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MEMORY, IMAGINATION, LEARNING, AND THE HIGHER INTELLECTUAL PROCESSES (EXPERIMENTAL)

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I. MEMORY AND IMAGINATION

(*a*) *Imagery.*—In an investigation of the effect of various subjective and objective factors upon the evoking of visual imagery, Burtt (8) found that the arousal of visual imagery of a stimulus tends to be facilitated by increase of complexity of contour of the stimulus, by increase in its size, by increased duration of exposure, by interest, and by motor reinforcement (movements of tracing its outline). The arousal of visual imagery tends to be inhibited by mental and motor distraction. The amount of facilitation is usually greatest in the case of motor reinforcement and interest, and least in the case of increased size and lengthened exposure; individuals differ somewhat, however, in their seriation of the facilitating factors. The mode of operation of these factors differs from individual to individual. Imagery of other modalities, notably kinæsthetic, may initiate or reinforce the visual image; the participation of these factors may in certain observers be essentially attentional, while in other individuals it may be essentially perseverative. In experiments with six observers, five variations of experimental procedure, Miss Clark (11) found that changes in clearness of the visual image are usually attended by objectively verifiable eye-movements; the correspondence between amount of eye-movement and kind of image is probably due to certain condi-

tions of attention; characteristic eye-movements seem to transfer from visual perception to visual imagery. She reports that however one may classify the various types of visual imagery, it is difficult to find images of pure type, the image of each type tending to blend into images of other types. Langfeld (28) assigned to his observers the task of reciting the alphabet as rapidly as possible, omitting certain specified letters. Their introspections show that their method of inhibiting the pronouncing of the forbidden letter consisted in associating (in the fore-period) some form of inhibition with an image of the letter which was to be omitted. Sometimes the inhibition of the vocal organs was directly associated with the letter; sometimes the words of the instructions served as an intermediary; or a movement of the hand or an emotion of fear constituted one term of the association. Imagery tended to drop out as the experiments progressed, but it reappeared in cases of doubt and difficulty.

(*b*) *Acquisition, Recognition, Reproduction.*—Gould and Perrin (24) obtained comparative records of children and adults in learning a maze. They employed a pencil maze; ten children and fourteen adults took part in the experiments. It was found that the average records of the adults were very much superior to those of the children, the superiority amounting to twenty per cent. measured in terms of the time required to make the circuit, twenty-eight per cent. in terms of the number of trials necessary for learning the maze, fifty-four per cent. in terms of excess distance travelled, and eighty-seven per cent. in terms of number of errors. The superiority of the adult is attributed to "more effective intelligence" and to "greater motor stability." Two characteristically different learning procedures were apparent—a hurried, non-analytic procedure, and a studious, analytic procedure; but there was no consistent correlation between mode of procedure and age of learner. The more efficient learner tends to make a relatively poor record at the outset and to acquire efficiency by degrees, the result being a curve which shows a relatively more pronounced initial slope and absence of steeples. The crucial part of the learning for both child and adult is represented by the first ten to fifteen trials; the ensuing trials represent the learner's effort to perfect the route. Littwin (29) summarized a number of the familiar investigations of learning, pointing out their pedagogical applications and indicating problems for future investigation.

Strong (39) investigated the relation between recognition and

length of interval between stimulations. Four books of advertisements were employed as material. In one case these were all presented at a single sitting; in another case, only one book at a sitting and the sittings one day apart; in a third case, only one book at a sitting and the sittings a week apart. A recognition-test after the lapse of a month showed that accumulated presentations are least effective and that presentations separated by an interval of a week are most effective. Advertising space is more effective when used less frequently in large amounts than when used more frequently in small amounts. In various forms of recognition experiment, where words were employed as stimuli, Dr. and Mrs. Strong (40) found that recognitive ability is capable of enormous improvement by practice; and that ability to recognize an experience and ability to localize it temporally are approximately coincident within the first few minutes after the original experience, but that the localizing capacity decreases much more rapidly than recognitive capacity. There are indications that localizing depends upon the same factors as correct recognizing. In a modified association-reaction experiment, where the same stimulus-words were presented at intervals of five minutes, one hour, and one day, it was found that an intimate relationship obtains between difference in recognitive ability and difference in association-time. The authors conclude that the process of recognizing is conditioned by a facilitation of nervous functioning—the experience of novelty and of familiarity being respectively the conscious correlate of hesitant and of accelerated conduction across the synapse. They believe that the experience of temporal localizedness is not qualitatively different from the experience of familiarity but is only a superlative stage of the latter; recognizing is a product of a relatively rough estimate of the amount of acceleration of conduction which has taken place, while localizing is the product of a more refined and accurate estimate of the amount of acceleration.

Misses Gamble and Wilson (21) sought to determine what is the significance of place-associations in recall. They presented nonsense-syllables, arranged in certain positions upon an exposure-tablet; in the test of recall (by the method of correct associates) certain syllables were presented in their original positions upon the tablet, while others were presented in "wrong positions." It was found that remarkable individual differences manifest themselves; on the whole, however, "right position" has a slightly greater tendency to evoke the correct associate than "wrong position,"

and to give rise to a more prompt recall. In a second experiment the same investigators presented nonsense-syllables by means of an exposure-tablet (simultaneously and with definitely spatial positions) and by means of a rotating drum (successively and with a constant and uniform spatial position), the total presentation-time being identical in both cases; in the test of recall, the stimulus-syllables were all presented in one particular position upon the tablet. Here again it was found that place-associations may be a really significant factor in recall. Of these two experiments, the former shows that the recall of one syllable by another is blocked if measures are taken to make the place-syllable associations interfere with one another; and the latter shows that syllable sequences are recalled better if the presentation is of such a sort as to foster the establishing of place-associations.

In experiments with 165 college students Gates (23) found that the average memory span for digits is 7.7 in auditory presentation, and 8.2 in visual presentation. When the length of the list presented exceeds the memory span the average efficiency of reproduction is decreased; there is, however, a type of individual (about eight per cent. of the group) whose reproduction is not impaired by the lengthening of the list. Miss Bennett (3) presented nonsense-syllables, digits, nouns and sentences in both visual and auditory fashion to nine observers. She determined how many elements of each sort of material could be reproduced immediately after a single presentation; and she also determined how many presentations were necessary in each case for a complete memorization of the material. She found a high correlation between the records obtained from the visual presentation and from the auditory presentation of each sort of material; and there are indications of a high correlation between ability to reproduce much after a single presentation and ability to memorize completely with few presentations.[1]

Miss Gamble (20) investigated the relationship between rate of repetition and tenacity of impression. Lists of nonsense-syllables were presented in auditory fashion, at five different rates varying between fifteen syllables per minute and seventy-five per minute. The tenacity of association was measured by the number of repetitions necessary for re-learning after an interval of two weeks. Marked individual differences manifested themselves in these experi-

[1] The author's meaning is not altogether clear; the reviewer infers from the context that she employs the term "mediate retention" in the sense of "complete memorization."

ments; of the four observers to whose results the author attaches greatest significance, two remembered the slow series better and two remembered the fast series better. There seems reason to believe that in those cases where rapid presentation proved to be more advantageous the advantage was due to the fact that the learners found it more difficult to maintain a keen concentration of attention when the rate of presentation was slow. Myers (33) asked fifty normal-school girls to study groups of words and figures with a view to reproducing them in exact order; he permitted them to devote as much time as they wished to the task. When the learners were grouped on the basis of degree of perfection of recall, it was found that the less perfect group had devoted less time to learning the material (490 seconds as compared with 531 seconds) and that they required more time for recall (220 seconds as compared with 123 seconds). Lyon (31) aimed chiefly to determine what relationship obtains between rapidity of learning and excellence of retention; but the investigation also touches upon various subsidiary problems such as the relation between memory for coherent and non-coherent materials, and the influence of age, sex and education upon learning and retention. The author's materials consisted of digits, nonsense-syllables, disconnected words, and selections of prose and poetry; his procedure consisted in recording the learning-time and subsequently (after intervals varying from one day to ten weeks) in testing retention either by a method of free reproduction or by a method of relearning. The learners, 426 in number, ranged between fourteen and thirty years of age; and they represented various degrees of education and various levels of society—students, instructors, business men, and inmates of prisons, workhouses and insane asylums. The author finds that the relation between rapidity of learning and excellence of retention can not be stated in any single general formula. The relation varies with variation in the quality of the material to be learned, and with variation in the length of interval between learning and recall; then, too, the several methods of measuring retentiveness furnish discordant results. The following general statements seem to be justified: When material is logically coherent the rapid learner proves to be more retentive; but the converse is true in the case of non-coherent materials. Individual differences in rapidity of learning are greater than individual differences in retentiveness. Women and girls learn more rapidly but retain less efficiently than men and boys. The rapid learner tends to employ

rhythm, to make use of the whole procedure in learning, and to rely upon his natural learning-type rather than to have recourse to a multiplicity of images from unusual modalities.

Günther (26) describes a number of early memories and reports the results of an unusual opportunity to test the fidelity of one of them. He had removed from his birthplace at the age of five and a half years and had not revisited the scene until twenty-five years later. Previous to this visit he sketched a plan of the house and grounds as he remembered them; employing this sketch as the basis for a test, he found that his fidelity of remembrance amounted, after a lapse of twenty-five years, to 81.5 per cent. In an investigation of the recalling of almost completely forgotten materials, Dr. and Mrs. Myers (34) asked their six observers to attempt to recall selections of prose and poetry which they had once been able to quote, but which were now almost completely forgotten. The records of these experiments, and of an additional experiment which consisted in recalling the names of former classmates, show that the total amount re-acquired in subsequent recalls was approximately twice as much as the content of the first recall; casual suggestions from visual and auditory stimuli, and from movements, ideas and feelings, served as factors in this process of re-acquiring fragments; feeling and general attitude of the observer toward his task was an influential factor in determining the success of the attempt to recall; the recall of rhyming words proved to be of great service in retrieving the rest of the stanza; the feeling of certainty that a given recall was accurate was usually well-founded, but the subjective assurance that the observer was unable to recall was frequently ill-founded.

Conard and Arps (12) undertook to determine what advantage is derived from the use of an "economical" method in the teaching of the fundamental operations of arithmetic—the method consisting in teaching the pupil to "think results only" (for instance, in the problem $8 + 5 + 7 + 9$, to think only of 13, 20, and 29). A group of thirty-two pupils was drilled for eight working-periods by means of this economical method, while a similar group was drilled for an equal number of periods by means of the "traditional" method. A final test showed that the "economical group" were now superior by thirty-three per cent. measured in terms of accuracy, by sixteen per cent. measured in terms of rapidity. In Wells's experiment (43) two practiced typists wrote from unfamiliar copy on each of fifteen days; two experimental sittings of five

minutes' duration took place each day, at the beginning and at the end of the regular forenoon's work. The instructions for the first ten days emphasized the desirability of speed, and for the last five days they emphasized the desirability of accuracy. The chief portion of the author's discussion is devoted to an analysis and description of the various sorts of errors, which he seeks to refer to different psychical levels. In a preliminary experiment Boswell and Foster (5) presented a story and a group of objects to each of two classes, in one case with the instruction that recall would be tested after twenty-four hours, in the other case with the instruction that the test of recall would be deferred for several weeks. In both cases, however, the test took place after several weeks, when it was found that those individuals who had learned for purposes of temporary retention were less successful in recalling the material than those who had intended to retain it for a longer period of time. In a second experiment, pairs of English-Chinese words were presented; and here again the learners were instructed in certain cases that the list was to be learned for temporary retention, while in other cases they were instructed that it was to be learned for permanent retention. The recall of all of the lists was tested (by the method of correct associates) after an interval of five minutes, and again after an interval of two weeks. The results show that slightly more of the "temporary series" than of the "permanent series" could be recalled after five minutes, while after two weeks the ability to recall the "permanent series" was slightly superior to the ability to recall the "temporary series." Remarkably enough, however, the recall-times show the opposite relation—after five minutes, recalling was slightly more prompt in the case of the "permanent series," but after two weeks it was slightly less prompt in the case of the "permanent series." The introspections of the observers revealed no constant or uniform differences between the modes of learning or the modes of recall in the two cases, although several observers reported that in the "temporary series" they were more concerned with the establishing of meaningful associations. Peterson (36) presented lists of words to classes of university students, in one case having the words copied without intent to learn, in the other case with intent to learn. Retention was tested by a method of free reproduction, immediately after presentation and again after an interval of two days. The results show that intent to learn is an influential factor, and that its effect upon delayed reproduction is considerably greater than upon immediate

reproduction—the increase in memorial effect being fifty per cent. in the former case and twenty-two per cent. in the latter case. The author believes that the effect of the intent is due to a difference in the degree of definiteness of the response-attitude in the two cases, and that the more definite response-attitude facilitates the establishing of certain definite associations.

Brugmans and Heymans (7) confirm Brown's finding[1] that less time is required for the reading of a list of color names than for the naming of a list of color stimuli. In supplementary experiments they found that the reading-time for words and digits is less than the naming-time for the corresponding objects; and that while the reading-time for unfamiliar symbols is longer at the outset than the naming-time for the corresponding objects, it soon becomes less as the result of practice. From these and other experimental findings the authors conclude that this difference in time required for reacting to verbal and to non-verbal material can not be explained from a difference in practice nor from a difference in the strength of the associations involved, as has been held by other writers; they believe, too, that Brown's assumption of a radical difference in physiological processes involved in the two cases does not contribute to a solution of the problem. Brugmans and Heymans, on the contrary, hold that the phenomenon is due to the fact that the reading attitude differs essentially from the naming attitude, the former giving rise to associative processes whose direction of conduction is more definitely determined toward a specific goal. When a verbal stimulus is presented it appeals to the reagent as a word to be pronounced; the associations aroused are therefore more definitely determined as to their direction, and hence they function more promptly in evoking the appropriate speech-movements. But when the stimulus is of a non-verbal sort its associative resultant is distributed instead of being concentrated in a single direction—for instance, a color stimulus may recall any object of similar color in nature or in art; and since in consequence of this multiplicity the associations tend less to issue in a single direction, interference is more likely to occur and the response is less prompt.

(*c*) *Practice, and the Transfer of Training.*—Since efficiency improves with practice, Fernberger (17) raises the question as to how many determinations must be made in an anthropometric test, and

[1] W. Brown, Practice in Associating Color Names with Colors. *Psychol. Rev.*, 1915, 22, 45–55; summarized in this Bulletin, 1916, 13, 347f.

how much practice should be acquired before one can be sure that the measurement of the subject's sensitivity is accurate and reliable. An investigation of this problem indicates that in lifted weights fifty determinations upon each comparison-pair is the minimum number upon which a measurement of sensitivity can safely be based. Boring (4), however, points out that the importance of practice consists not so much in its effect upon the magnitude of the limen as in its effect upon constancy of judgment; and he holds that in view of the extreme diversity of purpose for which limens are determined, it does not seem safe to place an arbitrary limit upon the number of observations. Harris (27) published data concerning 15,200 estimates of the number of objects contained in groups. The three observers were able to compare their estimates with the true value, and thus they had an opportunity to profit from their experience. An analysis of the data shows that experience seems to have but little influence upon personal equation, but that it tends to give rise to a greater steadiness of judgment. In Phillips's experiment (37) pupils in each grade, from the fourth to the eighth inclusive, were asked to add continuously (or to subtract or to multiply continuously) for a period of ten minutes, the score for each minute being recorded separately. It was found that from six to twelve per cent. more work is accomplished in the first minute than in any of the subsequent nine minutes, from which the author infers that an individual's ability in the fundamentals of arithmetic may be determined from what he accomplishes in one minute of work.

Chapman and Miss Hills (9) publish records of weekly tests of efficiency made upon 100 members of a typewriting class in a school of commerce. They find that negative acceleration in improvement is not an invariable characteristic of the curve of learning; positive acceleration (concavity of learning-curve) was found to be a frequent phenomenon and to continue through as many as sixty hours of practice. Murphy (32) undertook to discover what effect various distributions of practice have upon the acquisition and the retention of skill. Groups of normal-school students practiced throwing a javelin at a target, one group practicing five times a week, another group twice a week, a third group once a week. Unfortunately, the scores obtained by the various groups are incomparable with one another, and hence they do not throw any light upon the author's problem. In Thorndike's investigation (41) sixty-four educated adults practiced writing the

products of numbers—the practice, which entailed the writing of 3,840 products, being distributed differently for each of the six groups. The practice was preceded and followed by a test of efficiency. Improvement was found to be universal and large, amounting to an increase of one hundred per cent. of performance and a decrease of fifty per cent. of error. It turned out that when 640 multiplications are made in a single day, they are more profitably done at a single sitting than at four sittings; that whether practice is daily or every other day makes little or no difference in the improvement; and that whether practice is distributed over twenty-four days or accumulated into six days makes little difference provided the long day's work is done at one sitting. Individual differences are very great, certain individuals improving fifteenfold more than others; the most rapid workers tend to be most accurate; as to the form of the work-curve, there is no evidence of initial spurt and very slight evidence of final spurt. In a second investigation it was found that of fifteen college students who practiced typewriting, checking numbers, adding and multiplying, those who possessed initial high ability improved most—excepting in the case of typewriting where the opposite relation was found to hold. In a third investigation, Thorndike attacked the problem of the effect of work and rest upon mental efficiency—the mental function tested being ability to master the meaning of a paragraph. Twelve paragraphs were assigned, ten to be read at a continuous sitting, the other two after a period of rest. It was found that during the continuous sitting the time required for mastering the meaning increases slightly (about five per cent.) as the work is continued; and that it decreases by about fifteen per cent. after a period of rest. The quality of the work remains approximately constant throughout. In a fourth investigation Thorndike assigned to his observers the task of multiplying three-place numbers by two-place numbers; in one case a rest of twenty minutes was introduced after every five multiplications; in another case a rest of ten minutes was introduced; and in a third case the work proceeded continuously. The results show a slight advantage in favor of the ten-minute rest, both in immediate achievement and in subsequent effect.

Batson (2) investigated the process of acquiring skill in motor activities of different degrees of complexity. He found that no plateau appears in the learning-curve in cases where the learning consists in establishing a sensori-motor association of a very simple

sort, and where, therefore, the improvement is the product of a single factor—for instance, in learning to make such accurate estimations of time as would ensure success in striking a specified point upon a moving target. When the acquisition of skill is the product of several coöperating factors—as in learning to toss and catch a number of balls—the learner may adopt a procedure in which he distributes his attention more or less uniformly over the various factors, and he may by this means acquire control over them as a group; in this case again there is no plateau in the learning-curve. But if his procedure consists in isolating the factors and then in successively mastering each factor independently before proceeding to master the others, his learning-curve will be characterized by plateaus. Batson also discusses the influence of various subjective and objective factors, the phenomenon of warming-up, and the permanence of improvement.

Evans (16) studied the effect of distraction upon reaction-time. Reactions to visual, auditory and tactual stimuli were each subjected to visual, auditory and tactual distractions. Records obtained from six reagents show that all modalities of distraction lengthen reaction-time to stimuli of all modalities, the distractive effect being greater when the reaction-stimulus and the distraction-stimulus belong to the same modality. The distraction effect was decreased by practice, but was never wholly overcome. In a second experiment, six reagents practiced reacting to visual and auditory stimuli, both with and without distraction. Before and after the training they were tested in reactions to visual, auditory and tactual stimuli, both with and without distraction. It was found that practice in reacting to a given stimulus with a given distraction improves the reaction to a stimulus of different modality with the same distraction, and to the same stimulus with distraction from another modality. The author refers this improvement to a changed attitude or adjustment on the part of the reagent, which in turn is held to be a product of training in habits of attention. In Mrs. Cowan's experiment (14) lists of words and lists of nonsense-syllables were presented to children who were assigned the task of isolating as many pairs of words or syllables as possible and then of attending to each of these pairs. To this task the children devoted five minutes on each of forty days, the object being to train them in a "habit of attention." Tests of immediate recall of objects and selections of prose were made before and after this period of training. It was found that the practiced group showed

slightly greater improvement in memory for objects and in memory for prose than did the unpracticed group.

Coover's investigation of the transfer of training (13) covers an unusually wide range of mental functions, including sensory discrimination in several modalities, compass of attention, simple and complex reaction involving discriminations and choices of various sorts, the learning and reproducing of various sorts of material, etc. His findings demonstrate the existence of transfer throughout; and while he publishes numerous quantitative statements of the amount of transfer which took place in the several cases, the major portion of his discussion is devoted to an analysis of the factors upon which transfer depends. From the introspections of his observers Coover finds that practice in any activity tends to divest the activity of its adventitious accompaniments; when the activity is of a more complex sort it frequently happens that the reagent adopts a wholly new and more economical procedure in consequence of his training. He tends to acquire a more appropriate distribution of attention over the component processes and over the various possible reactions which he may be called upon to make; he is no longer delayed by non-essential concomitants nor distracted by extraneous stimuli; his attention becomes less variable and more capable of sustained concentration; his several modalities of imagery coöperate more effectively for purposes of recall; a greater number and variety of associative and apperceptive processes come into function, thus insuring a more accurate perception and a more complete and trustworthy reproduction. And since each of these factors may participate in other activities than the specific activity practiced, the effect of the practice may extend beyond the limits of the specific activity. In so far as the practice effect has to do with the material of experience (imagery, representative schemas, and the like) the author employs the term "transference of training"; in so far as the practice effect involves the form of experience (attitude, control of attention, elimination of non-essential concomitants) the author prefers to speak of "spread of training."

II. Conditions which Affect Mental Functioning

Chapman and Nolan (10) find that in the task of adding continuously for a period of sixteen minutes (twenty girls, seven working-periods each) much more is accomplished during the first minute than during any subsequent minute—the efficiency during

the first half-minute being twenty-nine per cent. greater than the average efficiency of the last twenty half-minutes of the working-period. Gates (22) reports an investigation of diurnal variations in memory and association. Groups of college students, 165 students in all, were tested at each hour of the day from eight in the morning until five in the afternoon. The tests included visual and auditory memory span, substituting, recognizing, and the remembering of coherent verbal material. It was found that average efficiency in all of the functions tested follows an irregular diurnal course, increasing progressively to a maximum at about ten in the forenoon and dropping to a minimum shortly after noon; the afternoon wave follows a somewhat similar course but the limits of variation are less wide here. Miss Curtis (15) aimed to discover whether the rapid repetition of materials to be learned is more fatiguing than the slow repetition. Her seven observers memorized lists of nonsense-syllables which were presented in auditory fashion, both the time and the number of repetitions necessary for complete memorization being recorded. In a preliminary series of experiments the investigator determined for each observer a rapid rate and a slow rate of presentation which gave equal learning-times. Various means of measuring fatigue were tested, none of which proved wholly satisfactory; it was finally decided to measure the amount of fatigue present by a multiplication test and by the observer's progressive loss of efficiency in memorizing. It turned out that those learners who made much use of visual imagery preferred a slow rate of presentation, while those "who appear to have been greatly aided by auditory-kinæsthetic preseveration" preferred a rapid rate of presentation. The results of the investigation are not wholly conclusive, due apparently to the presence of pronounced individual variations.

Fernberger (18) investigated the influence of mental and physical work upon judgments of lifted weights. The mental work assigned to his five observers consisted in mastering the content of difficult German prose, the work-period having a duration of thirty minutes; the physical work consisted in exercising the muscles of the right hand and forearm to the point of exhaustion by means of an ergograph. One hundred comparisons of lifted weights were made by each observer before and after the work-period. The mental work seemed to have no influence upon the judgment; but the physical work (which involved the same muscle-groups as were employed in the lifting of the weights) had a pronounced effect in

decreasing the ability to compare lifted weights. Painter (35) raises the question as to whether the onset of mental incapacity in consequence of extreme fatigue is abrupt or gradual. Does the exhausted worker find it possible, say, to multiply three-place numbers when he is no longer able to multiply four-place numbers? The author devoted himself continuously to the task of multiplying four-place numbers until he was no longer able to continue with the task (the duration of this sitting was slightly more than four hours). He found that the ability to do mental multiplication does not tail off gradually but terminates abruptly; at the stage where the ability to multiply four-place numbers is no longer present one finds it impossible to multiply any number by any other number.

Thorndike, McCall and Chapman (42) report an investigation in which forty students were submitted to various tests of mental efficiency (cancelling digits, naming colors, naming opposites, adding and multiplying) under widely different conditions of ventilation—varying between a hot, humid and stagnant condition of air, 86° F. with eight per cent. relative humidity, and an optimum condition, 68° F. with fifty per cent. relative humidity, forty-five cubic feet per person per minute of outside air introduced in the latter case. It was found that the students did as much work, that they did it as well, and that they improved as rapidly in the ill-ventilated room as in the well-ventilated room. Reed (38) assigned various tasks (silent reading, counting, adding, writing, multiplying) to his thirteen observers, and obtained graphic records of the tongue-movements which occurred during the performance of these tasks—the investigator hoping by this means to throw light upon the question as to the functioning of "inner speech." It was found that in certain observers, movements of the tongue are present throughout, in other observers they are never present, while in a third group they are present in the case of certain tasks but not in the case of other tasks (most frequently present in writing, least frequently in counting). From these and additional experiments where vocal-motor distractions were introduced, the author concludes that "inner speech" does not play an important rôle in mental functioning.

Miss Bronner (6) discusses the influence of attitude and emotion upon intellectual efficiency, and cites cases where indifference, ill-will and deceit on the part of the examinee were influential factors; and where such emotions as anger, fear, shame and the like vitiated the diagnosis. Lodge and Jackson (30) measured

the immediate reproduction (for passages of prose) of 179 college students. The reproductions are evaluated both by a qualitative method, which gives credit for organization and coherence of product, and by a quantitative method, which merely assigns a unit credit for each idea reproduced. The results indicate that the freshmen are the most intelligent group, a finding which the authors believe to be due to greater "natural ability." Students below the age of twenty-five tend to obtain a higher score than students above that age, and the women obtain better scores than the men. The authors conclude that the qualitative method of treating results is to be preferred.

III. Higher Intellectual Processes

Bartlett's investigation of perceiving and imaging (1) consisted in presenting materials (geometrical figures, pictures, ink-blots) and in subsequently asking his observers to report what they had seen or what they had imaged or been reminded of during the presentation. The presence of symmetrical features and novel features facilitates observation and subsequent representation; features at the top of the figure are more readily observed than features at the bottom. Observers tend to label, to criticize, and to evaluate the stimulus during the process of observing; but the most striking phenomenon is the observer's effort to find a meaning. This phenomenon is invariably present. Without it perception is impossible; and the various component processes which constitute a developed act of perceiving are to be regarded as ways in which the effort to find meaning express themselves in the presence of objective stimuli. In a complete act of perceiving may be found processes of imaging (a situation or an object is reinstated from previous experience) and processes of thinking (relations are apprehended). Both of these involve a freeing of the content from its sensory background, and the freeing may proceed so far that the processes take place in the complete absence of sensory stimulation. Imaging tends to retain a characteristic definiteness of content, and to be attended by well-marked feelings; thinking may be equally definite, but the definiteness appears as a characterization of that which is thought about, and feeling is here minimal.

In a study of the evolution of the concept, Gregor's procedure (25) consisted in having children and adults define the meanings of various concrete and abstract terms—chair, brain, crime, lease, cause, contradiction, sympathy, etc. He found that the concept

passes through a number of characteristic developmental stages. The primitive form of defining an object consists merely in stating its purpose or use ("a chair is something for sitting on"); or the defining of a term may consist simply in enumerating the varieties of object to which the term refers. From this primitive origin there gradually evolves a stage in which abstract terms and supra-ordinate concepts are employed, in groping and stumbling fashion at first but gradually more accurately and pertinently. The new concept may develop from a familiar one ("lease is a kind of buying;" "lease is buying something for a year"). At the lower stages of this evolution, accurate and refined differentiation is lacking and hence early connotations are too inclusive; the narrowing down to proper limits is a gradual process in which current forms of speech are among the most influential factors. Miss Fisher (19) investigated the process of abstraction and its product, the general concept. Her experimental material consisted of several series of pen-and-ink drawings of complex colored figures, each figure containing certain general features which were common to all the figures of the series, and certain particular or non-common features; a nonsense-name which designated the series was appended to each figure. These figures were presented in successive fashion, the observer being instructed that he would subsequently be asked to define the group term which designated the series, and to furnish an introspective description of the mental processes and procedures involved throughout. It was found that the process of abstraction is characterized by a succession of imaginal and sensational contents; the essence of the process, however, consists not in the mere presence in consciousness of these contents but in a characteristic behavior or mode of functioning of these contents. And this behavior can best be described in terms of their variations of relative clearness and focality, together with changes in their durative aspects (their rate of emergence, their degree of persistence, and their abrupt or gradual disappearance). Those contents which prove to be general or common obtain an ascendency over the other contents and prevail in consciousness, while the non-common contents remain unclear and non-focal or sink into oblivion. The visual predominance of the common features was frequently attended by vocal-motor processes of labelling and verbal characterization, by actual or ideated movements of tracing their outlines, and by experiences of imitating and empathy. The mental representation of the concept passed through a series of developmental stages as the

observer's familiarity with the series of figures increased. At the outset, the concept appeared in the form of definite and detailed concrete imagery, usually of a visual or kinæsthetic sort, which was frequently subject to panoramic mutations; but as the experiments progressed these detailed images were supplanted by imagery of a more and more abbreviated and schematic form. Meanwhile, verbal imagery (usually vocal-motor) was assuming a progressively more important rôle, until a stage was reached where the concept appeared almost exclusively in verbal terms. At a later stage, these verbal images in turn became more and more schematic and fragmentary and more and more telescoped, until finally there came a mechanized stage where, after sufficiently frequent recurrence, conscious representation of the content of the concept was wholly lacking—the request to define was here followed immediately by an automatized flow of verbal statement.

Wolters's investigation (44) aimed to discover whether there is any psychological difference between the affirmative judgment and the negative judgment. He assigned various prbolems to his seven observers, and had them give introspective descriptions of the mental processes involved in solving these problems. The problems were of two sorts: In certain cases an epithet or a predicate was to be supplied by the observer—here in the non-affirmative instances one is concerned with what the author calls "negatives of construction"; in other cases the observer was required to pass judgment upon the correctness of a statement or a picture—the non-affirmative instances are here called "negatives of denial." An examination of the protocols shows that affirmative judgments and negative judgments dô not differ in mental content or in the mental processes by which they are mediated. The two forms of negation, however, (negatives of construction and negatives of denial) are psychologically distinct. The negative of construction differs from the corresponding affirmative only in its verbal expression; logical theory distinguishes between affirmative propositions and negative propositions but there is no psychological difference between the judgments which underlie the two. Whether the resulting proposition is to be affirmative or negative, the course of the judgment is identical in the two cases; it is determined throughout by the thinker's purpose. The negative of construction demands the prior formation of a positive judgment, but the denial of a proposition may be immediate—it may take place without any previous analysis or positive judgment. The denial-negation

is a definite experience which is chiefly emotional in character but it may also contain kinæsthetic and other sensory ingredients. It is essentially a mental disturbance, a complex attitude of caution or even hostility. The corresponding consciousness of agreement or acceptance is less striking and less characteristic. The denial-negation, with its conspicuous components of emotion and kinæsthesis, has probably evolved from a primitive form of reaction; it has elements in common with the animal's combative resistance to interference.

REFERENCES

1. BARTLETT, F. C. An Experimental Study of Some Problems of Perceiving and Imaging. *Brit. J. of Psychol.*, 1916, 8, 222–267.
2. BATSON, W. H. Acquisition of Skill. *Psychol. Monog.*, 1916, 21 (No. 91). Pp. 92.
3. BENNETT, F. The Correlations between Different Memories. *J. of Exp. Psychol.*, 1916, 1, 404–418.
4. BORING, E. G. The Number of Observations upon which a Limen May be Based. *Amer. J. of Psychol*, 1916, 27, 315–319.
5. BOSWELL, F. P., & FOSTER, W. S. On Memorizing with the Intention Permanently to Retain. *Amer. J. of Psychol.*, 1916, 27, 420–426.
6. BRONNER, A. F. Attitude as it Affects Performance of Tests. *Psychol. Rev.*, 1916, 23, 303–331.
7. BRUGMANS, H. J. F. W., & HEYMANS, G. Versuche über Benennungs- und Lesezeiten. *Zsch. f. Psychol.*, 1916, 77, 92–110.
8. BURTT, H. E. Factors which Influence the Arousal of the Primary Visual Memory Image. *Amer. J of Psychol.*, 1916, 27, 87–118.
9. CHAPMAN, J. C., & HILLS, M. E Positive Acceleration in Improvement in a Complex Function. *J. of Exp. Psychol.*, 1916, 1, 494–507.
10. CHAPMAN, J. C., & NOLAN, W. J. Initial Spurt in a Simple Mental Function *Amer. J. of Psychol.*, 1916, 27, 256–260.
11. CLARK, H. Visual Imagery and Attention: An Analytical Study. *Amer. J. of Psychol.*, 1916, 27, 461–492.
12. CONARD, H. E., & ARPS, G. F. An Experimental Study of Economical Learning. *Amer. J. of Psychol.*, 1916, 27, 507–529.
13. COOVER, J. E. Formal Discipline from the Standpoint of Experimental Psychology. *Psychol. Monog.*, 1916, 20 (No. 87). Pp. 307.
14. COWAN, E. A. An Experiment on the Influence of Training on Memory. *J. of Educ. Psychol.*, 1916, 7, 31–38.
15. CURTIS, J. N. The Relative Amounts of Fatigue Involved in Memorizing by Slow and Rapid Repetition. *Psychol. Monog.*, 1916, 22 (No. 96), 153–190.
16. EVANS, J. E. The Effect of Distraction on Reaction-Time, with Special Reference to Practice and the Transfer of Training. *Arch. of Psychol.*, 1916, 37. Pp. 106.
17. FERNBERGER, S. W. The Effects of Practice in its Initial Stages in Lifted Weight Experiments and its Bearing upon Anthropometric Measurements. *Amer. J. of Psychol.*, 1916, 27, 261–272.
18. FERNBERGER, S. W. The Influence of Mental and Physical Work on the Formation of Judgments in Lifted Weight Experiments. *J. of Exp. Psychol.*, 1916, 1, 508–532.

19. FISHER, S. C. The Process of Generalizing Abstraction; and its Product, the General Concept. *Psychol. Monog.*, 1916, 21 (No. 90). Pp. 213.
20. GAMBLE, E. A. McC. Rate of Repetition and Tenacity of Impression. *Psychol. Monog.*, 1916, 22 (No. 96), 99–151.
21. GAMBLE, E. A. McC., & WILSON, L. A Study of Spatial Associations in Learning and in Recall. *Psychol. Monog.*, 1916, 22 (No. 96), 41–97.
22. GATES, A. I. Diurnal Variations in Memory and Association. *Univ. of Calif. Publ. in Psychol.*, 1916, 1 (No. 5), 323–344.
23. GATES, A. I. The Mnemonic Span for Visual and Auditory Digits. *J. of Exp. Psychol.*, 1916, 1, 393–403.
24. GOULD, M. C., & PERRIN, F. A. C. A Comparison of the Factors Involved in the Maze Learning of Human Adults and Children. *J. of Exp. Psychol.*, 1916, 1, 122–154.
25. GREGOR, A. Untersuchungen über die Entwicklung einfacher logischer Leistungen (Begriffserklarung). *Zsch. f. angew. Psychol.*, 1915, 10, 339–451.
26. GÜNTHER, A. Allgemeine Jugenderinnerungen und Lokalerinnerungen sowie Nachprufung letzerer auf ihre Richtigkeit nach 25 Jahren. *Zsch. f. angew. Psychol.*, 1915, 10, 285–299.
27. HARRIS, J. A. On the Influence of Previous Experience on Personal Equation and Steadiness of Judgment in the Estimation of the Number of Objects in Moderately Large Samples. *Psychol. Rev.*, 1916, 23, 30–48.
28. LANGFELD, H. S. Concerning the Image. *Psychol. Rev.*, 1916, 23, 180–189.
29. LITTWIN, M. F. Literature Memorization in the Light of Experimental Pedagogy. *Ped. Sem.*, 1916, 23, 502–527.
30. LODGE, R. C., & JACKSON, J. L. Reproduction of Prose Passages. *Psychol. Clinic*, 1916, 10, 128–145.
31. LYON, D. O. The Relation of Quickness of Learning to Retentiveness. *Arch. of Psychol.*, 1916, 34, 1–60.
32. MURPHY, H. H. Distribution of Practice Periods in Learning. *J. of Educ. Psychol.*, 1916, 7, 150–163.
33. MYERS, G. C. Some Correlations between Learning and Recall. *J. of Educ. Psychol.*, 1916, 7, 546–547.
34. MYERS, G. C., & C. E. Reconstructive Recall. *Amer. J. of Psychol.*, 1916, 27, 493–506.
35. PAINTER, W. S. Efficiency in Mental Multiplication under Extreme Fatigue. *J. of Educ. Psychol.*, 1916, 7, 25–30.
36. PETERSON, J. The Effect of Attitude on Immediate and Delayed Reproduction: A Class Experiment. *J. of Educ. Psychol.*, 1916, 7, 523–532.
37. PHILLIPS, F. M. A Comparison of the Work Done in the Successive Minutes of a Ten-Minute Practice Period in the Fundamentals of Arithmetic. *J. of Educ. Psychol.*, 1916, 7, 271–277.
38. REED, H. B. The Existence and Function of Inner Speech in Thought Processes. *J. of Exp. Psychol.*, 1916, 1, 365–392.
39. STRONG, E. K., JR. The Factors Affecting a Permanent Impression Developed Through Repetition. *J. of Exp. Psychol.*, 1916, 1, 319–338.
40. STRONG, M. H., & E. K., JR. The Nature of Recognition Memory and of the Localization of Recognitions. *Amer. J. of Psychol.*, 1916, 27, 341–362.
41. THORNDIKE, E. L. Notes on Practice, Improvability, and the Curve of Work. *Amer. J. of Psychol.*, 1916, 27, 550–565.

42. THORNDIKE, E. L., McCALL, W. A., & CHAPMAN, J. C. *Ventilation in Relation to Mental Work.* New York: Teachers' College, Columbia University, 1916. Pp. 83.

43. WELLS, F. L. On the Psychomotor Mechanisms of Typewriting. *Amer. J. of Psychol.*, 1916, 27, 47–70.

44. WOLTERS, A. W. The Process of Negation. *Brit. J. of Psychol.*, 1916, 8, 183–211.

VISUAL SPACE

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Only a few contributions to the literature on visual space were added during the past year. Buhler (2), in a very serviceable encyclopædic dictionary in the German language, gives a standard account of the laws and characteristics of visual space perception.

The advantage of side, or uniocular, vision over front, or binocular, vision to the moving animal in gauging the relative distance of objects, is convincingly discussed by Trowbridge (6). When a bird or mammal with lateral vision moves forward, the principal visual axis is perpendicular to its motion, giving the maximum apparent displacement of objects with every forward movement. Distance is judged by the relative displacement: objects near at hand suffer greater displacement than those more distant. This principle should be considered in any theory of orientation implying a sense of direction. Dabney (3) supplements Professor Trowbridge's article by calling attention to the fact that in estimating distance there may occur a "trigonometric operation, in which the distance between the eyes is the base of a triangle, the two lines of vision converging upon the observed object, being the other sides of the triangle."

Watt (7) upon a deductive and somewhat arbitrary foundation, denies the possibility of kinæsthetic components in visual perception of depth. Muscular sensations of convergence and accommodation do not fuse with purely visual sensations into a complex, nor do labyrinthine sensations fuse with the visual. Perception of distance, as in stereoscopy, is due to visual factors solely. Stereoscopic vision is primarily the production of a third direction or dimension of *form*, not space. The primary psychological factor in stereoscopic vision is the binocular disparation of form.

Ritter (4) reports an experimental study of the well-known tendency toward the overestimation of vertical distances. She