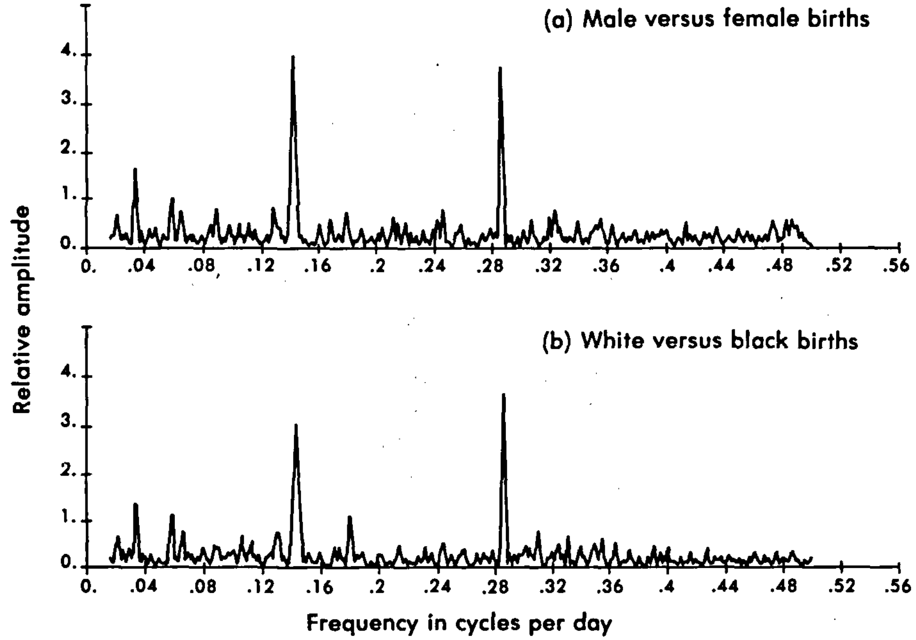

FIG. 2.—Cross-amplitude spectra for two pairs of independent time series

part of the lunar cycle. It is interesting that the correlations for induced births—those that involve the most medical interference in their timing—are smaller, fail to attain statistical significance, and show a much different time shift.

The lunar effect revealed by the cross-correlation results can be seen graphically when the shape of the cross-correlation function for any of the six time series of spontaneous births is compared to the ideal correlation of a sine wave with itself. Figure 3 presents the cross-correlations between total spontaneous births and the sine wave having the lunar period, in panel (*b*), and the cross-correlation between a sine wave equal to the lunar period and itself, in panel (*a*). The two are very similar in shape, indicating the correlation in the data is similar to the ideal cor-

TABLE 1

CORRELATION AND PHASE RELATIONSHIPS OF SIGNALS WITH THE LUNAR CYCLE: RAW DATA AND DATA WITH DAY OF THE WEEK AVERAGES REMOVED

CATEGORIES	RAW DATA		DATA WITH DAY OF WEEK REMOVED	
	Correlation	Maximum*	Correlation	Maximum*
Total births	0.13†	+1 day	0.17†	+1 day
Spontaneous births				
Total	0.19†	+0 day	0.21†	+0 day
Male	0.15†	−1 day	0.16†	−1 day
Female	0.17†	+1 day	0.19†	+1 day
White	0.17†	+0 day	0.19†	+0 day
Black	0.13†	+1 day	0.13†	+1 day
Induced births	0.07	+9 days	0.10	+9 days

*Maxima are expressed as deviations in days from third quarter.
†$p<0.05$.

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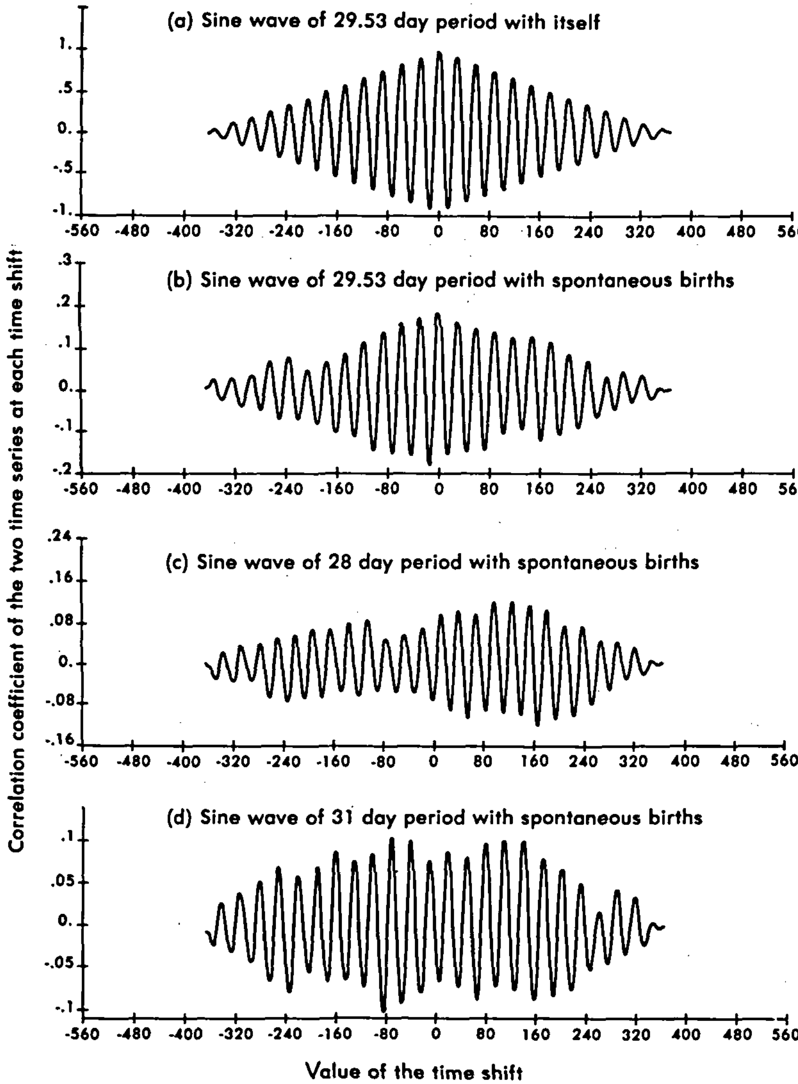

FIG. 3.—Cross-correlations

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relation. By contrast, correlations of the data with sine waves having periods of 28 and 31 days not only exhibit smaller magnitudes, but also more irregular shapes (see Figures 3(c) and 3(*d*)).

In sum, we find a weak, but definite, cyclic component of births that varies at or near the same period as the moon's phases. If the variation is assumed to be sinusoidal, the maximum births due to this effect occur at the time of third quarter. Because the human gestation period is approximately nine lunar cycles in length (Menaker and Menaker, 1959; Vollman, 1977), this finding provides little guidance on when or how the moon operates: at birth, by hastening labor; at conception, by making intercourse more likely or fertilization easier; or earlier, by synchronization of menstrual and lunar cycles, which are on the average about the same length (Vollman, 1977). Recent research

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has suggested support for the last of these linkages. Among the minority of women who have regular menstrual cycles of 29.5±1 days, a disproportionate number begin their menses during the half of the lunar cycle roughly centered on full moon (Cutler, 1980; Friedmann, 1981).

Most speculation on the moon-birth relationship emphasizes the concept of "biological tides," whereby the moon's gravitational pull affects terrestrial organisms, probably through influence on the fluid content of the body (Lieber, 1978). A basic weakness of this explanation is its assumption that gravity is the operant mechanism. The monthly variation in the moon's pull is too weak to expect a significant effect on something as small and distant as a human being.

A photic explanation seems more plausible. Considerable research has linked the importance of sunlight and circadian rhythms of day and night for human growth and functioning (Hollwich, 1979; Lewy et al., 1980), including reproduction. Some of these studies have demonstrated a connection between menstrual regularity and light. Blind women, for example, tend to have more irregular periods than women with normal sight (see Hollwich, 1979, for a review of this research). The results of one study (Dewan et al., 1978) are suggestive that the moon's light may affect fertility by synchronizing menstruation with the lunar cycle. When exposed to artificial light throughout the nights corresponding to menstrual cycle days 14–17, women had more regular periods than when they were exposed to total *all-night* darkness for these same cycle days. The authors speculate that regularity increases because the artificial light stimulates ovulation, an effect the moon may produce naturally. This explanation implies a fertility peak near full moon and, they suggest, offers a basis for the folklore which links romance to the full moon. Their inability to establish the time of ovulation in the light-regulated cycles, however, leaves moot the nature of the relation between light and ovulation. Perhaps it is not light per se that regulates the menses, but the rhythmic variation of light and dark over the entire lunar cycle. Our finding of a fertility peak at third quarter suggests that the period of decreasing illumination immediately after full moon may precipitate ovulation.

This conclusion must remain tentative, given the amount of artificial light in New York. Further investigation is needed of birth records for a place and period without artificial light. Such a task may be difficult, however, for the bureaucracy which permits adequate vital statistics rarely occurs away from the technology which provides street lights.

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