

Corn Consumption, Tryptophan, and Cross-National Homicide Rates

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Countries above the median in corn consumption have significantly higher homicide rates than countries below the median in corn consumption. Research from a variety of sources suggests the hypothesis that populations consuming corn-based diets may have high homicide rates due to a reduction in brain tryptophan and/or serotonin.

Cross-national differences in homicide rates are traditionally attributed to socio-cultural factors, especially cultural values condoning and prescribing violence in response to insult or frustration (Wolfgang and Ferracuti, 1967; Ferracuti and Newman, 1974; Anderson, 1976), and culture-conflict engendered by rapid social change (Clinard and Abbott, 1973). However, the origin of these value differences remains unexplained

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by the first of these hypotheses, and cultural values strongly opposed to violence have been reported in one exceptionally aggressive South American tribe (Bolton, 1973). Furthermore, contrary to the hypothesis of culture conflict, some developing countries have low rates of homicide.

While many factors undoubtedly contribute to these rate differences, such as the availability of firearms (Gillin and Ochberg, 1970), the possible influence of biologic factors has so far received little research attention. Altered glucose metabolism and various forms of brain pathology have been implicated in homicide, but most authors concur that such factors only apply in rare individual cases (Shah and Roth, 1974; Goldstein, 1974; Moyer, 1976; Hellon, 1975). A more general role for biologic factors in criminal violence can be suggested, however, in which dietary factors, amino acids, and brain neurotransmitters are implicated. This preliminary report, linking corn consumption and cross-national homicide rates, provides additional tentative support for such a view.

Tryptophan, Serotonin, and Aggression

There is a convincing body of evidence that the brain neurotransmitter serotonin (5-hydroxytryptamine; 5-HT) inhibits aggressive behavior (Valzelli, 1974; Daruna and Kent, 1976; Sheard and Davis, 1976; Greenberg and Coleman, 1976) and induces sleep (Jouvet, 1973; Koella, 1974). The synthesis and metabolism of 5-HT depends on the availability of the precursor amino acid L-tryptophan (Fernstrom and Wurtman, 1971; Fernstrom, 1977), with the transport of tryptophan into the brain being regulated by a ratio of free plasma tryptophan to neutral amino acids (Fernstrom and Wurtman, 1972). The inhibitory and soporific effects of tryptophan on behavior appear to be similar to, and to be mediated by, changes in brain 5-HT (e.g., Hartmann, 1977; Taylor, 1976; Smith et al., 1976; Marsden and Curzon, 1976; Geyer et al., 1976). Tryptophan is obtained exclusively from the diet; diets containing low amounts of this amino acid have been shown to lead to a depression of brain 5-HT and to behavioral responses known to be closely associated with aggression. Corn contains low amounts of tryptophan, and rats fed corn-based (tryptophan-deficient) diets have significantly lower brain 5-HT levels than control animals fed diets containing normal amounts of tryptophan (Fernstrom and Lytle, 1976). Rats fed the tryptophan-deficient diet (0.03 percent tryptophan per gram) also show an increased sensitivity to electric shock (Lytle et al., 1975; Messing et al., 1976), which is known to be associated with aggressive behavior and to be partially under serotonergic control (Harvey et al., 1976). These biochemical and behavioral effects can be reversed by injections or dietary supplements of tryptophan (Fernstrom and Hirsch, 1975; Hirsch and Fernstrom, 1976).

Hypothesis

These observations suggest that human populations consuming corn-based diets may have reduced brain tryptophan and/or 5-HT levels and may be prone to aggressive behavior, as evidenced by comparatively high rates of homicide. Corn-based diets are consumed in many Latin American

countries, and these countries are known to have exceptionally high homicide rates compared to most European, African, and Asian countries (Wolfgang and Ferracuti, 1967; Ferracuti and Newman, 1974; Clinard and Abbott, 1973; Anderson, 1976). Considering that homicides in developing countries, particularly in rural areas, are frequently underreported, the difference in homicide rates between Latin American and European countries (in which homicide statistics are more accurate) is likely to be even greater (Clinard and Abbott, 1973).

Several observations implicate tryptophan and its metabolism in criminal aggression. Many maize-eating populations have historically been prone to the deficiency disease pellagra (Roe, 1973; Goldsmith, 1975; Gopalan and Rao, 1975). Research on pellagra indicates: reduced plasma tryptophan levels (Trusswell et al., 1968), reduced 5-HT concentrations in platelets, reduced urinary excretion of 5-HIAA, and reduced 5-HIAA concentrations in cerebrospinal fluid (Raghuram and Krishnaswamy, 1975), suggesting decreased brain 5-HT activity in this disease. Furthermore, there are numerous reports of increased irritability, antisocial behavior, mania, and aggressiveness among the symptoms of both clinical and subclinical pellagra (Green, 1973; Roe, pp. 5, 38, 143, 145, 153, 1973; Goldsmith, pp. 583, 586, 1975; Gopalan and Rae, p. 506, 1975; Hoffer, pp. 204, 217, 220-221, 1973). At least two authors have noted a relationship between pellagra and violent crime (Wood, 1912; Hoffer, 1973). In one report of 1,150 persons accused of a crime and subjected to a medical examination, 206 (18 percent) suffered from pellagra. Of these, 118 (57 percent) were involved in crimes of violence, including 56 cases of murder or manslaughter. Over one-third of all the murderers diagnosed as insane had pellagra (Hoffer, 1973).

It has been suggested (Hoffer, 1973) that even the poorest North American diet contains about twice the Recommended Daily Allowance (RDA, 500 mg/day) of tryptophan (Food and Nutrition Board, 1968), a fact which, if true, would seriously weaken the hypothesis that tryptophan deficiency ac-

counts for some of the variation in homicide rates. However, although 500 mg/day may be sufficient to prevent pellagra, it could well be too low with regard to "psychic balance," since it has been found that normal subjects consuming twice the RDA of tryptophan over a one-year period "improved psychologically," whereas no such change occurred in another group in which the intake of tryptophan was not increased (Cheraskin et al., 1972). Moreover, although the requirement for tryptophan is low compared with other essential amino acids, it is possible that chronic ingestion of a marginally deficient diet could have untoward effects, in spite of the absence of any classical symptoms of deficiency disease, manifested as subtle disturbances of body, mind, and behavior. In fact, it has been suggested that subclinical pellagra associated with aggressive tendencies could be widespread in North America among disadvantaged groups consuming high-carbohydrate and low-protein diets (Green, 1973). About 10 percent of all patients attending the medical clinic of a large Indian community in Saskatchewan, Canada, were found to have subclinical pellagra, the symptoms of which included increased irritability and aggressiveness. Both perceptual and behavioral disturbances responded rapidly to dietary supplements of vitamin B3 (Green, 1973).

As a preliminary test of the hypothesis linking corn consumption and homicide, annual homicide rates were calculated from data published in the **United Nations Demographic Yearbook** (1972), and mean per capita corn intake was calculated from the USDA's **Foreign Agriculture Circular: Grains** (U.S. Dept. of Agriculture, 1976). Measurements were available for 53 countries, utilizing the most recent published figures for each country. Corn consumption per capita was determined by subtracting the published figures for animal feed consumption from the total (animal and human) consumption, multiplying by 39.4 to convert metric tons to bushels, and then dividing the quotient by the total population. Population figures (see **United Nations Demographic Yearbook**, 1972)

usually lagged a year or two behind the homicide figures. In some cases this discrepancy was reversed, and occasionally more pronounced.

It was found that of these 53 countries, those above the median in corn consumption (Md = 1.30 bushels per capita) had significantly higher mean homicide rates (10.69 per 100,000 population) than countries below the median in corn consumption (4.31 per 100,000 population), by t test ($t = 2.168$, d.f. = 51, $p = .0348$).

Conclusion

Although this very preliminary finding provides modest support for the hypothesis linking corn intake and homicide rates, it does not of course establish that the two variables are causally related via a dietary deficiency in tryptophan. A complete dietary analysis is therefore indicated, controlling for numerous factors, including total caloric intake, given that periods of famine and general protein-carbohydrate malnutrition have historically been associated with dramatic increases in criminality (Sorokin, 1975). In this way it will be possible to determine the relationship between violent crime and the intake of tryptophan *per se*. The present finding does, however, provide a starting point for dietary-cum-physiological theories of homicidal behavior and a possible means of explaining data that are not satisfactorily explained by socio-cultural factors alone.

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