1
Introduction

(1890)
William James

Psychology (Briefer Course), New York: Holt, Chapter XVI, "Association," pp. 253–279

William James was the greatest psychologist that America has produced. *Psychology (Briefer Course)* is a Psych 1 text, designed to give undergraduates an exposure to the main ideas of scientific psychology, as it was understood in the late nineteenth century. James wrote a two-volume set, *Principles of Psychology*, which was abridged and condensed to produce the shorter version. From our point of view, this was desirable, because in the abridgment James cut out details of exposition and experiment, which have not aged well, and left the main ideas and arguments, which have.

We have reprinted only the chapter on association in this volume, because of its remarkable foreshadowing of some of the main ideas of neural networks. However, the rest of the book is equally impressive in other ways, and is well worth reading as a source of insights that are still valuable. The book is available in paperback in several editions.

It is often not appreciated that James taught physiology for a while early in his career and knew a great deal about the structure of the brain. Chapters 2–9 of *Psychology (Briefer Course)* are devoted to a description of neuroanatomy and neurophysiology as understood at the time. Chapter 9 contains the wonderful line, "The way really to understand the brain is to dissect it" (p. 81), followed by a detailed description of how to obtain a sheep's brain, where to obtain an autopsy kit, and what to look for during dissection. It is hard to overemphasize the importance of this point, both to James and to those who wish to understand or model the brain as a working organ. Unfortunately, some of the currently available paperback editions of *Psychology (Briefer Course)* cut out the chapters with the neuroanatomy and neurophysiology, and renumber the remaining chapters. Looking back from the perspective of a century it is, first, remarkable how much was known about the brain in 1890, and, second, how much we have learned since then.

As James points out emphatically in several places, the brain is not constructed to think abstractly—it is constructed to ensure survival in the world. It has many of the characteristics of a good engineering solution applied to mental operation: do as good a job as you can, cheaply, and with what you can obtain easily. If this means using ad hoc solutions, with less generality than one might like, so be it. We are living in one particular world, and we are built to work in it and with it. As James put it (pp. 3–4),

> *Mental facts cannot properly be studied apart from the physical environment of which they take cognizance.* The great fault of the older rational psychology was to set up the soul as an absolute spiritual being with certain faculties of its own by which the several activities of remembering, imagining, reasoning, willing, etc. were explained, almost without reference to the peculiarities of the world with which these activities deal. But the richer insight of modern days perceives that our inner faculties are *adapted* in

advance to the features of the world in which we dwell.... Mind and world in short have evolved together, and in consequence are something of a mutual fit.

James' comment about rational psychology could be applied, unfortunately, to some kinds of current artificial intelligence and neural network research.

This evolutionary perspective is prominent in current neurobiology as well as in James' book, and should not be lost sight of when working with neural networks. The emerging field of neuroethology demonstrates over and over how tightly coupled details of nervous system organization and species specific behavior are. Frogs effectively see only moving bugs (Lettvin, Maturana, McCulloch, and Pitts, 1959). Toads see moving worms: light worms on dark backgrounds in the summer and dark worms on light backgrounds in the winter (Ewart, 1980). In primates, many cells in areas of temporal neocortex respond preferentially to faces (Baylis, Rolls, and Leonard, 1987). The number of such examples could be extended indefinitely. Camhi (1984) gives a series of wonderful stories about the close connection between the nervous system and an animal's behavior.

One important implication of this is that we should not be surprised if brains cannot compute everything, but only a small, but useful, subset of problems. Brains are only as powerful as they have to be, and are often surprisingly special purpose. The kind of brain organization that we seem to have is very poor at doing arithmetic and formal logic; when it was evolving, there were limited opportunities for doing either. But the ability to form concepts, to see that different things were examples of the same thing, was truly important, as were the abilities to form somewhat arbitrary associations, to make good guesses, and so on. It is surprising that our brains, which evolved for purposes like these, are capable of doing arithmetic and logic at all.

The most interesting thing about the chapter on association is that it presents a detailed, mechanistic model of association that is almost identical in structure to later associative neural networks. If James had thought in terms of mathematical models and had access to a computer, it is hard to believe that he would not have developed a computational network model for association.

First, James believed that association was mechanistic and a function of the cerebral cortex.

Second, he formulated a general elementary principle of association (James' emphasis): "*When two brain processes are active together or in immediate succession, one of them, on reoccuring tends to propagate its excitement into the other*" (p. 256). If we replace "brain process" with neuron, we have a correlational learning rule, almost identical to the Hebb synapse (Hebb, paper 4).

Third, there is a summing rule for brain activity (James' emphasis): "*The amount of activity at any given point in the brain cortex is the sum of the tendencies of all other points to discharge into it, such tendencies being proportionate (1) to the number of times the excitement each other point may have accompanied that of the point in question; (2) to the intensities of such excitements; and (3) to the absence of any rival point functionally disconnected with the first point, into which the discharges might be diverted*" (p. 257).

If we replace "point in the brain cortex" with neuron, or element in the connectionist

sense, then we have a model that gives neuron activity as the sum of its inputs, weighted by a connection strength given by the history of past correlations (point 1), and the current excitement of other neurons (point 2), and with an inhibitory mechanism (point 3). This structure is very close to any one of a number of network models using Hebbian synaptic modification and linear summation of synaptic inputs. This connection is made even stronger if we compare figure 57 in James with the diagram of a typical simple heteroassociative network (see, for example, Anderson et al., paper 22, figure 1).

James considers most complex events to be made up of numerous subassociations, all interconnected by "elementary nerve tracts." He also discusses, under the old psychological term *redintegration*, the ability of networks of partial associations to reconstruct the missing pieces through the cross associations. This tendency, which is shown by almost all connectionist networks and is usually held to be a virtue in them, is seen by James as a mixed blessing. He suggests what we would now call a control structure—interest—as a way to keep this tendency in check, which otherwise would lead to a mechanistic "core dump" containing excess detail.

It is worth discussing William James' connectionist model to show that modern neural networks are not as unique as sometimes claimed. The outlines of network systems were discussed in the nineteenth century. What is different today is the ability, thanks to the computer and general familiarity with mathematical analysis, to take such theoretical networks and actually construct them and use them. Our command of the detail, techniques, and application of modeling is now very much greater. However, the basic insights of James into the operation of the mind have not been fundamentally altered.

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Chapter XVI
Association

The Order of Our Ideas

After discrimination, association! It is obvious that all advance in knowledge must consist of both operations; for in the course of our education, objects at first appearing as wholes are analyzed into parts, and objects appearing separately are brought together and appear as new compound wholes to the mind. Analysis and synthesis are thus the incessantly alternating mental activities, a stroke of the one preparing the way for a stroke of the other, much as, in walking, a man's two legs are alternately brought into use, both being indispensable for any orderly advance.

The manner in which trains of imagery and consideration follow each other through our thinking, the restless flight of one idea before the next, the transitions our minds make between things wide as the poles asunder, transitions which at first sight startle us by their abruptness, but which, when scrutinized closely, often reveal intermediating links of perfect naturalness and propriety—all this magical, imponderable streaming has from time immemorial excited the admiration of all whose attention happened to be caught by its omnipresent mystery. And it has furthermore challenged the race of philosophers to banish something of the mystery by formulating the process in simpler terms. The problem which the philosophers have set themselves is that of ascertaining, between the thoughts which thus appear to sprout one out of the other, *principles of connection* whereby their peculiar succession or coexistence may be explained.

But immediately an ambiguity arises: which sort of connection is meant? connection *thought-of*, or connection *between thoughts?* These are two entirely different things, and only in the case of one of them is there any hope of finding 'principles.' The jungle of connections *thought of* can never be formulated simply. Every conceivable connection may be thought of—of coexistence, succession, resemblance, contrast, contradiction, cause and effect, means and end, genus and species, part and whole, substance and property, early and late, large and small, landlord and tenant, master and servant,—Heaven knows what, for the list is literally inexhaustible. The only simplification which could possibly be aimed at would be the reduction of the relations to a small number of *types*, like those which some authors call the 'categories' of the understanding. According as we followed one category or another we should sweep, from any object with our thought, in this way or in that, to others. Were *this* the sort of connection sought between one moment of our thinking and another, our chapter might end here. For the only summary description of these categories is that they are all thinkable relations, and that the mind proceeds from one object to another by some intelligible path.

Is It Determined by Any Laws?

But as a matter of fact, What determines the particular path? Why do we at a given time and place proceed to think of *b* if we have just thought of *a*, and at another time and place why do we think, not of *b*, but of *c*? Why do we spend years straining after a certain scientific or practical problem, but all in vain—our thought unable to evoke the solution we desire? And why, some day, walking in the street with our attention miles away from that quest, does the answer saunter into our minds as carelessly as if it had never been called for—suggested, possibly, by the flowers on the bonnet of the lady in front of us, or possibly by nothing that we can discover?

The truth must be admitted that thought works under strange conditions. Pure 'reason' is only one out of a thousand possibilities in the thinking of each of us. Who can count all the silly fancies, the grotesque suppositions, the utterly irrelevant reflections he makes in the course of a day? Who can swear that his prejudices and irrational opinions constitute a less bulky part of his mental furniture than his clarified beliefs? And yet, the *mode of genesis* of the worthy and the worthless in our thinking seems the same.

The Laws Are Cerebral Laws

There seem to be mechanical conditions on which thought depends, and which, to say the least, *determine the order in which the objects for her comparisons and selections are presented.* It is a suggestive fact that Locke, and many more recent Continental psychologists, have found themselves obliged to invoke a mechanical process to account for the *aberrations* of thought, the obstructive prepossessions, the frustrations of reason. This they found in the law of habit, or what we now call association by contiguity. But it never occurred to these writers that a process which could go the length of actually producing some ideas and sequences in the mind might safely be trusted to produce others too; and that those habitual associations which further thought may also come from the same mechanical source as those which hinder it. Hartley accordingly suggested habit as a sufficient explanation of the sequence of our thoughts, and in so doing planted himself squarely upon the properly *causal* aspect of the problem, and sought to treat both rational and irrational associations from a single point of view. How does a man come, after having the thought of A, to have the thought of B the next moment? or how does he come to think A and B always together? These were the phenomena which Hartley undertook to explain by cerebral physiology. I believe that he was, in essential respects, on the right track, and I propose simply to revise his conclusions by the aid of distinctions which he did not make.

Objects Are Associated, Not Ideas

We shall avoid confusion if we consistently speak as if *association,* so far as the word stands for an *effect, were between* THINGS THOUGHT OF—*as if it were* THINGS, *not ideas, which are associated in the mind.* We shall talk of the association of *objects,* not of the association of *ideas.* And so far as association stands for a *cause,* it is between *processes in the brain*—it is these which, by being associated in certain ways, determine what successive objects shall be thought.

The Elementary Principle

I shall now try to show that there is no other *elementary* causal law of association than the law of neural habit. All the *materials* of our thought are due to the way in which one elementary process of the cerebral hemispheres tends to excite whatever other elementary process it may have excited at any former time. The number of elementary processes at work, however, and the nature of those which at any time are fully effective in rousing the others, determine the character of the total brain-action, and, as a consequence of this, they determine the object thought of at the time. According as this resultant object is one thing or another, we call it a product of association by contiguity or of association by similarity, or contrast, or whatever other sorts we may have recognized as ultimate. Its *production,* however, is, in each one of these cases, to be explained by a merely quantitative variation in the elementary brain-processes momentarily at work under the law of habit.

My thesis, stated thus briefly, will soon become more clear; and at the same time certain disturbing factors, which coöperate with the law of neural habit, will come to view.

Let us then assume as the basis of all our subsequent reasoning this law: *When two elementary brain-processes have been active together or in immediate succession, one of them, on re-occurring, tends to propagate its excitement into the other.*

But, as a matter of fact, every elementary process has unavoidably found itself at different times excited in conjunction with *many* other processes. Which of these others it shall awaken now becomes a problem. Shall *b* or *c* be aroused next by the present *a*? To answer this, we must make a further postulate, based on the fact of *tension* in nerve-tissue, and on the fact of summation of excitements, each incomplete or latent in itself, into an open resultant (see p. 128). The process *b,* rather than *c,* will awake, if in addition to the vibrating tract *a* some other tract *d* is in a state of sub-excitement, and formerly was excited with *b* alone and not with *a.* In short, we may say:

The amount of activity at any given point in the brain-cortex is the sum of the tendencies of all other points to discharge into it, such tendencies being proportionate (1) *to the number of times the excitement of each other point may have accompanied that of the point in question;* (2) *to the intensity of such excitements; and* (3) *to the absence of any rival point functionally disconnected with the first point, into which the discharges might be diverted.*

Expressing the fundamental law in this most complicated way leads to the greatest ultimate simplification. Let us, for the present, only treat of spontaneous trains of thought and ideation, such as occur in revery or musing. The case of voluntary thinking toward a certain end shall come up later.

Spontaneous Trains of Thought

Take, to fix our ideas, the two verses from 'Locksley Hall':

"I, the heir of all *the ages* in the foremost files of time,"

and—

"For I doubt not through *the ages* one increasing purpose runs."

Why is it that when we recite from memory one of these lines, and get as far as *the ages*, that portion of the *other* line which follows and, so to speak, sprouts out of *the ages* does not also sprout out of our memory and confuse the sense of our words? Simply because the word that follows *the ages* has its brain-process awakened not simply by the brain-process of *the ages* alone, but by it *plus* the brain-processes of all the words preceding *the ages*. The word *ages* at its moment of strongest activity would, *per se*, indifferently discharge into either 'in' or 'one.' So would the previous words (whose tension is momentarily much less strong than that of *ages*) each of them indifferently discharge into either of a large number of other words with which they have been at different times combined. But when the processes of '*I, the heir of all the ages*,' simultaneously vibrate in the brain, the last one of them in a maximal, the others in a fading, phase of excitement, then the strongest line of discharge will be that which they *all alike* tend to take. '*In*' and not '*one*' or any other word will be the next to awaken, for its brain-process has previously vibrated in unison not only with that of *ages*, but with that of all those other words whose activity is dying away. It is a good case of the effectiveness over thought of what we called on p. 168 a 'fringe.'

But if some one of these preceding words—'heir,' for example—had an intensely strong association with some brain-tracts entirely disjoined in experience from the poem of 'Locksley Hall'—if the reciter, for instance, were tremulously awaiting the opening of a will which might make him a millionaire—it is probable that the path of discharge through the words of the poem would be suddenly interrupted at the word 'heir.' His *emotional interest in that word* would be such that its *own special associations would prevail* over the combined ones of the other words. He would, as we say, be abruptly reminded of his personal situation, and the poem would lapse altogether from his thoughts.

The writer of these pages has every year to learn the names of a large number of students who sit in alphabetical order in a lecture-room. He finally learns to call them by name, as they sit in their accustomed places. On meeting one in the street, however, early in the year, the face hardly ever recalls the name, but it may recall the place of its owner in the lecture-room, his neighbors' faces, and consequently his general alphabetical position: and then, usually as the common associate of all these combined data, the student's name surges up in his mind.

A father wishes to show to some guests the progress of his rather dull child in kindergarten-instruction. Holding the knife upright on the table, he says, "What do you call that, my boy?" "I calls it a *knife*, I does," is the sturdy reply, from which the child cannot be induced to swerve by any alteration in the form of question, until the father, recollecting that in the kindergarten a pencil was used and not a knife, draws a long one from his pocket, holds it in the same way, and then gets the wished-for answer, "I calls it *vertical*." All the concomitants of the kindergarten experience had to recombine their effect before the word 'vertical' could be reawakened.

Total Recall

The ideal working of the law of compound association, as Prof. Bain calls it, were it unmodified by any extraneous influence, would be such as to keep the mind in a perpetual treadmill of concrete reminiscences from which no detail could be omitted. Suppose, for example, we begin by thinking of a certain dinner-party. The only thing which all the components of the dinner-party could combine to recall would be the first concrete occurrence which ensued upon it. All the details of this occurrence could in turn only combine to awaken the next following occurrence, and so on. If *a*, *b*, *c*, *d*, *e*, for instance, be the elementary nerve-tracts excited by the last act of the dinner-party, call this act *A*, and *l*, *m*, *n*, *o*, *p* be those of walking home through the frosty night, which we may call *B*, then the thought of *A* must awaken that of *B*, because *a*, *b*, *c*, *d*, *e* will each and all discharge into *l* through the paths by which their original discharge took place. Similarly they will discharge into *m*, *n*, *o*, and *p*; and these latter tracts will also each reinforce the other's action because, in the experience *B*, they have already vibrated in unison. The lines in Fig. 57 symbolize the summation of discharges into each of the components of *B*, and the consequent strength of the combination of influences by which *B* in its totality is awakened.

Hamilton first used the word 'redintegration' to designate all association. Such processes as we have just described might in an emphatic sense be termed redintegrations, for they would necessarily lead, if unobstructed, to the reinstatement in thought of the *entire* content of large trains of past experience. From this complete redintegration there could be no escape save through the irruption of some new and strong present impression of the senses, or through the excessive tendency of some one of the elementary brain-tracts to discharge independently into an aberrant quarter of the brain. Such was the tendency of the word 'heir' in

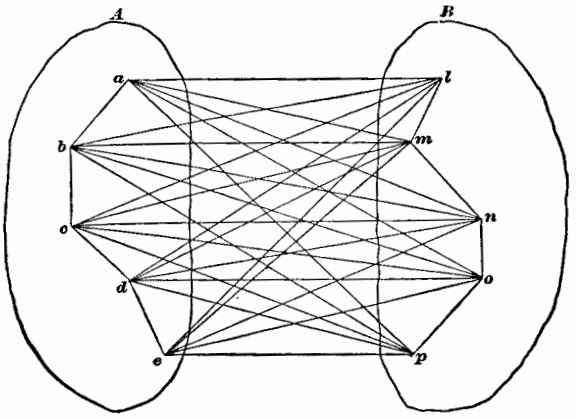

Figure 57

the verse from 'Locksley Hall,' which was our first example. How such tendencies are constituted we shall have soon to inquire with some care. Unless they are present, the panorama of the past, once opened, must unroll itself with fatal literality to the end, unless some outward sound, sight, or touch divert the current of thought.

Let us call this process *impartial redintegration*, or, still better, *total recall*. Whether it ever occurs in an absolutely complete form is doubtful. We all immediately recognize, however, that in some minds there is a much greater tendency than in others for the flow of thought to take this form. Those insufferably garrulous old women, those dry and fanciless beings who spare you no detail, however petty, of the facts they are recounting, and upon the thread of whose narrative all the irrelevant items cluster as pertinaciously as the essential ones, the slaves of literal fact, the stumblers over the smallest abrupt step in thought, are figures known to all of us. Comic literature has made her profit out of them. Juliet's nurse is a classical example. George Eliot's village characters and some of Dickens's minor personages supply excellent instances.

Perhaps as successful a rendering as any of this mental type is the character of Miss Bates in Miss Austen's 'Emma.' Hear how she redintegrates:

"'But where could *you* hear it?' cried Miss Bates. 'Where could you possibly hear it, Mr. Knightley? For it is not five minutes since I received Mrs. Cole's note—no, it cannot be more than five—or at least ten—for I had got my bonnet and spencer on, just ready to come out—I was only gone down to speak to Patty again about the pork—Jane was standing in the passage—were not you, Jane?—for my mother was so afraid that we had not any salting-pan large enough. So I said I would go down and see, and Jane said: "Shall I go down instead? for I think you have a little cold, and Patty has been washing the kitchen." "Oh, my dear," said I—well, and just then came the note. A Miss Hawkins—that's all I know—a Miss Hawkins, of Bath. But, Mr. Knightley, how could you possibly have heard it? for the very moment Mr. Cole told Mrs. Cole of it, she sat down and wrote to me. A Miss Hawkins—'"

Partial Recall

This case helps us to understand why it is that the ordinary spontaneous flow of our ideas does not follow the law of total recall. *In no revival of a past experience are all the items of our thought equally operative in determining what the next thought shall be. Always some ingredient is prepotent over the rest.* Its special suggestions or associations in this case will often be different from those which it has in common with the whole group of items; and its tendency to awaken these outlying associates will deflect the path of our revery. Just as in the original sensible experience our attention focalized itself upon a few of the impressions of the scene before us, so here in the reproduction of those impressions an equal partiality is shown, and some items are emphasized above the rest. What these items shall be is, in most cases of spontaneous revery, hard to determine beforehand. In subjective terms we say that *the prepotent items are those which appeal most to our* INTEREST.

Expressed in brain-terms, the law of interest will be: *some one brain-process is always prepotent above its concomitants in arousing action elsewhere.*

"Two processes," says Mr. Hodgson, "are constantly going on in redintegration. The one a process of corrosion, melting, decay; the other a process of renewing, arising, becoming.... No object of representation remains long before consciousness in the same state, but fades, decays, and becomes indistinct. Those parts of the object, however, which possess an interest resist this tendency to gradual decay of the whole object.... This inequality in the object—some parts, the uninteresting, submitting to decay; others, the interesting parts, resisting it—when it has continued for a certain time, ends in becoming a new object."

Only where the interest is diffused equally over all the parts is this law departed from. It will be least obeyed by those minds which have the smallest variety and intensity of interests—those who, by the general flatness and poverty of their aesthetic nature, are kept for ever rotating among the literal sequences of their local and personal history.

Most of us, however, are better organized than this,

and our musings pursue an erratic course, swerving continually into some new direction traced by the shifting play of interest as it ever falls on some partial item in each complex representation that is evoked. Thus it so often comes about that we find ourselves thinking at two nearly adjacent moments of things separated by the whole diameter of space and time. Not till we carefully recall each step of our cogitation do we see how naturally we came by Hodgson's law to pass from one to the other. Thus, for instance, after looking at my clock just now (1879), I found myself thinking of a recent resolution in the Senate about our legal-tender notes. The clock called up the image of the man who had repaired its gong. He suggested the jeweller's shop where I had last seen him; that shop, some shirt-studs which I had bought there; they, the value of gold and its recent decline; the latter, the equal value of greenbacks, and this, naturally, the question of how long they were to last, and of the Bayard proposition. Each of these images offered various points of interest. Those which formed the turning-points of my thought are easily assigned. The gong was momentarily the most interesting part of the clock, because, from having begun with a beautiful tone, it had become discordant and aroused disappointment. But for this the clock might have suggested the friend who gave it to me, or any one of a thousand circumstances connected with clocks. The jeweller's shop suggested the studs, because they alone of all its contents were tinged with the egoistic interest of possession. This interest in the studs, their value, made me single out the material as its chief source, etc., to the end. Every reader who will arrest himself at any moment and say, "How came I to be thinking of just this?" will be sure to trace a train of representations linked together by lines of contiguity and points of interest inextricably combined. This is the ordinary process of the association of ideas as it spontaneously goes on in average minds. *We may call it ordinary, or mixed, association*, or, if we like better, *partial recall.*

Which Associates Come Up, in Partial Recall?

Can we determine, now, when a certain portion of the going thought has, by dint of its interest, become so prepotent as to make its own exclusive associates the dominant features of the coming thought—can we, I say, determine *which* of its own associates shall be evoked? For they are many. As Hodgson says:

"The interesting parts of the decaying object are free to combine again with any objects or parts of objects with which at any time they have been combined before. All the former combinations of these parts may come back into consciousness; one must, but which will?"

Mr. Hodgson replies:

"There can be but one answer: that which has been most *habitually* combined with them before. This new object begins at once to form itself in consciousness, and to group its parts round the part still remaining from the former object; part after part comes out and arranges itself in its old position; but scarcely has the process begun, when the original law of interest begins to operate on this new formation, seizes on the interesting parts and impresses them on the attention to the exclusion of the rest, and the whole process is repeated again with endless variety. I venture to propose this as a complete and true account of the whole process of redintegration."

In restricting the discharge from the interesting item into that channel which is simply most *habitual* in the sense of most frequent, Hodgon's account is assuredly imperfect. An image by no means always revives its most frequent associate, although frequency is certainly one of the most potent determinants of revival. If I abruptly utter the word *swallow*, the reader, if by habit an ornithologist, will think of a bird; if a physiologist or a medical specialist in throat-diseases, he will think of deglutition. If I say *date*, he will, if a fruit-merchant or an Arabian traveller, think of the produce of the palm; if an habitual student of history, figures with A.D. or B.C. before them will rise in his mind. If I say *bed, bath, morning*, his own daily toilet will be invincibly suggested by the combined names of three of its habitual associates. But frequent lines of transition are often set at naught. The sight of a certain book has most frequently awakened in me thoughts of the opinions therein propounded. The idea of suicide has never been connected with the volume. But a moment since, as my eye fell upon it, suicide was the thought that flashed into my mind. Why? Because but yesterday I received a letter informing me that the author's recent death was an act of self-destruction. Thoughts tend, then, to awaken their most recent as well as their most habitual associates. This is a matter of notorious experience, too notorious, in fact, to need illustration. If we have seen our friend this morning, the mention of his name now recalls the circumstances of that interview, rather than any more remote details concerning him. If Shakespeare's plays are mentioned, and we were last night reading 'Richard II.,' vestiges of that play rather than of 'Hamlet' or 'Othello' float through our mind. Excitement of peculiar tracts, or peculiar modes of general excitement in the brain, leave a sort of tenderness or exalted sensibility behind them which takes days to die away. As long as it lasts, those tracts or those modes

are liable to have their activities awakened by causes which at other times might leave them in repose. Hence, *recency* in experience is a prime factor in determining revival in thought.*

Vividness in an original experience may also have the same effect as habit or recency in bringing about likelihood of revival. If we have once witnessed an execution, any subsequent conversation or reading about capital punishment will almost certainly suggest images of that particular scene. Thus it is that events lived through only once, and in youth, may come in after-years, by reason of their exciting quality or emotional intensity, to serve as types or instances used by our mind to illustrate any and every occurring topic whose interest is most remotely pertinent to theirs. If a man in his boyhood once talked with Napoleon, any mention of great men or historical events, battles or thrones, or the whirligig of fortune, or islands in the ocean, will be apt to draw to his lips the incidents of that one memorable interview. If the word *tooth* now suddenly appears on the page before the reader's eye, there are fifty chances out of a hundred that, if he gives it time to awaken any image, it will be an image of some operation of dentistry in which he has been the sufferer. Daily he has touched his teeth and masticated with them; this very morning he brushed, used, and picked them; but the rarer and remoter associations arise more promptly because they were so much more intense.

A fourth factor in tracing the course of reproduction is *congruity in emotional tone* between the reproduced idea and our mood. The same objects do not recall the same associates when we are cheerful as when we are melancholy. Nothing, in fact, is more striking than our inability to keep up trains of joyous imagery when we are depressed in spirits. Storm, darkness, war, images of disease, poverty, perishing, and dread afflict unremittingly the imaginations of melancholiacs. And those of sanguine temperament, when their spirits are high, find it impossible to give any permanence to evil forebodings or to gloomy thoughts. In an instant the train of association dances off to flowers and sunshine, and images of spring and hope. The records of Arctic or African travel perused in one mood awaken no thoughts but those of horror at the malignity of Nature; read at another time they suggest only enthusiastic reflections on the indomitable power and pluck of man. Few novels so overflow with joyous animal spirits as 'The Three Guardsmen' of Dumas. Yet it may awaken in the mind of a reader depressed with sea-sickness (as the writer can personally testify) a most woful consciousness of the cruelty and carnage of which heroes like Athos, Porthos, and Aramis make themselves guilty.

Habit, recency, vividness, and emotional congruity are, then, all reasons why one representation rather than another should be awakened by the interesting portion of a departing thought. We may say with truth that *in the majority of cases the coming representation will have been either habitual, recent, or vivid, and will be congruous.* If all these qualities unite in any one absent associate, we may predict almost infallibly that that associate of the going object will form an important ingredient in the object which comes next. In spite of the fact, however, that the succession of representations is thus redeemed from perfect indeterminism and limited to a few classes whose characteristic quality is fixed by the nature of our past experience, it must still be confessed that an immense number of terms in the linked chain of our representations fall outside of all assignable rule. To take the instance of the clock given on page 263. Why did the jeweller's shop suggest the shirt-studs rather than a chain which I had bought there more recently, which had cost more, and whose sentimental associations were much more interesting? Any reader's experience will easily furnish similar instances. So we must admit that to a certain extent, even in those forms of ordinary mixed association which lie nearest to impartial redintegration, *which* associate of the interesting item shall emerge must be called largely a matter of accident—accident, that is, for our intelligence. No doubt it is determined by cerebral causes, but they are too subtile and shifting for our analysis.

Focalized Recall, or Association by Similarity

In partial or mixed association we have all along supposed the interesting portion of the disappearing thought to be of considerable extent, and to be sufficiently complex to constitute by itself a concrete object. Sir William Hamilton relates, for instance, that after thinking of Ben Lomond he found himself thinking of the Prussian system of education, and discovered that the links of association were a German gentleman whom he had met on Ben Lomond, Germany, etc. The interesting part of Ben Lomond as he had experienced it, the part operative in determining the train of his ideas, was the complex image of a particular man. But now let us suppose that the interested attention refines itself still further and accentuates a portion of the passing object, so small as to be no longer the image of a concrete thing, but only of an abstract quality or property. Let us moreover suppose that the part thus

* I refer to a recency of a few hours. Mr. Galton found that experiences from boyhood and youth were more likely to be suggested by words seen at random than experiences of later years. See his highly interesting account of experiments in his Inquiries into Human Faculty, pp. 191–203.

accentuated persists in consciousness (or, in cerebral terms, has its brain-process continue) after the other portions of the object have faded. *This small surviving portion will then surround itself with its own associates* after the fashion we have already seen, and the relation between the new thought's object and the object of the faded thought will be a *relation of similarity*. The pair of thoughts will form an instance of what is called '*association by similarity*.'

The similars which are here associated, or of which the first is followed by the second in the mind, are seen to be *compounds*. Experience proves that this is always the case. *There is no tendency on the part of* SIMPLE *'ideas,' attributes, or qualities to remind us of their like.* The thought of one shade of blue does not summon up that of another shade of blue, etc., unless indeed we have in mind some general purpose of nomenclature or comparison which requires a review of several blue tints.

Now two compound things are similar when some one quality or group of qualities is shared alike by both, although as regards their other qualities they may have nothing in common. The moon is similar to a gas-jet, it is also similar to a foot-ball; but a gas-jet and a foot-ball are not similar to each other. When we affirm the similarity of two compound things, we should always say *in what respect it obtains*. Moon and gas-jet are similar in respect of luminosity, and nothing else; moon and foot-ball in respect of rotundity, and nothing else. Foot-ball and gas-jet are in no respect similar—that is, they possess no common point, no identical attribute. *Similarity, in compounds, is partial identity*. When the *same* attribute appears in two phenomena, though it be their only common property, the two phenomena are similar in so far forth. To return now to our associated representations. If the thought of the moon is succeeded by the thought of a foot-ball, and that by the thought of one of Mr. X's railroads, it is because the attribute rotundity in the moon broke away from all the rest and surrounded itself with an entirely new set of companions—elasticity, leathery integument, swift mobility in obedience to human caprice, etc.; and because the last-named attribute in the foot-ball in turn broke away from its companions, and, itself persisting, surrounded itself with such new attributes as make up the notions of a 'railroad king,' of a rising and falling stock-market, and the like.

The gradual passage from total to focalized, through what we have called ordinary partial, recall may be symbolized by diagrams. Fig. 58 is total, Fig. 59 is partial, and Fig. 60 focalized, recall. *A* in each is the passing, *B* the coming, thought. In 'total recall,' all parts of *A* are equally operative in calling up *B*. In

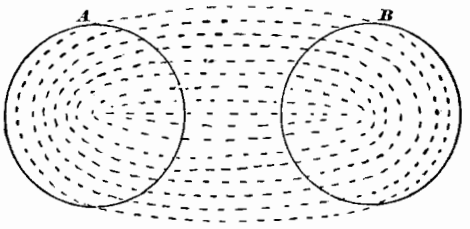

Figure 58

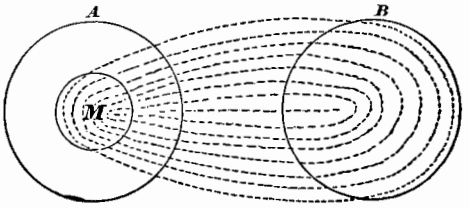

Figure 59

'partial recall,' most parts of *A* are inert. The part *M* alone breaks out and awakens *B*. In similar association or 'focalized recall,' the part *M* is much smaller than in the previous case, and after awakening its new set of associates, instead of fading out itself, it continues persistently active along with them, forming an identical part in the two ideas, and making these, *pro tanto*, resemble each other.*

Why a single portion of the passing thought should break out from its concert with the rest and act, as we say, on its own hook, why the other parts should become inert, are mysteries which we can ascertain but not explain. Possibly a minuter insight into the laws of neural action will some day clear the matter up;

* Miss M. W. Calkins (Philosophical Review, I. 389, 1892) points out that the persistent feature of the going thought, on which the association in cases of similarity hinges, is by no means always so slight as to warrant the term 'focalized.' "If the sight of the whole breakfast-room be followed by the visual image of yesterday's breakfast-table, with the same setting and in the same surroundings, the association is practically total," and yet the case is one of similarity. For Miss Calkins, accordingly, the more important distinction is that between what she calls *desistent* and *persistent* association. In 'desistent' association all parts of the going thought fade out and are replaced. In 'persistent' association some of them remain, and form a bond of similarity between the mind's successive objects; but only where this bond is extremely delicate (as in the case of an abstract relation or quality) is there need to call the persistent process 'focalized.' I must concede the justice of Miss Calkins's criticism, and think her new pair of terms a useful contribution. Wundt's division of associations into the two classes of *external* and *internal* is congruent with Miss Calkins's division. Things associated internally must have some element in common; and Miss Calkins's word 'persistent' suggests how this may cerebrally come to pass. 'Desistent,' on the other hand, suggests the process by which the successive ideas become external to each other or preserve no inner tie.

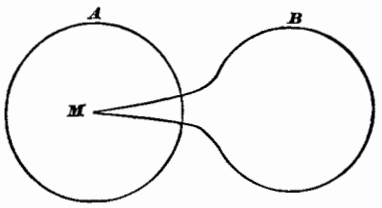

Figure 60

possibly neural laws will not suffice, and we shall need to invoke a dynamic reaction of the consciousness itself. But into this we cannot enter now.

Voluntary Trains of Thought

Hitherto we have assumed the process of suggestion of one object by another to be spontaneous. The train of imagery wanders at its own sweet will, now trudging in sober grooves of habit, now with a hop, skip, and jump, darting across the whole field of time and space. This is revery, or musing; but great segments of the flux of our ideas consist of something very different from this. They are guided by a distinct purpose or conscious interest; and the course of our ideas is then called *voluntary*.

Physiologically considered, we must suppose that a purpose means the persistent activity of certain rather definite brain-processes throughout the whole course of thought. Our most usual cogitations are not pure reveries, absolute driftings, but revolve about some central interest or topic to which most of the images are relevant, and towards which we return promptly after occasional digressions. This interest is subserved by the persistently active brain-tracts we have supposed. In the mixed associations which we have hitherto studied, the parts of each object which form the pivots on which our thoughts successively turn have their interest largely determined by their connection with some *general interest* which for the time has seized upon the mind. If we call Z the brain-tract of general interest, then, if the object *abc* turns up, and *b* has more associations with Z than have either *a* or *c*, *b* will become the object's interesting, pivotal portion, and will call up its own associates exclusively. For the energy of *b*'s brain-tract will be augmented by Z's activity,—an activity which, from lack of previous connection between Z and *a* and Z and *c*, does not influence *a* or *c*. If, for instance, I think of Paris whilst I am *hungry*, I shall not improbably find that its *restaurants* have become the pivot of my thought, etc., etc.

Problems

But in the theoretic as well as in the practical life there are interests of a more acute sort, taking the form of definite images of some achievement which we desire to effect. The train of ideas arising under the influence of such an interest constitutes usually the thought of the *means* by which the end shall be attained. If the end by its simple presence does not instantaneously suggest the means, the search for the latter becomes a *problem*; and the discovery of the means forms a new sort of end, of an entirely peculiar nature—an end, namely, which we intensely desire before we have attained it, but of the nature of which, even whilst most strongly craving it, we have no distinct imagination whatever (compare pp. 241–2).

The same thing occurs whenever we seek to recall something forgotten, or to state the reason for a judgment which we have made intuitively. The desire strains and presses in a direction which it feels to be right, but towards a point which it is unable to see. In short, the *absence of an item* is a determinant of our representations quite as positive as its presence can ever be. The gap becomes no mere void, but what is called an *aching* void. If we try to explain in terms of brain-action how a thought which only potentially exists can yet be effective, we seem driven to believe that the brain-tract thereof must actually be excited, but only in a minimal and sub-conscious way. Try, for instance, to symbolize what goes on in a man who is racking his brains to remember a thought which occurred to him last week. The associates of the thought are there, many of them at least, but they refuse to awaken the thought itself. We cannot suppose that they do not irradiate *at all* into its brain-tract, because his mind quivers on the very edge of its recovery. Its actual rhythm sounds in his ears; the words seem on the imminent point of following, but fail (see p. 165). Now the only difference between the effort to recall things forgotten and the search after the means to a given end is that the latter have not, whilst the former have, already formed a part of our experience. If we first study *the mode of recalling a thing forgotten*, we can take up with better understanding the voluntary quest of the unknown.

Their Solution

The forgotten thing is felt by us as a gap in the midst of certain other things. We possess a dim idea of where we were and what we were about when it last occurred to us. We recollect the general subject to which it pertains. But all these details refuse to shoot together into a solid whole, for the lack of the missing thing, so

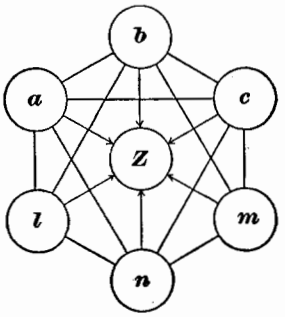

Figure 61

we keep running over them in our mind, dissatisfied, craving something more. From each detail there radiate lines of association forming so many tentative guesses. Many of these are immediately seen to be irrelevant, are therefore void of interest, and lapse immediately from consciousness. Others are associated with the other details present, and with the missing thought as well. When *these* surge up, we have a peculiar feeling that we are 'warm,' as the children say when they play hide and seek; and such associates as these we clutch at and keep before the attention. Thus we recollect successively that when we last were considering the matter in question we were at the dinner-table; then that our friend J. D. was there; then that the subject talked about was so and so; finally, that the thought came *à propos* of a certain anecdote, and then that it had something to do with a French quotation. Now all these added associates *arise independently of the will*, by the spontaneous processes we know so well. *All that the will does is to emphasize and linger over those which seem pertinent, and ignore the rest.* Through this hovering of the attention in the neighborhood of the desired object, the accumulation of associates becomes so great that the combined tensions of their neural processes break through the bar, and the nervous wave pours into the tract which has so long been awaiting its advent. And as the expectant, sub-conscious itching, so to speak, bursts into the fulness of vivid feeling, the mind finds an inexpressible relief.

The whole process can be rudely symbolized in a diagram. Call the forgotten thing Z, the first facts with which we felt it was related a, b, and c, and the details finally operative in calling it up l, m, and n. Each circle will then stand for the brain-process principally concerned in the thought of the fact lettered within it. The activity in Z will at first be a mere tension; but as the activities in a, b, and c little by little irradiate into l, m, and n, and as *all* these processes are somehow connected with Z, their combined irradiations upon Z, represented by the centripetal arrows, succeed in rousing Z also to full activity.

Turn now to the case of finding the unknown means to a distinctly conceived end. The end here stands in the place of a, b, c, in the diagram. It is the starting-point of the irradiations of suggestion; and here, as in that case, what the voluntary attention does is only to dismiss some of the suggestions as irrelevant, and hold fast to others which are felt to be more pertinent—let these be symbolized by l, m, n. These latter at last accumulate sufficiently to discharge all together into Z, the excitement of which process is, in the mental sphere, equivalent to the solution of our problem. The only difference between this and the previous case is that in this one there need be no original sub-excitement in Z, coöperating from the very first. In the solving of a problem, all that we are aware of in advance seems to be its *relations*. It must be a cause, or it must be an effect, or it must contain an attribute, or it must be a means, or what not. We know, in short, a lot *about* it, whilst as yet we have no *acquaintance* with it. Our perception that one of the objects which turn up is, at last, our *quoesitum*, is due to our recognition that its relations are identical with those we had in mind, and this may be a rather slow act of judgment. Every one knows that an object may be for some time present to his mind before its relations to other matters are perceived. Just so the relations may be there before the object is.

From the guessing of newspaper enigmas to the plotting of the policy of an empire there is no other process than this. We must trust to the laws of cerebral nature to present us spontaneously with the appropriate idea, but we must know it for the right one when it comes.

It is foreign to my purpose here to enter into any detailed analysis of the different classes of mental pursuit. In a scientific research we get perhaps as rich an example as can be found. The inquirer starts with a fact of which he seeks the reason, or with an hypothesis of which he seeks the proof. In either case he keeps turning the matter incessantly in his mind until, by the arousal of associate upon associate, some habitual, some similar, one arises which he recognizes to suit his need. This, however, may take years. No rules can be given by which the investigator may proceed straight to his result; but both here and in the case of reminiscence the accumulation of helps in the way of associations may advance more rapidly by the use of certain routine methods. In striving to recall a thought, for example, we may of set purpose run through the successive classes of circumstance with which it may possibly have been connected, trusting that when the

right member of the class has turned up it will help the thought's revival. Thus we may run through all the *places* in which we may have had it. We may run through the *persons* whom we remember to have conversed with, or we may call up successively all the *books* we have lately been reading. If we are trying to remember a person we may run through a list of streets or of professions. Some item out of the lists thus methodically gone over will very likely be associated with the fact we are in need of, and may suggest it or help to do so. And yet the item might never have arisen without such systematic procedure. In scientific research this accumulation of associates has been methodized by Mill under the title of 'The Four Methods of Experimental Inquiry.' By the 'method of agreement,' by that of 'difference,' by those of 'residues' and 'concomitant variations' (which cannot here be more nearly defined), we make certain lists of cases; and by ruminating these lists in our minds the cause we seek will be more likely to emerge. But the final stroke of discovery is only prepared, not effected, by them. The brain-tracts must, of their own accord, shoot the right way at last, or we shall still grope in darkness. That in some brains the tracts *do* shoot the right way much oftener than in others, and that we cannot tell why,—these are ultimate facts to which we must never close our eyes. Even in forming our lists of instances according to Mill's methods, we are at the mercy of the spontaneous workings of Similarity in our brain. How are a number of facts, resembling the one whose cause we seek, to be brought together in a list unless one will rapidly suggest another through association by similarity?

Similarity No Elementary Law

Such is the analysis I propose, first of the three main types of spontaneous, and then of voluntary, trains of thought. It will be observed that the *object called up may bear any logical relation whatever to the one which suggested it*. The law requires only that one condition should be fulfilled. The fading object must be due to a brain-process some of whose elements awaken through habit some of the elements of the brain-process of the object which comes to view. This awakening is the causal agency in the kind of association called Similarity, as in any other sort. The similarity *itself* between the objects has no causal agency in carrying us from one to the other. It is but a result—the effect of the usual causal agent when this happens to work in a certain way. Ordinary writers talk as if the similarity of the objects were itself an agent, coördinate with habit, and independent of it, and like it able to push objects before the mind. This is quite unintelligible. The similarity of two things does not exist till both things are there—it is meaningless to talk of it as an *agent of production* of anything, whether in the physical or the psychical realms. It is a relation which the mind perceives after the fact, just as it may perceive the relations of superiority, of distance, of causality, of container and content, of substance and accident, or of contrast, between an object and some second object which the associative machinery calls up.

Conclusion

To sum up, then, we see that the *difference between the three kinds of association reduces itself to a simple difference in the amount of that portion of the nerve-tract supporting the going thought which is operative in calling up the thought which comes.* But the *modus operandi* of this active part is the same, be it large or be it small. The items constituting the coming object waken in every instance because their nerve-tracts once were excited continuously with those of the going object or its operative part. This ultimate physiological law of habit among the neural elements is what *runs* the train. The direction of its course and the form of its transitions are due to the unknown conditions by which in some brains action tends to focalize itself in small spots, while in others it fills patiently its broad bed. What these differing conditions are, it seems impossible to guess. Whatever they are, they are what separate the man of genius from the prosaic creature of habit and routine thinking. In the chapter on Reasoning we shall need to recur again to this point. I trust that the student will now feel that the way to a deeper understanding of the order of our ideas lies in the direction of cerebral physiology. The *elementary* process of revival can be nothing but the law of habit. Truly the day is distant when physiologists shall actually trace from cell-group to cell-group the irradiations which we have hypothetically invoked. Probably it will never arrive. The schematism we have used is, moreover, taken immediately from the analysis of objects into their elementary parts, and only extended by analogy to the brain. And yet it is only as incorporated in the brain that such a schematism can represent anything *causal*. This is, to my mind, the conclusive reason for saying that the order of *presentation of the mind's materials* is due to cerebral physiology alone.

The law of accidental prepotency of certain processes over others falls also within the sphere of cerebral probabilities. Granting such instability as the brain-tissue requires, certain points must always discharge more quickly and strongly than others; and this pre-

potency would shift its place from moment to moment by accidental causes, giving us a perfect mechanical diagram of the capricious play of similar association in the most gifted mind. A study of dreams confirms this view. The usual abundance of paths of irradiation seems, in the dormant brain, reduced. A few only are pervious, and the most fantastic sequences occur because the currents run—'like sparks in burnt-up paper'—wherever the nutrition of the moment creates an opening, but nowhere else.

The *effects of interested attention and volition* remain. These activities seem to hold fast to certain elements and, by emphasizing them and dwelling on them, to make their associates the only ones which are evoked. *This* is the point at which an anti-mechanical psychology must, if anywhere, make its stand in dealing with association. Everything else is pretty certainly due to cerebral laws. My own opinion on the question of active attention and spiritual spontaneity is expressed elsewhere (see p. 237). But even though there be a mental spontaneity, it can certainly not create ideas or summon them *ex abrupto*. Its power is limited to *selecting* amongst those which the associative machinery introduces. If it can emphasize, reinforce, or protract for half a second either one of these, it can do all that the most eager advocate of free will need demand; for it then decides the direction of the *next* associations by making them hinge upon the emphasized term; and determining in this wise the course of the man's thinking, it also determines his acts.