foil for that particular pattern. Adult observers who rated the relative perceptual difference between the target and foil used in the experiments found the difference between target and foil in experiment 3 to be less than for the stimuli used in experiments 1 and 2. Taken together, the results of all experiments indicate that sensitivity to biological motion patterns becomes manifest in infants between the ages of 4 and 6 months. The comparability of the target and foil patterns used in experiments 2 and 3 suggest that the critical difference mediating this sensitivity is the presence or absence of the complex motion pattern that defines uniquely biological motion. The critical dimensions of stimulation that define such motion are not yet known, yet the results of experiments 2 and 3 suggest that sensitivity to it is not confined to a specific pattern.

These data force us to conclude that young infants are sensitive to biological motion. This supports the hypothesis that the mechanism responsible for such sensitivity is largely intrinsic rather than acquired slowly through experience. Yet it is not obvious why the youngest infants did not exhibit this sensitivity. Perhaps a postnatal period of growth is required before such a mechanism becomes functional. A similar growth period has been proposed as a requisite for the emergence of stereoscopic depth termination (*9*).

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References and Notes

1. J. E. Cutting, *Perception* **7**, 393 (1978); ———, D. R. Proffitt, L. J. Kozlowski, *J. Exp. Psychol: Human Percept. Perform.* **4**, 357 (1978); G. Johansson, *Percept. Psychophys.* **14**, 201 (1973).
2. G. Johansson, *Handbook of Sensory Physiology*, vol. 8, *Perception*, M. Jacobson, Ed. (Springer-Verlag, Berlin, 1978), pp. 675–711; *Sci. Am.* **232**, 76 (June 1975); in *Stability and Constancy in Visual Perception*, W. Epstein, Ed. (Wiley, New York, 1977); ———, G. von Hofsten, G. Jansson, *Annu. Rev. Psychol.* **31**, 27 (1980).
3. D. Y. Teller, *Infant Behav. Dev.* **2**, 135 (1979). The forced-choice preferential looking method incorporates the same logic and methodology as the two-alternative forced-choice method used in contemporary psychophysical research. A statistically significant departure from chance (50 percent) implies both discrimination between the stimulus pair and a preference for one stimulus over its partner.
4. The number of infants with fewer than ten trials because of sleepiness, fussiness, or equipment failure were: experiment 1, one from each age group; experiment 2, one from each age group; experiment 3, one 2-month-old and two 6-month-olds.
5. Experiment 1: 2 months, $N = 10$, range 68 to 79 days; 4 months, $N = 10$, range 111 to 130 days; 6 months, $N = 10$, range 164 to 190 days. Experiment 2: 4 months, $N = 10$, range 125 to 136 days; 6 months, $N = 10$, range 187 to 192 days. Experiment 3: 2 months, $N = 10$, range 63 to 70 days; 4 months, $N = 10$, range 122 to 132 days; 6 months, $N = 8$, range 190 to 210 days.
6. The target pattern was produced by video-recording a darkly garbed human running in place. Dots made of highly reflective tape were attached to limbs and torso. The foil pattern was produced by video-recording the motions of dots clustered in approximately the same area encompassed by the human runner. To facilitate clustering, each dot was attached to the end of a long wand; to provide motion the wands were moved manually by assistants, in apparently random directions. The background luminance of both video monitors was 25 cd/m^2; dot luminance was 51.3 cd/m^2; contrast (maximum − minimum/maximum + minimum) was 36 percent. Dot size in experiments 1 and 2 was 3.82° visual angle; in experiment 3 it was 1.15° visual angle.
7. V. Dobson and D. Y. Teller, *Vision Res.* **18**, 1469 (1978).
8. J. E. Cutting, *J. Exp. Psychol: Human Percept. Perform.* **7**, 71 (1981).
9. R. Fox, R. N. Aslin, S. L. Shea, S. T. Dumais, *Science* **207**, 323 (1980). For a review of investigations of stereopsis in infants see R. Fox [in *The Development of Perception: Psychobiological Perspectives*, R. N. Aslin, J. R. Albert, M. R. Petersen, Eds. (Academic Press, New York, 1981), vol. 2, pp. 335–381].
10. We thank J. Lappin and M. Powers for their comments on our manuscript, and E. Francis, K. Kymbal, A. Menendez, and R. Patterson for assistance in testing infants. Supported by National Institutes of Health grant EY00590 to R.F.

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(+)-Amphetamine Binding to Rat Hypothalamus: Relation to Anorexic Potency of Phenylethylamines

Abstract. *Saturable and stereospecific binding sites for (+)-[^{3}H]amphetamine were demonstrated in membrane preparations from rat brain. The density of these binding sites varies among brain regions and is highest in the hypothalamus and brainstem. Specific (+)-[^{3}H]amphetamine binding in hypothalamus is largely confined to synaptosomal membranes, rapidly reversible, and sensitive to both heat and proteolytic enzymes. Scatchard analysis of the equilibrium binding data revealed two distinct sites with apparent affinity constants of 93 and 300 nanomoles per liter, respectively. The effects of various psychotropic drugs as well as a number of putative neurotransmitters and related agonists and antagonists in displacing specific (+)-[^{3}H]amphetamine binding demonstrate that these binding sites are not associated with any previously described neurotransmitter or drug receptors, but are specific for amphetamine and related phenylethylamine derivatives. Furthermore, the relative affinities of a series of phenylethylamine derivates for (+)-[^{3}H]amphetamine binding sites in hypothalamic membranes is highly correlated to their potencies as anorexic agents. These results suggest the presence of specific receptor sites in hypothalamus that mediate the anorexic activity of amphetamine and related drugs.*

Amphetamine and related phenylethylamine derivatives have psychostimulant, hyperthermic, vasoconstrictor, and anorexic properties (*1*). Although biochemical studies have revealed potent effects of amphetamine on the neuronal release (*2*), reuptake (*3*), and metabolism (*4*) of biogenic amines, it is unclear which of these effects, if any, is responsible for the multiple pharmacologic actions of this class of drugs.

The use of radiolabeled psychotropic drugs of high specific activity has proven valuable in delineating the membrane (neuronal) sites of action for such drugs as opiate alkaloids (*5*) and benzodiazepines (*6*). We have examined the binding of (+)-[^{3}H]amphetamine to membrane preparations from rat brain. We now report the presence of stereospecific and saturable binding sites for (+)-[^{3}H]amphetamine that are located mainly in synaptosomal membranes, sensitive to heat and proteolytic enzymes, and regionally distributed within the central nervous system. The affinities in vitro of a series of phenylethylamine derivatives for (+)-[^{3}H]amphetamine binding sites in hypothalamic membranes were compared with their behavioral potencies as anorexic agents. The results suggest that these sites may be pharmacologic receptors mediating the anorexic action of these compounds.

Male Sprague-Dawley rats (100 to 150 g) (Taconic Farms, Germantown, New York) were killed and their brains were quickly removed and dissected on ice. In each experiment, hypothalami (*7*) from 8 to 12 animals were pooled and disrupted in 40 volumes (weight to volume) of ice-cold buffer (50 m*M* tris-HCl, containing 500 m*M* NaCl and 5 m*M* KCl, *p*H 7.4), with a Brinkman Polytron (setting 5 for 20 seconds). The homogenate was centrifuged at 30,000*g* for 10 minutes, and the resulting pellet was suspended in an equal volume of buffer. The binding of (+)-[^{3}H]amphetamine sulfate (specific activity, 15.7 Ci/nmole; New England Nuclear) was carried out on ice (0° to 4°C) for 20 minutes. A standard incubation contained 200 μl of membrane preparation, 50 μl of (+)-[^{3}H]amphetamine (5 to 500 n*M*) and 50 μl of buffer or drug. After incubation, the samples were quickly diluted with 5 ml of assay buffer and filtered through glass fiber filters (Whatman GF/B). Filters were washed three times with 5 ml of ice-cold buffer and air-dried; the radioactivity retained by the filters was measured in a liquid

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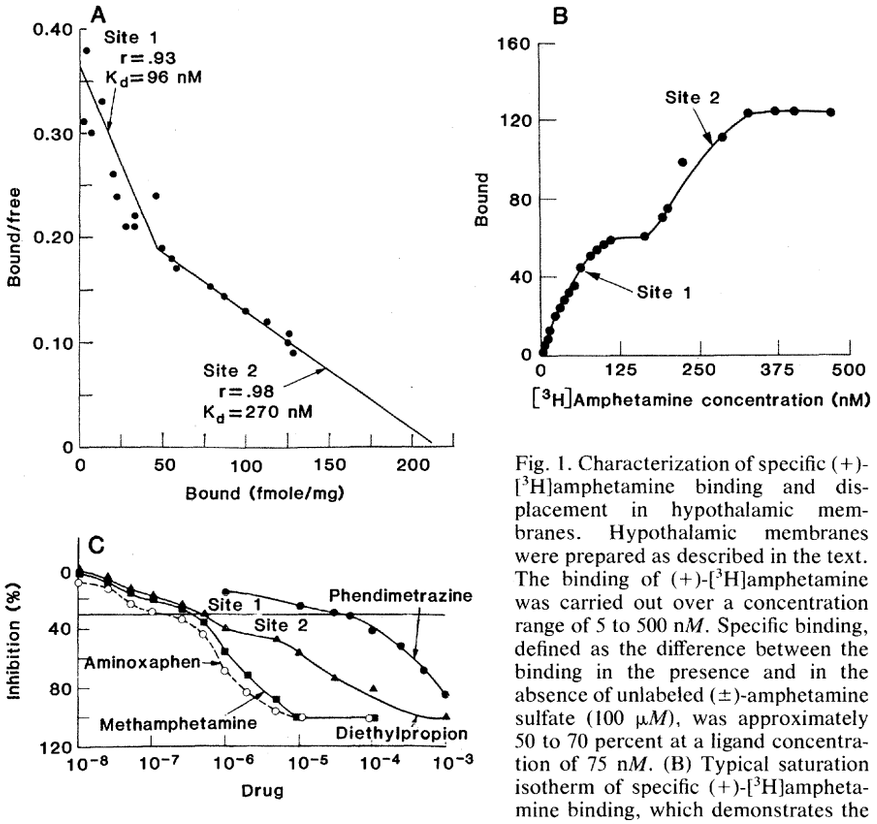

Fig. 1. Characterization of specific (+)-[^{3}H]amphetamine binding and displacement in hypothalamic membranes. Hypothalamic membranes were prepared as described in the text. The binding of (+)-[^{3}H]amphetamine was carried out over a concentration range of 5 to 500 n*M*. Specific binding, defined as the difference between the binding in the presence and in the absence of unlabeled (±)-amphetamine sulfate (100 μ*M*), was approximately 50 to 70 percent at a ligand concentration of 75 n*M*. (B) Typical saturation isotherm of specific (+)-[^{3}H]amphetamine binding, which demonstrates the presence of multiple binding sites. (A) Scatchard analysis of these data reveals two binding sites with apparent affinity constants (K_d values) of 96 n*M* and 270 n*M*. The corresponding B_{max} values for these sites were 95 and 215 fmole per milligram of protein, respectively. The Scatchard analysis and saturation isotherm are from a typical experiment repeated at least three times with similar results. See text for statistical analysis of these kinetic parameters. Scatchard plots were generated by a computer program developed in our laboratory. *Bound* refers to specifically bound (+)-[^{3}H]amphetamine, given as femtomoles per milligram of protein; *free* refers to the free concentration of (+)-[^{3}H]amphetamine, given as femtomoles per assay (0.3 ml) × 100. (C) Displacement of specific (+)-[^{3}H]amphetamine binding by four representative phenylethylamine derivatives at a ligand concentration of 75 n*M*. Evidence for two binding sites is apparent from the bimodal displacement of specific binding by these drugs. The K_i values of the various drugs (see Table 1) were calculated by visual estimation of the IC_{50} values for site 2 from displacement curves like those of (C).

scintillation counter (Beckman LS9000). Specific binding was defined as the difference between the binding observed in the presence and in the absence of nonradioactive (±)-amphetamine sulfate (100 μ*M*).

In preliminary experiments, the highest specific binding of (+)-[^{3}H]amphetamine and the best ratio of specific to nonspecific binding was observed in membranes prepared from hypothalamus (*8*). Therefore, subsequent experiments on the biochemical and pharmacologic characterization of these binding sites were carried out with hypothalamic tissue. Figure 1B is a typical saturation isotherm of specific (+)-[^{3}H]amphetamine binding to hypothalamic membranes. A biphasic saturation curve was consistently observed, suggesting the presence of multiple binding sites. Scatchard analysis of these data (Fig. 1A) demonstrates the presence of two distinct binding sites with apparent affinity constants of 93 ± 3 n*M* (*N* = 3) and 300 ± 30 n*M* (*N* = 3). The values of maximum binding (B_{max}) corresponding to these two sites were 95 ± 12 and 208 ± 11 fmole per milligram of protein, respectively. The presence of two binding sites was also apparent when the displacement of specific (+)-[^{3}H]amphetamine binding by various amphetamine-like drugs was examined (Fig. 1C). Bimodal displacement curves were observed for each of the amphetamine analogs tested. The best resolution of the differences in structure-activity relationships was observed for the low-affinity site (site 2 in Fig. 1C), and subsequent

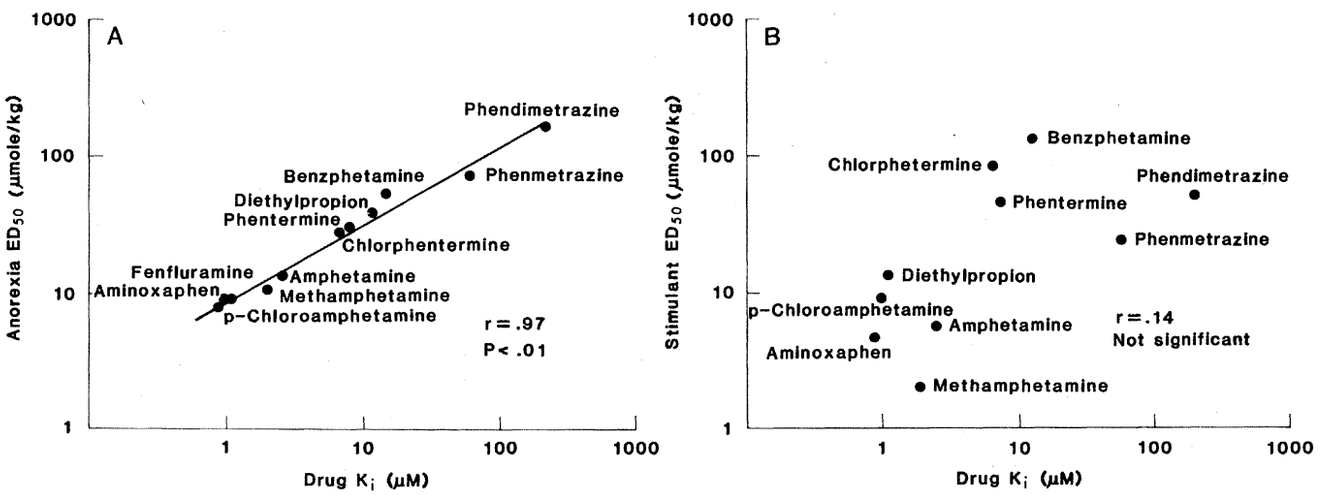

Fig. 2. Correlation between behavioral potencies of various phenylethylamine derivatives and their potencies in displacing specific (+)-[^{3}H]amphetamine binding in vitro. K_i values for the various drugs were determined as described in Table 1 and Fig. 1. Behavioral potencies have been taken from (*10*). For anorexia the ED_{50} values represent the dose of drug (in micromoles per kilogram) required to cause a 50 percent decrease in hunger-induced food intake. For stimulant activity, the ED_{50} values represent the dose of drug (micromoles per kilogram) required to cause a 50 percent increase in the response rate of rats in a continuous avoidance paradigm (*10*). Correlation coefficients were calculated prior to log transformation by least-squares analysis. A highly significant correlation (r = .97, P < .01) was observed between the K_i values and anorexic potency (A), but no correlation was apparent for the stimulant potency (B) of these drugs (r = .11, not significant).

studies on the effects of various amphetamine-like drugs on specific (+)-[^{3}H]amphetamine binding were carried out with the higher concentrations of drugs.

The subcellular distribution of specific (+)-[^{3}H]amphetamine binding was determined by fractionation of hypothalamic homogenates with sucrose gradient centrifugation according to the methods described in (*9*). The specific binding of (+)-[^{3}H]amphetamine was largely confined to the synaptosomal fraction, and only very low levels of specific binding were observed in the nuclear, mitochondrial, and microsomal fractions (data not shown). Incubation of the partially purified synaptosomal membranes at 80°C for 10 minutes or at 37°C for 30 minutes, in the presence of either trypsin (0.5 mg/ml) or pronase (1.0 mg/ml), decreased specific binding by more than 95 percent. These experiments indicate that the binding site is proteinaceous, as are other drug recognition sites (*5, 6*).

To ascertain whether (+)-[^{3}H]amphetamine binding is associated with any of the known neurotransmitter or drug receptors, we examined various compounds for their potency in competing for specific (+)-[^{3}H]amphetamine binding. Table 1 lists the displacement potencies (K_i values) for a series of phenylethylamine derivatives, as well as chemically unrelated receptor agonists and antagonists. These results suggest that (+)-[^{3}H]amphetamine binding is not associated with any of the well-known neurotransmitter or drug receptors such as α- or β-adrenergic, cholinergic, dopaminergic, opiate, serotonergic, or benzodiazepine receptors. Furthermore, several of the very potent presynaptic reuptake blockers of norepinephrine and serotonin (for example, desipramine and amitryptiline) were only weakly active in inhibiting (+)-[^{3}H]amphetamine binding (Table 1). In contrast, several amphetamine derivatives, including *p*-chloroamphetamine, fenfluramine, aminoxaphen, and methamphetamine were more potent than amphetamine in displacing (+)-[^{3}H]amphetamine binding. Significantly, the binding of (+)-[^{3}H]amphetamine is stereospecific, with the (+)-enantiomer of amphetamine approximately two- to threefold more potent in displacing specific binding than the pharmacologically less active (−)-amphetamine (*1*) (Table 1).

Since amphetamine and structurally related drugs have several major pharmacologic actions (*1*), we compared the affinities in vitro of a series of phenylethylamine derivatives for the (+)-[^{3}H]amphetamine binding site in hypothalamus with their reported behavioral potencies as stimulants and anorexic agents (*10*). Figure 2 shows the correlation observed between the values of the inhibition constant (K_i, in micromoles per liter) for displacement of specific (+)-[^{3}H]amphetamine binding and the values of the median effective dose (ED_{50}, in micromoles per kilogram) of these drugs for producing anorexia and motor stimulation in rats (*10*). A highly significant correlation ($r = .97$, $P < .01$) was obtained for anorexic activity (Fig. 2A), whereas no significant correlation was observed for the stimulant activity of these drugs ($r = .11$, not significant) (Fig. 2B). Fenfluramine, which is both a potent displacer of (+)-[^{3}H]amphetamine binding and an anorexic agent, is actually a behavioral depressant (*10*).

Table 1. Effects of various drugs and neurotransmitters on specific (+)-[^{3}H]amphetamine binding to hypothalamic membranes. The hypothalamic membranes were prepared as described in the text. The specific binding of (+)-[^{3}H]amphetamine is described in the text. Values representing the concentration of drug necessary to inhibit 50 percent of the specific binding (IC_{50}) were calculated from displacement curves similar to that shown in Fig. 1. K_i values were calculated from the formula

$$K_i = \frac{IC_{50}}{(1 + [L])/K_d}$$

where the concentration, [*L*], of (+)-[^{3}H]amphetamine was 70 to 80 n*M*, and the apparent K_d (affinity constant) was 300 n*M*. Values are means of three experiments, with standard errors less than 10 percent of the means. The following drugs were inactive ($K_i > 50$ μ*M*): naloxone, atropine, pentobarbital, phentolamine, haloperidol, tetrabenazine, phencyclidine, reserpine, clonidine, dihydroergocryptine, zimelidine, phenoxybenzamine, yohimbine, norepinephrine, serotonin, γ-aminobutyric acid, diazepam, and flurazepam.

Drug	K_i (μ*M*)
Amphetamine-related drugs	
p-Chloroamphetamine	0.8
Aminoxaphen	0.9
Fenfluramine	1.1
(+)-Amphetamine	1.6
Methamphetamine	1.9
(±)-Amphetamine	2.5
(−)-Amphetamine	3.8
Chlorphentermine	6.2
Phentermine	7.5
Diethylpropion	11
Benzphetamine	14
Phenmetrazine	58
Phendimetrazine	210
Other active drugs	
Dopamine	12
Chlorgyline	15
Iproniazid	20
Desipramine	20
Amitriptyline	25
Propranolol	30
Chlorpromazine	35

Taken together, these results demonstrate the presence of saturable and specific binding sites for (+)-[^{3}H]amphetamine in rat brain. The subcellular distribution of these binding sites suggests a neuronal localization similar to that of other neurotransmitter and drug receptors. Competition studies with a number of psychotropic drugs, as well as with various neurotransmitter agonists and antagonists, suggest that these sites are specific for amphetamine and related phenylethylamine derivatives. The high correlations observed between the potencies of a series of amphetamine-like drugs in displacing specific (+)-[^{3}H]amphetamine binding in vitro and in producing anorexia in rats suggest that these sites may represent receptors mediating the anorexic actions of amphetamine and related drugs. Future studies to determine whether these sites are located in pre- or postsynaptic membranes should clarify whether they modulate the release, reuptake, or response of other neurotransmitters involved in the regulation of appetite (*11*).

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References and Notes

1. C. D. Leake, *The Amphetamines, Their Actions and Uses* (Thomas, Springfield, Ill. 1958); J. H. Biel and B. A. Bopp, in *Stimulants Handbook of Psychopharmacology*, L. L. Iverson, S. D. Iverson, S. H. Snyder, Eds. (Plenum, New York, 1978), vol. 11, p. 1; K. E. Moore, in *ibid.*, p. 41; R. B. Lawlor, M. D. Trivedi, J. Yelnosky, *Arch. Int. Pharmacodyn. Ther.* **179**, 401 (1969); D. S. Segal, *Science* **190**, 475 (1975).
2. L. Stein and C. D. Wise, *J. Comp. Physiol. Psychol.* **67**, 189 (1969); A. Carlsson, in *Amphetamines and Related Compounds*, E. Costa and S. Garattini, Eds. (Raven, New York, 1970), p. 289; C. C. Chiueh and K. E. Moore, *Brain Res.* **50**, 221 (1973); A. J. Azzaro and C. O. Rutledge, *Biochem. Pharmacol.* **22**, 2801 (1973).
3. J. Glowinski and J. Axelrod, *J. Pharmacol. Exp. Ther.* **149**, 43 (1965); K. M. Taylor and S. H. Snyder, *Brain Res.* **28**, 295 (1971).
4. P. J. G. Mann and J. H. Quastel, *Biochem. J.* **34**, 414 (1940); J. H. Burn, *The Principles of Therapeutics* (Thomas, Springfield, Ill., 1957).
5. C. B. Pert, G. Pasternak, S. H. Snyder, *Science* **182**, 1359 (1973); S. H. Snyder, *Nature (London)* **257**, 185 (1975).
6. H. Möhler and T. Okada, *Science* **198**, 849 (1977); C. Braestrup and R. F. Squires, *Proc. Natl. Acad. Sci. U.S.A.* **74**, 3805 (1977); J. F. Tallman, S. M. Paul, P. Skolnick, D. W. Gallager, *Science* **207**, 274 (1980).
7. Hypothalami were dissected with the optic chiasma used as the rostral limit, the mammillary bodies as the caudal border, and the hypothalamic fissures as the lateral limit. Approximately 3 mm of tissue, beginning from the ventral surface of the hypothalamus up to, but excluding, the ventral thalamus was used.
8. In a preliminary report describing our use of hypothalamic membranes [S. M. Paul, B. Hulihan, R. Hauger, P. Skolnick, *Eur. J. Pharmacol.* **78**, 145 (1982)], we observed only the high

affinity binding site (site 1) shown in Fig. 1A. With higher concentrations of (+)-[^{3}H]amphetamine (>200 nM), as well as unlabeled (±)-amphetamine sulfate (100 μM) for measuring nonspecific binding, the presence of a lower affinity binding site (site 2) became apparent. In addition, comparatively large differences in structure-activity relationships were observed for a series of amphetamine derivatives in displacement studies of the lower affinity site (Fig. 1C). Whether this represents a difference in the pharmacologic profile between sites 1 and 2, or simply the fact that the binding to site 1 represented only 20 to 30 percent of the total binding, making resolution of structure-activity differences for this site more difficult, is not yet clear. Nevertheless, the brain levels of amphetamine following pharmacologically active doses are in the range 2 to 50 μM (J. Axelrod, *J. Pharmacol. Exp. Ther.* **110**, 315 (1954) and thus correspond closely to the apparent affinity constant of (+)-[^{3}H]amphetamine for site 2.

9. E. G. Gray and V. P. Whittaker, *J. Anat.* **96**, 79 (1962).
10. R. H. Cox, Jr., and R. P. Maickel, *J. Pharmacol. Exp. Ther.* **181**, 1 (1972).
11. S. F. Leibowitz, *Proc. Natl. Acad. Sci. U.S.A.* **67**, 1063 (1970); *Fed. Proc. Fed. Am. Soc. Exp. Biol.* **32**, 754 (1973); D. L. Margules, *J. Comp. Physiol. Psychol.* **73**, 1 (1970); J. E. Ahlskog, *Brain Res.* **82**, 211 (1974); G. A. Oltmans, R. Olsauskas, J. E. Comatz, *Neuropharmacology* **19**, 25 (1980).

12. We thank R. P. Maickel for providing many of the phenylethylamine derivatives used in this study.

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Sugar Infusion Can Enhance Feeding

Abstract. *An investigation was made of the role of glucose in the regulation of hunger and satiety in the rabbit. Glucose, when infused intraduodenally at a low rate (1 milliliter per minute), produced a decrease in food intake. However, when glucose was infused into the duodenum at a high rate (3 milliliters per minute), the rabbits nearly doubled their food intake during the first half-hour after infusion. It is hypothesized that the rapid arrival of glucose in the duodenum may produce hunger.*

Thirty years ago, Mayer (*1*) postulated the glucostatic theory of hunger, which states that low cellular utilization of glucose stimulates hunger and food intake and that satiety signals terminate food intake when cellular glucose utilization is high. The theory has generated extensive research showing that the administration of glucose suppresses subsequent food intake (*2*). However, the role of glucose in the regulation of hunger and satiety is not that simple. Contrary to what might be predicted on the basis of Mayer's hypothesis, clinicians have often reported that the carbohydrate content of the diet is directly related to hunger (*3*). Similarly, several animal studies have shown that access to a sugar solution can produce an increase in food intake (*3*). These results suggest that, rather than producing satiety, carbohydrates sometimes stimulate appetite and hunger. We now report that when glucose is infused into the duodenum at a slow rate, food intake is suppressed, but that when glucose is infused at a more rapid rate, food intake increases sharply.

Female New Zealand rabbits (2.3 to 3.2 kg) were housed individually in canine flight kennels in a temperature-controlled room (17° to 20°C) with a 12-hour light-dark cycle. Purina Pelleted Rabbit Chow (40 percent carbohydrate, 16 percent protein, and 2 percent fat) and tap water were provided to each animal without restriction throughout the experiments. All the animals were implanted with intraduodenal cannulas (*4*), allowed to reestablish preoperative food and water intake levels, and then adapted to the test apparatus.

Tests were conducted 1.5 hours after lights out. The animals were infused intraduodenally (10 ml per 3 kg) with a 0.3M glucose solution and a 0.15M NaCl solution (equiosmolar control) in randomized order, with an interval of 2 to 3 days between tests (*5*, *6*). Infusants were heated to 39°C, the average body temperature of the rabbit. Ten rabbits received infusions at a high rate (3 ml/min) and seven rabbits received infusions at a low rate (1 ml/min). Following the infusion procedure, each cage was equipped with a metal food box that provided input signals to a microprocessor-based data acquisition system (*7*). Food intake was monitored continuously for a 4-hour period, during which the animals were left undisturbed.

When glucose was infused at the high rate, subsequent food intake was en-

Table 1. Meal-related parameters and total food intake as a function of rate of intraduodenal delivery of glucose and saline. Values are means ± standard errors for the first half-hour after infusion.

Rate of infusion	Size of first meal (g)	Meal size (g)	Feeding rate (g/min)	Total food intake (g)
High (3 ml/min)				
Glucose	8.39 ± 0.76*	7.60 ± 0.47†	1.33 ± 0.10‡	11.81 ± 1.39‡
Saline	6.22 ± 0.59	5.15 ± 0.82	0.91 ± 0.14	6.55 ± 1.02
Low (1 ml/min)				
Glucose	5.00 ± 0.44§	4.78 ± 0.95	0.86 ± 0.18	6.69 ± 1.92
Saline	7.67 ± 1.36	6.34 ± 1.70	0.84 ± 0.16	6.34 ± 1.70

*Significantly different from corresponding control value ($P < .02$) (*8*). †$P < .03$. ‡$P < .01$. §$P < .04$.

Table 2. Meal-related parameters and total food intake as a function of volume of intraduodenal delivery of glucose and saline. In the statistical analysis, the volume factor did not enter into a significant interaction. Therefore, all differences were significant regardless of volume. As in the first experiment, during the 4-hour period there was no compensation for the increase in food intake observed in the first half-hour after infusion ($P < .05$). Values are means ± standard errors.

Volume of infusant	First meal after infusion			First half-hour after infusion			
	Latency (minutes)	Meal size (g)	Satiety ratio*	Meal size (g)	Feeding rate (g/min)	Meal frequency	Total food intake (g)
10 ml per 3 kg							
Glucose	3.37 ± 1.26†	7.81 ± 1.18‡	2.87 ± 0.73§	6.82 ± 0.92 ‖	1.27 ± 0.08¶	1.67 ± 0.21**	10.80 ± 1.62††
Saline	6.55 ± 2.36	6.05 ± 1.08	5.78 ± 2.07	5.95 ± 1.09	0.79 ± 0.12	1.17 ± 0.17	6.77 ± 1.23
20 ml per 3 kg							
Glucose	4.17 ± 1.85†	6.98 ± 1.67‡	3.37 ± 0.66§	7.00 ± 1.34 ‖	1.21 ± 0.11¶	1.67 ± 0.21**	10.53 ± 1.11††
Saline	5.84 ± 1.15	4.48 ± 0.92	4.92 ± 0.77	5.05 ± 0.67	1.04 ± 0.10	1.33 ± 0.21	6.25 ± 0.72
30 ml per 3 kg							
Glucose	4.41 ± 1.45†	8.23 ± 1.55‡	3.04 ± 1.02§	7.65 ± 1.50 ‖	1.21 ± 0.07¶	1.67 ± 0.33**	11.20 ± 2.23††
Saline	15.76 ± 4.17	5.77 ± 1.01	3.54 ± 0.31	5.43 ± 1.09	1.15 ± 0.12	1.33 ± 0.21	6.35 ± 0.87

*The ratio of the interval between the first meal after infusion and the next meal to the size of the first meal. †Significantly different from corresponding control value ($P < .02$). ‡$P < .007$. §$P < .03$. ‖$P < .05$. ¶$P < .02$. **$P < .005$. ††$P < .006$.

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