# Possibility and Necessity of Applying Mathematics in Psychology

J. F. Herbart (1877)

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**J. F. Herbart** (1877)
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[Herbart's essay on the "Possibility, &c., &c.," consists of a paper read before a scientific body, and a preface and notes which were added afterwards. The notes are longer than the paper itself, and the preface partly polemic. The allusion, at the end of the essay, to natural philosophy, is too brief to be satisfactory.

Whatever else may be thought of the essay, it is the best introduction to the mathematical part of his psychology written by Herbart, and it has, in my mind this peculiar merit, that if we take the contradictory opposite of every one of his positions, we get a pretty clear idea of the relation between Algebra and Hegel's method, and this is to be expected, because Herbart's metaphysics furnish the most exhaustive indirect argument against the supremacy of the principle of identity and in favor of the dialectic method, if used in the same manner. -- TRANS.].

To the most matured and most earnest faith that this very undertaking, to which I have devoted not only the following essay, but my very best efforts for years, is to be classed among the most necessary and most urgent enterprises that ever can be proposed to the scientific world, there is joined the consciousness -- and it is sometimes quite disheartening -- that I must esteem myself happy, if I but succeed in commencing a work, the fruitful development of which has necessarily to be left to others. -- [From the preface]. [p. 252]

Socrates has received praise from all centuries because he recalled philosophy from heaven to earth and to man; if he could rise from the dead, and, acquainted with the present state of our sciences, should look once more to the heavens for the purpose of appropriating there something that might be beneficial to men, he would behold much less of modern philosophy than of mathematics, and see the efforts of that science crowned with the most brilliant success. I then imagine him to ask: "Tell me, ye exceedingly wise men, what is better, soul or

matter? What is more important for you to know, the inclination of the axis of the earth or the causes of the vibration of your opinions and dispositions? What is more necessary for you to know, the stability of the solar system or the means by which your principles and customs may strike firm root? From what are you more likely to suffer, from the perturbation of the planets, or from the revolution of your States? And if mathematics are of such excellent help in your investigations, why do you not endeavor to use them for the solution of problems the most important and the most necessary? Or, if mathematics are of such authority among you that you are inclined to rely upon them in preference to every other science, why are they condemned to be employed on one hand for objects so distant as hardly to invite the curiosity of a few learned men, and on the other, for objects so closely related to the lowest wants of the body that their constant use has a degrading tendency?" Would it be satisfactory to reply to such questions that mathematics served in arsenals and before the walls of beleaguered cities also? that they taught us not only how to increase but how to destroy human industry? We would hardly like to expose ourselves in such a manner to sarcastic remarks of the philosopher. Who could succeed, however, to anticipate the net of questions with which he might capture and deliver us from inveterate habits of thought? I, for one, do not care to try it, especially as something else concerns me more directly than the manner in which Socrates might express his astonishment as to the limited use we make of mathematics. For I am aware that my attempt to apply mathematics in psychological investigations has been a matter of amazement to some contemporaries, and that such amazement has been reproduced quite lately by the publication of a treatise concerning a measure for, and the most general conditions of attention. But the smaller the number men who read a treatise solving a complicated dif- [p. 253] ferential equation, the greater is the probability that such amazement will be the end of the matter, and that they will take no further interest in the subject. I am, therefore, determined to furnish a brief report of my undertaking in other language than in algebraical signs, for once -- an undertaking dating as far back as the last months of the eighteenth century -- the germ of which I found, even before that time, in the school of Fichte -- with which I have busied myself ever since, and without losing sight of it at any time, though interrupted often and for long periods, and from which I now intend not to desist until my preparatory labors are advanced far enough to be taken up by mathematicians of greater skill than I possess myself. Before reporting, I shall mention the plausible counter-arguments to which said astonishment is referable, and having answered them, I hope to find a favorable hearing for my demonstration, that it is possible and necessary to use mathematics in psychology.

The first of the plausible reasonings which oppose me is really nothing but force of habit, and, as far as the form of its presentation is concerned, leans upon an assertion entirely untrue. People never heard that mathematics have been applied to anything but objects which either are or may be located in space, e.g., to forces increasing or decreasing according to certain distances, and the effects of which may be measured and accurately observed. It is not comprehensible what measure a man could find to determine and compare the quantity of acts of the mind, and of the changes of perceptions, emotions and desires. Our thoughts are quicker than lightening, how could it be possible to observe and delineate their course? Man's inclinations are as unstable as the wind, his dispositions as uncertain as the weather; who could, as to them, perceive quantities that might be brought within a law of mathematical regularity? But where we cannot measure, there we cannot count; hence it is impossible to use mathematics in psychology.

Such is the syllogism compounded of the fetters of habit and of an assertion evidently untrue. For, to commence with the last, it is palpably untrue that we can count and reckon only where we could measure. Quite the reverse! Any and every law of quantitative ratios, either hypothetically assumed or even known to be false, admits of the substitution of numbers, and we have necessarily to try hypothetical explanations of recondite but important matters, and we have, by careful calcula- [p. 254] tions, to ascertain what consequences would result therefrom, before we can find which of the different hypothetical laws agrees with experience. The older astronomers tried eccentric circles. Kepler tried the ellipsis to rhyme with it the motions of the planets; he then had to compare first the squares of their annual motions with the cubes of their mean distances, before he could find that their relation was identical with regard to all. Newton had, in like manner, to try whether a force of gravitation inversely as the square of the distance would be sufficient to keep the moon in its course around the earth; and if this supposition had

not been satisfactory he would have tried another power, say the cube or fourth or fifth power, and computed the results and compared them with the data of observation. This indeed is the very great benefit of a mathematical hypothesis, that we may survey the possibilities within the limits of which the facts must be found, long before we are in possession of sufficiently definite experience, and that we are thus enabled to seize upon very imperfect hints to get rid of, at least, the grosser mistakes. Long before a transit of Venus could serve for ascertaining the parallax of the sun, a trial was made to find the distance between sun and earth by means of the enlightened hemisphere of the moon. It was impossible, for all our observations of time are much too rough from psychological reasons to apprehend accurately the exact moment; nevertheless, this trial produced the knowledge that the distance of the sun must be several times that of the moon. This example illustrates that a very imperfect estimate of magnitudes, where no accurate observation is possible, may be very instructive if properly used. And was it necessary to have a measure for our solar system before its general arrangement could be known? Or, (to take an example from another field of thought) was it impossible to investigate the laws of motion, before it was settled with precision how many feet a body falls in a second at a given point of the surface of the earth? Such investigations as to the last units of measure are very difficult indeed, but, fortunately, they form separate problems, for the solution of which our knowledge of the fundamental laws need not wait. It is true that measuring invites calculation, and that every regularity of phenomena, especially if it can be observed without difficulty, is a stimulus for mathematical research. Inversely, the less that symmetry occurs in the facts, the longer is scientific inquiry delayed. If the celestial [p. 255] bodies moved in more resisting media, and if their masses were not so very small compared with their distances, astronomy would, perhaps, be no farther advanced than psychology is today, and could not even hope to regain from the number of observations what is wanting in accuracy.

It is alleged, as a second objection, that mathematics treat only of quantities, whereas actions and states of greatly different qualities are the subject of psychology.

In order to refute this argument scientifically, I should proceed to show from metaphysics that the real, true and original qualities of simple elements are completely concealed from us, and that they, therefore, cannot be the object of any investigation whatsoever; moreover, that where we believe that we apprehend a difference of qualities in common experience, the cause thereof is very often a difference of quantities merely, as, e.g., when we believe that we hear the qualitative difference of sounds and of their great number of harmonies and disharmonies, while in fact strings of different length are vibrating faster or slower. But I shall not dive quite to the bottom of the question at this time. I do not care to prove in this place, the proposition that no variety of original faculties is co-existing in the soul: the prejudice of a multiplicity of different quantities inhering in the same identical substance may pass unmolested, though it belongs to the first conditions of true knowledge to be free from that. It may be sufficient to assert that however great the number of fictitious qualities which a man may distinguish in his soul, he certainly cannot deny that over and above them there is an infinite variety of quantities determining mental action. Our thoughts are stronger or weaker, more or less clear; their coming and going is faster or slower; their number at every moment greater or smaller, our susceptibility for perceptions, our excitability for emotions and passions is variable to a greater or less extent. These and innumerable other differences of quantity which obviously occur in mental states, have been reckoned among the less essential modifications, but unjustly, and this is the true reason why the lawful consistency of mental phenomena has not been discovered. I can illustrate only quite briefly by a single example that those modifications supposed to be unessential are in truth all-important. Everybody knows what sleep is, and that it consists in a suppression of our perceptions which is perfect in deep sleep, imperfect during dreams. But very few are mindful [p. 256] of the fact that but an extremely small portion of our thoughts are present to our mind at any time, even during the moments of most attentive wakefulness, that all the rest influence us as little as they do in sleep, or, to speak more definitely, that most of our thoughts are latent, and but few are free at any time.

Let us now cast a glance at physics and at the theory of free and latent caloric. What was that science before the important distinction was duly considered? Precisely in such a state is psychology to-day. All mental states and products depend first of all upon the fundamental condition that some or other perceptions are awake, for sleep, whether total or partial,

suppresses everything within its reach, or, in other words, those perceptions which by the law of their equilibrium are latent have, for the time being, no influence whatever upon what is going on in our consciousness. It is different with regard to perceptions which are in such a state of supposition according to the laws of their motion; the latter operate quite strongly upon our dispositions, passions and emotions; it is impossible, however, here to develop the distinction between statics and mechanics of the mind.

Other objections are based upon popular opinions concerning the so-called higher faculties of the soul; and I know full well, I have had but too long an experience, that I here offend most potent prejudices, prejudices quite insuperable for the simple reason that men do not wish to lay them aside, that they violently refuse to reflect upon what is contradictory to them. These prejudices are concentrated in the words: genius and freedom. What is genius? Let me answer by a comparison, for the sake of brevity: genius is a planet. Neither of them follows the straight road, their course is that of a curve. They sometimes appear to be stationary, sometimes to move in a retrograde direction, at first slow then fast, then slow again; all at once they rush forward, dive into glory of the sun, and in its company perambulate the heavens, yet again for a short time only, after which they prefer to scintillate in darkest night and flash the more brilliantly, the greater their opposition is to the star of the day. I confess that these words fit a planet better than genius, but the similarity will be apparent enough. The course of planets is determined by calendars, since calendars obey the planets. Genius would, in like manner, be governed by psychology, if there was as much true science at the bottom of it as there is in calendars. [p. 257] So much about genius, who cannot refuse to follow a law, though he may be unaware of the same; for the ignorance thereof is no proof of its non-existence.

But what shall I say about freedom? First of all, that I am almost tired of speaking of it. I have often and long ago explained the causes of confusion and error as to this point, and presented my explanations in all manner of forms; I have dissected the original judgments, from which the ethical imperative is derived, and have defined each one of them separately; I have proven that these judgments which lay down the distinction between what is worthy of praise or blame, between what is good or bad must necessarily be involuntary and opposite in their nature to the nature of the will, because the least confusion of their difference tends to bias the judgment and to vitiate moral purity. From the moment that these principles became clear to my mind, the mist of the supposed incomprehensibility of the freedom of the will was scattered, the sublimity and holiness, connected with that name, was transferred somewhere else, and what now remains of freedom, to-wit, the capability of doing evil, the source of vulgarity and vice cannot be controlled more effectually than by tearing from it the deluding mask of the name of liberty, and recognizing in the same a parasitic growth which, like moles and warts, increases and decreases by laws of psychological necessity, and which, under definite conditions, may be destroyed or prevented. What I here say agrees in certain points with the pious sentiments which warn man not to seek the origin, much less the law of evil and good in his own self, i.e., in his will, and is perfectly consistent with the idea of responsibility by which the act is considered as the effect of the will, the will as the effect of the moral character, but which decides nothing as to the cause of the character, and ignores this cause.

All these difficulties connected with the idea of freedom would soon vanish, if men did not entertain the strangest notions with reference to the will which is left, after the transcendental liberty is taken away. To him who says, I cannot conceive of a will which, as such, is not free, we can only say, keep your freedom, for it certainly exists in the sense in which you take the word. The life of the human soul in the mind is no puppet show, no showman stands behind to pull the wires, but our innermost life is identical with our will, and this life has its rule [p. 258] within itself, and does not receive it from outside; nevertheless, this rule is fixed and certain, and it has, on account of this fixed certainty, more resemblance with something otherwise altogether heterogeneous, to-wit, with the laws of pressure and resistance, than it has with the miracles of a liberty which is said to be incomprehensible.

We now proceed to the proof that mathematics can be applied in psychology, and have to distinguish, for that purpose, as to the matter to which, and as to the form in which they may be applied. The possibility in question depends partly on the quantities offered to the psychologist,

partly upon the methods used in the investigation. It seems to be more convenient to set aside the quantities, at present, and to point out the manner of procedure. For I fear lest my aim will recall former failures, and recent frivolous attempts to imitate mathematics in philosophy, or to play with algebraical signs without knowledge or purpose, a use of mathematics which is certainly very different from the one I have proposed. The root of those other absurdities is to be found in the ignorance as to the true nature of metaphysical problems which mathematics are utterly incapable of solving, and which -- in order to avoid trouble and perplexity -- have always been evaded with great skill by that science. He who feels at home in metaphysics, may find opportunities to improve points intentionally skipped in mathematics or left unfinished, as the theory of parallels, of the infinite, the irrational, and everything connected with the idea of continuity. Quite different means, abilities and efforts, must be joined for metaphysical problems, and new skill must be acquired in new methods, so that we are very far from being able to use mathematics as a pattern there.

Mathematics are indeed impotent outside of the region of quantities, but the art with which these are brought into subjection wherever they are met, is truly admirable. Let us remember the nets which that science has woven around the heavens and the earth, those systems of lines relating to azimuth and altitude, to declination and right-ascension, to longitude and latitude; those abscissas and ordinates, tangents and normals; those trigonometrical and logarithmical functions which are all ready and waiting to be used. Surveying this apparatus, we comprehend that mathematicians do not owe their success to some supernatural influence but to a very natural cause; we seem to see a vast variety of [p. 259] the most ingenious machines bearing witness to a very extensive and very lively industry, and which are well fitted to produce true and imperishable riches. And of what does this apparatus consist? Does it consist of real objects? Let us call to mind examples! What is the celestial globe? Is it a real, massive sphere, upon which we may draw spherical triangles? It is a useful fiction, an instrument of thought, a convenient form for the totality of all optical lines which may be produced to the stars, and which are considered with reference to direction merely, and without reference to length. What is the centre of gravity? Is it a real point in a body? What the centre and the axes of revolution? Why do mathematics treat of a mathematical lever which has no reality? Why do mechanics treat of the motion of points, of simple pendulums, of the fall of projected bodies in vacuo? Why not directly of the material lever, of matter in motion, of the path of the projectile in the atmosphere? In a word, why does that science use so many fictitious, auxiliary quantities, why does it not directly compute what is found and what occurs in the real world? The answer is contained in the question: those fictions are real helps, those abstract quantities are means to analyze, or limits between which the quantities of observation must be included to approximate the latter with greater and greater accuracy. It is true, psychology cannot directly imitate mathematics, but the latter carries the peculiar procedure described wherever they are used. We may, therefore, conclude that if mental states and actions really depend on quantities, the computation of the latter will likewise only be accomplished by reducing them to more simple, more convenient quantities between which the observations have to be included, or with which they have to be connected for the purpose of approaching their quantitative relation as closely as possible. For this reason it must be expected that we can deduce scientifically a very simple and very general type of volitions merely, and of certain chief classes of emotions and imaginations and the like; the individual reality is very sure to escape mathematical determination and limitation. Nothing could be more ridiculous than the fear that, by some sorcery of numbers and letters, we might be robbed of our secrets, or tracked into the recesses of the heart; the shrewdness of the world will, in this regard, always remain much more successful and dangerous than all mathematics and psychology combined. [p. 260]

It is now time to point out definitely the quantities admitting calculation. We have to begin with what is most simple, and, at first, to set aside all connection of the perceptions among themselves. There are then left only two quantities for our consideration: the intensity of each separate elementary sensation, and the degree of antagonism in each pair. This is already matter enough for calculation and for discovering the primary source of two quite general psychological phenomena, namely, of the fact mentioned above, that by far the most of our perceptions are latent at any definite moment, and secondly, that, as long as psychological causes do not supervene inducing sleep, not all perceptions become latent together, nor all except one, but that something always is present to the mind, during the time of wakefulness,

and that that something is never quite simple, but more or less complex. These facts would have been a matter of astonishment and a subject of inquiry, if facts occurring daily and to which we get accustomed were not, to most men, a matter of course.

The calculations occasioned by the intensity of each separate sensation and the degree of antagonism in each pair are very simple; they become however much more complicated when the third quantity is introduced: the degree of union between the sensations. The former results are then changed and others added. Moreover, a fourth quantity now enters: the number of the sensations differently connected. Especially noteworthy are the longer or shorter series of perceptions, connected imperfectly and in such a manner that the second is joined to the third, the third to the fourth and so on, while the first and third, second and fourth, and so on, are connected in a less degree, or not at all. Such series of perceptions are somewhat like filaments or fibres, by means of which richer mental organs are construed, and they have their certain laws of susceptibility and irritability, a better knowledge of which is all-important in psychology. Distant, but very unsatisfactory guesses are contained in what is known by the name of association of ideas; more definite knowledge depends upon calculation and has most important consequences, not only for the theory of memory, imagination and understanding, but also for the analysis of emotions, desires and passions. Nothing shall prevent me from saying publicly, that mathematics discloses, in this region, an almost unlimited ignorance in which psychology has remained hitherto. Seat and ori- [p. 261] gin, even of the construction of definite forms of space and time, is to be found here, and not in general, original forms or categories of sensation.

New determinations of quantity arise, with regard to series of perceptions previously formed, according as these are stimulated at one or several points, or are more or less in a state of involuntary or evolution, and are apt to follow, when larger or smaller textures have already been construed from what I called filaments and fibres, from the difference of their construction. This construction must be similar in different men, to a great extent, on account of the common objects of sense, which furnish the occasion for producing and joining perceptions; but it is subject to considerable modifications, depending upon individual organization, and consequent upon surrounding circumstances and habits, which latter may be modeled by education. The last point deserves attention. Humanity is not an endowment of man, but the effect of culture; the savage man is an animal in which humanity may be developed by means of society. The hypothesis that a superior being took care of the first men and educated them, conflicts less with experience than the other, that humanity gradually slipped from the originally higher state to the lower; for geography and anthropology show the barbarous state of isolated tribes, and hence that humanity proper depends upon society. This fact is little valued by psychologists who hold that reason and common sense, reflection and self-observation are original powers of the human soul.

So much, however, is matter of common observation, that not all perceptions are joined equally well, that they are active in very different degrees, and that therefore the same relation must obtain between centres of thought of different intensity, which occurs between new observations and older experience reproduced by the former: hence, that there is not only an apperception of things, but also of perceptions within, a reason which repeats by reflections and conclusions the same process which is transacted when sensations are assimilated by judgment and formed into mental pictures. But what kind of process is it? I believe that I know it, yet I cannot explain it here. I may say, however, that the higher activities of the mind cannot possibly be investigated as to their true sources and laws, as long as those which are lower in the scale, which are similar and upon which the former depend, are not known any better; and, though I [p. 262] hardly think that mathematical analysis will ever penetrate into these highest regions of reason and will, I hold the same to be indispensable as a basis for the knowledge of those highest objects of thought, lest, if the more delicate modifications of truth remain hidden, we should, as heretofore, fill the gaps of our knowledge with gross errors, and should contract indifference for philosophy when we witness the contention of parties who are equally far from undisputed ground.

This thought forms the transition to the last part of my argument. It is not only possible, but

necessary that mathematics should be applied in psychology; the reason for such necessity is, in a word, that the aim and end of all speculation is otherwise absolutely beyond our reach, and that aim and end is: mathematical certainty. This necessity to establish our theories definitely is the more urgent, the greater the danger is that philosophy may soon relapse into the state in which it is already in France and England. It is a manifest blindness of most of the living German philosophers that they do not see this danger. If they knew mathematics, (and I mean a little more than the elements of geometry, or quadratic equations, or the signs of the differential and integral calculus) -- if they understood mathematics, they would know that an indefinite talk, interpreted differently by each individual and which only multiplies the disputes, cannot possibly -- notwithstanding the beauty of presentation and the sublimity of the subject matter -- keep abreast of a science which instructs and elevates by every proposition uttered, and which elicits never-ending admiration -- not for the vast spaces it has measured, but for the exhibition of the most stupendous human sagacity. Mathematics is the ruling science of our time; its acquisitions grow daily, though noiselessly. He who does not befriend it, will have it his enemy in the future.

I have now to explain the cause why mathematics not only possesses such certainty but why it transfers the same to the objects to which it is applied. It is true that the primary cause is to be found in the perfect accuracy of its elementary definitions, and every science must look to this condition of stability itself; none can borrow or receive it as a gift from another, psychology no more from mathematics than the latter from the former. But that is not all. As soon as the human mind tries long chains of syllogisms or difficult problems generally, the difference of the great number of parts has a tendency to unsettle [p. 263] their limits alternately, and not only danger but suspicion of error commences, because we cannot inspect the particulars of the totality at once with equal distinctness, and we have, finally, to rest in the belief that we have not made a mistake at the start. Every one knows that this is true even in the elementary use of mathematics, in arithmetical operations. No one will imagine that we find it any better in the higher branches of mathematics. Quite the reverse; the more complicated the operation, the quicker, in rapid progression, grows uncertainty and suspicion of hidden mistakes. How, then, do mathematics proceed to remedy an evil to which they are subject themselves in the highest degree? Are the arguments filed again and again? Are new rules given how to apply previous rules? Nothing less! Every isolated operation, considered in itself, remains in a state of very great uncertainty. But there are proofs of calculation! Upon the soil of mathematics there are a hundred different ways leading to every point, and if we obtain precisely the same result by taking these hundred different roads, we are satisfied that our result is correct. Calculation without such proof is not better than none at all. Just so it is with regard to every isolated argument in any part of speculative science; it may be ever so clear, it may be perfectly true and correct and yet it does not create permanent faith. He who should hope, either in metaphysics or psychology, to see himself rewarded by perfect certainty of knowledge, nay even by a certainty generally communicable, on account of extreme carefulness bestowed upon the accuracy of definitions and correctness of conclusions, will certainly be sadly disappointed. It is necessary for that purpose that conclusions be established independently of each other, and that they corroborate each other without the least suspicion of a circle, and furthermore, that experience itself confirm the results of speculation, not only in general, but in an infinite number of cases and with reference to all theories which proceed from experience or judge about experience.

Before closing, I have now to call your attention to that one condition without which matters of experience and theories cannot be compared with any degree of accuracy. All experience is modified by quantities, it is liable to the greatest changes of quality, if the conditions of quantity are changed. Shall I illustrate? Shall I remind you of the celebrated question of physicians, what is poison? of a definition so difficult, because excess [p. 264] of what is most wholesome may become injurious, while a suitable quantity may transform poison into medicine. But why should I detain you with so obvious matters? What I wanted to prove is in broad daylight, to-wit: Every theory, to admit of comparison with experience, must be developed until the same embodies the modifications of quantity which occur in experience or are inseparable from its principles. Before reaching this point theory remains a castle in the air, exposed to every gust of doubt, incapable of co-operating with convictions already established. But all relations of quantity are in the hands of mathematicians, and it may thus be seen at a glance that all

speculation which pays no attention to mathematics, which does not try to open communication with them, in order to distinguish the various modifications which take place by a change of quantities, is a play of thought, or, at best, an effort which cannot reach its aim. Many a noble tree grows upon the soil of speculation which is neither planted by mathematics, nor cares for them, and I am very far from declaring it a noxious growth. It may grow, but it cannot bear fruit without mathematics. There is, however, a sort of empirical faith even as to this point which cannot be acquired but by individual practice and use of mathematics. We must have seen with our own eyes, as it were, how calculation draws conclusions from known premises which were altogether unexpected, how it directs attention to conditions, the importance of which did not occur to our mind, how it destroys half-truths which we did not avoid in spite of our most careful cautiousness.

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