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A STUDY OF PUZZLES WITH SPECIAL REFERENCE TO THE PSYCHOLOGY OF MENTAL ADAPTATION.[1]

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Recent researches, stimulated largely by increasing educational concern for the capacities and interests of childhood, have resulted in a heightened scientific appreciation of play activities not only as one of the supreme revelations of human nature, but also as a most fruitful field for the study of mind. An important and rapidly growing literature, psychological and anthropological, has added much to our knowledge of the history and nature of plays and games.

One form of play, that represented by puzzles, has, however, received little attention. To show the range of this aspect of play and to indicate its somewhat special relations to fundamental problems, is the chief purpose of the present study.

Its chief lines are:

1. A consideration of some of the wider aspects of play activity, and its relation to puzzles.
2. A classification and a brief analysis of puzzles, together with a description of the puzzle *quale*.
3. A consideration of puzzle-interest, as determined by examination of questionnaire data.

[1] I wish to express my very great obligation to all the members of the Psychological Faculty of Clark University for valuable assistance,—especially to President Hall for kindly and generous coöperation at all times, and to Dr. E. C. Sanford for the suggestion of the topic, and for advice and criticism in the working out of it.

4. An experimental study of typical modes of mental reaction; (a) as determinative, in part, of the puzzle *quale*, but chiefly (b) as supplying a basis for the comparative study of the natural logic of children, men, animals.

5. Some practical applications of the foregoing.

I.

The Biological and Psychological Import of Play. What is play? Is it meaningless outflow of energy; or may it be of serious import for the life of the animal?

Two chief theories are in the field. One, that of Schiller and Spencer, interprets play as an expression of the overflow of energy. Movements are indulged in because there is a surplus of energy which must somehow be expended. Whatever useful practice and experience may result from this random activity is in a sense accidental. This view has long held a prominent place in psychology, and has certainly given important emphasis to the physiological prerequisite of play. But it is at best only a physiological theory. It fails to explain adequately why plays should assume this and that form, why these forms should vary so considerably among different species of animals and races of men.

As supplementing the Schiller-Spencer physiological view with a biological explanation, the theory of Prof. Groos [1] marks an important step in advance.

While recognizing the importance of abundance of energy as a precondition, Groos denies its universal validity, citing instances of animals which play, even when fatigued almost to exhaustion. Play is the expression of an instinct, whose teleological import is discoverable in most of the movements of animal or child. Play is a "*Vorübung und Einübung*" of activities which soon are to be necessary to the serious life of the adult animal. Of course the teleology of play is not conscious in the young. Its immediate motivation is pleasure:

1. Pleasure in the satisfaction of instinct.

2. Pleasure in vigorous activity, as such. This certainly has high value. Wundt considers it the chief motive in many forms of play. The heightened circulation of the blood, and the like, may be conceived to increase the excitability of the brain, and thus facilitate formation of new association paths.

3. Joy in "being a cause." This introduces an emotional element. Preyer emphasizes it as important. Lessing

[1] Karl Groos: "*Die Spiele der Thiere*," Jena, 1896.

thought it gave the child a deeper sense of his own reality. Not only do children exhibit this delight, but according to Groos, the kicking of a stone, the striking down of weeds with a cane by an adult in the course of a pleasure walk, may be interpreted as the expression of a pleasure in producing change.

This "*Freude an Ursache-sein*," in last analysis, may be pleasure in triumphing over obstacles, the joy in success, victory. Nietzsche translates Darwin's "struggle for existence" into a struggle for power, contest for dominion over surroundings. Its first expression in the young infant is in its attempt to master its own body. So joy in the overcoming of difficulties may be the ultimate and ripest motivation of these activities.

Many movements of the young thus represent a kind of experimentation. The stretching out and drawing in of limbs, seizing, clawing, scratching, gnawing,trying the voice, lifting and letting fall of objects, tearing, pulling, are some of the animal movements of this sort, many of which also appear in children.

It is of central importance to note that most of these play instincts are not highly specialized at birth. Most are more or less general and rudimentary forms, which may be largely modified by experience.[1] The significant point is that they furnish the initiative, at least, for certain activities essential to the life of the organism. They, together with imitation, thus protect the animal until intelligence is ripe enough to mediate proper adaptations. They also prepare the way for intelligence by leading the animal to exercise itself in many ways, and thus acquire a large repertoire of coördinations which intelligence may later utilize; for intelligence and reason cannot utilize any "material" which has not already been a part of the conscious experience of the individual. As is well known, no act can be accomplished voluntarily whose elements, at least, have not already been performed without volition.

The educability of the animal, that is, its adaptability to new conditions, obviously would be decreased by too large a number of instincts of a highly elaborated and specialized kind. Therefore these general play instincts and imitation must have fair field in order that the creature may be most responsive to new conditions. So important is individual

[1] "*Alle Jugendspiele beruhen auf Instincten. Diese Instincte sind nicht so vollkommen, nicht so sehr in allen Details dem Gehirn eingegraben, wie sie es sein müssten, wenn sie sich erst im Ernstfall äussern würden; dafür treten sie aber schon in der Jugend auf und können in Folge dessen durch Uebung noch rechtzeitig ausgebildet werden.*'" P. 74.

experience for the elaboration and adaptation of these instincts that Groos declares there must be childhood in order that there be time for play.[1] "*Die Thiere spielen nicht, weil sie jung sind, sondern sie haben eine Jugend, weil sie spielen müssen.*"[2]

To Groos, plays thus face the future. They are a definite preparation for the serious life of adult years. Moreover, as a preformist, he would even deny that any of these activities are due to the inheritance of the results of the conscious activities on ancestors. Without entering the discussion of Weissmannism *vs.* Lamarckianism, suffice it to say that some recent writers,[3] as well as earlier ones,[4] insist upon the "lapsed intelligence" view of the instincts involved. In this view, plays may be reverberations of activities of ancestors. To choose a single instance: the fighting plays[5] of boys, and indeed the whole round of activities of a certain period which mark the average youth, for a time, as a "young savage," find their readiest explanation not in relation to a serious life of the present, but in the fact that the individual is a recapitulation of the race, and that the activities in question are such as primitive man engaged in with full consciousness and definite purpose. The implications of the "reverberation" view might seem to threaten the prospective-reference aspect of Groos's theory. The dispute, however, concerns the origin of instincts, and given the instincts both parties may well agree in their propædeutic value.

Many psychologists seem to assume that certain special instincts have value for the individual, in that they are ephemeral. They rise, and under favorable conditions stimulate somewhat the unfoldment of the organism and decline. Their chief value, indeed, lies in the fact that after making their contribution to the enrichment of "soma" or "psyche," they fall away, and leave either more valuable habits, or plasticity in possession.

Nothing seems more certain than that the congenital inheritance of the child, rich as it is, does not provide sufficiently for the exigencies of his life.[6] Just this distinction marks him off from the young of the lower animals. The

[1] *Ibid.*, p. 68.
[2] Introduction, p. 6.
[3] "A Study of Fears," G. Stanley Hall, AM. JOUR. PSYCH., Vol. VIII, p. 2.
[4] G. H. Schneider: "Der Menschliche Wille," Berlin, 1882, p. 68. G. H. Lewes and E. B. Tylor also.
[5] "Teasing and Bullying," F. L. Burk, *Ped. Sem.*, Vol. IV, p. 3.
[6] The child may, as James says, have a larger absolute number of instincts than lower animals. However that may be, *relatively* to the needs of his life, the child is less adequately provided for.

latter come into the world with a relatively highly developed instinctive equipment. And in the words of Preyer "the more kinds of coördinated movements an animal brings into the world, the fewer he is able to learn afterwards." In the child "the equipment of the lower animals is replaced by the plasticity for learning by consciousness."[1] Learning must be provided for through instincts of the more general sort, as imitation and those of play; or through intelligence; or through both instincts and intelligence. For Baldwin, the play instincts are not alone sufficient, and for Groos imitation is not. Certainly the acquisition of the mental legacy involves more than either,—intelligence.

Play and imitation, as yet, have been considered only in so far as they enable the individual to acquire the simple elements of his inheritance. Even here there may be need of invoking intelligence. But man is inventive as well as acquisitive. Intelligence "grows from more to more," if not phylogenetically, certainly from infancy to maturity in the individual.[2]

Assuming as the criterion of mentality "the pursuance of future ends and the choice of means for their attainment,"[3] intelligence may be regarded as a variation which enables the organism to make better adaptations. Its neural prerequisite is plasticity. But efficient plasticity is possible only through wide variety of experiences. The modification of the nervous system, produced by experience, exhibits two opposing tendencies: one conservative, the other radical; one making for automatism, the other for variability.

The tendencies which make for mechanization include the arsenal of specialized instincts as well as the simpler forms of imitation. The echolalia of children exhibits the tendency of the circular form of reaction, in its simpler aspects, to produce the reiteration which makes for habit. Mere variety of experiences raining in upon the nervous system is not enough to preserve plasticity. In the teeth of this gravitation toward fixedness, there must be a spontaneity to take advantage of this variety. The animals most gifted with experimenting tendencies, those which utilize changes in environment most promptly, will be favored in the struggle for existence.[4]

The case is similar with man. Granting that an advanced

[1] Baldwin: "New Factor in Evolution," *Am. Naturalist*, July, '96, p. 540.

[2] Morgan: "Habit and Instinct," pp. 343 ff. Gladstone, Benjamin Kidd and Edward Bellamy are quoted as disbelieving in a progressive increase in mental capacity in the race within recent times.

[3] James, Vol. I, p. 8.

[4] Cf. H. R. Marshall: "Consciousness and Biological Evolution," Part II, *Mind*, Oct., '96.

civilization demands a degree of adaptiveness for which inheritance cannot adequately provide through specialized instincts, granting also that mental adaptation, as such, constitutes a distinctive feature of life in a highly organized and rapidly changing social environment, the play activity assumes the double function of furnishing exercise both to those instincts which represent the relatively unchanging core of life, and to intelligence itself.

Let it be called a general impulse or general instinct to exercise the intelligence as such.[1] Such a gymnastic must consist in the most widely various sorts of activity, a deployment as far as possible of all resources of body and mind in ways which are to be of use later. Those races and individuals that feel strongly the impulse thus to deploy the intelligence and exercise the "mental muscles," and find it a joy in itself, must be favored in the struggle for existence. The play instinct thus marks its possessors as the bearers of those qualities which guarantee the continued growth of science, invention, and civilization.

The classification of plays and games, by Johnson,[2] well exhibits how they shade by almost imperceptible gradations from the forms which exercise the muscles, up to those in which the mental gymnastic predominates. Of puzzles, the majority are stimuli to intellectual effort, and thus one of the various forms of this propædeutic activity.

Many plays and games, also the more serious occupations of children, may draft off this spontaneity, and disguise it under forms of action for practical ends. The impulse, cannot well at any stage be entirely "blind," and the original motives may be greatly elaborated and modified. Instead of the mere pleasure in activity continuing to furnish the sole motive, joy in being a cause, pleasure in triumphing over difficulties may become prominent. One aspect of the latter must be the feeling of rivalry. Many social games of higher

[1] Lloyd Morgan would call these highly complex and indefinite coördinations "impulses," restricting the word "instinct" to the more definite coördinations. But in spite of this narrower use of instinct, Morgan admits that some instincts are only relatively definite (*Nature* 18, A, p. 95). Marshall (*Mind*, N. S. 5, p. 380) insists that "impulse" connotes a subjective condition, and that instinct viewed as unconscious action for ends, must be expanded to cover all complex actions which bear such mark, no matter how variable may be the coördinations. "Paternal instinct," "maternal instinct," are highly complex, and represent highly indefinite coördinations, many of which are unpredictable. Nevertheless they *are* instincts. So in the latter sense have we ventured to use the word "instinct" in relation to the mental tendency discussed above.

[2] "Education by Plays and Games," G. E. Johnson. *Ped. Sem.*, III, 1.

grades are largely motivated by this spirit of competition, and even in puzzle activity it sometimes appears. But it seems probable that there is in all play activity a residuum of pure delight in activity as such. If the competition motive were the sole incentive to play activities, its explanation on some association hypothesis, as an acquired interest, might be available. Such a view, however, would need to explain why such activities should be made a basis of rivalry unless they first possessed a certain inherent interest.

Restricting the discussion to puzzles, the following are offered as some of the evidences of the existence of the instinct in question. Most people who really enjoy puzzles say they solve them simply for the sake of learning how. Many specifically deny the existence of competition as an incentive, and many prefer to work alone.

Furthermore, in spite of the mental strain and dilemma produced by a puzzle,—an unpleasurableness, which with some persons may become strong enough to produce nervous distress and marked aversion,—the mind is again and again attracted and engaged. Many persons report a distaste for puzzles, but say they find themselves drawn to them, and once having begun, find difficulty in letting go. It is hard to believe, however, that the difficult as such, without relation to possible practical experience, can be uniformly attractive. It seems rather that the difficult as represented by games and puzzles is a special aspect of the baffling which epitomizes and typifies most of the intricate forms of reaction which are met with in the actual experiences of the individual and which perhaps have been important in the history of the race. This, of course, implies a definite propædeutic function. Whether definite or only general, and whether or not the difficult, as such, is alone sufficient under any circumstances to stimulate human interest and excite intellectual activity, the above facts seem best explained by the assumption of a general intellectual play instinct or impulse.

Summary. Intelligence is no exception to the law of exercise. Just as those animals, which by fortunate variation were born with a tendency to indulge in preliminary exercise of those activities which were to serve the serious ends of adult life, were favored by natural selection, and were able to transmit such advantage in the form of general play instincts, so in a more special way those creatures, endowed with the strongest tendencies to exploit the intelligence, may have perpetuated this superiority as a general intellectual play instinct.[1]

[1] It need hardly be explained that the designation of the above tendency as "intellectual" disregards the old tripartite division of

CLASSIFICATION.

So far as known, no attempt to classify all varieties of puzzles has hitherto been made, and even those writers who have sought to reduce to some order the multiform mathematical recreations have failed to find an adequate scheme of classification, while those who have attempted to arrange mechanical puzzles have fared no better. These failures are not strange when it is remembered that many puzzles are "*sui generis*." Others possess characteristics which require their classification in several distinct rubrics. In the present study the systematization is of the most tentative nature and is merely designed to indicate the wide range of puzzle materials and to emphasize the more important types. The groupings will therefore often be somewhat arbitrary.

The chief groups are: Language and Word; Mechanical; Mathematical; Logical and Philosophical; Dilemmas of Etiquette, Ethics, etc.

Language and Word Puzzles.

One of the most primitive groups. The most prominent varieties are:

The Riddle:—A question usually describing the object in question in a paradoxical or ambiguous way.

The riddle which is reputed to have caused the death of Homer, and which is still current in Brittany, is as follows: "What we caught we threw away; what we could not catch we kept."—Lice. Another, found in both France and Germany: "Lives without a body, hears without ears, speaks without mouth, to which the air alone gives birth."—Echo.

The Rebus (literally by things):—Generally a riddle, part of which is expressed in pictures or symbols. Sometimes the Rebus is little more than interpretation of pictures or symbols, the content being in no other way ambiguous.

The Conundrum:—Usually a riddle, where the play is upon words rather than upon things. The solution often turns upon a pun: "Why is O the noisiest of the vowels? Because all the rest are inaudible."

The Enigma:—More poetical form of riddle. Often involves, also, a play upon words: One of the most excellent of this category is the following by Schiller, on the *Rainbow*:

"A bridge weaves its arch with pearls
High over the tranquil sea;
In a moment it unfurls
Its span unbounded, free.
The tallest ship with swelling sail
May pass 'neath its arch with ease,
It carries no burden, 'tis too frail,
And when you approach, it flees.
With the flood it comes, with the rain it goes,
And what it is made of, nobody knows."

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mind into Cognition, Feeling and Will. Intelligence is conceived to be not merely cognitive, but all these. Later in this paper we hope to show how voluntary ability is fostered and developed through the demand of these activities for voluntary attention and persistence in general. Even the moral nature thus becomes involved to a degree.

The Charade:—Often nowadays used synonymously with "Enigma." More properly it is usually a series of riddles or enigmas, each of which has reference to a single letter, or syllable of a word, or parts of a compound word, the whole series taken together referring to some word-total. Archbishop Whately is credited with the following charade: "My *first* is equality, my *second* inferiority; my *whole* superiority."—Peerless (Peer-Less). The following by Charles James Fox has the metrical form:[1]

My *first* is expressive of no disrespect,
But I never call you by it when you are by;
If my *second* you still are resolved to reject,
As dead as my *whole*, I shall presently lie."—Herring (Her-Ring).

There are many minor variations of the charade—some of more juvenile form—as, "My *first* is in lamb, but not in sheep; My *second* in shallow, but not in deep," etc.—where each line refers to a single letter. Another species, also, of great popularity among children is that in which action enters. Many of the objects are suggested by gestures and other expressive movements, by costume, and the like, thus bearing some resemblance also to the Rebus. The dramatic element appeals powerfully to the imagination, and hence is the earliest form of the charade which interests children.

Word Squares, Diamonds, etc.:—A series of riddles the answers to which are words which are to be arranged so as to form certain geometrical figures, as squares, diamonds, etc. Here an element of geometry of situation may also enter. Furthermore, induction and deduction of very definite sort are demanded. If one of the riddles be guessed outright and the word put in its proper place in the scheme, it often serves as a basis for the deduction of the remaining words. This type is too familiar to need illustration.

The Acrostic is similar to the Word Square, but usually is more difficult because only the initial letters of the discovered words are used to spell the required answer. The Double Acrostic uses both initial and final letters to spell two words. This latter form has had a special vogue in some quarters, notably in Ireland. A collection entitled "Dublin Acrostics" was published a few years ago. The Acrostic is also so prominent in puzzle columns of periodicals as to need no exemplification here.

Logogram, Metagram, Decapitations, Curtailments, Retailments are a few varieties of the puzzle wherein the word in question is made to undergo various changes. Macaulay, Fox, and William Pitt have written classical examples of the above types. The following by Macaulay illustrates the metrical type of the Logogram, although poetical form is not necessary:

Cut off my head, how singular I act!
Cut off my tail, and plural I appear!
Cut off my head and tail—most curious fact!
Although my middle's left, there's nothing there!
What is my head, cut off? A sounding sea!
What is my tail, cut off? A flowing river!
Amid their mingling depth, I fearless play,
Parent of softest sounds, though mute forever.
Answer: Cod.

Hidden Words, and the like, are somewhat similar to the above group. Altogether there are more than thirty species of language and word puzzles. It is obvious that many of these not only challenge ingenuity and involve the logical processes, but also have point as information tests.

In most of the puzzles above described, the riddle element persists, however complicated by logical, verbal and other conditions.

[1] "Cassell's Book of Sports and Pastimes," p. 953.

Mechanical.

This class includes almost all the puzzles of commerce. They are denominated mechanical[1] because of their more or less substantial construction (being made of wood, iron wire, etc.), and present the conditions of the problem in tangible and portable form. Hoffman, whose book includes the most extensive treatise on the puzzles of commerce, describes upwards of 140. The main lines of his classification are followed in this section.

1. *Those puzzles dependent on dexterity and perseverance.* This group forms an exception to the definition of a puzzle as "a demand for an intellectual adjustment." While discrimination is indeed to a considerable extent involved, the main requisite is a nice coördination of muscles. Among the representatives of this group is the familiar "Pigs in Clover."

2. *Those dependent upon some trick or secret.* This is also a low type of puzzle, but requires more ingenuity and resource than the foregoing class. As examples here, are magic money-purses with hidden lock, money-banks and snuff-boxes. In these the illusion of impossibility is strong, and the secret is usually discovered only after repeated trials and in the most unexpected places.

3. *Physical Puzzles.* Most of these involve unique applications of well-known physical laws, as those of motion and gravity. Accordingly, some of the best of this class can be performed with very little apparatus, and in consequence are not fully represented among the puzzles of commerce. These are classified here because they represent a certain degree of advance in mental difficulty over the preceding group. More familiar examples of this sort are "the blowing of a small cork into a bottle"; "removing a napkin from beneath an inverted goblet of water, without moving the goblet or disturbing the water." The totally unfamiliar action of physical laws perplexes and baffles.

4. *Dissected or Combination Puzzles.* Includes all materials so constructed that from given fragments other figures or designs are to be made. All "cross" and "square" puzzles, as well as forms analogous to dissected maps, where materials and not simply diagrams are used, are included. The characteristics of this class will be considered under the head of Geometrical Puzzles. The geometrical imagination seems the chief faculty exercised.

5. *More complicated and elaborate puzzles.* A somewhat miscellaneous group. Many are constructed of wire—others of rings and loops of cord. The usual task is to separate links or remove rings from loops of cord, and the like. They represent a distinct advance in complication over the foregoing types. The element of illusion is often strong. Some appear entirely impossible. They require procedure so unaccustomed that the individual is unable to picture the solution. They are designed to baffle the visual, and chiefly the geometrical, imagination.

As early suggested the above classification makes no claim to completeness. It only serves to pass in review, and to characterize roughly the puzzle materials in question. Mechanical puzzles of

[1]Hoffman: "Puzzles Old and New," N. Y., 1893.

still higher order are also mathematical, and hence will be considered in the latter group.

Mathematical.

Here will be followed the classification of the mathematicians. "After the recreations which depend uniquely upon number, come those in which position is concerned. After the problems involving number and position, should come those recreations into which movement enters."[1] Leibnitz's suggestion offers a practical basis for the grouping of a large majority of mathematical puzzles, and in lieu of a better scheme it will be followed in this section.

1. *Numerical Puzzles.* Chiefly arithmetical. Bachet and Ozanam, whose works are the chief sources, offer a large number of these numerical and arithmetical problems. Nearly all play, either upon the application of unfamiliar properties of number, or else derive their puzzle quality from the fact that their solution is possible only through higher mathematics, whereas the ordinary man tries to solve them by means of arithmetic, and hence fails.

Some of the most famous of these puzzles are as follows:—1. To find a number selected by some one; 4 solutions. 2. "To find the result of a series of operations performed on any numbers (unknown to the questioner) without asking questions." Others partake less of the trick-nature than the above, as: "What number which divided by 2 gives a remainder of 1; divided by 3, remainder of 1; divided by 4, 5 or 6, remainder 1; but divided by 7, no remainder?" Also problems of fractions dealing with queer legacies and the like, abound. Some contain little of the real puzzle quality, but it is difficult to draw the line. Puzzles involving arithmetical progression form a rather distinct class. Some are mechanical puzzles, as the Tower of Hanöi and "Cardan's Rings" (better known as Chinese Rings). The puzzle quality depends upon the fact that no novice will appreciate that they involve progression, but will proceed in a simpler way.

Geometrical. All these problems deal in a special way with form and position, and the larger proportion also with number.

1. *Dissected and Combination Puzzles.* Nearly all geometrical. A given figure having been cut up into various segments, the experimenter is required to rearrange the fragments so as to form another figure or figures of different character. As already mentioned, the dissected map game and the well-known Richter building block games are analogous to these. There are perhaps fifty puzzles in this group. A single instance:—"Given a Greek cross of card-board. Required by two straight cuts so to divide it that the pieces when united shall form a square." The draft on discrimination, imagination and constructive ability is considerable. Sometimes the problem is purely synthetic; from given fragments, a figure of a specified design is to be constructed. The fragments are often bizarre, and the usual modes of conceiving the figure avail little. In short, the whole procedure is set contrary to habitual modes of imaginative construction. Many of the familiar puzzles with matches also belong here.

Another small group so emphasizes certain aspects of the puzzle

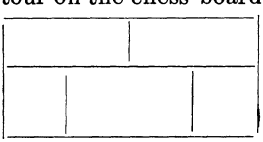
[1]Leibnitz's Letter to De Montmort, July 29, 1715.

quale as to deserve passing mention. One of the most prominent of these is as follows: A rectangle containing 64 small squares of equal size, is to be cut and reconstructed as a rectangle of different dimensions, and containing 65 apparently equal squares instead of the 64. This problem, in a way, gives the key to the paradoxical quality of most of the puzzles of the group. These paradoxes involve the element of illusion, and that in turn depends almost entirely on the inability of the eye to compare correctly the dimensions of figures where their relative position is changed.

2. *Statical Puzzles of Position.* Some of these are not clearly marked off from those of the foregoing group. The element of position is here the distinguishing feature. Number, also, frequently enters. Points, cards, counters are to be grouped in difficult combinations; as, for example, the sixteen court cards are to be arranged in a square. No row, column or diagonal is to contain more than one card of each suit and rank. Tesselation problems, map-painting puzzles, where, with a small number of colors, all the counties of a state are to be so painted that no two contiguous counties shall have the same color. Also many very familiar problems current in advertising literature, as: "How may a gardener plant eleven trees in such manner that they shall form twelve rows, with three trees in each row?"

3. *Dynamical Puzzles of Position.* These involve movement as well as position, and include nearly all the puzzles with counters, all chess and checker puzzles, railway switch and ferry-boat problems, the 14-15-16 puzzle, and many others. The "ferry-boat" problems come down from Bachet and even earlier writers. Of several varieties, the following is one of the simplest: "The captain of a company of soldiers comes to a river. The only means of transit is a boat wherein two children are paddling about, and which is so small that it will only hold the two children or one grown person. How is the transit to be effected?"

4. *Unicursal Puzzles.* A given figure is to be traced without retraversing any part of the route. Mazes, labyrinths, the knight's tour on the chess-board are examples. By formulæ the mazes may be analyzed, and the correct starting-points, as well as the minimal number of strokes necessary to trace the whole figure may be determined beforehand. A well-known simple case of maze is given on the margin. Some have extremely elaborate and tortuous forms.



Logical and Philosophical Puzzles permit of little classification. For the reason, also, that they cannot well be treated apart from their historical setting, they are included in the Appendix within the appropriate historical sections. For somewhat similar reasons Dilemmas of Etiquette, Strategy and Ethics do not appear in this scheme of classification. See Appendix.

The foregoing survey suffices to show the wide range of puzzle materials. It may be safely said that puzzle interest has levied tribute in every domain of culture material.

What marks distinguish a problem as a puzzle, and what is the "puzzle" state of mind? Each of these questions obviously involves the other, and hence both will be consid-

ered in this section. De Morgan defines a paradox as "something which is apart from general opinion, either in subject matter, method or conclusion."[1] A puzzle may be defined as a problem which is apart from the usual experience of the given individual either in subject matter or method. The method, however, is the relatively more important trait. Any problem which fulfills these conditions and which is tried chiefly for the sake of the reaction, and for the solution as such, may be a puzzle. It follows as a necessary corollary that the puzzle *quale* is in part a function of the experience of the given individual. To a mathematician armed with the principle involved, no new form of unicursal problem can possess more than a minimal puzzle element. As previously stated, nearly all puzzles make chief draft upon the more intellectual capacities. And herein lies the possibility of the introduction of every resource by which the mind may be confused and perplexed.

Some are puzzles by sheer superlativeness of intricacy. They bewilder through the multiplicity of alternatives presented. The "*Umfang*" of consciousness is not great enough to take in all the conditions necessary at any stage of the procedure. The complexity of conditions is rendered still more serious through modes of construction, which prevent the usual foresight of the end, and often, also, throw considerable difficulty in the way of mentally registering the steps already taken. A familiar instance is the recent mechanical puzzle "16 to 1." The edges of an almost closed ring are to be worked to the centre of a disk which contains a labyrinth on either side. While the subject is intent upon planning the next move on one side, the difficulties on the opposite side drop from memory, along with the whole plan of this obverse side. The puzzle thus hampers both retrospection and prevision.

Most of the possible devices which may produce *illusion* are found among puzzles. This is a distinctive feature of many. Of the rich variety of modes of this illusion quality, a few are as follows: *Geometrical illusion*. Where an unusual manipulation of a figure produces an effect simply because the geometrical imagination is not able to picture the exact consequences. The illustration, already mentioned, of cutting a rectangle containing sixty-four small, equal squares, so that it may be reconstructed into another rectangle containing sixty-five equal squares. *Illusions of impossibility*:—A wire ring is placed over large wire loops and presented in such a way that the removal of the ring seems out of the question.

[1] "Budget of Paradoxes," Introduction.

Manipulation of the wire loops may quickly modify the general form sufficiently to dispel the illusion. *Illusions of simplicity:*—The task is made to appear much simpler than it is in fact. The result is that the experimenter begins with too little consideration of the conditions involved. In many puzzles the possibility of success or failure is decided by the first step in the procedure. Apparent simplicity, therefore, leads to a premature reaction, and once drawing the mind into the maze produces a perplexity often beyond extrication. This type of puzzle seems especially effective for persons of "explosive type" of will. *Suggestion of false method:*—Of course mere intricacy may have the effect of so clouding the issue that the important features are not easily discoverable. But more definitely to produce this result, many puzzles suggest at every turn a *modus operandi* which always leads to failure. The real method is often veiled with consummate skill. As simple illustrations, may be mentioned arithmetical puzzles which really demand algebraical treatment; many mechanical and labyrinth puzzles.

Search for a general psychological explanation of the above facts brings one to the consideration of the nature of mental reactions. Modern theories of apperception have emphasized anew the truth that the mind acts in more or less habitual ways. It tends to follow lines of least resistance. There are varying degrees of elasticity of these mental habits. At one extreme are what may be termed mental reflexes—with fixed range of routine—analogous in definiteness to spinal cord reflexes. These correspond to certain uniformities in the experience of individual and perhaps of race. At the other extreme are generalized habits with fixed but wide range of plasticity. Witness the habits governing the use of syntax, and the like. These correspond to a considerable variety in the general uniformity of experience. When the mind is confronted by the new, what happens? Those ideas and remembered adaptations which seem to be most closely related to the new phenomenon are called up by association. The law of analogy holds here. Now, if the new suggests analogies to *many* different complexes of ideas, the process of assimilation is checked until one or another complex becomes prepotent. Finally, if the phenomenon is so constituted that it not only elicits many different habits, but also emphasizes unimportant features of its own content as essential, we have the discharge of a reaction which temporarily clears the field. But such an inadequate response usually multiplies the former difficulties, and so there is a new strife of tensions, more painful deliberation, which in time may be eliminated by the discriminative selection of the appropriate

mode of procedure. The progressive discovery of more and more important and vital resemblances or analogies between the new and old, is of course one of the most significant factors in producing successful adaptation.[1]

This is exactly what happens in the puzzle. The individual brings to bear reactions which are not adequate. On the one hand the old habit is attempting to reduce the new to terms of itself. On the other hand the new is waging war on the fixed, the habitual, and thus makes for new adjustments and a higher degree of plasticity. More definitely, many typical puzzles are thus designed, first of all, through wide or simply perverse suggestiveness, to "swamp" the mind with the multiplicity of more or less incongruent trains of ideas and motor tendencies called up. The dice seem loaded against the normal exercise of what James calls "sagacity"—the ability to pick out the essentials and ignore the accidents. For it is obvious that "sagacity," everything else equal, is potent inversely as the number of alternatives presented. Complexity may quickly reach a point where it is impossible for even a Newtonian mind to single out the essentials. Mind, as we know it, "cannot drive the whole universe abreast," but must take it tandem.[2]

To summarize briefly:—In spite of wide diversities of mental experience of human beings past and present, there is also evidence of great uniformity. Every creature shares to a degree in such uniformity, for all inhabit, roughly speaking, the same world. Uniformity and reiteration of experience make for habitual modes of response. The facts of association of ideas and of perception express these uniformities of mental deportment. These fundamental modes

[1] As this is intended only as a rough sketch or scheme of the processes, no account is taken of the processes of judgment, and the like, which certainly enter with deliberation, but which act only on materials which association offers.

[2] Since writing the above my attention has been called to the following from Mach: "A considerable portion of mental adaptation takes place unconsciously and involuntarily under the natural guidance of the facts presented to the attention. If this adaptation has become sufficiently comprehensive to embrace the vast majority of the occurring facts, and subsequently we come upon a fact which runs violently counter to the customary course of our thought without our being able to discover at once the determinative factor likely to lead to a *new* differentiation, then a *problem* arises. The new, unusual and marvelous act as a stimulus, which irresistibly attracts the attention. Practical considerations, or even bare intellectual discomfort, may engender a volitional frame of mind requiring the removal of the contradiction, or a consequent new mental adaptation. Thus arises *purposive* thought, adaptation, *investigation*." "Analysis of the Sensations," Chicago, 1897, p. 159.

of adaptation in men and animals, may be conceived to have survived because, on the whole, more successful than other possible modes. As has been shown, it is not necessary to assume that they have been thoroughly adequate to all experiences with the new. Indeed, if such adequacy existed, the history of human perplexity and the toilsome progress of attempts to penetrate into the unknown would be different from what we find them. Developed first in accordance with the needs of practical life, and in its lower forms adjusted to a narrow range of possible experiences, the unusual and baffling need not be especially complex. It need only present unfamiliar connections of things. Therefore, as we hope to show in the section devoted to experimental data, puzzles largely derive their "*quale*" from the fact that they thus set against the current of natural tendencies and habits.

II.

Puzzle Interest. Questionnaire Results.[1]

In order to secure data for the study of interest in puzzles, a syllabus was issued, containing the following questions, among others.

1. Have you ever been interested in Puzzles, some of the types of which are as follows:

A. *Mechanical Puzzles.* (1) Those dependent largely upon manual control and dexterity, as Pigs in Clover, Spider and Fly, and many others. (2) Those dependent on some trick or secret, as magic match-boxes, purses, money-banks, ball in barrel, key and ring, etc. (3) Those puzzles, as united hearts, interlaced triangles, ball and spiral, links, circles, and the like, wherein the problem is to separate the parts, or to remove rings or loops of cord from wire circles or loops of twine, etc. (4) More complex forms such as Chinese rings, Tower of Hanöi.

B. *Geometrical Puzzles.* (1) Dissected or combination puzzles, analogous to dissected map game, where geometrical forms are to

[1] For the data obtained, the writer wishes to express his thanks to a large number of persons who contributed valuable individual reports, and also to the following, who collected considerable masses of data: Miss Lillie A. Williams, State Normal School, Trenton, N. J.; Dr. Gertrude Edmund, Superintendent of the Training School, Lowell, Mass.; Miss Laura Teft, Superintendent of Kindergarten, and Prof. A. P. Wills, both of the Colorado State Normal School, Greeley, Col.; Dr. Theodate L. Smith, Mount Vernon Young Ladies' Seminary, Washington, D. C.; Principal George C. Purington, Maine State Normal, Farmington, Me.; Prof. Will S. Monroe, State Normal School, Westfield, Mass.; Prof. Noble Harter, Superintendent of Schools, Brookville, Indiana; Superintendent C. L. Hunt, Clinton, Mass.; Principal F. W. Doring, High School, Woonsocket, R. I., and many members of the Association of Collegiate Alumnæ.

be constructed from given fragments; or to cut a given figure into a certain number of pieces so as to produce another given figure, etc. (2) Other geometrical puzzles involving movement and position, as arrangement of counters or checkers in certain forms, arrangement of cards in peculiar squares or other orders in which they possess a unique sequence. (3) Tracing of intricate figures, as mazes, labyrinths. (4) Chess and checker problems. (5) Ferry-boat and railway switching problems. (6) The famous 14-15-16 puzzle, and those of similar nature. (7) Geometrical figures made with given numbers of matches, and the like.

C. *Physical Puzzles.* Where the play is upon some unusual or unexpected effect of well-known physical laws, as those of gravity, equilibrium, motion; blowing a cork into a bottle; removing a napkin from beneath a glass of water without touching or removing the glass; balancing coins, horses,—are a few of the many puzzles of this type.

D. *Arithmetical Puzzles.* Very numerous. Chiefly involve peculiar and unfamiliar relations and properties of numbers.

E. *Quibble and Catch Puzzles.* Also numerous. To give a single instance: how take one from nineteen and leave twenty?

F. *Language and Word Puzzles.* Riddles, rebuses, enigmas, charades, conundrums, anagrams, hidden words, word squares,—diamonds, etc., beheaded words, dropped letters, doublets, and many others.

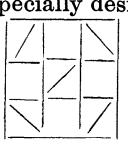
2. When was your interest in any of the above types of puzzles greatest? In what kinds did you find most pleasure? *Did the order or preference change with age, and if so, in what direction?* Please name any puzzles that have lately interested you. Will you kindly name and describe what seems to be the best puzzle you have seen?

Remember that answers in the negative are not without value.

3. When are you, or were you, most interested in working out puzzles—when alone, or during a social evening? Are they ever resorted to as a relief from ennui? Ever as a mental gymnastic, or is the competitive spirit uppermost? Do you usually persist until the problem is solved, or do you give up easily?

4. Do you know persons of pronounced puzzle interests? If so, please state age, sex, temperament; are they usually strong in school work or study? In what kinds of mental work do they seem most efficient—mathematics, physics, literature, etc.? Do they seem especially original or inventive?

6. Please note cases of children proposing more or less original riddles, even in such simple forms as "Guess what I have!" "Guess who!" where the question is clearly put as a poser, and not simply to attract attention. Also any cases of punning, making charades, guess-games, more or less spontaneously entered into by children. Any cases of "stumping" or "daring," where the task is really a puzzle and not merely a feat of strength or courage. The ages of greatest pleasure in riddles, as well as in conundrums and puns, are especially desired.



Trace a figure similar to the illustration without retracing any lines, and without lifting the pencil. Note time required for solution. How many trials before successful? Mark starting-point in each case with a large dot, and enclose the paper in your answer to this syllabus. Any notes on your method will be of value.

9. Is the puzzle-loving mind or state like that of the scientific man bent on solving problems of laboratory or study? Or do puz-

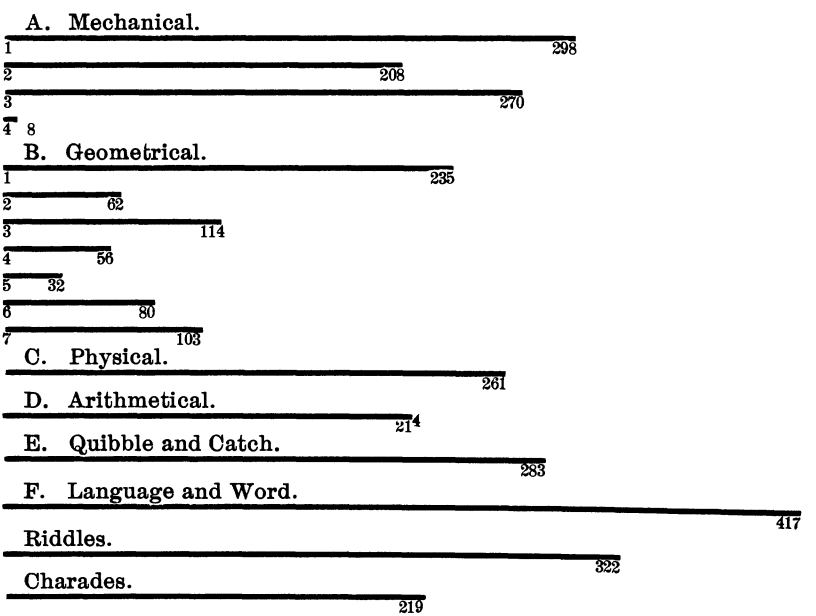
zles cultivate love of unsolvable questions, and make one impractical? Is it in danger of becoming an absorbing passion? What is the educational value of puzzles? Do children ever get nervous about difficult ones?

In response were received 556 reports, many complete, others containing replies to only a few of the questions. Of the 556 papers, 416 were from women and girls, 140 from men and boys. Ages varied from 10 to 40 years. Most of the returns, however, were from pupils in normal and training schools, with ages ranging from 16 to 30 years. Less than two per cent. report no interest in puzzles. A considerable number testify to only a mild interest.

Distribution of Interest. The chart on page 449, based upon the replies to the first question, furnishes a graphic demonstration of the wide variation of puzzle interest. Every mention of interest in any of the types is recorded. Language puzzles are more generally interesting. Next in order come mechanical, quibble and catch problems, geometrical puzzles, etc. Among the sub-classes Riddles lead, while, as A (1), mechanical puzzles dependent largely upon manual dexterity rank second. The prominence of these classes seems easy of explanation. They naturally represent the earliest and most rudimentary aspects of puzzle interest, and appeal to many in whom that interest never becomes a plant of further growth. The "mechanical" appeals probably because the problem is presented in so concrete and portable form. The definiteness of a problem may be assumed to be a condition of its attractiveness, and the delight in physical activity may be a motive. Children often value physical activity above mental activity. The delight in perception of motion also has strong influence with the same. Several children said they liked to watch the "pigs" move in "Pigs in Clover." In such puzzles the object is sometimes a drop of mercury, which has strange fascination. Had a larger number of men been represented in the above report, the relative importance of the mechanical type would doubtless have been much accentuated. As it stands, the first three sub-classes of *A* rank high. The Riddle, as indicated elsewhere, reveals a very fundamental and universal aspect of mental activity and human interest. Its very early beginning, and its perennial and permanent charm for many, render it one of the most significant of all the types of puzzles. Quibble and catch problems, while taxing and stimulating mental alertness, also often possess an element of humor of the crude sort. The prominence of many of the geometrical types seems largely due to their concreteness and to the constructive interests of the young. The earlier

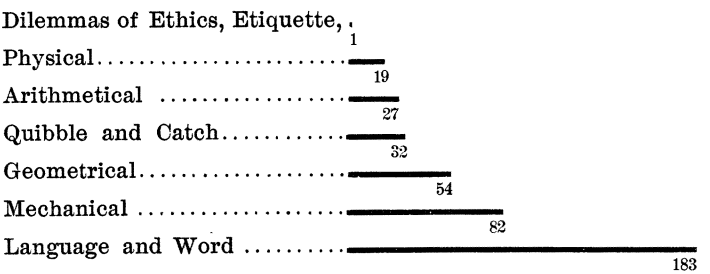
interest in geometry, as compared with number, as shown below in the curves of puzzle interest, suggests important pedagogical applications. Two classes, Logical and Philosophical, and Dilemmas of Etiquette, Ethics, etc., naturally did not find many devotees among persons of the ages of most of those reporting, although many confess to great interest in dilemmas of a personal nature, without being able to offer concrete illustrations. A few of the cases described are here given:

F., 20.—Specially fond of dilemmas of a personal nature. *F.*, 17.—Always interested in these. Remember one when quite small. Picture of man unarmed crossing a stream on a log. On his left a huge hippopotamus, on his right an alligator, behind a tiger, in front a great python. I pondered over this, trying to find some way to save him, but finally decided he must die, and thought if I were in his place I would choose the snake-bite, as that would not hurt him so much, and then I thought there was a possible chance of his jumping by the snake. *F.*, 17.—Interested in picture of ship in storm. Man overboard; large fish coming towards him. How save the man. *F.*, 20.—Very fond of scenes in books which involve dilemmas, as, where Enoch Arden returns home. In Silas Marner, etc. *F.*, 17.—Wonder what I would do if placed in an awkward position. *F.*, 18.—Interested when several persons are together to discuss them. *F.*, 18.—Very polite major bicycling with two ladies as rain began to fall. Lady Maud said, "I shall go back." Lady Mary said, "I shall go on." What did the major do?

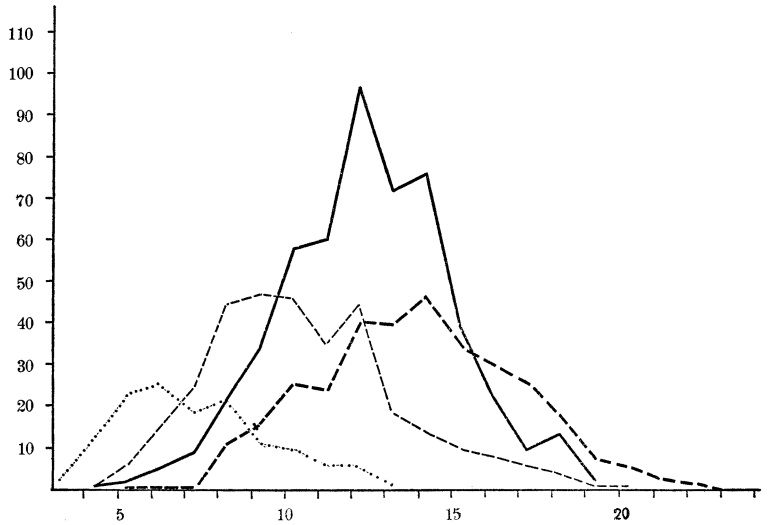


Cases of Special Interest. In examining the returns there appeared many instances of extreme pleasure in a certain kind of puzzle, an interest which, in most cases, did not later shift in full intensity to those of any other type. The appended diagram indicates the great predominance, in this respect, of language puzzles. It must be kept in mind, however, that the majority of those reporting are women. The number of persons represented is 286, some appearing more than once in the record where a new group of puzzles was taken up with the old interest.

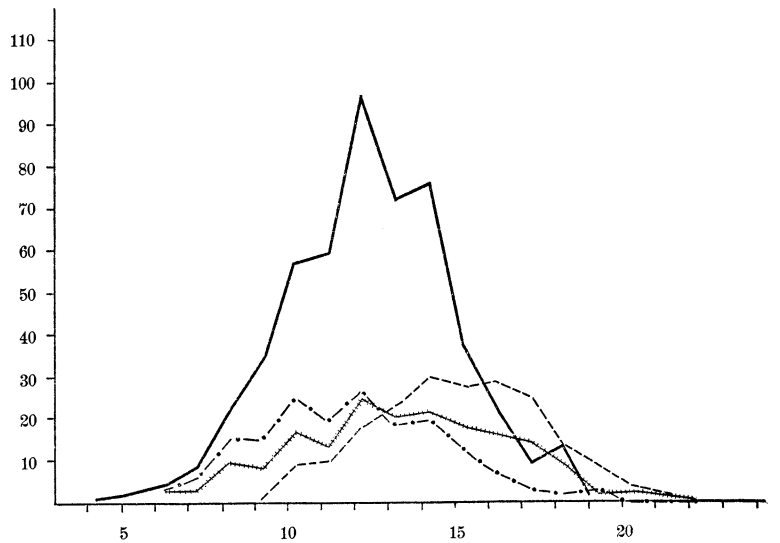
THE PUZZLES IN WHICH THE GREATEST PLEASURE IS TAKEN.



Age of Greatest Interest. The following diagrams contain not only the curve of greatest general interest, but those of the greatest interest in many of the different types. The "general" should, of course, include all the others but the incompleteness of data has prevented. For instance, some persons report only age of greatest general, while others give only age of special interest. All those, furthermore, who give but one terminus to their period of greatest interest in general or in particular, could not be included. Cases of persons of pronounced interest among those much older than any represented in the curves, suggest that the curve should not approximate so closely to the base line from 17 on. The sharp breaks are due largely to preference for even numbers in reporting. The summit of the theoretically correct curve would probably be at 11, 12 and 13. Among details of special curves, guess-games and simple riddle-making begin earliest, say, at 3 years, and reach the highest point from 5 to 8. Riddle interest proper, beginning at 4, culminates at 8, 9 and 10. Language puzzles, exclusive of riddles, are most in favor from 12 to 15, while arithmetical, beginning about 9, reach their height from 14 to 17. Geometrical, of simplest forms, similar to building-blocks and dissected games, appear at 6, culminating at 11 to 14. The curve for mechanical puzzles has a much more symmetrical form, but the cul-



Curve of General Puzzle Interest, 150 persons.
Curve of Greatest Interest in Language Puzzles, exclusive of Riddles, 78 persons.
Curve of Greatest Riddle Interest, 108 persons.
Curve of Greatest Interest in Guess Games and Original Riddles, 121 persons.



Curve of General Puzzle Interest, 150 persons.
Curve of Greatest Interest in Mechanical Puzzles, 65 persons.
Curve of Greatest Interest in Arithmetical Puzzles, 60 persons.
Curve of Greatest Interest in Geometrical Puzzles, 53 persons.

mination is reached considerably earlier, say from 10 to 13.

The above curve, of "greatest interest," manifestly can only be roughly representative of the facts. The data are not sufficiently accurate to indicate a difference between the sexes in this regard, a difference which probably exists. But allowing for obvious sources of error, the curve indicates, with a high degree of probability, that the culmination of the puzzle aspect of the mental play instinct falls in the immediate prepubertal stage of growth. It marks the close of the period just preceding adolescence. Curiously enough the culmination coincides with the period of highest "specific intensity of life"— that is, the period when "children attain and pass the flood tide of growth and of their vitality, as measured by their power to resist death."[1] "In respect to specific intensity of life, that of girls maintains a relatively high level from 9 to 12, inclusive, culminating at 11 to 13, while that of boys maintains a high level from 10 to 15, having its culmination at 12 and 13.[2] The greater surplus of energy at this period may be one reason for the greater puzzle interest. But most important is the neurological evidence. With decrease in rate of growth of bulk of the brain at about the 9th year, at which time its weight is not far short of what it is to be throughout life,[3] it is fair to assume *a priori* that the systems of cortical association fibres now begin to develop more rapidly. And, indeed, Wernicke states that at about the 12th year there is a marked increase in the medullation of these fibre-systems, which must be present before there is great activity of reason.

Experimental data concerning growth of reasoning power, though, as yet, all too meagre, furnish corroboration for the above neurological assumption. Hancock[4] finds ability to solve arithmetical problems to vary with the rate of growth. Girls show a decreased rate at 9 or 10 and 13; boys at 8 and 14. The 12th year in both sexes is therefore a period of rapid improvement. Mrs. Barnes[5] finds the power "of legitimate and imaginative inference" to have strongly developed at 12 and 13. "On the critical side the power is rare, but when present, clear and strong from the age of thirteen and upwards." Such evidence, whatever modifica-

[1] Hartwell: "Report on Physical Training," Boston, 1894, pp. 50-51.
[2] *Ibid.*, p. 51.
[3] Donaldson: "Growth of the Brain," New York, 1895, p. 104.
[4] J. A. Hancock: "Children's Ability to Reason," *Ed. Rev.*, 1896, pp. 261-268.
[5] "The Development of the Historical Sense in Children," Part I, *Studies in Education*, No. 2, p. 52.

tions later researches may impose, points to a rapid and considerable expansion of "elaborative" mental processes in this period. It is thus an intellectual age par excellence.[1]

Now, as to the general relation of puzzle activity to this prepubertal period, the following tentative explanation is offered: The culmination of boyhood and girlhood witnesses the individual comfortably adjusted to his environment. Ideals have changed only slowly. New interests have not intruded abruptly. "Being a boy" or "being a girl" has, in short, become easy, and the energies are not all taxed to maintain the equilibrium of life. Thus a mental surplus which expends itself in play. Adolescence comes with its vast enlargement of horizon. As by a leap the boy has approximated to the stature and many of the ideals of a man; the girl those of a woman. The feeling of mal-adjustment, the strain of adaptation to the new and strange demands which crowd one another, may well call out all the reserve of mental and moral strength; and in the "*Sturm und Drang*," intellectual play languishes.

Furthermore, may not this prepubertal intellectual play activity bear direct propædeutic relations to adolescence? The resulting flexibility of mind, due to the breaking up of narrow modes of thought, and the accompanying increment of gain in strength and poise of intellect and will, may help somewhat to mitigate the dangers of the "new birth." While such a suggestion is, as yet, almost wholly speculative, it seems probable that more intimate knowledge of adolescence may show that in spite of its apparent abruptness, the organism has long been gathering its forces for such a crisis.

Change of Order of Preference with Age. The obvious facts are: (1) That order does change with age. (2) The change is from the simple to the more complex forms. (3) Riddles, Rebuses and simpler Charades give way to the Conundrum, Enigma, Word Square, Hidden Words, and the like.

No typical order is derivable from the data. Wide individual differences prevail. The following order seems, however, roughly true for the largest number of persons: (a) Riddles and simpler forms of Mechanical Puzzles. (b) Charades, Conundrums, Quibble and Catch Puzzles, simpler forms of Geometrical Puzzles. (c) Arithmetical, more complex Mechanical, Geometrical, Language. (d) Logical and Philosophical. Dilemmas of personal nature.

In reading the returns it was impressive to note the logical development and the growth in mental versatility indicated

[1] Twelve is the age when Rousseau would have Emile, after the years of freedom from restraint, put under formal tuition.

in the shiftings of interest, as age increases. The Riddle, Rebus, Charade and simple Mechanical Puzzles, which, at most, call into exercise only the crudest and simplest logical methods, gradually, but perhaps not uniformly, yield to greater complication and refinement of procedure in the Word Square, and the like, with their more sustained and definite use of inductive and deductive processes. In complex Mechanical, Arithmetical and Geometrical problems, not only is procedure more involved, but the value of increased mental span, of improved geometrical imagination, is much in evidence. With age, the increase in value of "information," or knowledge, for successful solutions, notably of Language Puzzles, is also marked.

Original Riddles and Guess Games. This category belongs so largely to games, rather than to mere puzzles, that it seems best to give to it separate consideration. Here one glimpses the incipience of the originating and the inventive faculties in a somewhat striking way. The appended records furnish a better picture than would any description:

F., 9.—Little girl, has made up a half-dozen very good riddles. *F.*, 6, 8 and 13.—Very fond of making up riddles. Will sit by the hour and give riddles to each other. *F.*, 12.—Composes the names of "hidden trees" and other hidden words. *F.* and *M.*, 9.—Children of this age greatly interested in riddles. Will spend nearly all the noon-time intermission at school in telling and trying to guess riddles. Nearly all boys. *F.*, 5 and 6.—After looking at picture-book, one said, "Now let us play; you take the book, and I'll guess what picture you turn to." *F.*, 8 and 9.—In the evening the little girls would sit on the lawn and play a game, such as, "I see something beginning with O.; what is it?" When raining would play charades. *F.*, 5 and 6.—I'll guess what picture you turn to. *M.*, 6.—Very fond of having person guess any problem he may put. Gets angry if some one does not guess. When he has heard a riddle will apply the same conditions to some other object, and then is much vexed when laughed at. Instead of saying, "What is it a wagon cannot go without, and yet is not necessary to it?" W. B. might say, "What is it a lamp cannot go without?" *M.*, 8.—Likes riddles, and never so happy as when some one will sit down and amuse him with such questions. Having heard, "What has eyes and cannot see?" he made up a riddle, "What has feet and cannot walk?" Answer, a table. *M.*, 8.—Made up riddle, "Why is an apple round like an orange?" *F.*—Guess color, the initial being given, or person's name. *M.*, 4.—Hands behind back, "I've got something round and green, with a hard coat inside the green. Guess what it is?" Answer, walnut. *F.*, 6.—Often goes out of the room, wraps things up, and then will come in saying, "You can't guess what I have here." *F.*—"Guess what I have?" "Guess where I'm going?" etc., are a few of many forms of problems, mostly given, perhaps, for the sake of attracting attention, but occasionally through real desire to put a problem. Children usually prefer to set the problem for others; some, however, have a passion for answering. The passion for dramatic action also finds frequent expression in their delight in charades, many cases of which are reported. A single instance: *F.*, 17.—When

11 or 12 years old, my schoolmates and I were very fond of charades. Saturday afternoons we would arrange curtains, dress to represent different characters, and spend whole afternoons acting charades. Another reports, when 6 or 7 years old, playing charade. In one a snake was represented by the children lying on floor and crawling in imitation of snake.

Some of the Motives and Conditions favorable to Puzzle Activity. Of 419 who answered Question 3 of the syllabus, 189 prefer to be alone when working puzzles; 22 sometimes like to be alone, sometimes prefer trying in a company; 224 are most interested in puzzles during a social evening. With many, the desire to work alone is evidence of greater interest. Some say they prefer to try the more difficult ones away from the distraction of companions. The significant fact here, however, is that almost half the total number reporting prefer to try puzzles alone. This number includes nearly all those of "pronounced interest." The replies to the following questions were vague and unsatisfactory: "Are they (puzzles) ever resorted to as a relief from ennui? Ever as a mental gymnastic or is the competitive spirit uppermost?" Many seemed unable to tell why they attempted to solve puzzles. But the results, such as they are, yield the following statistics; 67 say they resort to puzzles as a relief from ennui; 47 as a mental gymnastic; while 165 find the competitive spirit to be stronger than the above motives. Many of the above 165 are persons of no great interest in puzzles. The interest in such cases is by contagion and imitation. The desire to work alone, and for the pleasure of the work, which is predominant in those who testify to a marked puzzle interest, strongly suggests some of the conditions of scientific research, which often needs to be unsocial and for the love of the work, in order to be most effective.

In response to the last question, "Do you usually persist? etc.," a large majority claim to persevere. But most important of all the facts discoverable in the responses to the question, as to motives, etc., are the persistence and tenacity with which a puzzle bids for attention, and holds it. The problem often needs to be examined in a most casual way, and for the briefest time, in order to cramp the attention and give to the relevant ideas, together with desire to solve the problem, many of the features of a fixed idea or dominant impulse. Nothing perhaps more strongly evidences the instinctive substrate of puzzle activity. The following are a few of the cases which have called attention to this point:

M., 38.—"I dislike puzzles extremely. But if I 'fool' with one for a little while, it seems to challenge me, to 'dare me' to work it, and I cannot 'let go' until it is solved. On one occasion, I was busy in conversation in a store, and my hand and eye accidentally

and automatically became engaged with the 'Tower of Hanöi.' Before I fully realized what it was all about I was deep in the attempt to solve it."

F., 17.—"I generally lose patience the first time and put the puzzle away then. I take it up again in a few days and try at different times until I get it."

F., 13.—"Have often become disgusted with puzzles and tried to push them aside, but they would remain in mind and bother me so much that I would be compelled to go and finish them."

F., 17.—"Generally work until I get the puzzle. Always feel uneasy if I don't and can't settle my mind on anything else."

F., 14.—"If it takes two or three days, I work till I get it."

F., 14.—"Usually persist until I get angry with puzzles. Then I will put them aside for awhile, but invariably take them up again."

Pascal somewhere says that men strive to accomplish difficult feats in a game, in order that they may boast of it to their friends. That the competition motive also accounts for much play activity needs no further evidence, but in view of the considerable number who solve puzzles for the mere pleasure, who may not even have in mind the gymnastic value, there is ground for the belief expressed in the opening chapter of this study, that puzzle activity is an expression of an intellectual play instinct. Any number and all varieties of conscious motives may cluster about the activity, but the instinct furnishes the initiative, and brings it about that puzzles are a congenial exercise.

Opinion Concerning Educational Value. In answer to the question, "What is the educational value of puzzles"? a wide variety of responses was received. Nearly all, however, ascribed greater or less value to puzzle activity. A few considered it harmful or useless. The pooling of opinion results as follows: Heading the list of those capacities which are thought to be improved by such exercise, stands reasoning or thinking. 37 persons say puzzles make one a "good thinker"; 72 persons say it cultivates "reasoning faculty"; 18 emphasize "accuracy of thinking"; 19, "trains one to think quickly"; 31 specially urge that it develops "tenacity, perseverance, patience"—as one writer put it, "it gives a moral training"; 35 mention its value in developing "power of concentration"; to 25 it has great value as "general mental discipline"; 19 mention that it trains the "power of close observation and accurate perception"; 13 mention it as a valuable "memory training."

Although such a consensus can have only suggestive value, it must be said that many of the above opinions are from teachers of long experience, many of whom write from personal observation.

The almost unlimited range of puzzle material, and what is more important, the range of capacities which may through

them receive valuable exercise, reveal the thoroughness with which the intellectual play impulse is equipped to do its work in producing versatility. While most puzzles represent odd and unusual modes of presenting a difficulty, they nevertheless deal with the fundamental principles of the sciences from which their material comes. A well arranged series of arithmetical puzzles would induct one into an intimate knowledge of the more important properties of number. Geometry might well be largely appropriated in the same way. Moreover, the forms of illusion and distraction which make the puzzle quality are such as one must experience in ordinary dealings with the new. Puzzles tend to emphasize the usual sources of error into which the mind is prone to fall in its every-day experiences. In such facts as the above rests security from wasteful use of energy. So impressed with the value of the puzzle was Chalotois, a French royal commissioner of education, that in his "*Essai d'éducation nationale*," published 1763, he wrote as follows: "I take it for granted that a child already knows how to read and write, and even to draw; these are necessary. I think that the first things which should occupy him from 5 or 6 to the 10th year are history, geography, natural history, *physical and mathematical recreations*,—knowledge which is within his reach because it falls under the senses, because it is the most agreeable and consequently the most proper to occupy the child."

Cases of Pronounced Puzzle Interest. Had the correspondents, who themselves possessed pronounced puzzle interest, added their own cases to those reported under this head, the number would have been greatly augmented, perhaps more than doubled. As it stands, 128 such persons are reported, of which number 36 are women and 92 men. Distribution as regards age shows 97 to be 24 years or less; 24 from 24 to 48, and 23 from 50 to 80 years. 90 of 109 are reported to have been studious and proficient in school work. Some of the remaining 19 were reported as bright, but not interested in school work, while a few were positively dull. One city school principal writes that the majority of those in one of his classes, who solved a given puzzle most readily, were among the weakest in school work.

Among the subjects in which persons of pronounced puzzle interest are said to be most efficient, Mathematics is mentioned in 62 cases; Literature, 20; Physics, 17; Mechanics, 5; Drawing, Language, Music and History, each 3. Some, of course, excel in more than one branch. As to originality and inventiveness, 82 are reported as one or both, while 18 are neither inventive nor original. The words are

evidently used in a somewhat ambiguous sense, occasional returns showing that originality may consist in the simple ability of dazzling others with novelties, in the way of tricks, etc. Nevertheless, considerably more than half the whole number can be safely credited with real originality, though in varying degrees. Some have done creditable literary work; others are successful inventors. The temperament in only 32 cases is reported, but even these data are sufficient to prove that not only the nervous and sanguine, but also the bilious and phlegmatic may possess remarkable interest in puzzles. Below are some of the cases:

M., 10.—Bright in mathematics, but poor speller. Constantly working at puzzles, riddles and rhymes. Very original and inventive. *M.*, 12.—Very fond of puzzles. Will not give up until he can do it. Very inquisitive. Asks the "whys and wherefores" of all machinery he sees. Inventive, but poor in school-work. *F.*, 9.—Greatly interested in puzzles of all kinds; sometimes makes puzzles out of picture cards, etc. *M.*, 10.—Originated some kind of puzzle with strings—a very good one, too. When younger was very fond of guess games. *M.*, 12.—Tries for puzzle prizes. Very persevering temperament. Fond of arithmetic, specially original and inventive. Remarkable child. *M.*, 13.—Fond of puzzles, and quite successful. Not very strong in school-work, but passionately fond of reading. Power of invention marked. *F.*, 15—Spends much time solving puzzles and making puzzles for magazines. Best in arithmetic. Very skillful at making things about house, being very original and inventive. *M.*, 15.—Often made puzzles for his own use. Has a book of puzzles. If he sees a good one, he will cut one out of wood for himself. More interested in physics than in any other study. *F.*, 16.—Long an invalid. During this period delighted in puzzles, original. *M.*, 15.—Fine at anything mechanical, yet not a particularly brilliant scholar. Not specially original in thought, but extremely so in practical affairs and construction. *M.*, *M.*, *F.*, 17-21.—One family. Girl almost entirely deaf and has been nearly blind. Not good in school-work; exceptionally dull at all kinds of work. Takes to music pretty well, but that is all. Poor readers, but enjoy games, riddles and puzzles. Not original. *M.*, 18.—Very queer, not very bright nor studious, but a good typesetter. Always trying something new, but seldom succeeding. *M.*, 14-18.—Peculiar temperament, no business ability, no interest in school, but great reader; best in literature; neither original nor inventive. *F.*, 10.—Would give herself up completely to puzzles, until they were taken away. *M.*, 14.—Would work for hours on a puzzle, but could not put his mind to the most simple problem in arithmetic for five minutes. Actually stupid at some things. Far behind class of pupils of his own age. *M.*, Adult—Fond of mathematical puzzles, strong in mathematics, and has done some very creditable work in literature. Not specially original or inventive. *M.*, 60.—Scholar. Especially original thinker. Never gives up a puzzle when once begun. Daughter inherits his love of puzzles and works at them with some energy. *M.*, 36.—Always prided himself on his puzzle collection and on his ability at chess. Good in arithmetic and a great reader, but seems weak-minded or crazy on mining. Not the least original, inventive or

practical. *M.*, 50.—Believe he would neglect his meals any time to work out a puzzle. Very intellectual, shrewd in business, fond of study. Specially original. *F.*, 30.—Invalid. Unusually strong mind. Fine student. Omnivorous reader. Comes of a family of inventors, and seems to inherit some of it. *M.*, 25.—As a boy I have often gone to his house on rainy days, and found him making and solving puzzles of string and wire. No interest in school-work. Specially original and inventive. *M.*, 29.—Extremely fond of puzzles. Most efficient in reasoning logically and thoroughly. Extremely original and inventive. Spirit of investigation wonderful. Devoted to experimentation and devotes most of his spare energy to it. *M.*, 52.—Minister. Especially strong in literature. More original than inventive. *M.*, 22.—Whole family very quick at puzzles. Excellent in drawing and mathematics. Is now a draughtsman. Has devised and patented several puzzles. *F.*, 17.—Whole family exceedingly interested in puzzles. Enjoying making and inventing puzzles. Every new visit to their home reveals some new puzzle which they want you to try.

M., 22.—Has a perfect mania for chess problems. I have seen him go off by himself at a picnic to work such problems. Is a professor of mathematics. Do not think he is specially original or inventive. *M.*, 28.—Cannot read at all. Solves puzzles of all kinds and seldom fails. Specially original and inventive. *M.*, 50.—Tries each new puzzle as soon as it comes out. Very bright, well-read man.

F., 70—It has been a serious question whether I have not foolishly spent a great many precious hours in the last sixty years which might have been more profitably employed than in solving charades, anagrams, enigmas, etc.

In a way it may have had an educational value, but that was not my *object* in doing it. It has been for *pure enjoyment, recreation* and FUN, and I have got lots of each of them out of it. I *do* think it quickens the perceptions and keeps the mind active. It has led me to study in the direction of history, biography, literature, mathematics, astronomy, and mythology, not for the sake of the *information*, but to find solution of a puzzle. I cannot remember the time when not interested in these things, and interest increases rather than diminishes with years. I best enjoy solving *alone*, as I want no hint of solution and want all the *time* necessary. Numerical enigmas interest me very much. I have learned more of Bible geography, biography, feats of valor, words of wisdom, numbers, as "enigmas of forties or of sevens," from this kind of enigmas than I ever did from consecutive reading. Very few names or places in the Bible seem unfamiliar. For years a column in ——— was devoted to Biblical enigmas, which I never failed to study out, some having as many as 150 or 200 letters, and the whole being some passage or passages of Scripture.

In later years, have enjoyed anagrams very much; only last month sent in solution for a prize; conundrums and puns do not appeal so strongly to me; mechanical puzzles I like, but they tire me; I get nervous if I cannot see through them. Only yesterday I came across my "Pigs in Clover," and stopped all work till I had them in the pen. I never stop at a railway station where there are handbills, without taking some prominent word and trying how many words I can make from it. I can get few persons interested in this; have one brother and a niece who enjoy it as much as I; another brother cares nothing about it; not inherited, this interest; don't like studies requiring memory chiefly, but like anything I have to *dig* out.

M., 45.—Nervous; mechanical genius, an inventor with notions and hobbies. *M.*, 44.—Nervous; inventor; they say he has never failed to work any puzzle; designer, draughtsman, inventor and practical mechanic. The puzzle characteristic is peculiar to his family, and they all have mechanical skill, ingenuity, but little business ability. I am convinced that "puzzle" ability goes with inventiveness, mechanical skill, etc. Men excel; they excel in mathematics, physics, etc.

In a sketch of the late Prof. Sylvester, the great English mathematician, published in a recent issue of the New York *Post*, the following statement appears: "Prof. Sylvester was all his life long, down to his latest years, an indefatigable solver of exercise problems, such as are proposed in the *Educational Times*. He considered them an indispensable whetstone of the wit; his whole style of analysis carries the marks of such exercise."

The significant points, in résumé, are that the puzzle interest may endure throughout life; that, on the whole, persons of pronounced puzzle interest make a favorable showing intellectually. Most are interested in every-day problems, and succeed in practical affairs; they certainly stand high for originality and inventiveness. Is this sustained puzzle interest different in kind from that which marks the prepubertal period? With the insufficient data at hand, no satisfactory answer can be made. With some individuals, it may well be an abnormal persistence of tendencies which should have fallen away long before the individual had reached maturity. But in others, as in Prof. Sylvester, the play instinct has been fostered, apparently because it served the purpose of intellectual gymnastics. Among very old people of leisure, it may be a veritable recrudescence of play activity.

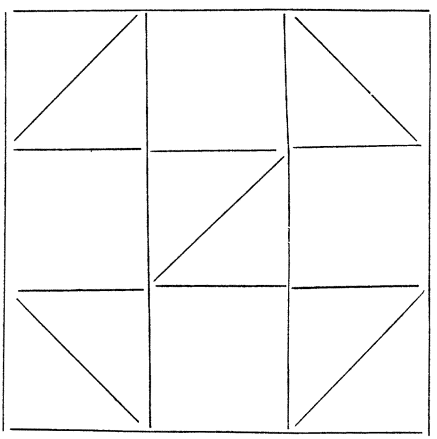
Summary.—The most salient facts concerning puzzle interest are as follows: The interest is fairly general among young people; interest is distributed over a wide range of puzzle materials. Of these, the mechanical and language groups are most popular; puzzle interest shifts with age. In general the change is from Riddles, and the simple Mechanical and Geometrical Puzzles, to more complex forms of the Language, Mechanical, Geometrical, and also Arithmetical types; the age of greatest general interest in puzzles is about 12. No difference in this respect as regards sex is discoverable. This prepubertal stage is probably marked by rapid development of the elaborative mental processes, and may be denominated as largely an intellectual epoch; puzzle interest may persist throughout life; most persons of pronounced puzzle interest seem original and inventive, and are not as a rule unpractical.

III.

EXPERIMENTAL.

For the purpose of making experimental determination not only of methods of solving puzzles, but chiefly of the development of mental adaptation in general, the following problem was submitted to children in the schools of Worcester.[1] These results were, in turn, compared with those gained from tests upon adults.[2]

The puzzle used belongs to the unicursal or labyrinth types and was devised by Tait. An illustration is here appended.



This puzzle was chosen mainly, because: (1) The problem is sufficiently difficult of solution to require a number of trials. (2) The instructions as to procedure are easily followed. The subject is required merely to trace all the lines without lifting the pencil and without any retracing of lines. A sheet containing twelve reproductions of the

[1] These tests were rendered possible through the courtesy of Superintendent Carroll and the school authorities of Worcester. I was assisted in the supervision of the experimentation by my wife, and by Mr. E. W. Bohannon of the University. The work was also greatly facilitated by the cordial coöperation of the principals and teachers of the schools above specified. The generous and able assistance of Miss Emily Viets in a series of valuable preliminary tests in the kindergarten of the Salisbury street school deserves special mention.

[2] The experiments outside the University were conducted at Providence by Dr. Hattie E. Hunt, of the Training School; and at Indiana University by my friend and honored teacher, Dr. W. L. Bryan. Their important contributions are gratefully acknowledged.

design, eleven of which were in broken lines, the other serving as a model, was supplied. When the subject had failed on one figure, he was required to try the next, and so on, taking care to mark the starting-point each time in some distinguishable way.

The figure is so constructed that the place of beginning is of prime importance. There are only two points from which successful movements may start, and these are on the inside of the figure, at the termini of the middle diagonal.

The mathematician Euler developed a formula for such figures, and for one conversant with his rules, this problem offers no real difficulty. Using such a mathematical analysis as a norm, it may be assumed, a few chance successes apart, that all cases of failure are due to an inadequate conception of the problem. So it might be possible to arrange in a series all analyses of the design, according to the degree of adequateness of conception. So much for the purpose and import of the problem.

After a series of preliminary tests upon members of Clark University, the experiment was made in the third, fifth and eighth grades of the Oxford street and Elizabeth street schools, and in the third, fifth and ninth of the Woodland street school. A later series of individual tests was made at the Salisbury street school, also on teachers of the schools of Providence, and lastly on advanced students in psychology at Indiana University. These individual experiments will receive separate consideration.

Mass Tests.

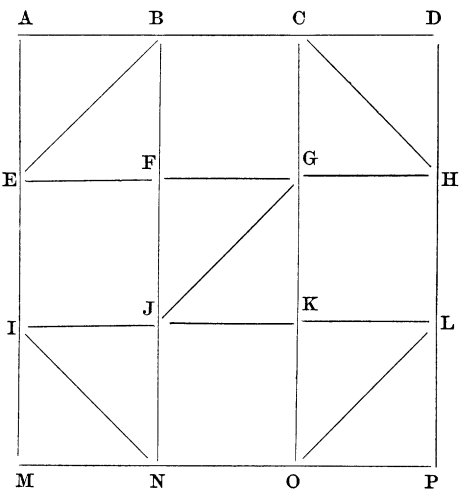
At the first three of the above-named schools, the problem was given to all the children in a room at the same time. They were furnished with uniform papers, were given explicit directions, and were more than once reminded that they could begin anywhere they chose. Twenty minutes was the allowed time. If a pupil thought he had succeeded he made the fact known, and the time required for solution was recorded. The total number tested in these mass trials was 471, distributed as follows: 169 in Grade III, 154 in V, 61 in VIII, 87 in IX.

Almost without exception the children entered into the problem with great interest, and there is every reason to believe that most of them made every effort to solve the puzzle. Participation in the test was entirely voluntary in every case. Most of the children voted that they liked puzzles, and many wished to continue after the expiration of the allotted time. There were some failures to follow the instructions, not only in the lower grades, but sometimes in the higher. In the

first series, in Grade III, Oxford street, the children were allowed to decide for themselves when they had solved the problem. On inspection many had omitted lines, and some were greatly surprised when the fact was pointed out. Others plainly had lifted the pencil in order to escape failure, while still others had retraced certain lines. As most of these mistakes seem to have been made without intent to deceive, observations were made on further cases of like kind, and will receive consideration below. After this experience the instructions were made still more explicit, with the result that the proportion of errors of this nature in later tests was materially reduced.

Results. From these mass tests only qualitative results of the more general kind were expected. The average number of trials does not greatly vary with age, although the younger children show a slightly greater number. The circumspection with which pupils proceeded increased noticeably up the grades. The youngest children worked rapidly, and failing, passed quickly to the next figure. While this was also true of some in the higher grades, it was nevertheless patent that these pupils exercised more deliberation, and there was a greater attempt to analyze the figure and to determine the causes of failure. While it is impossible to make a precise quantitative statement of the increase in *variety of attack* in the higher grades, this fact was most prominent. The younger children, with few exceptions, show little ability to profit by their errors. They either began in the same place in many successive trials, and seem to have repeated their former unsuccessful movements again and again, or their variation was too slight to be of consequence. In Grade V there is a smaller proportion of these automatic repetitions, while in VIII and IX they had still further decreased, although it must be noted that such cases occur even among adult subjects. As regards ability to profit by errors: In case of a few pupils of Grade III, and in still larger proportion with those of V, more marked variations are produced by a former error. The new movement shows vague appreciation of the total conditions of the problem, and there is less focusing on single lines than calculation of the effect of moves on several lines. In VIII many show radical reconstruction of order of moves, following failure, and usually the *adjustment is prompt.* In V radical reconstruction does occasionally occur, but more slowly. It appears that among younger pupils, error must be repeated before its full significance is appreciated. With age, the movements seem more and more directed by deliberation and fuller realization of the conditions of the problem.

Conventional Reactions:—Examination of the nature of the beginnings in the separate trials brought forward some facts of interest. All subjects were explicitly told to begin wherever they chose, and among the younger children the reminder was repeatedly given. In spite of this, however, the beginnings are of a very conventional sort.



In the figure here given the junctions of the lines are lettered, for convenience in indicating various parts of the figure. Barring a few cases, where beginnings were made in the middle of some line, these junctions represent the range of starting-points. If the "dice were not loaded," the starting-points would be distributed equally among 16 positions. As there are 4 inside and 12 outside points, 75% of the beginnings, on such an assumption, should be on the outside.

Results:—The percentage is too great in favor of the outside among the younger children, and too small among the older. In Grade III, 87% of *all beginnings* are on the outside; in V, 83%; VIII, 73%; while in IX only 68%. For adults only 61%. In only a relatively small number of cases is the starting-point of the first trial on the inside. A view of the distribution of beginnings among the various outside points throws yet more light on the question. As to beginnings in upper left-hand corner: In III, 41% of all beginnings were at *A*: V, 29%; VIII, 22%; IX, 15%; adults, 10%. Furthermore 57% of all beginnings are somewhere on the top

tine *(A, B, C or D)*, while only 10% were on the bottom line *(M, N, O, P)*.

Now, if we consider the *number of individuals* who begin at any given point, we find that 57% of all persons begin sometime at *A*. In Grade III, 66%; V, 66%; VIII, 45%; IX, 43%; adults, 36%. When the construction of the puzzle is recalled, and especially the fact that only beginnings at two inside points can possibly lead to success, this predominance of outside starting-points, notably among the younger children, is of considerable significance. It shows that children are probably under the sway of a deeply set habit, learned from reading, writing and drawing. This leads them to begin at the top and generally at the upper left-hand corner of the design. Failure is not effective in inhibiting this tendency. In older pupils and in adults this tendency seems, in part, overcome by other conditions, although it still exists. Their range of experience is wider, and hence the predominance of any one fixed tendency is minimized.

Furthermore, these beginnings throw some light upon the perception of the figure. Very many of the youngest children invariably went round the square, suggesting that this form, which is at once most familiar, and so placed in the design as to constitute the outline of the whole, catches the attention and holds it at the expense of the other possible combinations of form. This view is corroborated by the testimony of adults, namely, that first trials were often haphazard, preceded by little analysis of the figure. This, together with the general absence of deliberation in children, would seem to prove, pretty conclusively, that nearly all first trials, at least, are not planned, and hence the outline of the figure, and the usual method of drawing, are all the more potent in determining procedure. Still another fact points to the rôle of these habits. Many who studied the figure discovered the error of beginning on the outside, by their inability to dispose of the inner diagonal. This usually suggested that the diagonal be disposed of first, and hence beginnings on the inside were almost imperatively indicated. In spite of this difficulty, however, one which nearly every subject must have experienced in some degree, the outside initiative still tended to persist.

Individual Tests.

In order to observe more exactly how far age influences capacity to vary effectively, to profit by errors, a series of individual tests was made on pupils of the Salisbury street school. Of a total of 64, 11 boys, 10 girls were from Grade III; 11 boys, 12 girls were from V; 11 boys, 9 girls from

VIII. Both boys and girls were chosen in alphabetical order. They were brought into a room in groups of six, and two children were assigned to each of the three observers. They were given instructions as above described, and the observers attempted to record each move made in the attempted solution. While it would be highly desirable to make a quantitative formulation of results, the complicated conditions prevent. So many are the possible permutations, so diverse may be the causes of any slight change, and so unequally effective in altering the picture of the whole is such a variation, depending on whether the change comes near the beginning or toward the close of the trial, that in view of all these difficulties, resort must behad to the clinical method of presenting typical cases. The following seem as nearly representative, as possible, of their respective grades. In the tables a sufficient part of the total movement in each case is given to convey a fairly accurate notion of the whole. The letters refer, of course, to the lettered diagram above :

ORDER OF MOVES IN TYPICAL ATTEMPTS AT SOLUTION.

GRADE III.

R. F., boy, age 8.
M I E A B C D H L P O N M
C H L O — N I — E A *
E A — C H*
E B C H L O N I E
E B C H L O N I E
E B C H L O N I E
I E F G H L P O N M I†
E F G H D C B A E I M N O P L H C G K O
M I E A B C D H L P O N M
M I E A B C D H L P O N M
M I E A B C D H L K J
E B C H
M I E B D H L P
* Omitted certain lines. Put in only the diagonals.
† Retraced from I to A a second time.

B. G., boy, age 7.
A B C D H L P O N M I E A
A B C D H L P O N M I E A
A B E I N O L H C D H L P
A E I N J F E B
A B E I M N I J K G J F B C G H C D H L P O L K O N J
A B E I N O L H C B I J N +
I N J G F J N I E B A E F B C D H C G
A B E F B C D H C G F J N M I N O K J G H L O P L K G
E I N J G C B A E B F G I M N O K +
A B F E I M N I J F G C B

G. A., girl, age 7.
$\frac{BC}{2}$ C D H L P O N M I E A
$\frac{BC}{2}$ C D H L P O N M I E A
$\frac{BC}{2}$ C D H L P O N M I E A

C D H L P O +*
B E F G H +
C D H L P O N M I E A B C G K O L K J I N J G E B F
C D H L P O N M I E A B C H G F B E F J G K J N I J
B F J G C D H — — — — — — — — — P O N J I M I E +
G J F B E A B C G H C D H G K G F E I J N +†
C D H C B A E B F G J I E F G H P
C D +
G H D C H L P O L K G C B A E B F +

* Gets inside for first time.

† Said she would begin on inside; perhaps she could do it that way.

J. F., girl, age 8.
A B C D H L P O K J I M +
A B E A B F J +
A B C D H L P O N M I E A
E B F J N I J G H C D H L K O L P O N M +
A B C H G K J G F E B F J I N M +
H +
J G C H G F B E I M N O L K J I N J F E A D H L P O K G

GRADE V.

M. C., boy, age 10.
C H G C D H L P O L K G F B E A B C
I J K L H D C B A E B F G C H G J F E +
J G K J +
J G C H D C B A E B F +

Never tried a puzzle before. Cannot always repeat his success.

J. D., boy, age 11.
P O N M I E B A E
D C G H C
M I N
A B E B C G
P O L K O N J G
P L O N J G H
D C B A E I M N O P K O L
F E A B
B A E F B C I J F G J K G H L K O L P O N M I N J

G. W., girl, age 11.
A E I M N O P L H D C B A
E A B F E B C G F J +
A E I M N I J N O P
B A E F G H D C B F J N +
B A E B F J N O +
B A E I M N O P L K J I N J +
C B A E I M N J +
D H L P O K G C H G F E B
G J N M I E F J I N O K G F B A E B C G H C D +
G J N M +
G J N I J K +
G J +

J. M., girl, age 10.
A B C D P O N M I E A
E B F J I N O L K J G F
C H G J I E A B C D H L O P L
O L K G J N O P L H G F E I
N I M N O P +
J G H L K J F E B A E I M N I J N O L P O G F +

GRADE VIII.

F. E., boy, age 13.
N I M O P L O K +
B E A B C D H C G +
E B A E I M N O P L H D C B F +
H G F +
D H L P O N M I N J +

E F B E A B C H
N M I J K G J F G +
I J G C D H +
Traces before marking.

M. E., boy, age 14. D C H G C B F E B A E I J F G J K G
C B F E B A E I J +
G C H D C B F E B A E I J F G K O L P O N M I N J +
Studies before marking.

E. A., girl, age 12. M N J F B E
N +
H D C H G C B A E B F E I M N I J N O P L O K J
J E K O P L O N J I N M I E F B E A B C D H C G H L K J F G
Studies it first, tracing with finger. Sees quite far ahead that she cannot succeed.

L. D., girl, age 13. M N O P L +
A E I M N I J F E B F G +
B E F B C G H C D H L P O L K O N J K G F J I M N I E A B
H C D H G C B +
E I M N I J N O K L O P L H G K J G F E A B F J
G J I E A B F E B C G F J N M I N O P L O K L H D C H G K J

Even from the cases given, one can scarcely get a full realization of the remarkable increase in variation from III to VIII. As in the mass tests, while automatic repetition, or slight and inconsequential variation, is the rule in the lowest grade, in V there is already appreciable growth in resource, initiative, intelligent utilization of previous failures. In VIII the progress has been relatively greater still. Even in the higher grades, however, appeared a few cases where routine prevailed. In other instances, where variation was considerable and intelligent, there were occasional relapses into routine. This latter may, in part, be due to a temporary relaxation of attention.

On a basis of the study of the records, supplemented by observation as well as occasional questioning of children in III, the following analyses are offered as fairly descriptive of their procedure; they throw much light on the above mentioned characteristics of their movements. There are two slightly different cases: (1) The child discovers in a just completed trial that one or more lines are omitted. These lines sometimes, of course, are on the inside, sometimes on the outside of the figure. No matter. The child starts again at the old beginning place, or as near to it as possible, and modifies his former movements just enough to include the line or lines in question. This generally results in the omission of other lines; and this, in turn, leads to similar slight modifications, and so on. (2) Lack of foresight is manifested in a slightly different way. Again repeating his former movement, the pupil comes, say, within a single move of his old dilemma. Only then does he veer, and then only just enough to avoid the immediate pitfall, without regard to

others into which his change hurries him. Comparing the most successful adaptations of these children with those of higher grades and of adults, the following seems in general true: The young children succeed through a long series of slight variations. Occasional relapses into movements which are useless, indeed occur; but the trend is by a slow and primitive method of exclusion, toward the goal. Among older persons, the adaptation is usually approximated more by leaps and bounds, that is, through wider variations.

Résumé. Without attempting here to coördinate intimately the main results of the above experiments, some such statements as these seem warranted: The lack of circumspection, the conventional beginnings, the automatic repetitions of former movements, the slight and inconsequential variations, the frequent relapses into former routine, after failure of a slight variation, in short, the general tardiness in profiting by errors, of children in III, slowly makes way in older children for greater prevision, more adequate analysis of the design, less conventionality and automatism in procedure, more radical reconstruction of plan in successive trials, all of which leads to greater promptness in profiting by mistakes.

Experiments upon Youths and Adults.

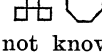
A large number of older persons, perhaps 300 in all, described their method of solving the same puzzle. Of this number, 72, who had some training in introspection, were given the task as a special problem. When they had successfully traced the figure, some such questions as the following were asked: 1. Why did you begin where you did in each trial? 2. Did you study the figure before beginning? Before each trial? About how long in each case? 3. Into what did you resolve the figure? Did conception of the figure change with successive trials? 4. Do you usually plan work thoroughly before beginning? How is it in composition, etc.? Some typical replies are here arranged so as to furnish a picture of the several degrees or levels of intelligent procedure, and to indicate some of the relations of visual and motor-mindedness.

Simpler modes of procedure: *F.*—No reason in beginning where I did in No. 1. Later attempted to cover lines not covered before; studied figure somewhat; 11 trials, 18 minutes. *M.*, 24.—Studied 20 seconds; began on outside; tried several times from about the same point; then began in the middle; chiefly guess. *F.*—No reason in No. 1; did not study; generally start in quickly on any subject. *F.*—No reason; changed beginning point because I could not cover lines first time; studied very little; did not analyze; 7 trials. *F.*—No reason; changed because I could not cover all lines; studied figure somewhat, but did not analyze; 5 trials. *F.*—No

reason; in second or third, saw that I could cross from one square to another by use of diagonals, and then fill out square; studied very little; generally start right in, then see my mistakes and correct them. *F.*—No reason; no reasons in others, but began at just any point. *F.*, 19.—Started in upper left-hand corner simply from force of habit; in fifth trial started at middle diagonal, because that had given trouble.

The following seem to represent some advance over the preceding: *F.*—No reason in No. 1; then the figure reminded me of another puzzle, but my trial did not succeed; in No. 3, after starting, saw my way; studied a little, then would try; saw figure first as a cross, then at last as squares and diagonals. *F.*—"E" looked like a good beginning; in No. 2 had another plan; in No. 3 supposed should have to begin somewhere in the middle; studied figure some time; generally studied first and arranged later; saw the figure as a lot of squares with diagonals. *F.*—Started to draw the square first, but at the same time wanted to get in the diagonals, so began at E. M.—No. 2 had no particular reason for beginning at N; in third, started with J G because it had given trouble; did not study figure much; usually do, however.

Some of the best types are as follows: *M.*, 29.—Mathematician; began at middle diagonal; sought points possessed of more than four lines; that suggested inner diagonal. *M.*, 33.—College professor; first tried by horizontal sections; then sought some principle; middle diagonal caught my attention; it must have some significance; after long inspection began there, and succeeded; in working puzzles always found it necessary to seek for a principle, rarely getting anything by chance or luck. *M.*—Studied short time; saw I could finish inner square first, then complete the rest. *M.*, 31.—Have had experience in mathematical puzzles; spent four minutes studying first figure before starting; about three minutes for second, which gave correct result; found myself continually running ahead of the lines to see that I kept out of the tendency to close myself in.

Visual and Motor Types: Although many of the cases already given suggest the somewhat fundamental differences in procedure of the eye-minded as compared with the motor-minded, this distinction seems sufficiently important to warrant special attention. The following cases are in point: *M.*, 60.—Worked it out by eye before using pencil; noticed continuity of  and  ; saw these two could be easily associated; then tried the inner oblique line, first making sure of connections of terminus in right-hand lower corner. *M.*, 26.—Tried to imagine the figure as two, or at most, three definite figures as follows:  ; saw I could trace the first two continuously, but did not know how to dispose of the diagonal in the middle; then I began disposing of it first, and the solution came with surprising quickness. *M.*, 23.—Looked it over before using pencil; two trials; in composition always plan arrangement or treatment before using pen.

While it is more difficult to point out those of more pronounced *motor-type*, a few, such as the following, seem to be dependent almost wholly for a connected view of the conditions, upon first tracing the figure. *M.*, 20.—Began on outside; rather haphazard beginning; repeat same beginning in order to hold it in mind; memory of figure improves with trials. *F.*—Did not study figure; my first

failure gave clue to second figure; generally start in upon work without thinking much about it; 4 trials. *F.*, haphazard beginnings; generally start right in, then see my mistakes and correct them; 3 trials. *F.*, nearly all early beginnings haphazard; usually start out at once, and see what I can make of it, and then I study it; 8 trials.

With persons of motor-type, there is a more or less tentative marking at first; the mind hovers until the actual experiences give a clear-cut notion of all the conditions of the problem; many of the early trials often seem aimless, but the record shows that although the "*motiles*" make a larger number of trials than the "*visives*," they succeed about as quickly. The "eye-minded" make few trials, and each stroke of the pencil is of high purposive import; they do their "fumbling" mentally; that most persons, however, are not predominantly eye or motor-minded, but rather belong to the "mixed type," goes without saying; the majority of those reporting are probably of the latter.

Abstracting for the moment, from the distinction just made, and considering the individual cases above given from the standpoint of the degree of intelligence of procedure indicated, it is possible to discriminate at least two, and perhaps three "levels." (1) *Conceptual.*—All those cases in which the search for a principle dominates, where careful analysis of the problem, where comprehensive appreciation of relations are marked characteristics, belong in this class. The word "Concept" connotes this level, which, however, is marked off from lower orders by no fixed boundaries. (2) *Receptual.*—Most of the numerous cases which fall below the highly rational types above designated belong here. These cases present almost infinite variety and resist hard and fast classification. They of course include eye-minded, motor-minded and the mixed type, just as does the conceptual group. They also represent varying degrees of approximation to the Conceptual. The word Recept designates the mental processes involved rather than Concept. The word is used with the realization that it connotes a lower stage of mental process than often appears in this group. But with this qualification it has value, in lieu of a better, in such a crude grouping. Reason, acute analysis, is here supplanted by a more hazy and insufficient realization of the relations involved. Errors, only by a considerable repetition, are able to produce any marked change in the order of the move; one sub-class may be distinguished, however, and some of its characteristics may be held to represent fairly the whole group. This subsidiary group we venture to designate "*Receptual motor.*" It possesses the following characteristics: There is a very great dependence upon preliminary tracings, for a realization of the conditions of the problem. Unlike the Conceptual-*motiles*, however, the experience gained does not result in a comprehensive concept of the

problem; there is no prompt discovery of the principle involved. With some, a Micawber-like disposition to wait for the difficulty to solve itself, seems prominent; some cases reported show as many as 15 trials, all in a measure haphazard; in others, the right notion of the figure slowly dawns after, say, 8 or more attempts. Repeated failures by a sort of summation thrust their import upon the subject, and like a composite photograph bring out the essential features of the required complex. While there may be considerable appreciation of relations, either the ability or the disposition to reason out the problem promptly seems lacking. This group, however, ranks higher than that of "sense-trial and error," to be considered later. Manifestly, it would be far from the truth to assert that a given individual in the prosecution of every sort of task need exhibit the same "level" of method. In proportion to the unfamiliarity and in general, the difficulty of the problem, his procedure may descend almost or quite to the lowest "levels." This fact must not be forgotten. Probably all inventors and discoverers often exhibit traces of many "levels" of procedure in the course of a single adaptation.

Of great value for the psychology of scientific method would be the detailed account of the procedure of the most successful experimenters. Unfortunately few have left even a general record of the kind in question. But there are enough data at hand to show, at least, how erroneous is the popular notion that the great discoverer in science somehow marches straight to the truth by some divine unerring method. "In all probability," says Jevons, "the errors of the great mind exceed in number those of the less vigorous one. Fertility of imagination and abundance of guesses at truth are among the first requisites of discovery."[1] Faraday said: "The world little knows how many of the thoughts and theories which have passed through the mind of a scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examination; that in the most successful instances not a tenth of the suggestions, the hopes, the wishes, the preliminary conclusions have been realized.[2] Mach[3] and others have shown that accident may play an important rôle in discovery, but accidents can only be utilized by a mind quick to appreciate their significance. Newton seems to have been at times able to establish a theory by a series of experiments so carefully planned that

[1] "Principles of Science," p. 577.
[2] Quoted in "Principles of Science," p. 578.
[3] "On the Part Played by Accident in Invention and Discovery," *Monist*, Jan., 1896.

few, if any, were abortive and almost every one crucial. But of course we cannot tell how much preliminary mental "fumbling" took place in order that the happy result might be accomplished. Edison's account of the invention of his electric light gives an insight of rare value into methods of invention. "Through all those years of experimentation and research, I never once made a discovery. All my work was deductive, and the results I achieved were those of invention pure and simple. I would construct a theory and work on its lines until I found it was untenable. Then it would be discarded at once and another theory evolved. This was the only possible way for me to work out the problem. . . . . I speak without exaggeration when I say that I have constructed 3000 different theories in connection with the electric light, each one of them reasonable and apparently likely to be true. Yet only in two cases did my experiments prove the truth of my theory. My chief difficulty was in constructing the carbon filament. . . . . Every quarter of the globe was ransacked by my agents, and all sorts of the queerest materials used, until finally the shred of bamboo, now utilized by us, was settled upon."[1]

This method of Edison certainly does not belong to the highest level, but for exhaustiveness and for the particular demand of his problem, who can say it was not the very fittest? These data are not sufficiently specific to throw much light on our special problem, but they suggest the possible variation of method, with the task in hand, and also indicate somewhat of the importance to psychology of a mass of more specific data concerning invention and investigation.

Summary.—As to the method of youths and adults: 1. Nearly all study the figure; many see several moves in advance; few successive trials are without circumspection. 2. A large majority, nevertheless, make a haphazard beginning at first. 3. There are wide individual differences in the conception of the figure; and this often changes in successive trials. 4. Most are early struck by the middle diagonal as a clue. 5. As compared with children, nearly all profit quickly by errors. 6. Two stages or "levels" of procedure and adaptation are roughly indicated: the conceptual and the receptual. 7. Eye and motor-mindedness have considerable influence upon the resulting adaptations.

Animal and Child Method.

Certain considerations demand a wider survey of the prob-

[1] "Talks with Edison," G. P. Lathrop, *Harper's*, Vol. 80, p. 425.

lem of conscious adaptation. If, as every one to-day agrees, life is "the continuous adjustment of internal relations to external relations;"[1] if the whole nervous system of organisms is a differentiation of tissues with the supreme function of preserving the results of former adjustments and the effecting of new ones; if, furthermore, for creatures in the ascending scale of life, consciousness is increasingly the instrument or the concomitant of all adaptations to new conditions,—then may we confidently seek a genetic view of the natural forms of adaptation, of the natural logic which organisms employ in dealing with novel situations. Of manifest importance to biology and psychology would be the natural history of such processes, from the lowest forms of conscious life to man, as well as from primitive man and the child to the adult scientest. Some studies of animal method, notably those of Romanes, Lubbock, Lloyd Morgan, Binet and Hodge, have shown the richness of the field. Similar studies of children have as yet scarcely passed the anecdotal stage.

In the case of animals, Lubbock found ants to be very stupid about discovering larvæ, when the latter were removed only six inches. The tracings of the paths of these ants remind one of a badly tangled mass of threads. Bees also have in varying degrees the same difficulty in finding their way. Lubbock put a bee into a bell glass 18 inches long and with a mouth $6\frac{1}{2}$ inches wide, and turned the closed end toward the window. After an hour's trial the bee failed to make its escape. Flies got out at once. Another bee tried fruitlessly for half an hour, when the open end of the jar was turned toward the window and the bee flew out at once. Bees slowly learned to find their way, after a number of experiences.[2] Hodge found that a blindfolded shepherd dog's logic of search was no more systematic than that of Lubbock's ants, while Lloyd Morgan says that dogs using both sight and smell show the same bungling researchings.

Turning now to a slightly different aspect of the question of method, we find by far the most elaborate and precise experiments upon dogs, made by Lloyd Morgan. So typical are they that it seems best to describe one of the tests somewhat in detail.[3]

The dog, Tony, is a fox terrier about 14 months old. The scene of operations is a field, along one side of which run vertical rails about six inches apart, between which the dog can readily pass. There is one place where a rail is absent, and the gap is therefore

[1] Herbert Spencer, "Principles of Biology," N. Y., 1882, I., p. 80.
[2] "Ants, Bees and Wasps," pp. 278-9.
[3] "Introduction to Comparative Psychology," London, 1894, pp. 255 ff.

wice the usual width. Along one side of the field, at right angles o that described, there is an ordinary open iron fencing.

"*First Day.*—Standing on the path adjoining the field, and separated from it by the first mentioned vertical rails, I sent the dog after a short stick into the field, and called him back through the railings. The stick caught at the ends; I whistled and the dog pushed and struggled vigorously. He retired into the field, lay down, and began gnawing the stick. I called him and he came up slowly to the railings, and stuck again. After some efforts he put his head on one side, and got the stick, a short one, through. I patted him, and showed him my satisfaction. Then I sent him after it again. He came up to the railings with more confidence, but, having the stick well by the middle, found his passage barred. After some struggles he dropped the stick and came through. I sent him back to fetch it. He put his head through and seized the stick by the middle and then pulled with all his might, dancing up and down in his endeavors; wriggling his head in the efforts, he at last got the stick through. A third time he again stuck; again dropped the stick; and again seizing it by the middle tried to pull it through. But when I sent him after it he went through himself, picked it up by the middle, and tried to push his way through, succeeding after many abortive attempts by holding his head on one side."

On the second day a short stick was first used. First time the dog brought it cigar-fashion, and when it struck a rail turned his head and brought it through. But in several succeeding trials always seized it by the middle, and struggled as on the first day; had same experience with longer stick, but soon hit upon the plan of avoiding the struggle and coming around by way of the open fence.

On the third day he showed no improvement, but more quickly shirked the problem by running around to open fence. After several weeks another trial showed no improvement.

In other experiments when the stick was so placed that it could most easily be seized in the most effective way, namely, by one end, the dog failed to take advantage of it, but seized it by the middle.

At another time the dog was given a cane heavily loaded at one end; at first he grasped it by the middle, which made the carrying of it a most awkward performance. After two hours' experience he had gradually learned to seize it at a balancing distance, nearer the heavy end. He had slowly learned to profit by his mistakes.

Hodge[1] in his study of the homing of pigeons was led to investigate the natural logic of search. Believing that those animals survive who have developed the most exhaustive methods of searching a given area for food, he sought to discover how nearly the procedure of carrier pigeons approximates to the ideal. For comparative determinations he devised the following experiment, which was chiefly tried by children and adults. A ball is so hidden in a square field that the ball can be seen when the observer is twenty feet distant. From a stake in the centre as starting-point, what is the best method of finding the ball? The mathematically best method

[1] "The Method of Homing Pigeons," *Pop. Sci. Monthly*, April, 1894.

is a path of spiral shape, the distance between the lines being 40 feet. This involves practically no researchings. Another logical method is that of a series of straight paths gridironing the field in a way. This involves the searching of some areas a second time. Simpler logical methods might be described here; but enough, perhaps, has been said to make clear the conditions of the test and the means of grading the methods. As to results, most of the adults approximated very nearly the theoretical curve. A boy of 12, however, starts for the fence, follows it for some distance, then turning in, discovers the ball by accident. His curve is somewhat logical, but naturally of lower degree than those of adults. Tests of a number of children varying in age from 3 to 12 show surprisingly little logic. The tracings of a bright six-year-old girl resembled the tracings of Lubbock's ants, revealing scarcely a trace of system, and full of researchings of areas, already searched time and again. After 75 minutes she still failed to find the ball, which adults discovered in from 4 to 12 minutes.

Experiments made by the writer upon a number of kindergarten children, by means of the "20-Question" method, also emphasizes the "hit-and-miss" nature of their logic. At first the children were tested individually. The teacher thought of some object, and as the familiar game goes, the child was to discover what it was by questioning, the questions being such as could be answered by "yes" or "no." In only one or two cases was there more than a suggestion of systematic procedure. The typical form was a series of questions about particular things: "Is it a squirrel?" and the like. The very same questions were occasionally repeated by the same child. In the few exceptional cases above noted, a general question, such as, "Has it four legs?"—"two eyes?" when answered was made little use of. For instance, the child immediately, when told it did *not* "have four legs," would ask, "Is it a bear?" Investigation of the nature of the questions shows that "recency and vividness" of concrete experiences were responsible for nearly all. There had been a squirrel in the room only a few days before, and so on. There was also a rather remarkable uniformity in the questions of the various children, indicating the narrow range of associations and memories available upon such a demand.

The test was much enjoyed by the children, and became a fixture in the program of the school, all the pupils taking part together. Gradually they began to use some methodical means and to appreciate the value of general questions. This was no doubt due in part to imitation, as the questions

gravitated quickly toward a stereotyped form, and that not the best possible. But even then, after somewhat narrowing the possibilities by the use of general questions, they tended to break away from system, and began to "plunge," by means of particular questions. The intuitive as well as the explosive nature of child thought would not down, and successes were often remarkable.

So much for animal and child method. The similarities are too obvious to need special comment. But we are brought face to face with the old question: Are these forms of reason, or can they be explained in terms of simpler processes? Lloyd Morgan, proceeding with the postulate, that no action is to be explained in terms of a higher process if it can as well be explained in terms of a lower, holds that animal procedure in general, although intelligent, is not reason. *The* method *par excellence* of dog and chick and monkey is that of sense-trial and error. The animal learns by sense experience and without the aid of the more direct path, namely, perception of relations. This perception of relations constitutes reason. True, according to Morgan's optical simile, such perception of relations is implicit in the animal's cognition, is in the indirect field of consciousness. It must come into the focus before it can be largely effective in determining procedure, and in Morgan's opinion it probably never does become focal in animals.

Another illustration may be taken from Morgan. The dog wishes to go out into the road; there is a fence between. In thrusting his head through successive spaces in the fence, as dogs are wont to do, he, by chance, strikes one space above which lies the latch of the gate. In throwing up his head the latch releases the gate. Meanwhile the dog has turned away as if to return to the house, all unconscious of his happy stroke. The noise of the swinging gate, perhaps, attracts his attention, and discovering his opportunity he rushes into the road. With remembrance of success he goes next day, and thrusts his head mechanically through many spaces until he finally strikes the right one, and again the gate opens. Now, according to the above view, if he perceived relations, if he were not the victim of his train of associations and coördinations fixed by the first day's experience, he would go straightway to the latch. But no. Three weeks of successive trials are needed to enable him to strike this space at once. Even then he continues to lift the latch with the top of his head rather than by the more economical method of using his muzzle.[1] This is one of the best illustrations of the bungling nature

[1] *Ibid.*, pp. 289 ff.

of the method of sense-trial and error. None of the links in the chain of associations lapse readily enough to facilitate readier passage to the goal. It is a process of slow and toilsome perfectioning, and indeed may never become quite perfect.

As to whether animals do not at all perceive relations, present knowledge cannot decide. Perhaps the more intelligent of them do have an awareness of simple relations and make use of them in adaptations. Romanes' Cebus[1], in his learning to unscrew and screw the handle of the hearth-brush, strongly suggests that there was some perception of relations involved. Hiram Stanley[2] has also urged that other animals are thus conscious. Certainly any attempt to draw a too sharp line of demarkation between man and brute seems to do violence to present views of mental evolution. This much seems true: some of the higher animals may have a rudimentary perception of relations. Most of the adaptations of animals are on the sense-trial and error "level."[3]

The features of this "sense-trial and error" method are briefly these: 1. Repetition of many useless movements, simply because they have been made before, and refuse to make way for a short circuit. 2. Relative slowness in profiting by errors. A number of repetitions is often necessary in order to effect any change in procedure. 3. When variations occur, they are in general relatively slight. In short, successful adjustment is the result of a large number of experiences, and is attained by a series of slight variations.

We have found the procedure of children predominantly of the "sense-trial and error" order; but that they may perceive simple relations and make simple adaptations thereby, is perhaps true. The very early appearance of this ability cannot be doubted. A case in point is the oft-quoted one of Preyer's child, who in the 17th month used a traveling bag as a foot-stool from which to reach for something.[4]

[1] "Animal Intelligence."

[2] *Psychological Review*, III, pp. 536-41.

[3] The above view receives some neurological support from Flechsig's recent work, "*Gehirn und Seele.*" In this the author maintains that the cerebral cortex of adult man is composed not only of a number of sensori-motor centres, but also of areas of higher order, called "associational," which are assumed to be representative of the elaborative mental processes, which of course deal with "relations." In the newly born child no "*Associations-centrum*" is functional. In most animals these areas are not even present. The evidence as regards animals, while not conclusive, points in general to the distinction we have been considering.

[4] Preyer: "Development of the Intellect," N. Y., p. 12.

But most of the demands upon children are sufficiently complex to throw them back, in the absence of imitation, upon this last and deepest resource, "sense-trial and error."

As earlier suggested, in older persons also, this primitive mode has a much larger place than is often suspected. Not only excessive unfamiliarity and complexity of the new situation, but also fatigue, temporary loss of interest, a fleeting state of mental muddle may produce a relapse into the animal method. A well-known scientist reports that in dealing with complex tables and statistics, and the like, he often when tired finds himself repeating again and again some trivial or important step, long ago really disposed of. This phenomenon in the absent-minded is too familiar to need illustration.

We are now in position more fully to analyze and interpret the results of our experimental puzzle test. The problem of conscious adaptation resolves itself into two questions: 1. What is the nature of the perception of the difficulty? 2. What is the resulting method of procedure in solving the problem? First as to the nature of the conception of the problem. Introspective notes by the children not being obtainable, we must infer their notion of the problem largely from their procedure. Most began on the outside of the figure. A large number of the younger pupils drew the square first, and only after repeated trials did they press into the intricacies of the inside of the figure. From these facts we infer an incomplete comprehension of the design. How explain this inadequacy? (*a*) Recent studies of children's drawings, notably the investigations of Barnes, Lukens and Baldwin, show that children are most impressed with outlines. Any connected view of elaborate details is apt to escape them. In the above experiment the outline, *i. e.*, the square, is very familiar and simple. Some children, furthermore, thought they had traced every line, when some were really omitted. (*b*) Another factor which may have considerable significance is that the complexity of the inside of the figure may have at first repelled them. (*c*) The testimony of adults renders it extremely probable that the children, when they finally did enter the figure, were also troubled by the oddness of the middle diagonal; still very few seem to have attached to it any great significance.

As to procedure, may it not have been determined in somewhat the following manner? The outline square caught the attention and set going tendencies fixed by long habit, to draw the square, etc. This movement once made tends to be repeated. It may be a form of the circular reaction, if you please, and the child is doing just as the animal—"imitating"

his former movements, consciously or unconsciously. Repeated failures lead to a dissatisfaction with the movements, and the result is variation. But so great is the inertia of the nervous mechanism, so weak the power of inhibition, that repeated failures seem unable, in most cases, to produce radical removal of the source of error. In the light of the above facts, it may be said that the child, even so old as eight years, is rather like an animal in method of adaptation than like the human adult. The young child is a reflex and automatic organism. His narrow motor and sensory experiences enable a few tendencies and habits to rule with a potency, which yields only to time and wider experience. With age the motor habits become rich in variety, and when action is demanded tend to neutralize one another, and make for that hesitation which enables "considerations" to tilt the balance more easily in favor of the best alternative.

What, then, of the so-called "plasticity" of childhood? If the above conclusions are true, plasticity does not, as often implied, mean resource, initiative, promptness of adaptation to the new. It must mean, rather, that children are imitative beings, and hence can quickly learn new ways of doing. Every normal child may indeed be a "genius," but not of the inventive and creative sort. Just as recent researches indicate that he is less inventive in language than formerly thought, so in other phases of activity, less and less is being credited to his initiative, and more to imitation. This does not degrade the mental status of children, but rather dignifies imitation as the great means by which the mind gets experience. Inventiveness is a plant of slow growth. Protected as he is from the bewildering complexity of environment, the child only slowly gains the wide variety of experiences which favors creative activity, and which makes for the higher adaptability that is necessary for adult life.

It is a coincidence of some suggestive value that many of the characteristics of mental adaptation may be described in phrases descriptive of evolution in general. Evolution, as generally considered, is a series of small successive changes. Many facts accentuate the unequal rate of change. The extreme of this tendency is found in the theory which emphasizes "sports"[1] as the usual method of evolution. These "sports" represent a rapid summation of changes, thus supplanting *slow* unfoldment by spurtiness. Even Galton[2] admits that these "sports" *may* be conceived as accumulations of successive small increments, although he inclines to the view of large increments. Now, in almost every field of growth, spe-

[1] Cf. Galton: "Natural Inheritance," London, 1889.
[2] *Ibid.*, pp. 32 ff.

cial cases of the above are discoverable. The spurtiness of physical growth, the periods of slow unfoldment of a member or an organ, or of the whole body, followed by a rapid acceleration; in the psychophysic domain the summation of subliminal stimuli is too familiar to need further description. Moreover, in the field of conscious attention, favorable conditions, many of which are perhaps physiological, produce the same summation phenomenon. Bryan and Harter have recently shown that the improvement in learning to "receive" telegraphic messages, while rapid for a time, ceases at a point just below the required proficiency, to be followed later by a second stage of more rapid improvement.[1] This description seems generally valid for all complex mental adaptations, and suggests anew the important rôle of the subconscious physiological factors in producing occasional accelerations.

If the different methods of adaptation be arranged in a series, as follows: Sense-trial and error, Receptual, Conceptual, certain general statements seem warranted. (1) *Objectively viewed:* With approximation to the highest level, there is greater and greater acceleration of adaptation. Variations are wider, and the goal is attained more and more by leaps and bounds. Furthermore, adaptation is more *comprehensive*. This also represents acceleration. (2) *Subjectively:* There is a greater and greater activity and elaboration of central processes, conscious and unconscious. Sense-trial and error can cope successfully and promptly with only a relatively simple environment, whereas the methods of higher level are imperative for complex adjustments. The economy of time, with rise in the scale of method, measured both by gain in comprehensiveness as well as in promptness, may be found, on further investigation, to follow some such law as that of the improvement due to habituation.[2]

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[1] "For many weeks there is an improvement which the student can feel sure of, and which is proved by objective tests. Then follows a long period when the student can feel no improvement, and objective tests show little or none. At the last end of the plateau the messages on the main line are, according to the unanimous testimony of all who have experience in the matter, a senseless clatter to the student, practically as unintelligible as the same messages were months before. Suddenly, within a few days, the change comes, and the senseless clatter becomes intelligent speech."—"Studies in the Physiology and Psychology of the Telegraphic Language," Bryan and Harter. *Psych. Rev.*, Vol. IV, No. 1, p. 52.

[2] Influence of habit proper, in increasing promptness of conscious adaptations, is best seen in the operation of such generalized habits as those of the physician in diagnosing disease. Inquiry among members of this profession developed the fact that while the novice

IV.

General Conclusions. Psychic development results in conscious adjustments to outer relations, which increase in number, complexity and variety. As well known, this development is not uniform, but falls into fairly well-marked stages.

The play instincts bear teleological relations to this growth. (1) The play impulse probably arose through the fact that those animals which in play gained preliminary exercise of activities useful in maturity survived in the struggle for existence. Play also serves as an index of the nascence of certain interests, capacities and even epochs of development.

The intellectual play instincts seem ripest in the immediate prepubertal years, and may correspond to an increase in the medullation of the associative fibres of the cortex, which is the prerequisite of function of the elaborative mental faculties. Puzzles which epitomize the more complex types of relations which may produce illusion or error are most interesting at this period. Intellectual play may develop mental flexibility, versatility, and even power of will, which in turn are of manifest importance for the more exacting and intricate reactions which come with adolescence.

The line of growth in ability to cope with environment, is indicated by three roughly demarkated stadia or levels: Sense-trial and error, Receptual, Conceptual. The method employed in a given case is determined partly by the capacity of the individual, partly by the difficulty of the problem, but in general, Sense-trial and error is predominantly the level of animal and child.

In closing, one or two rather obvious connections of this study with Pedagogy and Individual Psychology may be pointed out.

If the business of Education is to help the child to acquire the most economical and adequate means of meeting the demands of increasing complexity of life, then it must provide

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slavishly follows some standard scheme of diagnosis, which is an exhaustive application of the method of exclusion, with experience, he gradually dispenses with the detailed scheme, and finally may learn to go straight to the mark as by intuition. One physician says, "When a man steps into my office, I may mentally say, without a moment's reflection, 'That man has valvular disease of the heart.' Now, if called upon to give reasons for my judgment, considerable reflection is required, and even then some salient details may not come into clear consciousness, although my diagnosis has been correct." Now, when it is remembered that physicians deal not with disease, but with sick people, and that perhaps no two cases are alike, hence offering a somewhat new problem, the gain in time is more significant.

for his induction in proper season, from the sense-trial and error level into the modes of more prompt and comprehensive adaptation. The early school years belong of course to the sense level, but the rising curve of puzzle interest marks the prepubertal age as the time to hasten transition to the higher mental methods. The young child's simple, crude, sketchy, halting, analogical modes of appreciating relations may now be safely supplanted by more rigid and logical regimen. Furthermore, if too great difficulty of task, fatigue, temporary muddle, or loss of interest, tend even in the adult, whose conceptual processes are long established, to throw the mind back upon lower levels of adaptation, the adjustment of task to pupil receives new emphasis. The hygiene and practical importance of attempting the difficult only when in the top of condition rests on this ground.

The present trend of Psychology, in many quarters, is clearly away from the simpler problems of sense and muscle, and toward the more complex and immediately interesting questions of emotion, psychogenesis, pedagogic and individual psychology, or in Wundt's phrase, "individual characterology." For the testing of some of the most important qualities of mind and character an unusually rich material is offered by the extant collection of puzzles, and a properly graded set of such tests could hardly fail to furnish much valuable data. It is very evident, from the progress already made in this field, that the simpler tests of reaction-time, memory-span and discriminative sensibility are not so well suited to bring out those individual differences that are of account in the general conduct of life as are tests more closely related to the complex activities in question.

APPENDIX.

HISTORICAL NOTES ON PUZZLES.

An inventory of puzzles shows them to cover a wide field and to be rich in number and variety. But the varieties within a single group are often reducible to a relatively small number of typical forms, many of which are of ancient origin. This paucity of type-forms and their persistence seem to be a result of a sort of a survival of the fittest. Tylor,[1] speaking of games, says: " . . . . when a game is once worked into perfect fitness for its place in the life of boys and men, it may last on with remarkable permanence, as when we see represented in the ancient Egyptian tombs the counting game, well known to us by its Italian name, "*morra;*" . . . . . Thus there is always a fair chance of finding in existence in modern times any of the popular games of the ancients." That the same statement is equally true of many puzzles, can be easily shown. Especially true is it of the Riddle.

[1] E. B. Tylor: "Geographical Distribution of Games," *Journal Anthr. Inst.*, IX.

Language Puzzles.

The Riddle:—The origin of the Riddle is not known, but it has been and is now found pretty generally even among peoples of a low degree of mental advancement. To quote Rolland:[1] "From the Vedic riddles to the riddle contests of Scandinavian gods, or of German minnesingers; from the famous question of the Sphinx to the '*Philosophies des Enigmes*' of Menestrier; . . . . ; from the riddle that caused the death of Homer to those which amused all the Wolofs,—we find great variety, wide contrasts, but nevertheless a fundamental resemblance." They play upon analogies among things perceived. Essentially, the primitive mode of invention is as follows: Some one discovers a new analogy among natural objects, formulates a question concerning it, and thus a new riddle is born. While the most primitive forms have chief reference to natural objects, the evolution of the riddle reflects the shifting of man's chief interest from external nature to man himself. Some of the most famous riddles among the Greeks have this human focus.

Just when, in the development of a people, riddle-making begins and also the period when it loses its soberer aspect and becomes a mere sport or pastime, are not easily determined. They bear obvious relation to intellectual status. Tylor thinks that the simpler forms, the "sense-riddles," belong thoroughly to the mythologic stage of thought, and are in consequence found at home among the upper savages, and range on into lower and middle civilizations. "The making of riddles," says he, "requires a fair power of ideal comparison, and knowledge must have made considerable advance before the process could become so familiar as to fall from earnest into sport. In higher states of culture, riddles begin to be looked upon as trifling. They survive only as the remnants of child's play."[2] The rôle of the riddle in education among lower races must be important. Among the Basutos "riddles are a recognized part of education and are set like exercises to a whole company of puzzled children."[3] It is training in that analogy-thinking which is indeed the true father of generalization and classification, whose high perfection is reflected in modern science. Even among people of higher culture, the ability to answer riddles was considered a proof of great sagacity. The ability to interpret some of the replies of the Greek oracles was a supreme test of wisdom.[4] Among Semitic peoples the same criterion existed. Samson's riddle, and Solomon's success in answering the questions of the Queen of Sheba, need only be mentioned. Mr. Lockhart has translated a Hebrew manuscript which claims to give the list of problems proposed by the Queen of Sheba. There are nineteen in all, and some are certainly remarkable.[5] In Märchen, and ballads of a later period, the hero's chance of winning his beloved, or of escaping threatened punishment, often turns on his power of answering riddles.

Analysis of the riddle shows it to contain some of the chief elements of literature. The anthropomorphizing and personalizing tendencies, which often characterize it, show the riddle to be closely related to the fable. And having its deepest roots in the perception

[1] Rolland: *Devinettes ou Énigmes Populaires de la France.* Edition of 1877, Paris.
[2] Tylor: "Primitive Culture," I, p. 91.
[3] *Ibid.*, I, 90 ff.
[4] "Greek Oracles," F. W. H. Myers, Hellenica, London, 1880.
[5] "The Riddles of Solomon in Rabbinic Literature," J. H. Stewart Lockhart, *Folk Lore*, I, 1890.

of analogies in nature, the riddle is brother to the metaphor, which has been so important in the development of languages and myths. A riddle may, indeed, be defined as a metaphor or group of metaphors, whose usage has not yet become common and whose explanation is not evident.

The Enigma:—While the riddle may have been important in the intellectual life of the Hebrews, its wide development and rich elaboration seem to have been reserved to the Greeks. One of its modifications, the enigma, merely a riddle in poetic form, was tried by the greatest Greek poets, and some even devoted whole poems to them, as the Syrinx, attributed to Theocritus. In the "riddle-revivals" of later periods, as we shall see, the culmination was always in an interest in enigmas.

Before proceeding to consideration of the import of riddles, it is perhaps worth while to note several other forms of language puzzles at least three of which are closely allied to the groups already discussed. *The Rebus* also bears evidence of very ancient lineage. Generally it is a form of riddle in which the problem consists in the interpretation of pictures or objects. This use of object-method obviously requires in its simpler forms no very high degree of intellectual advancement. It may well be a reverberation of man's earlier modes of symbolic expression. One of the earliest examples recorded is as follows: When the Scythians were invaded by Cyrus, they sent messengers bearing arrows, a rat and a frog; implying that unless he could hide in a hole like a rat, or in water like a frog, he would not escape their arrows. André asserts that the rebus had a considerable vogue in ancient Italy. In Via Appia, Rome, is a tomb still existing, that of a certain Publius Philo-*musus* which has on it well executed bas-reliefs of *mice*.[1] Cæsar,[2] while one of the masters of the Roman mint, placed the figure of an elephant on the reverse side of public money in defiance of law, because "Cæsar" meant "elephant" in the Punic language. Even in England to-day, complicated rebuses abound on monumental brasses, tombs and sculptures.[3] In the rebuses most familiar among us, alphabetical writing and picture writing are usually combined. *The Conundrum* is perhaps of much later origin than the rebus. It is a riddle involving a play upon words, often in the form of a pun, and thus presupposes a considerable acquaintance with language and the facile use of a somewhat elaborate vocabulary. The conundrum is said to have been a favorite source of entertainment at the later Roman feasts. It is one of the last forms of riddle to fall thus to the level of a mere pastime.

The Charade is also an elaboration of the riddle. Two chief forms are distinguishable. In one, the object referred to is described by other objects, but generally by action or gestures of persons proposing the problem. In its higher form, it resembles the enigma in that it is set in metrical form, but the riddles involved have reference to words, or parts of words, instead of objects. This form of charade, which has maintained its dignity as an amusement for adults, is probably of very recent birth, not being known in France, at least, in 1771.[4] Within two or three years several volumes of charades have been published in this country and enjoy wide popularity.

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[1] J. Lewis André: "Puns and Rebuses in History and Archæology," *Reliquary*, XXIII, p. 169.
[2] D'Israeli: "Curiosities of Literature."
[3] André: *ibid.*
[4] D'Israeli: "Curiosities of Literature."

The Anagram, although a language puzzle, partakes somewhat less of the riddle element than do the foregoing. It involves the construction of a significant word or phrase from the letters of a given name. Originally oriental, it became known to the Hebrews, who classed it among the cabalistic sciences. They believed occult properties to reside in proper names. Finally the anagram became current among the Greeks. "Plato had strange notions of the influence of anagrams, when drawn out of person's names, and later Platonists were full of the mysteries of the anagrammatic virtues of names."[1] Anagrams thus constructed from letters of the name of a given person, often even influenced his choice of vocation. This mystic significance of the anagram thus almost eclipses its puzzle element. Its later use as a puzzle, however, entitles it to some notice in this sketch.

The above seems to represent the more fundamental types, out of which most of the later forms of language puzzles have grown.

Revivals of Interest in Language Puzzles.

At certain later epochs there are traces of renewed interest in language puzzles, and especially in riddles and enigmas. Such periods seem to coincide with seasons of intellectual awakening. In the latter half of the 7th century, Adhelm, Bishop of Sherbourne, left a number of enigmas in Latin hexameter which have been repeatedly printed. Before his time there was a collection of Latin enigmas, each containing three hexameter lines. The revival thus begun propagated itself throughout the remainder of the Anglo-Saxon period. There were eighty riddles and enigmas in English before the Norman conquest. In Protestant countries the Reformation put a stop, for a time, to the riddle-making.

In the 17th century, a great riddle era in France, there was considerable publication. At this time, Menestrier also wrote his "Philosophy of Enigmas." The taste spread to England. Swift, Cowper, Fox and others wrote a number. One of the famous prose riddles of this period was that by Fox, on a "Watch." "I went to the Crimea; I stopped there, and I never went there, and I came back again." More than a score of Swift's enigmas are printed.[2] Some are of considerable length, notably these: "On a Pen," "On a Corkscrew," "The Gulf of all Human Possessions," "An Echo," "On a Shadow in a Glass." One of the best of the briefer ones—that "On Time"—is as follows:

> "Ever eating, never cloying,
> All-devouring, all-destroying,
> Never finding full repast,
> Till I eat the world at last."

Again, in the 18th century, notably in France, the interest in riddles and enigmas became marked, Voltaire and Rousseau writing, among others. "*Mercure de France*" became a repository of riddles and enigmas, the solution of which was sufficient to make a reputation in society.[3] To such exuberance of mental energy, and especially the delight in playing with language, is to be ascribed the invention of other intricate word puzzles, as the acrostic, word-square, charade, and the like. Boccaccio wrote a giant acrostic of fifty cantos.[4] During the Elizabethan age, words and verses were tortured into the most fantastic forms. Acrostics and chronograms were much in vogue.

[1] D'Israeli: "Curiosities of Literature."
[2] Works of Jonathan Swift; edited by Sir Walter Scott, Vol. XV, London, 1883.
[3] Art. "Riddles," Chambers' Encyc.
[4] D'Israeli: *ibid.*

Summary. Language puzzles, and especially riddles, arising from the same soil that produces literature and mythology, seriously engage the mind of peoples of relatively low degree of intellectual advancement. They depend upon perception of analogies, which is the predominant characteristic of the thinking of early peoples and of children.[1] The riddle probably plays a serious rôle in education among lower races. But later, when perception of analogies becomes sufficiently easy, these puzzles lose their soberer aspects and serve merely as amusements. The later development of language puzzles shows the influence of growing culture. The riddle makes way for the enigma, with its regard for literary form; for the conundrum, which savors of the three R's; and finally for the acrostic, word-square and charade, which take one farther and farther from the natural objects that were the original theme of riddles.

Mathematical Puzzles.

The germs of mathematical puzzles must have appeared early in the development of mathematics, but the first works devoted to them date from the 16th century. The list of works since that time, containing either a general collection of these, or special consideration of single problems, numbers upwards of 120. De Bouvelle's "*Propositions arithmeticæ ad acuendos juvenes*," printed 1543, (credited at different times to Bede or Alcuin) is said by Lucas to be the first known beginnings of mathematical recreations. Perhaps the best known and most popular works of this class, however, are Bachet's[2] "*Problemes plaisans et délectables*," Paris, 1612, which has gone through several editions, the last two in 1874 and 1879 respectively; and Ozanam's "*Récréations mathématiques*," Paris, 1694, of which also a good many editions have been sold, and which has been much revised and popularized by Montucla. A translation into English of Montucla's edition was published by Charles Hutton early in this century. A later edition bears the date of 1840. These works of Bachet and Ozanam are the chief sources of the modern mathematical puzzles which appear in popular works on the subject, and in juvenile periodicals. Two recent works deserve mention: Ball's "Mathematical Recreations and Problems"[3] and Lucas' *Récréations mathématiques*,"[4] in five volumes. A long line of distinguished mathematicians, including Cardan, Tartaglia, Fermat, Leibnitz, Euler, Listing, Plateau, Thompson, Sylvester, Story and Ch. Henry, have interested themselves in problems in this field. Several histories of the attempts at the "Quadrature of the Circle" and of the forms of "Magic Squares," bear abundant testimony to the fascination which these problems possess for the mathematical mind. "Magic Squares," moreover, were invested with a mystic signification which long endured. Albrecht Dürer, in his famous "Melancholy," engraved in 1514, has represented a magic square, showing that even in his day, it retained at least a symbolic meaning.

The 14-15-16 puzzle, so much in vogue within comparatively recent years in this country, is said to have been invented by an Englishman 200 years ago. It has been mathematically treated by Story and others. Puzzles of the labyrinthine and maze types, so

[1] Cf. Jastrow: "Natural History of Analogy." Proceedings Am. Ass'n Advancement of Science, 1891.
[2] Cf. Bibliography in Lucas' work.
[3] London, 1892.
[4] Paris, 1882.

familiar in puzzle columns, have a history. These forms have always fascinated men. The famous labyrinths of ancient times—the Egyptian, Cretan and Samian—were reckoned among the wonders of the world, and were held to be unthreadable. The Egyptian labyrinth contained more than 3000 chambers. In the middle ages the custom of constructing in the walls and pavements of churches labyrinthine designs, is well known. The same pattern also came to be a feature of landscape gardening, and the labyrinth of Hampton court is one of the most famous in England. Mathematical interest in the labyrinth in all its varieties, and also its vogue as a puzzle, probably dates from the middle ages. Tremaux and others have published rules for threading such figures.

These instances illustrate sufficiently, perhaps, how many puzzles have from early times strongly appealed to the human mind. It is hardly a chance coincidence that so much of myth and mystic meaning has clustered about them, in view of their peculiarly baffling quality.[1] On the other hand we have seen how some problems (as the 14-15-16 puzzle), although originally invented to amuse, may by competent mathematical treatment be lifted to the plane of a real and perhaps important problem, and thus contribute in a direct way something to the enrichment of science.

Mechanical Puzzles.

The history of this group is even more meagre than that of the preceding. Aside from those mechanical puzzles whose mathematical tractment has been exploited, very little account is obtainable. It may be expected, however, that anthropological investigation will show the same wide distribution and similarity of origin that have been found in the case of games. The University of Pennsylvania's exhibit at the Columbian Exposition contained 129 mechanical puzzles, most of which are of oriental origin.[2] The larger number are not, as commonly believed, invented in China and Japan, but rather in India. Sporadic invention of puzzles has indeed occurred in modern times in Europe, while America has made something of a name for the ingenuity of its inventors in this line. But few are entirely original, and the usual *modus operandi* of the puzzle maker is to graft onto an old type enough slight modifications to give the appearance of novelty, and commend the whole to the public by a fetching name. The distinct types of puzzles are few in number.[3]

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[1] To illustrate how myth and legend tend to cluster about puzzles, the following concerning the familiar mechanical problem, the Tower of Hanöi, is in point. M. De Parville gives an account of the origin of the toy, "In the great temple of Benares, beneath the dome which marks the centre of the world, rests a brass plate in which are fixed three diamond needles, each a cubit high and as thick as the body of a bee. On one of these needles, at the creation, God placed sixty-four discs of pure gold, the largest disc resting on the brass plate, and the others getting smaller and smaller up to the top one. This is the tower of Bramah. Day and night, unceasingly, the priests transfer the discs from one diamond needle to another, according to the fixed and immutable laws of Bramah, which require that the priest must not move more than one disc at a time and that he must place this disc on a needle so that there is not a smaller disc below it. When the sixty-four discs shall have been thus transferred from the needle on which, at the creation, God placed them, to one of the other needles, tower, temple and Brahmins alike will crumble into dust, and with a thunder-clap the world will vanish . . . ."—Ball, "Mathematical Recreations," p. 78.

[2] Stewart Culin, *A. J. Folk Lore*, VI, 22.

[3] Perhaps nowhere are some of the characteristics of the problem-solving instinct more clearly exemplified, and the essential unity of the human mind, in spite of the differences of time, nationality or race, more clearly indicated, than in the history of attempts to solve a peculiar group of problems whose insolvability has called down upon them the opprobrious epithet of "Follies of Science." Prominent among these

Logical and Philosophical Puzzles.

Although Zeno of Elea, the "father of dialectic," is indirectly perhaps the first important source of puzzle material of this sort, its chief development falls in two later epochs, one ancient, the other mediæval, namely, among the sophists and the schoolmen. Both agree in exalting the formal aspect of thought, and acquired marvelous skill in the handling of phrase and proposition, which, as it degenerated, often sunk matter in method and made discussion a rhetorical swordplay.

Two of the minor sophists, Euthydemus and Dionysodorus, are of this sort. Plato draws a memorable picture of them in his "Euthydemus."[1] Claiming to be masters of the art of eristic, or fighting with words, they stand ready to teach for a consideration. A few of the questions which were put to the youth Cleinias give a fair idea of their expert word-juggling. "Cleinias," says Euthydemus, "who learn, the wise or the unwise?" "The wise," is the reply. . . . "And yet when you learned you did not know and were not wise." Again: "And do they learn what they know or what they do not know?" "The latter." "And dictation is a dictation of letters?" "Yes." "And you know letters?" "Yes." "Then you learn what you know." "But," says Dionysodorus, "is not learning acquiring knowledge?" "Yes." "And you acquire that which you have not got already?" "Yes." "Then you learn that which you do not know." And so it goes. If we wonder how any people should have taken such word-juggling seriously, we should remember the status of the Greek mind. Every philosophic idea was in a state of flux; contradictions were rife; logic was not yet written; there was no analysis of grammar. Language was first beginning to perplex human thought. The contribution of the sophists to the intellectual activity of the Greeks was genuinely important. It is now admitted that they led to the systematic study of grammer, rhetoric, philology, and were the necessary propædeutic for the logic of Aristotle.

The most interesting and ingenious arguments of the sophists survive in the logical treatises, but any attempt to classify the whole range of their puzzles would be futile. Many depend upon ambiguity of meaning of terms. Others are of more intricate logical form.

The puzzle interest in Greece did not die with the sophists. According to Diogenes Laertius, Chrysippus, the stoic, wrote six different treatises upon Eubulides' famous puzzle, "The Liar," and Philetas of Cos studied himself to death in attempting to solve it.[2]

Three illustrations will sufficiently exemplify the sources of the puzzles of this early period. Zeno's arguments against the reality of motion, of time, space, the manifold, and the veracity of sense perception, can be characterized, as to form, by a single one against motion. Motion cannot begin, because a body in motion cannot arrive at another place until it has passed through an unlimited number of intermediate places.[3] Of a later period the following are representative: — The Protagoras-Eualthus argument. Eual-

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are Duplication of the Cube, Trisection of the Angle, Quadrature of the Circle, Astrology, Alchemy, and Perpetual Motion. Most are of great antiquity and have a voluminous history, but Perpetual Motion has received little attention historically. No prolonged or systematic search for the origins of this problem seems to have been made. From data already gathered, there are evidences of a close relation of this mechanical idea to certain biological and philosophical concepts; and in yet other respects, it offers a field for profitable psychological study.

[1] Jowett's edition of Plato.

[2] Bowen's "Logic," p. 289.

[3] Ueberweg: "History of Philosophy," I, p. 57.

thus received lessons in rhetoric from Protagoras, it being agreed that a certain fee should be paid if the pupil were successful in the first cause he pleaded. Eualthus neglected to take any case and Protagoras sued for his fee. Eualthus defended himself in court and it was consequently his first case. Protagoras argued, "If I be successful in this case, O Eualthus, you will be compelled to pay by virtue of the sentence of these righteous judges; and should I be even unsuccessful you will then have to pay me in fulfillment of your original contract." Eualthus replied, "If I be successful, O master, I shall be free by the sentence of these righteous judges; and even if I be unsuccessful, I shall be free by virtue of the contract." The "Syllogismus Crocodilus," Eubulides' "Liar," "All rules have their exceptions," are a few of the numerous puzzles of this group. Finally, there is a group which plays upon the manner of asking questions, so bringing it about that either an affirmative or negative involves one in apparent admissions of a damaging nature. "Have you left off beating your father?" is obviously of this sort.

Among the schoolmen is seen the apotheosis of formal logic. The mission of scholasticism was to furnish a rational basis for the Christian faith. "They burden themselves with the weight of a logical instrument which Aristotle created for theory and not for practice, and which ought to have remained in a cabinet of philosophical curiosities without ever being carried into the field of action."[1]

Disputation was the great means of education. Dexterity in framing and solving sophisms was reckoned a scholarly accomplishment and one of the special fruits of a university training. In spite, however, of the indictment of Milman[2] and others, that these activities never had nor cared to have any bearings on the life and practical opinions of mankind; in spite of their failure to add directly a single new idea to science,—nevertheless the mind of semi-barbarous Europe was thereby trained for the vast work of the modern world.

This being as it may, there can be no doubt about the arid subtleties of its decadence. Even St. Thomas Aquinas—the "greatest giant between Aristotle and Newton" — is carried away by his devotion to logic. In his *Summa Theologiæ* — where everything is thrown into Aristotelian form—are found discussions and logical demonstrations of such propositions as these: "Angels are composed of action and potentiality." "Every angel differs from every other in species." "The bodies assumed by angels are of thick air." "Many angels cannot be in the same place." "The velocity of an angel is not according to the quantity of his strength, but according to his will." "The motion of the illumination of an angel is three-fold, or circular, straight and oblique." Others discussed whether the angel Gabriel appeared to the Virgin Mary in the shape of serpent, dove, man or woman. Young or old? In what dress? Garment white or of two colors? Linen clean or foul, etc.? What was the color of the Virgin Mary's hair? Was she acquainted with the mechanic or liberal arts?

Through more than a century thousands debated the problem, "When a hog is carried to the market with a rope about his neck, which is held at the other end by a man, whether the hog is carried to the market by the *rope* or by the *man*?" The "free-will" discussion gave rise to famous problems. One of these was invented

[1] Taine: "History of English Literature," I, pp. 214-15.
[2] Milman: "Latin Christianity," VIII, p. 267.

by J. Buridan[1] (died about 1358), and is widely known as "Buridan's Ass." "An ass is equally pressed by hunger and by thirst; a bundle of hay is on one side, a pail of water on the other. Will he die for want of both, or will he make a choice?"

Remembering that a puzzle is a problem whose solution is an end in itself—a problem attempted mainly for the pleasure derived from the activity — the question naturally rises, are the above fairly called puzzles? Were they not dealt with because they had application to real questions and principles of philosophy and morality? It cannot be denied that most were originally of that sort. Aquinas certainly cannot be charged with admitting to discussion any matter which does not bear directly upon the serious task in hand. Even the apparent trivialities were important in his logical arches. It is when torn from their setting and employed as theses at a later period, when logic had fallen to the plane of a mere gymnastic, that they degenerate into mere puzzles.

Logical puzzles of this sort find few devotees to-day, though some who have reached that stadium in the study of logic and metaphysics which brings a certain mastery, find a temporary pleasure in them. A more distinctly modern species of logical puzzle grows out of the study of logical theory. The following is quoted from the "Life of De Morgan": "(1) For every z there is an x which is not y. (2) Some y's are z's. Some x's are not z's."[2] Prof. Jastrow[3] has also recently published one of this sort: "Granted that A is B, to prove that B is A. B (like everything else) is either A or not A. If B is not A, then by our first premise we have the syllogism: A is B: B is not A: ∴ A is not A; which is absurd, therefore B is A."

Whether any of the larger present problems of philosophy, epistemology, ontology and metaphysics, often take on the puzzle *quale*, may well be doubted, but that they occasionally do so in some minds seems likely. That such problems are attempted at first simply for the pleasure of the activity, is hardly possible. As Kant says: "It is in vain to assume a kind of artificial indifferentism in respect to inquiries, the subject of which cannot be indifferent to human nature."[4]

But what shall be said of the fascination which the antinomies exercise upon some minds? What of the devotees of ontology, who, refusing to accept the verdict of critical philosophies, press on by old and fruitless methods to the ultimate reality, to the absolute? It must be conceded that as the original impulse fails and as the solution of ultimate questions seems more and more remote, there appears to come in some minds a tendency to manipulate the cherished formulæ, just as the mathematicians often do theirs, to see what will "come of them," or to keep the dialectic muscles in the top of condition.

Dilemmas of Etiquette, Law, Strategy, Ethics, Etc.

To the majority of mankind the supremely interesting problems are those dealing with practical life. But for the very reason that they have a practical focus, they are not strictly classifiable as puzzles. Hence little more can be done than to suggest in the briefest and most fragmentary way a few lines along which are discoverable cases, which seem to possess a modicum, at least, of puzzle quality.

[1] De Morgan: "Budget of Paradoxes," p. 28.
[2] *Knowledge*, III, p. 7.
[3] *Science*, N. S., V, p. 105.
[4] "Critique of Pure Reason," Introduction, Trans. by Müller, p. XXI.

Mason[1] quotes the observation of a whaling captain, that the Eskimo often go out, in sport, to difficult places, and having imagined themselves in certain straits, compare notes as to what each one would do. Fifteen years ago the puzzle mania in England, after a long vogue of acrostics and the like, finally went over to personal dilemma puzzles, not unlike those of the Eskimo. They ran like this: "A certain man does so and so, and in consequence finds himself in such and such a delicate moral situation, what shall he do?" The popularity of certain stories which pose a dilemma, as the "Lady or the Tiger?"; and so-called mystery stories, a device of modern newspaperdom, wherein the culmination of the plot is left to the ingenuity of the reader, are further illustrations in point. The correspondence columns of many periodicals to-day also show the almost morbid degree of interest, on the part of some, in questions of etiquette. How many of these problems belong strictly to the puzzle field cannot be determined.

In the field of strategy the puzzles are perhaps few, but of exceeding interest to some minds. One of the writer's friends occasionally whiles away a tedious quarter of an hour by planning an impenetrable fort, and then attempts to make his way in.

From the very nature of Casuistry as an application of reason to particular cases where conflicting or apparently conflicting duties are involved, it became the source no less than scholasticism of formal distinctions, of logical subtleties, which are the rich soil for the possible growth of puzzle material. But, as in the case of philosophy, it is only in its degenerate states, and not always then that its problems are fairly to be called puzzles, having in general entirely practical ends. The later works on casuistry (up to 1700) contain such problems as these, "Does a man who steals four shillings commit a mortal sin, or only a venial one?" "Does a man who blasphemes twenty saints at once, commit twenty sins, or only one?" The culmination of this rank development is perhaps in the doctrine of Probabilism, which rested on the theory that the moral law does not bind in cases where it is doubtful, and that it may be considered doubtful if theologians of name have denied that it binds in particular cases. This was an obvious opportunity for endless discussion, and the moral laxity which the principle permitted was so effectively branded by Pascal in his "Provincial Letters" as to lead to the condemnation of the doctrine and the temporary overthrow of the Jesuits in France.

Civil law also furnishes nearly the same favorable conditions for subtle distinctions, and most of the decisions of courts are often difficult applications of principles to particular cases, and hence a form of casuistry in the original meaning of the term. The development of Roman law, with its necessarily great emphasis on definition and fine shades of meaning, must have been also especially responsible for that love of logic-chopping which is supposed to survive to-day in the law courts.

Enough has been said, perhaps, to make it patent that questions of law, strategy and ethics may degenerate into mere puzzles, and when they do so, belong to the Logical and Philosophical groups.

It remains to speak of the abnormal and genuinely morbid aspects of the mental state of puzzle. Nowhere is an abnormal turn so likely as in the field of the ethical and practical. The type of man or woman constantly brooding over fine distinctions of motives and conduct, full of forebodings as to the outcome of simple acts, which, at most, are of little real consequence, and which

[1] "Origin of Inventions."

should have been relegated to automatism, is too sad and too familiar in literature and in life to need illustration. The perspective of life is lost, and the painful unrest tends to color in sombre hue the whole stream of thought.

In distinctly morbid cases also (*Grübelsucht*, or Insanity of Doubt), the matters over which the patients ponder are those discussed in the last two sections. "One patient doubts everything, even his own existence, and is totally unable to arrive at any definite conclusion on any subject. Another cannot discuss a subject without indulging in the tiresome process of hair-splitting, and in so doing exhausting all the subtleties of scholasticism concerning matters more or less familiar or hackneyed." On the basis of the ideas which prevail in the minds of these unfortunates the following classification has been made: The *Metaphysicians*, who ponder abstruse questions. Who created God? What is the origin of language? What is immortality? and the like. The *Realists*, who think of more trivial questions. A Russian prince, for instance, wonders "why men are not as tall as houses." Another wonders why there is only one moon, and not two. The *Scrupulous*, who constantly struggle for precision in statement. They weigh fine distinctions in order to be truthful. The *Timid*, who speculate about personal or bodily accidents and their consequences. The *Reckoners*, full of anxiety to know the numbers of things, who count buttons, windows and every conceivable object.[1] Like the normal philosophical and ethical examples, these questionings, in so far as they are undertaken for supposed ends of conduct, would be excluded by a rigid definition of puzzles, but in so far as they are undertaken merely from an undefined impulse to reach a solution, they would come fairly within.

[1] Ball: "Insanity of Doubt." Tuke's *Dictionary Psych. Med.*