other end of the molecule. The bioassays (Table 1) revealed that compound **2** had no juvenile hormone activity even when tested in high concentrations.

We next investigated JH analogs containing an aromatic ring. As a model compound we selected the geranyl ether of *p*-hydroxybenzoic acid (Table 1, compound **3**) (*4*). As the peptidic counterpart, we prepared the ethyl ester of L-isoleucyl-L-alanyl-*p*-aminobenzoic acid (compound **4**). Though this substance shows an overall similarity with **3**, especially with respect to the general size of the molecule and the locations of the alkyl substituents, some of the methylene groups of compound **3** are replaced by =CO and —NH— groups. Isoprenoid juvenile hormone analogs are already known in which methylene groups are replaced by both =CO (*5*) and —NH— (*6*) groups.

In contrast with **2**, compound **4** exhibits substantial juvenile hormone activity for pyrrhocorid bugs when dissolved in olive oil and injected or when dissolved in acetone and topically applied on the body surface of freshly molted final (5th) instar larvae. Doses of 0.5 μg in topical applications cause the appearance of half-larval adultoids. This activity for the Pyrrhocoridae is similar to that found for the model terpenoid compound **3**. It is somewhat more active than juvabione and much more active than methyl farnesoate, farnesol, and many other terpenic JH analogs. Like the juvabione-type compounds, the peptidic ester **4** shows a high degree of specificity and appears to be inactive for the pentatomid bugs or for the Coleopteran *Tenebrio*. As far as we know it is the first peptide with JH activity.

The JH activity of some terpenic compounds can be enhanced by introduction of one or more chlorine atoms (*7*). We therefore exchanged the amino group of isoleucine in **4** for the chlorine atom (by chlorinating deamination) (*8*) to obtain the ethyl ester of 2-chloro-3-methyl-valeryl-L-alanyl-*p*-aminobenzoic acid (compound **5**). This substance showed approximately the same activity as the original tripeptide ester **4**. Consequently, no potentiation of the hormonal activity was realized by the introduction of the chloride atom.

Replacement of the ester group in aromatic juvenile hormone analogs by the methylenedioxy group often causes a shift in species specificity. Such compounds are generally more active on pupae of Coleoptera and less active on Hemiptera. As an example of this type of compound we selected the 3,4-methylenedioxyphenylether of geraniol (**6**) (*4*). We prepared an analogous compound to our tripeptide ester **4** with 3,4-methylenedioxyaniline instead of the ester of *p*-aminobenzoic acid. This isoleucyl-alanyl-methylenedioxyaniline (**7**) showed decreased activity for the hemipterans and low but definite juvenile activity for *Tenebrio* pupae.

Our results document a pharmacobiological similarity between determined isoprenoid and peptide compounds with respect to JH activity. The data suggest that the relations between structure and activity may in principle be similar in both peptidic and isoprenoid JH analogs.

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8. The substance **2** was obtained as a crystalline solid [melting point 121 to 122°C; $[\alpha]_D^{25}$, 45.5° (2 percent in methanol)] by means of dicyclohexylcarbidiimide condensation of 5-ethoxycarbonyl-4-methyl-4-pentenoic acid (mixture of *cis-trans* isomers) with methyl ester of L-valyl-L-alanine. Compound **4** was obtained in crystalline form [melting point, 161 to 162°C; $[\alpha]_D^{25}$, 69.2° (2 percent in methanol)]. The tripeptide ester **4** and the dipeptide derivative **7** were prepared by a stepwise approach starting from *p*-aminobenzoic acid ethyl ester or from 3,4-methylenedioxyaniline, respectively. The compound **4** was synthesized from benzyloxycarbonylamino acids as intermediates. The protecting group was removed by treatment with HBr and acetic acid. Nitrophenylsulphenylamino acids were used for the synthesis of **7**, and the protecting group was removed by treatment with HCl and methanol. Dicyclohexylcarbodiimide served as condensing agent in both cases. Compound **7** formed an oily material (mass spectrum peaks at 321,290,262,238,208,182,157, 137,100,88, and 44). The chloroderivative **5**, obtained by the action of $NaNO_2$ in HCl, was noncrystalline material (mass spectrum peaks at 368,350,332,323,287,263,221,204,192,176,168, 165,120, and 97). All the crystalline compounds gave correct elemental analysis data.

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Mueller-Lyer Illusion: Effect of Age, Lightness Contrast, and Hue

Abstract. *Mueller-Lyer figures produced by lightness contrast (white on black) and by hue contrast in the absence of lightness contrast (red, yellow, green, or blue on gray) were presented to subjects aged nine to adult. Contrary to Piagetian expectations, the illusion magnitudes resulting from the colored figures did not decline with age.*

Piaget (*1*) has argued that the well-known diminution of the Mueller-Lyer illusion with age (*2*) and with repeated trials (*3*) is due to an increase in perceptual activity which involves decentration, or comparative looks at various parts of the figure. I proposed (*2*) that the decline in the magnitude of the illusion, at least under conditions of fixation using a small figure exposed tachistoscopically, is due to the decline in sensitivity to contours which are produced by brightness or lightness contrast (*2*).

The research reported here shows that there is no decline in magnitude of the illusion as a function of age when the Mueller-Lyer figure is produced by hue contrast. The Piagetian explanation, therefore, is not a necessary one, although it may be sufficient under certain conditions.

Piaget says, "If our schema is correct, an optico-geometric illusion has to do with unequal densities of encounters on the elements of the figure, and thereby with their incomplete couplings. It follows that compensations which lead to a diminution of errors must consist in an equalisation of the density of encounters and in the completion of couplings: and it is precisely in such a situation that we may expect to find repeated explorations and improvements with practice" (*1*, p. 147). He also says, ". . . the absolute value (of the illusion) itself depends on the relative completeness of the couplings, so it is understandable that these 'primary' errors diminish with age.

This follows because, with increasing age, there is increasing visual exploratory activity and a consequent rise in the number of couplings" (*4*, p. 138).

Eysenck and Slater (*5*), Day (*3*), and Pollack and Chaplin (*6*) have shown that repeated or prolonged presentations of a Mueller-Lyer figure subtending a small visual angle under fixation conditions do not result in the illusion's diminution, indicating the failure of repeated simultaneous comparisons of, or encounters with, parts of the Mueller-Lyer figure to produce diminution (*7*). However, I (*2*) demonstrated such a diminution with age, using small figures fixated under tachistoscopic (100 msec) conditions. This last finding is correlated (r, −.49; $P < .01$) with a corresponding rise with age in the threshold for detection of a contour produced by an intensity difference. These data are in accord with the finding by Wicklegren (*8*) that the magnitude of the illusion is increased by increasing the brightness contrast of the oblique parts of the Mueller-Lyer figure relative to the ground. Such results suggest an explanation alternative to that of Piaget, namely, that changes in illusion magnitude with age may be due to changes in sensitivity to the contour processes which may produce the illusion in the first place (*9*).

The data cited above provided the background needed to test the necessity of Piaget's (*1*) cognitive explanation for the diminution of a primary illusion, such as the Mueller-Lyer, with increasing age. If Piaget's explanation is a necessary one, the magnitude of the illusion when the Mueller-Lyer figure is produced by hue contrast in the absence of lightness contrast should also decrease with age. My (*10*) account of ontogenetic changes in primary, or type I, illusions, however, would lead to a contrary expectation, namely, that an illusion figure produced by lightness contrast would result in a diminution of the magnitude of illusion with age, but an illusion produced by hue contrast alone would not.

Middle and lower class white public school children ranging in age from 9 to 14, 20 from each of grades 3 through 8, were employed as subjects. Subjects were represented equally by sex; none showed any color defect as measured by the AO Pseudoisochromatic plates, and all had binocular acuity of at least 20/25 as measured by the Master Orthorator. An additional sample of 10 male and 10 female university students ranging in age from 18 to 25 was chosen to provide an adult sample.

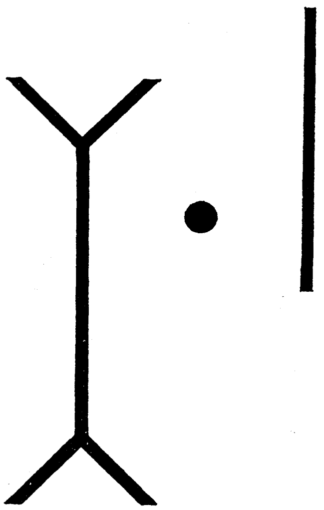

Fig. 1. Version of the Mueller-Lyer figure used in the experiment. The length of line between the forks is almost always overestimated.

The stimulus figures were the open or overestimated component of the Mueller-Lyer figure, and straight unbounded comparison lines (Fig. 1). All lines were 1 mm thick. The oblique inducing lines were 5 mm long and the standard line between the obliques was 22 mm. The comparison lines varied in 0.5-mm steps from 20 mm to 29 mm. Both figures were vertical and placed symmetrically, one 5 mm to the left and one 5 mm to the right, with respect to a central fixation point on a 35 mm² field. The dimensions of the display were 1°54′ by 1°54′ (visual angles), and maximum figure length was 1°7′ in the vertical dimension. The figures were constructed of Munsell papers. Five series of figures were used: 5R5/6 (red), 5Y5/6 (yellow), 5G5/6 (green), and 5B5/6 (blue) on N5/gray, and N9.5/white on N2/black. Thus all of the spectral hues differed from their grounds in saturation only. The figures were presented tachistoscopically for 1500 msec each at a viewing distance of 1500 mm in illuminant C. The intensity of illumination at the eyepiece was 1.14 apparent ft ca (12.54 lu/m²). The order of presentation of the hues was randomized across subjects, and left or right location of the standard was counterbalanced. A converging method of limits was used. Six trials were used for each hue.

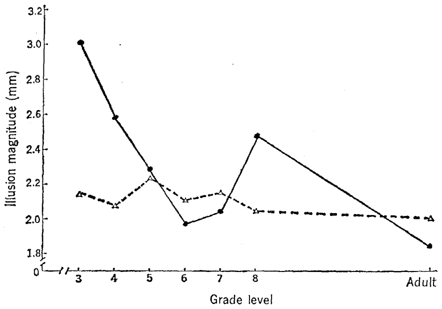

Fig. 2. Magnitude of Mueller-Lyer illusion (mm) as a function of school grade level. The solid line represents age changes for the white Mueller-Lyer figure on a black ground. The dashed line represents age changes for the red, yellow, green, and blue Mueller-Lyer figure on gray grounds of equivalent lightness averaged together.

The data for the figures produced by hue contrast alone were examined across ages first by means of analysis of variance. No main effect of age was obtained, but there was a significant main effect of hue (F = 17.92, d.f. = 15,342). The Newman-Keuls test (*11*) showed that the red figure produced by far the largest illusion; the blue and yellow figures did not differ from one another, but the green figure produced an illusion significantly smaller than that of all the others. Because there was no age by hue interaction, the scores across hues were averaged for each subject, and compared with those obtained for the white figure on the black ground. A similar analysis of variance yielded no significant main effect of age, and a significant effect for contrast type, which is of little interest in itself. More importantly, there was a significant age by type of contrast interaction (F = 2.61; d.f. = 6, 133; $P < .05$) (see Fig. 2). Separate analysis of the effect of the white figure alone across age showed a significant decline (F = 2.78; d.f. = 6, 133; $P < .05$). A trend test indicated that only the linear component of the function was significant (F = 9.36, $P < .01$).

The unavoidable conclusion which emerges is that there is no uniform ontogenetic trend, independent of contrast type, for the magnitude of the Mueller-Lyer illusion under conditions of foveal fixation and tachistoscopic presentation. Piaget's cognitive explanation simply does not account for the data. An explanation in terms of differential sensitivity to lightness contrast and hue contrast (*2*, *12*, *10*) remains tenable (*13*). It would seem that, at best, the Piagetian explanation would require prolonged viewing conditions of free head and eye movement, probably with large figures. This set of conditions perforce confounds sensory factors with those of scanning, attention, and temporal integration of sensory inputs.

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7. Even though encounters and couplings mediated by eye movements might be minimized by using small, fixated figures exposed briefly, as I have done, Piaget (*1*) argues that such mediation may take place through attention shifts as well.
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9. In later research [R. H. Pollack, *Psychon. Sci.* **3**, 351 (1965)] I found that the threshold for the detection of a hue as distinct from gray did not vary significantly with age, although there were hue differences. Later, Skoff and Pollack [E. Skoff and R. H. Pollack, *Percept. Psychophys.* **6** (4), 244 (1969)] showed that visual acuity as measured by minimal bar separation did not change between ages 6 and 14 when the bars were red or blue on gray backgrounds of equal lightness. Finally, Pollack [R. H. Pollack, *Proc. Amer. Psychol. Ass.* **1970**, 53 (1970)] used Mueller-Lyer figures in four hues on equal lightness backgrounds, as well as in white on black. There was an illusion in adults in all cases, although there were significant hue differences: red, blue, white on black, yellow, and green, in descending order of magnitude.
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14. I thank Mr. Ronald Howard, principal of Arbor View School, District 89, Illinois, Mr. Lloyd Cash, principal of Lanier School, Hall County, Georgia, and their staffs for their cooperation in providing subjects for this experiment. Supported by grant HD 4348 from the National Institute of Child Health and Human Development.

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Body Temperature: Possible Ionic Mechanism in the Hypothalamus Controlling the Set Point

Abstract. *The body temperature of many mammals is set at or around 37°C. The mechanism for this set point appears to depend on a constant and inherent balance between sodium and calcium ions within the posterior hypothalamus. When this region is perfused in unanesthetized cats, an extracellular excess or a normal physiological concentration of sodium ions evokes a rise in body temperature if calcium is not in the perfusate. At the same site, an excess or normal concentration of calcium ions causes the temperature to fall when sodium is absent.*

According to the monoamine theory of thermoregulation (*1*), serotonin (5-HT) and norepinephrine (NE) are released possibly as transmitters from the anterior hypothalamus in functional opposition to one another in order to control the temperature of an animal around a given set point (*2*). Acting within the same hypothalamic site, one amine activates the heat-production pathway when the animal is cold, and the other stimulates the heat-loss pathway when the animal is warm (*3*). However, the theory does not account for the mechanism in the central nervous system whereby temperature is intrinsically set and maintained in most mammals at a constant level of 37°C or thereabouts.

Recently, it was found that a solution of isotonic NaCl caused shivering and a rise in temperature when it was perfused through the cerebral ventricles of a conscious cat (*4*). By adding calcium in a normal physiological concentration to the NaCl solution, this hyperthermic response was blocked. As a result of these findings, it was suggested that the calcium level in the hypothalamus may be the physiological basis of the set point.

We now propose that the set point for body temperature is localized within the posterior hypothalamus and is determined and maintained by the inherent ratio in the concentrations of two essential cations, Na^+ and Ca^{2+}. This concept is based on experiments in which the balance between Na^+ and Ca^{2+} levels was selectively altered within specific regions of the hypothalamus.

In each of ten cats, four guide tubes were implanted stereotaxically with the use of aseptic precautions and procedures described earlier (*5*). The tip of each tube rested at a locus above the rostral or caudal parts of the hypothalamus—those regions classically implicated in thermoregulation (*6*). A polystyrene pedestal was affixed to the skull and capped so that a sterile preparation could be maintained throughout the experiments. Postoperatively, body temperature was monitored by a thermistor probe inserted to a depth of 10 cm into the colon, and the temperature of the animal was plotted continuously before, during, and after each perfusion.

To alter the ionic concentrations within the anterior or posterior hypothalamus, a double-walled concentric "push-pull" cannula (*5*) was lowered through each guide tube. The tip of the inner "push" cannula extended 1 mm beyond the end of the outer "pull" cannula, so that a sphere of tissue only 1 mm in diameter was perfused. Since inflow and outflow rates were identical, the perfusion fluid was drawn off at precisely the same rate as it was pumped in (*7*). Bilateral hypothalamic sites were perfused simultaneously at a rate of 50 μl/min for 20 to 30 minutes; the temperature of the perfusate at the cannula tip was the same as the cat's brain temperature (*8*).

When a solution containing normal physiological concentrations (*9*) of both Na^+ and Ca^{2+} (143 m*M* Na^+ and 2.6 m*M* Ca^{2+}) was perfused at sites in the posterior hypothalamus, the temperature of the cat remained unchanged. However, if a calcium-free solution containing a normal or an excess amount of Na^+ (at a concentration 13.6 m*M* to 34.0 m*M* greater than the physiological concentration) was perfused at the same site, the animal began to shiver almost immediately and its temperature rose sharply. This hyperthermic response is shown in Fig. 1 (top). Accompanying the rise in temperature were other changes associated with heat production, including vasoconstriction and piloerection. On the other hand, if the Na^+ was omitted from the perfusate and a solution containing normal or an excess in Ca^{2+} ions (at a concentration 2.6 m*M* to 13.0 m*M* greater than the physiological concentration) was perfused at the same site in the posterior hypothalamus, the temperature of the cat fell sharply. During this Ca^{2+}-evoked decline in temperature, which is illustrated in Fig. 1 (center), vasodilation, slight sedation, and a decline in respiratory rate also occurred. Data in Table 1 illustrate the average changes in temperature from the baseline level, following the localized perfusion of Na^+, Ca^{2+}, and other ions within the posterior hypothalamus.

To control for the factors of both tonicity and the action of other cations, several other solutions were used for the "push-pull" perfusions of the posterior hypothalamus. A normal Krebs solution (314 m*M*) (see Fig. 1, bot-