Bodily correlates of human mental activity

thesis presented for the degree of
Doctor of Medicine

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With the passage of time, the theories, hypotheses and methods formulated by researchers to satisfy their insatiable curiosity and unquenchable thirst for knowledge continue to flow and supplant each other.

Man, faced with an insoluble problem, behaves in a manner similar to that of the rat/mouse, which finds itself locked up in a laboratory box with no exit, at the whim of the experimenter. This situation brings to mind Iriarte's famous fable about the Squirrel, who is asked "all your comings and goings, my friend, do they lead anywhere?" as applicable to the field of scientific research.

No sooner has an idea, thought, or doctrine taken hold of the field that a newer one sees the light of day and a lengthy considerable time may elapse before the earlier competitor resurfaces and claims the field again. This is certainly so in the history of civilizations and human life, where the symbolism of the "eternal retour", or of the serpent biting its own tail, or the genius of Aristotle and Nietzsche, speak of the cyclic nature of the universe. Notwithstanding appearances, a careful study of the successive formulations, will lead us to conclude that these reappearances or resurrections are never exact copies of the ones that preceeded them, only similar.

What recurs is not identical to what had been proposed or occurred, it only looks like it. When looking for a symbol to represent life's circular way of evolving, we would like to choose the spiral. There is no doubt that this symbol/figure is the most accurate onomatopoeic representation of the reality of evolution . In the spiral, as in the circle, there is regression but in the latter the regression is absolute while in the former it is not. There is an opening, an optimism in the spiral, while in the circle, there is a pessimism, a negativity, which makes it a totally inaccurate representation of life. Nietzsche supporters failed to observe that the classic serpent, drawn as it bites its tail, leaves the tail out of the animal's mouth and ouside the confines of its body.

When old hypotheses and scientific doctrines reemerge, they do so enriched by the gains of experience and in their new guise offer advantages that they could not present when first seeing the light. This is the present day situation in anthropology where the concept of unitarianism, which had been overthrown by those of animism and

materialism, and replaced by dualism, has gained ground to the point that there can be no doubt that man is an integral unitary being. This unity of body and mind is reminiscent of the classical principle of concensus unum yet in its present form it exhibits significant deviations/variations from it.

Gone are the days when man was thought of as a mysterious conglomerate of body and soul (mind), the former measurable, the latter unmeasurable. The death knoll has also sounded for Bichat's theory of man as made up of two systems: the vegetative and the relational, functioning independently of each other. Vitalism and neovitalism appear to be on their way out too, while a doctrine that could be entitled "biochemical-functional interdependency in man," is making very visible gains.

Present day biologists think of man as a harmonious ensemble of coloidal suspensions enclosed by a doubly-thick membrane. The complex structure of its myceliums endows them with an extraordinary surface instability, an intense metabolism and a great capacity to be affected by the medium (*sensitivity*). Man's capacity to vary thresholds and respond, at different times, to a given stimulus in modified ways, is permitted by the continuous variability of its matter and by the fact that tissue nutrition is, up to a point, independent of the medium surrounding it. Given that it is theoretically impossible for a stimulus to impinge twice *on the same living matter*, the relative diversity of reponse must not be seen as a contradiction but rather as an affirmation of the principle that states that the *sensitivity* of human beings is directly and exclusively related to their make up and physiochemical structure.

Furthermore, given the synergetic functioning of the human organism and the numerous and marvellous correlations that exist between his various organs, it is inconceivable that any activity could occur in isolation. As Le Dantec, Sherrington and Watson, have already stated, the simplest response, the merest bit of activity, demand the involvement of the whole being. It is reassuring to see that a philosopher, a physiologist and a psychologist, have reached the same conclusion while traveling along different routes.

Is it still conceivable that mental activity could exist independently? Is mental activity an independent function? Should mental activity not be seen as the result of *global activity*, not only from the soul, the brain and the nervous system, but of the *whole organism*.? Where should the line be drawn between psychic (mental) and physic (bodily) functioning? We are certain that if physiologists were to set aside their dogmatic scruples and to undertake a systematic study of the modifications that arise in man during periods of mental activity, they would become convinced of the causality that exists between mental activity and alterations in physical functions, which, up to now, have been considered of secondary importance.

We are of the view that mental activity has a much wider bodily connection than has been believed. This connection, clearly noticeable, even to the lay observer, during emotional states, is also present when involved in pure mental work and goes further than the changes studied up to now under the heading of "attendant motor manifestations of attention". We are familiar with manifestations like inhibition, staring,

crunching of eyebrows, changes in breathing, etc., all of which can be brought about at will by the subject while his attention is somewhere else. As students, have we not at times pretended to pay attenton to escape the boredom of an uninteresting lecturer? or, viceversa, pretended indifference while concentrating to the maximum?!

It is precisely because we are only familiarized with *imitable* changes that can be brought at will by the subject, that psychologists still think in terms of dual components of attention, the bodily and the psychic , and extend this duality to all mental activity. Biologists, on the other hand, state that human thought is no more than a complex bodily function involving the whole body. To search for evidence of this position what is needed as a prerequisite is a somatic change concomitant with mental activity that is not present *with any other process or device,* and has *periodicity related in intensity and duration* to the mental activity. Meeting these requirements, among the many somatic manifestations that accompany mental activity, we can find three somatic changes: the psycho-pupilar reflex, the psychogalvanic reaction, and the psycho-plethismographic reflex, all of which are of undeniable value.

It is not our intention to seek to define these reactions/reflexes, nor to quote outcomes of studies undertaken by many researchers. We wish our thesis to be original, in spite of its possible faults. Later we may refer to them again but for now, what interests us is to point out that the above mentioned three reflexes have against them the fact that *they are not* exclusive or *specific to mental activity.*

The psycho-pupilar reflex, which is extremely cumbersome and difficult to test, is the most sensitive to mental activity; nevertheless, the eye's accommodation over a very short time muddles its results, and could not be tested for 5-10 minutes. It is regrettable that the admirable work of the Munich school on this reflex, in particular the work of W.S. Inmann(1) on occular symptoms in emotion , which promisess new paths , is presently in danger of being forgotten.

The psychogalvanic reflex, on the other hand, is enjoying great success. Most experimental psychology laboratories have nowadays the complicated installation required for its study and we can expect a copious bibliography on the subject. And yet, given the variability in its causality, we cannot consider it to be a specific manifestation of mental activity, not even of the emotional state of the subject, due, as it is, to the polarisation of skin responses, also found in cats and frogs (whom we cannot assume to have other than a very limited mental activity). Moreover, Prideaux -whom we consider to have studied this reflex under the best laboratory conditions, states in his last two articles that there are various non-psychic causes capable of bringing about an identical galvanometric deflexion and it is also possible to cause its disappearance with an injection of atropine, while it is well known that this substance does not affect psychic activity.

To be fair we must mention data favorable to this reflex. We refer to its alterations found in patients with mental disorders, its absence during narcosis and sleep, as well as in cases of idiocy, imbecility or severe dementia, and this is why we consider it valuable in mental physio-pathology. This must not blind us to the fact that it

is its lack of periodicity that accompanies psychic functioning, which does not allow us, at any given moment, to recognize whether the subject under study is engaged in thinking or otherwise.

Finally, as to the psycho-plethysmographic reflex, it has been the subject of study for the longest time and the technology it requires is doubtless the simplest, which make it very well researched, but it also lacks the criteria of specificity and periodicity necessary to provide an exact somatic translation of the thinking process.

Within the cardio-vascular correlates of mental activity, however, studied but not published to our knowledge, we hope to find what we have been searching for, that is to say, *a somatic manifestation specific to mental activity, with identical periodicity and, up to a point, in direct relationship with its intensity.* This being the core objective of this thesis we would like to deal with it in the main body of the presentation.

Cardiovascular Correlates of Mental Activity

A well-honoured tradition places the heart at the center of all psychic processes. Popular belief, poets in their lyrics, and scientists, have adhered for a long time, to the proverb "we think with our brain and feel with our heart", which they used until quite recently as a satisfactory explanation of the independence of our emotional and intellectual lives.

It was only in the third decade of the XIX century, that the French physicist Poiseuille engaged, with his neurodynamometer, in the study of changes in circulation caused by various experimental causes.Unfortunately, he omitted, among the causes, to study those of psychic life, and it is only in the second half of that century, that we come across, for the first time, a scientific study by Mosso(2) on the influence exerted by psychic life (emotion, word association, expectant attentiveness) on the heart and blood vessels of the brain and arm, particularly. This genial Italian physiologist advanced the knowledge of plethysmography (initiated by Poiseuille) and placed it at the forefront of the study of changes in blood flow during physical and mental activity.

Since then, a great number of researchers have made such a study their priority, either by using Mosso's apparatus or the more advanced plethysmographs of Lehmann, Kupper, Binet and Courtier, Weber, Wiersima, Hallon and Comte, Hertzlika, etc. Their number has been as large as the discrepancies in their results. We do not intend to deal with their contradictory conclusions but as a curiosity we will include the synoptic chart that Camis (3) has prepared on the subject, which gathers and synthesises the most meaningful studies.

Riassunto schematico delle ricerche sulla correlazione fra stati psichici e variazioni organiche.

A). Sensazione spiacevoli o estati psich. spiac. o deprimenti.

Autori.	Vol. d. art.	Stato dei vasi	Frequenza cardiaca	Polso	Respirazione	Pressione sangu.
Kiesow.						Per lo più aumento, talvolta diminuzione.
Binet et Vaschide.						Aumento.
Angell e Mc. Lennan.		Costrizione.				
Lehmann.		Costrizione.		Polso più debole.		
Shields.	Ness. variaz.	Ness. variaz.	Ness. variaz.			
Binet et Courtier.		Costrizione.	Dimin.	(Paura).	Più pr.	Dimin. (P.)
			Aument.	(Trist.)	Più pr.	Aument. (T.)
Lehmann.	Lieve aum. seguito de disminuzione (Paura).	(Depress.) Costrizione.	Breve au. seguito de dim.		Nessuna variazione.	
Dumas.		Costrizione.		Polso acceler.		Aument. o diminuz.
Angell e Thompson			Aument., dimin. o uguale.	Polso piccolo.		
Vaschide.			Aumentata.			
Montanelli.		Costrizione.	Aumentata.		Più freq.	

Autori.	Vol. d. art.	Stato dei vasi	Frequenza cardiaca	Polso	Respirazione	Pressione sangu.
Martius e Minnermann.			Diminuita.		Rallentata.	
Shepard.	Aumentato quasi sempre.		Aumentata quasi sempre.			
Berger.	Aumentato vol. cervello.			Disminuzione. Ampiezza del p. cerebrale.		
Gamble.					Più superficiale	

Riassunto schematico delle ricerche sulla correlazione fra stati psichici e variazioni organiche.

B). Sensazioni e stati psich. piacevoli o eccitanti.

Autori.	Vol. d. art.	Stato dei vasi	Frequenza cardiaca	Polso	Respirazione	Pressione sangu.
Binet et Vaschide.						Aumentata.
Angell e Mc. Lennan.		Costrizione.				
Lehmann.		Dilatazione.		Polso più ampio.		
Shields	Nessuna variazione	Nessuna variazione.				
Binet et Courtier.		Costrizione			Più prof.	
Dumas						Aumentata o diminuita.
Angell e Thomson.		Costrizione.	Aumentata, diminuita o uguale.	Polso più piccolo.		

Autori.	Vol. d. art.	Stato dei vasi	Frequenza cardiaca	Polso	Respirazione	Pressione sangu.
Vaschide.			Aumentata.			
Montanelli.		Costrizione.	Aumentata. (nella Paura).		Piu freq.	Aumentata.
Martius e Minnerman.			Diminuita.	Polso meno freq.	Meno freq.	
Shepard.	Aumento quasi sempre		Aumentata quasi sempre.			

H. Jong (4), a Dutch scientist from Amsterdam, in a recent article presents in great detail the state of the art on this question and makes reference to a series of interesting and original experiments, carried out with normal and mental health subjects, using Lehmann's apparatus, and reaches a series of conclusions, some of which merit careful study, so as to be better able to integrate our own results with them.

According to H. de Jong (most physiologists and psychophysiologists are in

agreement with him) in the plethysmographic tracing of every normal person, *in a state of both physical and mental repose,* there appear alterations of three types: a)cardiac, b)respiratory and c)vasomotor. In the first type we can observe only isolated pulsations, while in the second and third type are to be found an ensemble of various pulsations, which, given their wavy nature, have received the name of Traube-Hering and Mayer waves, respectively. It is only in the work of Leon Fredericq that the respiratory nature of Traube-Hering waves has been put in evidence. The vasomotor origin of the Mayer waves, visualized by Kuppers, has been by now satisfactorily evidenced.

In the recorded plethysmographic tracing of a subject to whom a stimulus requiring mental activity has been presented there will be registered *the normal plethysmographic reaction: ie an initial increase in the amplitud of the pulse, with an elevation, followed by a descent of it and a marked diminution in the height of the pulsations.* De Jong explains this initial raise by an increase in *cardiac* activity, while the descent and decrease are considered to be the result of the *vascular reaction* which cnsists of a peripheral *vasoconstriction*, with an abdominal and cerebral vasodilation. This reaction is independent of the type of stimulus and the nature of the mental activity undertaken (pleasant/unpleasant, emotional/perceptual, pure, associative, imaginary, etc.) but will only be observed when the tone of the vascular muscles is normal or hyponormal. In fact, given an abnormal increase in this tone we will witness the so called psyco-plethysmograhic semi-spastic, spastic or hyperspastic reactions, typical of the catatonic states. It seems, in line with de Jong's thinking, that the vascular reaction to mental activity is in indirect proportion to the degree of contraction of the vascular muscles..

It must be pointed out that the vascular reaction to mental activity lasts as long as the latter, without any symptoms of periodicity. However, this reaction is not specific to mental activity and can also be observed during muscular work, when fatigue sets in, as proven by Weber (5).

It is hard to believe that the number of writers on the subject of cardiovascular correlates of mental activity, involving the use of other registering apparatus (sphymograph, cardiograph, sphymomanometer, oscilometer, ect.) is remarkably small and their published results, owing to their inconsistency, do not deserve mention, with the exception of Binet's & Vaschide (6) and more recently of Bickel's (3) . These authors studied blood pressure changes using Potain's esphymomanometer, the former, and Uskoff's esphygmotonograph, the latter and have come to the conclusion that all mental activity is accompanied by a raise in blood pressure,. which in some cases can raise the mercury by 2 or 3 cms.

Bearing in mind the exquisite sensitivitry of the mechanisms that regulate blood flow in the various organs, we have to acknowledge the rough nature of the cardiovascular changes accorded by up to the present research to the engagement in mental activity.. One fact stood out, given that psychic activity is fluctuating or periodical with interruptions of 7-12-25" depending on the nature and intensity of pauses, the cardiovascular changes should register the same periodicity and be *parallel to the fluctuations and variation of the attention* (7), *we would expect to find*

fluctuations or ondulations of the blood pressure. Ernest Weber, one of the most hard-working authors on this matter, found in the tracing of the *brain pulse, ondulations* , which in his view, were the direct translation of *tension ondulations, of a 7-12" periodicity, which coincided with the fluctuations of attention and did not appear in the plethysmographic tracings of the arm, simulaneously enregistered*(8).

It has been our expectation, based on Bayliss'(9) authoritative view, that given that the cerebral hyperemia that accompanies psychic activity is the result of corresponding changes in the general blood flow , we found ourselves, -apriori-, almost certain of finding in any of the extremities *the blueprint or mould*, of Webers'waves, that is to say, *the cardiovascular translation of the attention waves or mental activitty waves.*

By virtue of our position as person in charge of psychometrics in the Institute for Vocational Guidance of Barcelona, we were in daily contact *with an excellent experimental sample, made up of children from the public schools, youths from the Worker's Apprenticeship Institute and adults who voluntaritly came for professional testing*, we decided, given that we also had the necessary laboratory equipment, to undertake systematically *the study of changes in the oscilographic tracing obtained by Pachon's capsule, brought about by mental activity.* From April 1922 to this day, with the help of our assistants, Dr. C. Soler Dopff and J.M.Lucena, and later of Drs. Peris and Rocha our research has fully proven, the existence in the extremities of a new type of esphygmic waves, *coexisting with conscious mental activity,* and brought about only by it.

Before describing our Methodology in detail and giving the results of our study, we would like to acknowledge our deep gratitude to all of those who took part in them, especially to Dr. Soler Dopff, my dearest friend, who put so many hours into it; to Dr. Aguilar, for allowing us the use of two oscilographic capsules (one his own) and finally to professors Drs. Pi Suner, Bellido, Fano and Wayemburg, whose advice and explanations helped me to achieve a clearer view and put an end to possible errors and existing doubts.(10)

METHODOLOGY FOR THE STUDY OF CARDIOVASCULAR CORRELATIONS OF MENTAL ACTIVITY

a) *Instrumental*

The contrivance used by useed entailed, with minor variations, the following:

l. *A Pachon oscilometer*, built by the firm Boulitte.

2.A *Pachon oscilographic capsule,* built by the same firm. This capsule when used together with the oscilometer and the help of an arm band makes for comfortable registering of the pulse. It is based on the same principle than the oscilometer and posseses a constant sensitivity, regardless of the pressure of the system. It is by far superior to and an excellent replacement to the use of the common esphygmoscopes and esfygmographs.

The apparatus consists of a stationary "box", the membrane of which has a lever with a special joint (registered under S.G.D.G.), which, while maintaining the lever in a fixed position, allows for the precise transmission to the lever, of the movements of the membrane The capsule and the box establish communication with the outside through interconnecting tubes by the use of a spigott or tap. Moreover, the capsule is in direct contact with the armbanad and the "box" with the oscilometer. Of course, the apparatus requires positioning the writing lever on the registering cylinder paper.

3. A *Verdun pneumograph.*

4. A *Marey Drum*, to register the movement of the pneumograph on the cylinder.

5. An *electric clock, counting seconds,* built by the Harvard Society of Physiological Apparatus

6. A *Duprez signal* which inscribes in the kimograph the seconds indicated by the clock

7. A *Duprez signal* (not always used*)* connected to a Morse key and a battery generator of 2 volts. to register in the kimograph the presence or absence of the various stimuli.

8. A *registering cylinder with a double drum* built by the Harvard Society of Physiological Apparatus, to regulate the speed.

9. A *table* where the Subject can lie down.

10. An *affixing contrivance*, an armband or other method, to affix the spot where the pulse is taken in the forearm or leg. At first we used Mosso's ergograph armband; later a splint and a Cambridge bandage. Finally, when experimenting with sophisticated subjects, we did not immobilise the limb but simply asked the subject to keep as relaxed as possible, checking *in visu* the limb wearing the armband as well as retrospectively getting the Subject's comments.

11. *The Stimuli.* These have been heterogenouss, sometimes only verbal, at other times actual tests used in Vocational Guidance (Vascchide's test of attention, dot counting, jigsaw puzzles, mechanical tests (railway test) aand sorting tests). For experiments with emotional stimuli to test for changes in blood flow, we have used the shooting of a pistol, the flaring of magnesium, as well as Jung's word association test and Woodworth's emotion questionnaire. We will comment further about these when presenting our results.

b) Personnel

Besides the Subject and the Experimenter, two othere assistants are needed. One to present the stimuli and jot down their effects and the other to keep an eye on the equipment registering the graphs.

c) Procedure

The Subject is invited to lie down on the table and make himself comfortable, as if he were to fall asleep on it. A screen is placed between him and the equipment. The procedure is only started after acquainting the Subject with the layout of the laboratory and the staff so as to minimise his apprehension and mistrust. He is told that the experiment is about measuring the strength of his pulse and cautioned to avoid all movement of the arm or leg and head and cut himself off what is going on around him so that he can *achieve the maximum degree of physical and mental relaxcation*. Then the armband is put in place and the pneumograph is attached somewhat loosely. The cuff is applied, either on the writst, in the middle third of the arm, or in the lower part of the leg, above the ankle. This is followed by the placement of the needles on the same vertical, for time (Duprez signal), breathing (lever of the drum connected to the phneumograph) and pulse (oscilographic capsule) making sure that the last two in particular

coincide(1). When all this is in place, we connect the oscilographic capsule to the cuff or muff on the one side and to the oscilometer on the other by means of the rubber tubes to obtain the pulse tracing. The spigot or tap, when open, plays the same role as the separator in the oscilometer. When closed, the capsule and the armband are isolated frm the rest of the system and the heartbeat registers in the lever doing the writing. The blood pressure of the Subject has been measured beforehand and air is injected into the system by means f the oscilometer's bomb while the spigot is open, until reaching a level of pressure above the subject's minimal. The usual optimal pressures are:12 for the arm and forearm, l3 for the leg (with the Subject lying down; 15 for the leg if the Subject is sitting down.). A test run on the tracing can be done with the spigot closed.

Model of the dispositive used in the psychmetrics lasboratory of the Institute of Vocational Guidance for the testing of cardiovascular correlations of mental activity.

Once we have ascertained that things are working well, we free the kimograph's lever and begin to register the tracings.

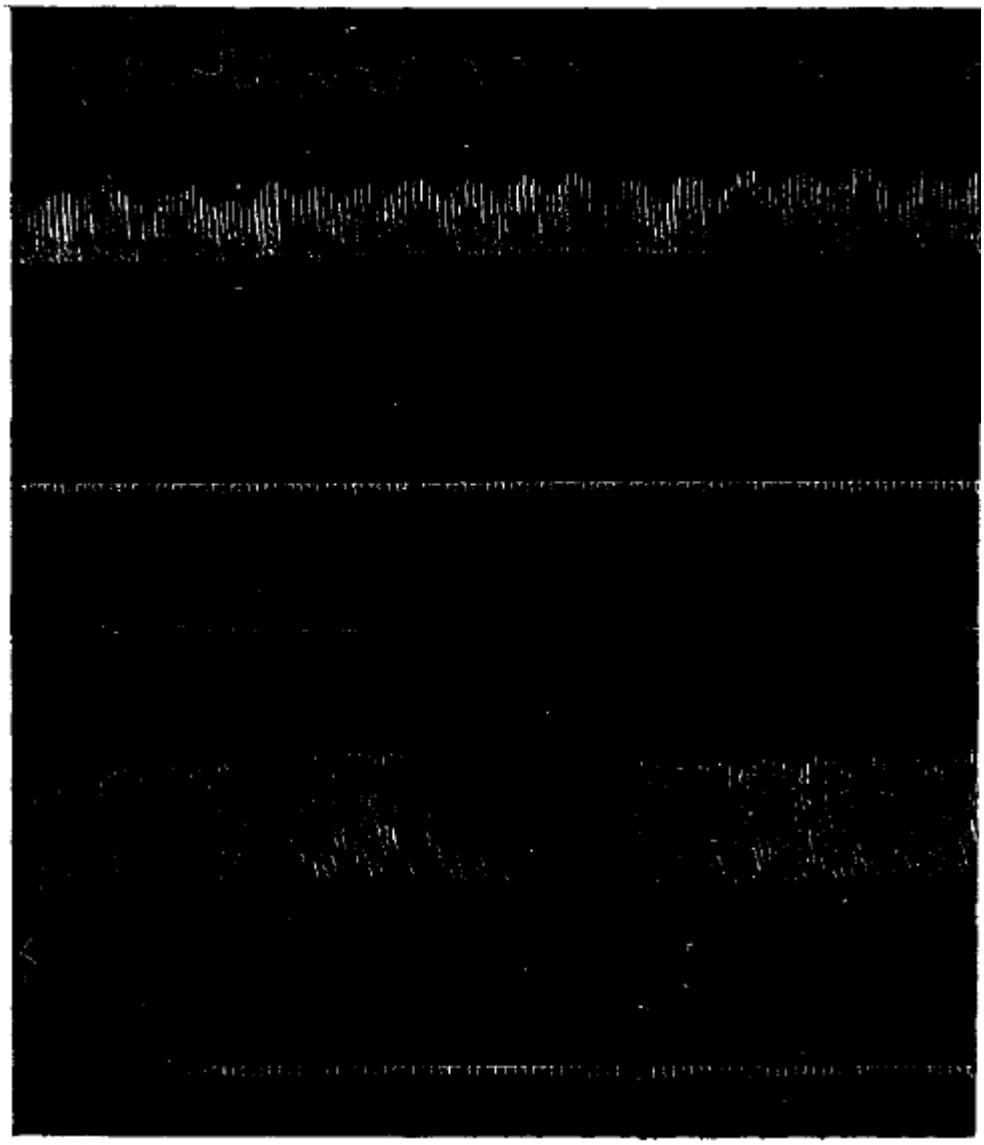
In Fig 2 the tracings are visible. The top one corresponds to the breathing, the middle one to the pulse and the lower one to the time. Half way down on the oscilographic tracing can be seen the arrow indicating the moment when the Subject (a public school student) was ordered to multiply in silence and by heart, 18x9. Immediately after the arrow can be appreciated the presence of the ondulations caused by the mental activity.

d) *Results*

To give an orderly description of our results would be cumbersome, not only by the large number of instances in which the experiments were carried out (over 200) but also for their varied outcomes. *Because of this we will offer an extract of our most significant and most consistent results.*

The oscilographic tracings obtained when the Subject is in physical and mental repose vary with the position of the muff. When the muff is in the mid-third of the arm, the pulse reaches its maximal amplitude and the same occurs with the deep respiration waves - in particular if the Subject is not supine-. It is our impression that the changes are the result of arm movements caused by the thorax's inhalation and exhalation. The arm movements bring with it an increase in volume in the limb, which is sufficient to cause these oscilations, as has already been shown by de Jong in his plethysmographic tracings.

When the cuff is placed above the wrist and,even more so, when it is placed above the ankle, the respiration waves are not as evident and the key to their occurrance is to be found in the limb's *internal* changes. It must be pointed out that these oscilations, the same as the ones registered in the oscilographic tracings, *are independent of the amount of pressure exerted* and are in proportion to the relative amplitude of the pulse. We must further remark that when the muff is not placed on the arm -or when, if on the arm, maximum precaution is taken to impede all movement- the respiratory waves offer variations of two types: in one, the variations occur at the expense of the maximal lines, while on the other, at the expense of the minimal lines. The rise in the tracing coincides in both types with the inhalation and the descent with the exhalation, but alterations in the minimal line are almost unnoticeable while in the maximal line are noticeale while being minor.



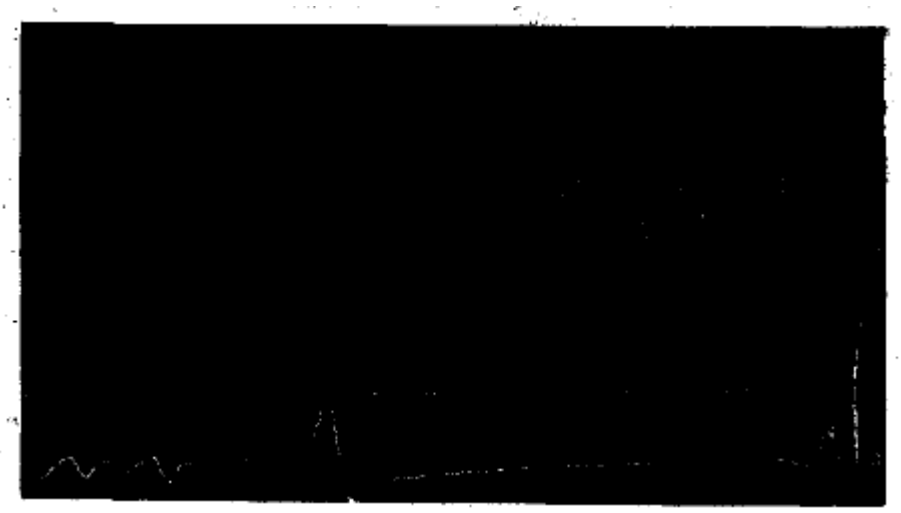
Graph of cardiovascular changes

In Fig 3 we present two typical examples of this contradiction. The impression gained is that, in the top tracing, is only the heart which responds to the respiratory process. In the bottom tracing, on the other hand, it appears that the vessels play the major part. In both tracings the degree of pressure applied was identical -15-, given that both subjects exhibited the same minimal pressure in the ankle -13- which is where the muff was placed. The top tracing began with the Subject still talking -as will be revealed by a reading of the pneumogram- and did not sink into complete relaxation until the 4th breath. Moreover, both oscilograms are typical of normal tracings, where the ondulations of Traube-Hering and Mayer_, of 2nd and 3rd. degree, already mentioned in normal plethysmograms, were observed.

When a Subject, deep into physical and mental repose, is asked to perform a mental task, we will notice, in the oscilogram, *a new type of ondulation whose amplitude and intensity is in direct relationship to the task's difficulty* for him, and therefore, *to the effort required by him to accomplish it.* The *duration* of the oscilations vary from subject to subject and for each

with the difficulty and nature of the task presented. *These ondulations are totally differentiable from the breathing and rythmic vasomotor Mayer ondulations*, which can also be observed during periods of mental rest and during sleep. We feel encouraged to describe these ondulations as being of fourth order and to label them *sphygmopsychic waves.*

Fig.4 offers evidence of this wave change in the oscilographic tracing during mental activity: In the top half of the graph is the oscilogram during rest, and in the lower half, the oscilogram during mental activity in which our waves appear and their total independence from respiration ascertained. This particular tracing was obtained with a subject 16 years of age, lying down, with the muff in his wrist. The pressure in the first part of the tracing was of 12 divisions, and only 10'5 in the second, because of the Subject's complaint of too much pressure from the cuff. The slight increase in the oscilographic wave coincides with the moment when he signaled his discomfort. During the second half the Subject was asked to keep doubling the 2345 digit. The dots visible under the tracing coincide with the moment at which the Subject tapped the table with the index of his other hand to let us know he had, silently and menally, carried the sum. The loss in wave amplitude that can be observed in the lower half is caused by the lesser pressure in the cuff.



The independence of the sphygmopsychic waves from respiration is further proven in Fig.6, where we present the graph of two oscilographic tracings from our assistant Dr. Lucena, while performing the multiplication of 716x18 and naming three words ending in "dal", both breathing normally and without breathing ,as is shown in the lower pneumograhic tracing. The cuff was placed in the middle third of his left arm and the pressure was of 12.5.

We are confident that graphs in Figs. 4 and 5 *will* serve to prove the independence that exists between our waves and breathing, which will also be observable in future tracing presentations.. The average duration of these ondulations is of 7-12", although in some cases they can last up to 25 or 30".The number of seconds is identical to the duration of the ondulations in blood tension of the brain vessels, first described by Weber and related by him to the fluctuations of attention. The fluctuations, already detailed by Urbantschisch, in 1875, vary from subject to subject, with the mental task to be performed, and under certain circumstances like fatigue, digestion, or substances affecting the nervous system, but on the whole their average duration is also 7-12", in extreme cases the difference could be as much as 4" or as little as l'. It is our contention that sphygmopsychic waves can be interpreted as work waves, and as such, as indices of attention fluctuation. We shall come back to this view but for the present we feel that there are other facts calling our attention.

Firstly, as we mentioned when describing repiratory waves', sphygmopsychic waves are of three types:

a) maximal ondulations, where the changes in the oscilographic tracings occur in the top line,

b) minimal ondulations, where these changes occur in the bottom line,

c) differential ondulations in which the tracing moves alternatively up and down while maintaining its intrinsic ratio.

At first glance the differential waves could be intepreted as the result of an increase in volume of the limb in the muff (as reinforced by their similarity to the respiratory waves obtained in the arm, when the limb is completely immobile and there is deep breathing). While the other two types could be considered to be the result of changes of volume in the arteries, caused by heart impulses (in the first) and vascular reaction (in the second). In fact, their interpretation demands a more complex explanation.

A further significant fact is that minimal waves (11) are the most frequent, followed by the maximal and the rarer ones are the differential. Minimal waves are observed in subjects who exhibit maximal respiratory waves. We have two further graphs of the same individuals from whom we have presented two oscilographs while in repose in Fig 2. In Fig 6,in the graph belonging to the subject with maximal respiratory waves, can be observed maximal sphygmopsychic waves while in the graph belonging to the subject with minimal respiratory waves. the predominant waves are minimal sphygmopsychcic ones.

Insert Fig 6.
Leg oscilogram with cufff above the ankle and 15tension

In this figure the top tracing = Pneumogram, inferior tracing=Oscilogram.

Starting at the first white spot, the Subject is asked to count from memory the number of chairs in his flat (but tell us later). The second white dot corresponds to the moment when he tells us. Note the drop in the tracing following this. There is also an increase in amplitude, on account of mental activity.

Insert Fig 7

Leg oscilogram with 15 tension

The mental task required here was the naming of words starting with CH (which is an associative task).We have earlier on stated that the intensity of ephygmosychic waves is in direct relationships with the effort required by the mental activity. We can observe this in this individual as he moves from recall, to associationn, to creative mental tasks. For most subjects, the tasks demanding the most effort are mathematical calculations. Within even one of these tasks itself, like the inversion of digits, the waves increase with the number of digits to be remembered and inverted.

Insert Fig 8
Arm oscilogram (cuff placed above the wrist), with12 tension

Starting at the first white dot in the tracing, the Subject was asked to *repeat* digits. After the arrow, he was asked to repeat digits backwards.

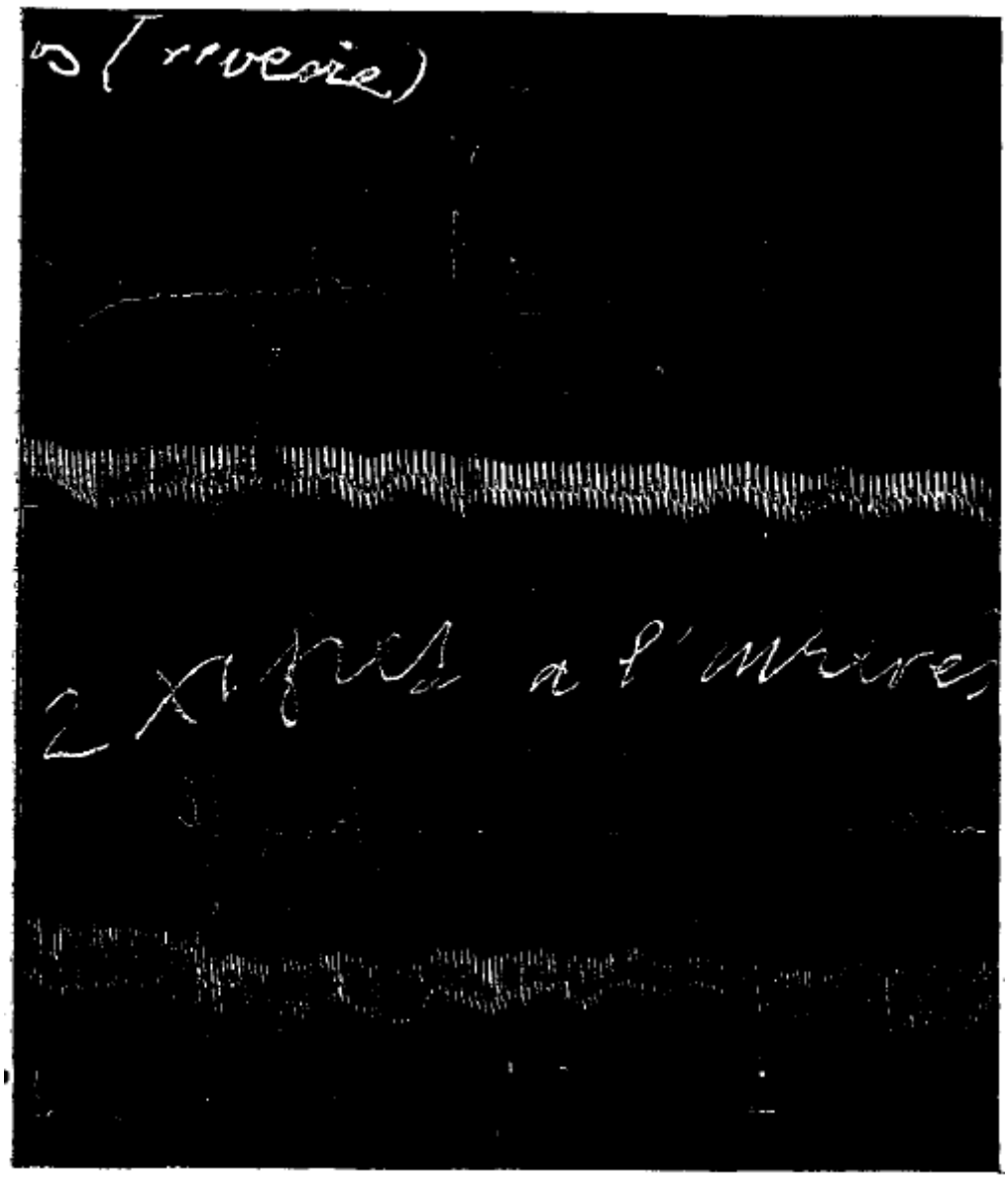
Insert Fig 9
Arm oscilograpm, tension 12

Here the Subject was asked to repeat six digits backwards (the white dots indicate the start of the presentation of stimuli), followed by repeating six letters backwards. At this second request the esphygmopsichic waves become less clear. In retrospect the Subject commented that he had found the first task to demand more attention that the second. The initial wave corresponds to the subject's expectative, while listening to our instructions. The wave that starts in the second half of the graph is also a wave of expectant attention since the Subject anticipated the continuation of the test.

Insert Fig 10
Leg oscilogram, tension 15

The required mental task here was repeating digits backwards. The letter "d"

denotes the start of the digits. The letter "r" conveys the Subject's response. The letter "F" denotes the Subject's failure to correctly repeat the digits backwards. Numbers 6, 7, 8, and 9, denote the number of digits in each task Noticeable is the progressive increase in the waves with the effort demanded by the mental task. Furthermore, we can also observe the progressive increase in amplitude of the oscilographic tracing as well as the disappearance of the waves, as soon as the mental task ceases. Within these waves are respiratory waves and, even, towards the end, Mayer waves.



Leg oscilogram, tension 14'5

Our Subject here was Dr. Peris. He was invited, at the first cross, to recall by heart the symptoms accompanying phosphoric acid toxicity. At the second cross, he was instructed to stop thinking; at the third, he was asked to recite the symptoms out

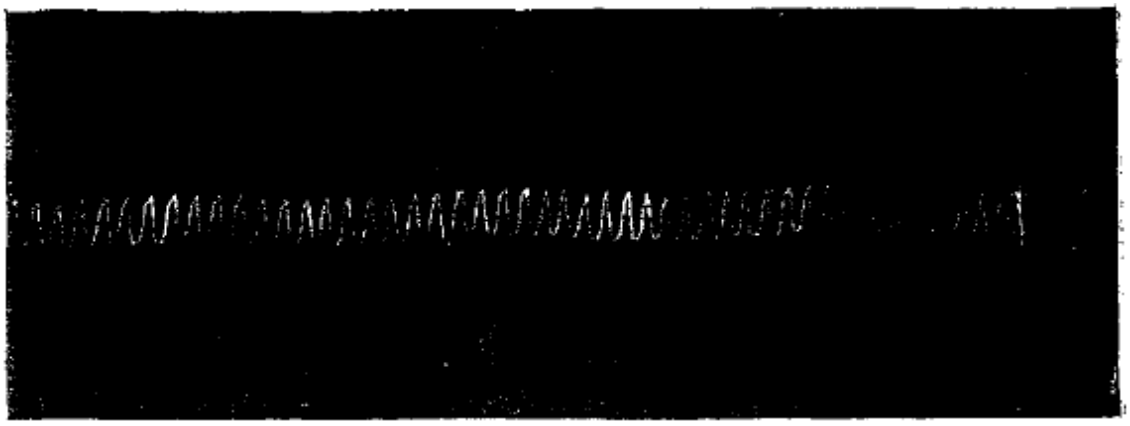
loud. Retrospectively, he confirmed that at the start of the test he enjoyed a few seconds of complete mental rest (this is revealed in the graph by the disappearance of the sphygmopsychic waves and the increase in the respiratory ones (Traube-Hering). The effects of this mental rest appear also between the second and third crosses, when he was instructed not to think. There is, as well, an increase in wave amplitud after the 1st and 3rd crosses. It is obvious that sphygmopsychic waves become more pronounced when the subject has to give his answer out loud than when he is doing it internally. If others are listening, the results can be criticised and he is forced to perform a more intense reflexive task.

A further graph will be shown in Fig 12, to evidence even more conclusively the effect we have been talking about,. In it Dr. Rocha, with the cuff in his left arm and tension 12, was asked to silently think, in a speaking voice afterwards, and to resume the task in silence, a mini lecture on *pericarditis*. On the time line are marked the shifts during the required tasks (B= silent presentation, A=aloud presentation.The last dot denotes the instant in which he is told to stop working altogether).

Insert Fig 12 here

These graphs offer clear evidence of the reason for the waves; they are not the outcome of a greater muscular effort, that is to say, respiratory and circulatory, caused by the effort required to speak aloud, since they do not change when the subject is thinking in silence. There are those who might object that they could be the outcome of an increase in muscular tone concomitant with the concentration effort (attention). The graph in Fig 13 should put an end to this objection. In this figure we have superimposed two oscilograms of the leg from the same subject. During the first one, the leg was totally relaxed while the Subject was in a state of reverie, while on the second (starting with the vertical lines) the Subject was experiencing the greatest possible tension having been asked to invert 12 digits. In spite of the difference in the subject's *mental and physical attitude*, we find sphygmopsyshic waves in both. To be noted with interest in the first graph, is the wave that appears towards the center , which is *followed* by a very deep breath. Retrospectively, the Subject affirmed that this was caused by his visualizing his future office.

The most conclusive evidence of the psychic nature of the waves rests on their absence in cases of idiocy or marked imbecility, and their weaker presentation in abnormal clients, while they are present in paranoid subjects. We were limited in our laboratory as to the number of psychopaths with various mental disorders in sufficient numbers to assemble robust data. However, we do possess some tracings which are pretty illustrative.



In this figure we present the tracing of a 45 year old paranoid man with delirium: he thinks he is the son of an aristocratic lady, who refuses to acknowledge him because to do would be to make public her indicent behavior. He reports to have no wish to hurt his mother but only to obtain some financial compensation, since, he says, it is unfair that his brothers live in opulence while he lives in poverty. As he was being asked to give the facts on which he builds his filial origins, we hooked him to obtain an oscilogram (see top tracing) with the cuff placed in the medial third of the an affixed armed. We were unable to obtain a pneumogram, but the waves that are visible -with an average duration of 12"- cannot be confused with respiratory or Mayer waves. Careful perusal allows to ascertain that , on the whole, his pulse accelerates as his narrative progresses . In spite of the Subject having retold his delirious story hundred of times, his narration was not devoid of affect or delivered by an automaton. Nor did he behave in an agitated manner during the testing.

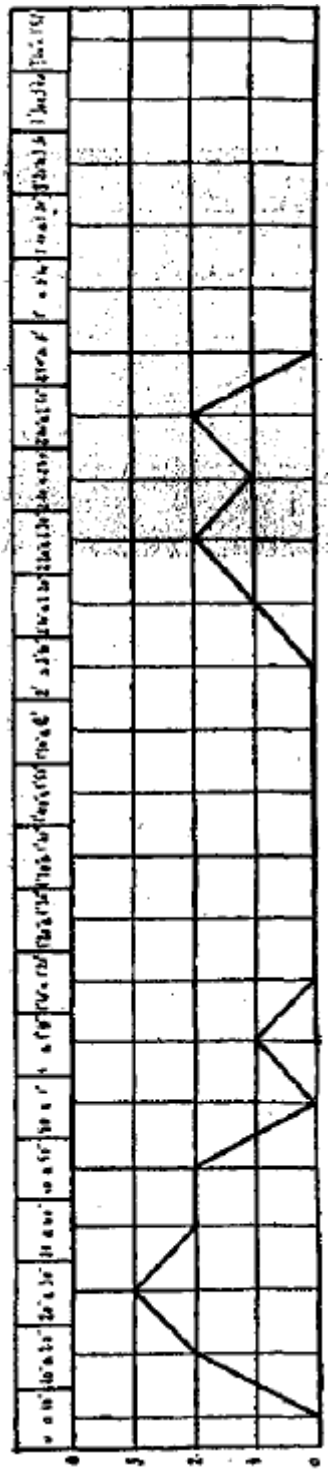
A the lower oscilogram, from the same subject some minutes later, confirms the existence of sphygmopsychic waves during the test of repetition of digits. The white dots and crossess denote the moments of the presentation of the stimuli and his replies. As the mental task becomes more complex, the intensity of his waves increases, ie number of digits went from 5, to 6, to 7 (error), back to 6 and then to 5.

Insert Fig . 14

This is the oscilographic tracing of a 22 year old, higher than average imbecile , who was asked to say words starting with the letter P. In 5 minutes he gave 4 words. There is an absolute absence of sphygmopsychic waves in his tracing, while the Traube-Hering and Mayer waves, although dampened, are visible.(Cuff in the forearm, Tension 10'5).

In an effort to prove that our sphygmopsychic waves coincided with Urbanitschic attentive waves, we have conducted various experiments, with considerable technical difficulty, which we did not totally overcome, in spite of using volunteer subjects well versed in introspection, and of patient disposition. In the first series we used the Vaschide test of attention as mental activity. We had an assistant behind the subject, with a cronometer to register the moment when errors occurred

(failure to cross out signs) . This allowed us to make a comparison between the timed errors and the oscilographic tracing. We had anticipated that when the errors occurred there would register a decrease in our waives or even their miomentary absence in the tracing. We had to admit to no relationships between these facts. Rationalizing further, and observing very carefully the unfolding of the test, we came to realize that the the *absence* of attention did not translate into errors by the subject, but rather in the *slowing down of the speed with which the signs were crossed out).* Another quandary was how to ascertain whether this slowing down was the result of the *changes in task difficulty from line to line in the test* or of a fluctuation of attention. In 2 of the 15 experiments carried out we found he number of waves registered in the oscilograph and the number of relative delays in the performance of the task coincided. Conscious of this difficult and that the Vaschide's test measures the degree of resistance of the individual to the acruing fatigue brought about by accommodation, we changed the nature of the task and chose for our second series of experimenta, the XX test of association. We considered the test of PP, given the level of education of our subjects, would have proven too easy *as a mental task.*



Graph of the number of words.The coordinates indicate the number of words, while the abcises measure time in intervals of 10'.

We met with considerable more success in this second series because we obtained a clear morphological relationship betwen the number of words given and the oscilographic tracing. We offer the oscilopneumatic tracing (from Dr. Peris) and the verbal graph of another Subject in which the relationship is most apparent. The mental task was to think and say as many words as possible starting with the letter X. The white crosses pinpoint the start and end of the experiment. The total time of the test was of 3 minutes and 48 seconds, with a total of 16 words given, in the following order: xantopsy, xantine, xantroproteic, xylophone, Xilonides, xilos, Xenius, Xumetra, Xercavins, Xalabarder, Xatari, xauen, xifoides, xantoccomic, Xirgu, Xifra. During the first minute, he gave 9 words, during the second, only one,during the third 6 and none in the fourth. A look at the tracing tells us in a general way, that the interdistance between the three elevations corresponds with the average distance in the three series of sphygmopsychic waves. The interval betwen the second and third minute tracings during which no words were spoken is devoid of sphygmopsychic waves and is about the same in both graphs.

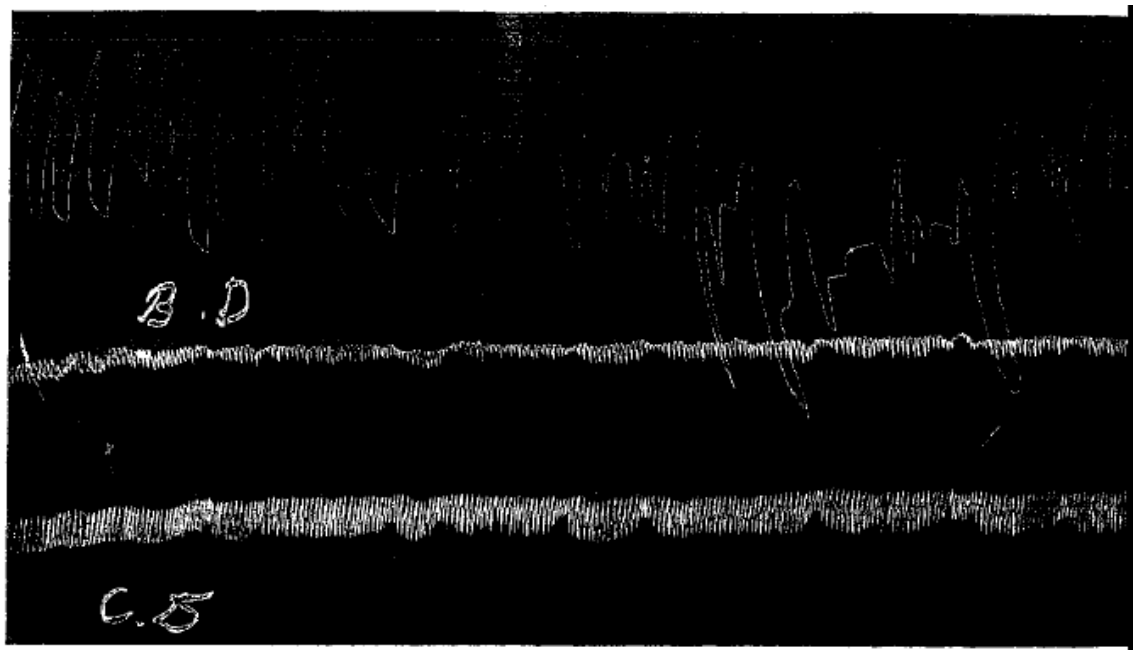
This interesting oscilogram offers us a wave periodicity rarely available to us in our experiments. During the working intervals we find the same 5 waves in both. It makes sense that the resting intervals get longer as the experiment progresses, the first lasts 22 seconds, while the second lasts 55 and the third one exceeds a minute. It is for the same reason that the number of words during working intervals decreases as the experiment progresses.. When the first word is spoken in the second minute (1'9") it coincides with the appearance of a sphysmopsychic wave which cuts into the resting. If we bear in mind that the word pronounced then is Xalabarder, and that his word is closely associated with the one preceding it Xercavins (conceptually related) (12), it is understandable that we interpret this as a residue of the first working wave (shown in the oscilogram by the five initial sphygmopsychic waves). We are safe in assuming that the Subject did not exhaust his knowledge of words starting with X, He told us that during the day, and without any great mental effort, he had thought of a further 11 words. He confirmed that he found the test exhausting, which explains the abnormal duration of the rest periods in between. Needless to say, the task is much easier when the initial leter appears frequently in our lexicon. With the letters HH, the within intervals of 115 subjects, were of 11"45" while in the tests with the letter P-, the same subjects had intervals of only 5"21'.

We think we have by now proven the presence of sphygsmopsychic waves, the relation betweentheir appearance and the difficulty of the mental task, their coincidence with changes in attention, their independence from the subject's *attitude* and their absence in individuals with mental deficits. It only remains for us to elucidate two more ambiguities: 1) are they really *cardiovascular*, 2) are they *specific* to mental activity, unable to be brought about by other causes.

With regard to the first hurdle, we took into account that the purpose of oscilographs is to register changes in volume and that therefore -by virtue of the counterpressure on the limb exerted by the cuff- we are increasing the opportunities of registering the presence of changes in arterial volume. Nevertheless, the changes in muscular volume should be equally registered - although with much lesser intensity- in the oscilographic tracing if we bear in mind, as well, that all mental representation carries with it a motor element. According to behaviourists, a subject in a state of *complete and absolute relaxation* finds itself unable to think, so it is not so far fetched that we feared that our waves could be the outcome of imperceptible movements of the extremity or of changes in muscular tonus, that accompanied the mental activity. The presence of the waves when the subject surrenders totally and plunges into a state of *reverie*, close to sleep, seem to argue against this. On the one hand, the fact that they are visible regardless of whether the cuff is placed in the arm, wrist or above the ankle, in spite of the differences in muscular mass involved in each position, argued in favor of discarding the muscular factor.

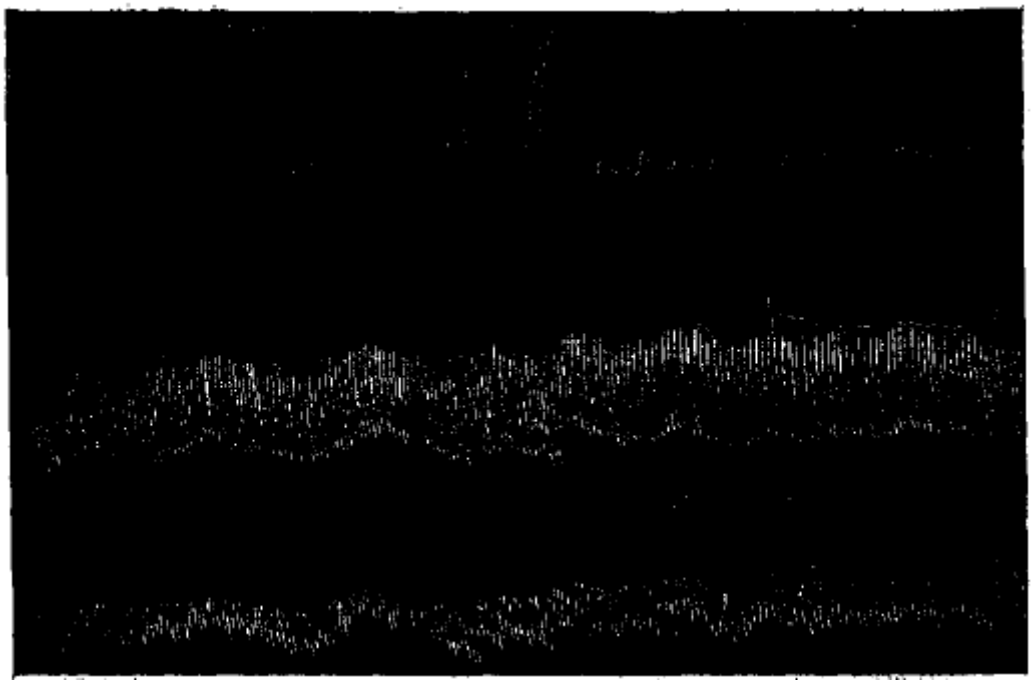
On the other hand, the changes in volume in the segment enclosed in the cuff, could be accepted as explanation for the *global* dislodgement of the tracings but not as explanation for the *intrinsic or relative* changes in it, and these,as we have already pointed out, are the most frequent to appear. We addressed the question posed by Prof. Lipman "could these waves be the result of purely *localised* changes in circulation

brought about by the compression exerted by the cuff", or to word the question differently "how certain can we be that these waves appear with the same intensity and frequency in the other extremities?". The fact that they were present regardless of existing pressure (we have, in fact, tracings obtained after subjecting the examinee's extremity to a counterpressure of 35cma.of Hg for as long as 5 minutes) inclined us to believe, from the start, that they were more than a local reflex. To prove this we employed *two oscilogoraphic capsules* successively placed on both arms, forearmss and legs, in an arm and the opposite leg, in the other arm and its opposite leg, with variations in the pressure for each capsule and limb. In the next figure we offer two oscilograms as proof that this was so and excused us from having to make further commentary.



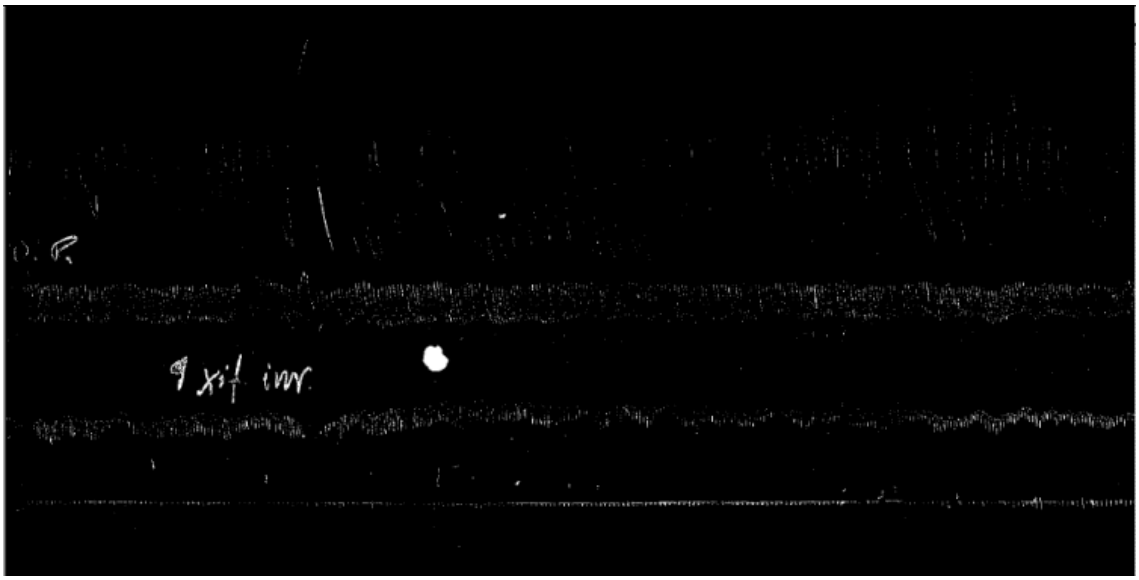
Simultaneous oscilograms of the right arm (Tension 14,min.10'5) and right leg (min.tension 11'5)
Top tracing is from the pneumograph

The mental task for the subject here was to think about and speak aloud words ending in "ic", between the first two crosses; ending in "ac" between the second and third crosses, and words ending in "h", after the third cross. The sphygmopsychic waves are more visible in the 1st and 3rd crosses (particularly the 3rd), which corresponds to the difficulty of the task



Simultaneous oscilograms of right leg and left forearm (leg tension 15, forearm 11,min 10).

The mental task here was to perform in the mind geometric progressions on the basis of number 2. Observe the deep breaths that appear at the end of the first wave of mental activity (observable in the 3 first sphygmopsychic waves).On the first deep breath the Subject moved his body , which resulted in a diplacement of the graph. From then on, the white dots under it denote the beginning and ending of the digits



Simultaneous oscilograms of left leg (top tracing) and right arm

(lower tracing), with even tension (15). At the very top is the pneumogram, at very bottom is the time line in seconds.

We are convinced that our last three graphs in Fig. 16, 17 and 18, have put to rest the possibility that our waves could be the result of muscular changes, given that one has difficulty to envisage that muscular masses of different volume and shape would register simulaneously changes in the oscilographic tracing, corresponding to such a degree. We have to think, therefore, in terms of a *general* cause of uniform character, and this can only be the changes in vessel calibration, resulting from either vasomotor influxes, heart beat, or even as a result of both.

The issue of whether sphygmopsychic waves are specific to mental activity, or can be brought about by other factors, remains to be proven. To do this we invited our subjects to adopt an *attitude* portraying and reflecting the utmost attenetion, without in fact presenting nothing to which they had to attend. Periodically, the subjects held their breath, made it deeper, stared at a given spot somewhere, frowned, in short, gave a perfect simulation of the possible somatic effects that accmpany intense attention. Not one of them was able to succeed in registering the sought after waves. We obsserved instead, sudden displacements of the registering needle owing to the lack of fine grading in their voluntary movements. We conducted a second series of experiments to test the effects of *physical or muscular activity* on the oscilographic tracing. We asked the subjects to perform arm movements with weights in their hands of increasing number of kilograms, until fatigue set in. Also, with the cuff in the arm or forearm they had to do rhythmic flexing exercises of the feet and holding exercises with or without weights. As in the previous experiments, we failed to obtain any ondulations resembling sphygmopsychic waves. We made gains in our knowledge of the changes that muscular work effects on the oscilogram, while engaged in it, *there registers a gradual increasee in the frequency of the pulses and an initial decreasee in the amplitude of the tracing*; without ever registering a periodic ondulation (while the respiration waves of Traube-Hering and Mayer's vasomotor waves. continue to appear, but with lesser emphatically).

Given the negative outcome of our efforts to recreate sphygmopsychic -or oscilopsychic waves, if it seems preferable to label them thus- we felt we had proven, for the moment at least, their specificity and therefore met the last criterion to be fulfilled so as to consider them to be a real body manifestation of the thinking process.

Another objection was made, and the need arose to clarify whether the waves were the result of the mental activity itself or of the *emotionality* that accompanies it One hurdle we encounter here is the multiple definitions of emotion as a concept that scientists offer. We shall try to give an operational definition of the concept as applying to our work. "Is it possible that mental activity by itself does not result in these changes, but could be weighted by an additional factor on account of the experiments being conducted in a laboratory, with intimidating equipment , closely watched by others, so that resulting sphygmopsychic waves are consequence of the emotion felt, in particular by Subjects who themselves work in the laboratory, an d have a dual interest (individual and team) in the outcome of the experiments?"

We were sure -a priori- of the outcome but felt that we had to address the question, which we did with a new series of experiments to test the effect on the oscilographic tracing of *emotional states* experimentally induced, and therefore lending themselves to being registered at the moment they occurr. We started y using naive subjects submitting them to the *surprise shock* with the classical stimuli: a shot of magnesium, or switching off the light (visual stimulu), a shot with a pistol with gunpowder (auditory stimulus) and removing some of the boards of the table in which the subject was lying. The results varied according to the subject's emotionality: it is quite common that reaction to the above stimuli will give rise to shifts in body position causing sharp displacement of the tracing, and thereby masking the cardiovascular changes registered in it. When the masking does not occur because of the subject's movement we find two types of reaction, to which we have given the names of *stenid and astenic*. In the first one, there is an increase in the amplitude of the pulsess, a slight drop in their frequency and a sudden increase (in the bottom line) of the minimals. In the second reaction, we have a decrease in pulse amplitude, an increase in the frequency and a sudden drop, as registered in the bottom line. There is no record of the presence of sphygmopsychic waves with any of the stimuli presented.

If we use more complex emotional stimuli like Jung's word association test, or Woodrowth's emotion questionnaire, our results are even clearer. There is in the oscilographic tracing an inhibition or momentary withholding of the sphygmopsychic waves (as the effect on the subject of the required verbal mental activity, whether a word out of the list in the word-association is presented or a question from the questionnaire is read, results in awakening of the subject's emotion. We have written in greater more detail on this subject in the 3rd issue of the "Annals of the Institute of Vocational Guidance" and prefer not to extend on it now, since this is of secondary importance in our work. Proof exists that, if during an emotional state we observe sphygmopsychic waves these are exclusively brought about by the mental activity required of the subject. Emotion by itself, instead of producing our waves, interferes with them, because their production also interferes with mental activity.

Interpretation of results

This is always the most demanding part of any research, and in this case even more so, given the difficulties arising from the multiplicity of factors that can contribute to modify oscilographic tracings (not all of them known perhaps).

Are we justified in interpreting the rise and fall of the oscilograms' bottom line as the direct consequence of changes in the minimal tension? Can we relate changes in the oscilograms' top line to changes in the maximal tension? If we focus on the amplitude of the tracing can we take it to be an indication of corresponding increases in differential tensions (Pusdruck)? These three fundamental questions do not have a simple answer. The difficulty does not lie in considering changes in the oscilogram as *absolutely* dependent on changes in arterial tension and blood pressure but in deciding whether we can accept these as a *relative* expression of the said changes. To deal with this question one must, firstly, analyze certain facts and compare the alterations brought about in the plethysmograph tracing by certain processes that do not do so with the oscilograph tracing and viceversa. Must bear in mind that the oscilogram registers alterations in arterial tension with a *sensitivity far superior to that of the plethysmogam,* and inversely, *is musch less affected by changes in the total volume of the extremity.*

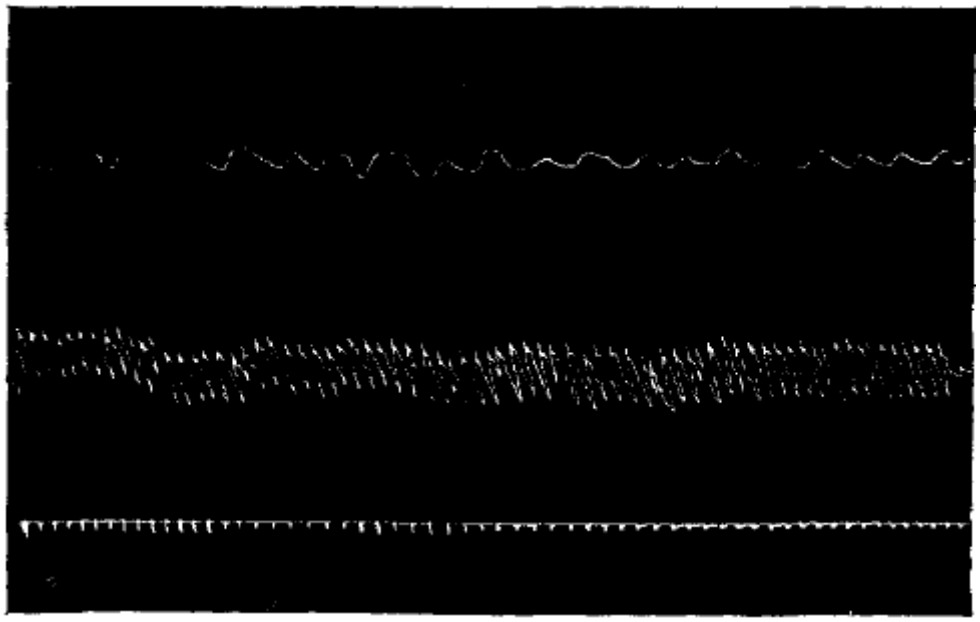
There are several ways to confirm the above. To observe the inalterability of the oscilogram's level when counterpressure on the limb increases or decreases by one or two cms. of Hg (which is equivalent to a rise and drop, respectively of the volume in the segment that is enclosed by the cuff. To study the inalterability of the oscilogram's level at the beginning and at the end of a difficult mental task of long duration, which, as proven with the plethysmogram, always brings about a decrease in the volume of the extremities. This proves that blood circulation in the veins and capilaries, which can have such an effect on the plethysmograph's tracing, hardly touch the oscilogram's. The greater sensitivity of the oscilographic capsule, in contact with the other apparatus registering arterial pulse, without exertion of counterpressure, would make it possible for it to register changes that the others do not.

A further fact of significance is the inversion of the plethysmographic and osscilographic tracings in the course of intense mental tasks. The pulse's amplitude decreases in the former as mental activity increases, while in the latter it increases. This paradoxical finding emphasizes the fundamental differences that exist between them. The loss of amplitude in the first can be explained, in our view, by the *decrease in blood volume* reaching the limb segment contained in the plethysmogram, after each sistolic heart pulse.It is not difficult to visualize that the superficial vasocontriction brought about by mental task, results in lessblood reching the extremities and produces changes in the their volume and the changes brought about by the sistolic beat become lesser. Giventhat the plethysmogram nly registers these it is to be expected that the amplitude of the plethysmogram will be less (owing to displacements of the registering needle similar to arterial pulse). The increase in amplitude in the oscilographic tracing can be explained inversely *by the higher abruptness of the deviation of the arterial wall*, when the pulse wave reaches it in vasoconstriction circumstances, which will cause a

greater displacement of thc capsule's needle. It is an established fact that the amplitude of the sphygmogram, for instance, is accentuated in cases of arterial vasoconstriction, becausse of the loss, almost absence, of elasticity, acting as shock absorber of the arterial wall.

Such an increase in amplitude can also be brought about by an increase in maximal tension which takes place because of the need to maintain even the differential pressure, in spite of the greater height of the minimal (the outcome of vasoconstriction). We have observed that after an intense and prolonged mental task the maximal tension rose, from subject to subject, as much as by 1-1'5-2 cms. of Hg (as measured by the manometer next to the Pachon's oscilometer). We must bear in mind that tension in veins and capilaries cannot be overlooked in an oscilographic tracing. This serves to justify our guardedness in accepting that the oscilographic tracing alterations are exclusively due to changes in blood tension. The fact that minimal sphygmopsychic waves appear preferentially in young subjects (the youngest in our sample was a 6 yrs. old) while the maximal sphygmopsychic waves appear with greater regularity in adult subjects of a certain age (our eldest was 46yrsold.) leads us to the supposition that vasomotor reactions to mental activity decrease with age and need to be compensated by greater stress on the heart. We are , nevertheless, conscious that this relationship has not been sufficiently proven.

What is certain is that the heart does not remain indifferent to mental activity (bear in mind we are speaking of *emotionless* activity). Proof of this is to be found in more than the *periodic increases in pulse* as can be detected from our graphs. We refer to the various arythmias and pulse loss, caused by mental activity in perfectly healthy, normal individuals, in their circulation. A case in point is to be found in Fig20 in the tracings presented in it.



Conclusion. In the extremities subject of our research we hav found a blood pressure ondulation which is exclusive to the performance of mental activity and must be referred to the ondulations in pressure of the brain vessels, described by Ernst Weber as being in synchrony with attention fluctuations. This type of ondulation, for which we have chosen the name of sphygmopsychic, can be easily put in evidence with the use of Pachon's oscilographic capsule,with the cuff position in any of the extremities, while the subject is engaged in performing a mental task. It is our opinion that this is the only bodily process that can be taken to be a true manifestation of the thinking function. Given the ease with which these ondulations can be easily researched in all sort of individuals, their systematic study must lead to uncovering facts of great theoretico-practical import.

Dr Mira was awarded the highest honours for his doctoral thesis by unanimous decision of the Tribunal, made up to Dr. Tomas Maestre, Dr. Cardenal, Dr. Tello, Dr. Piga, Dr. Loza.

Madrid, April 1st, 1922

References and Notes

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(2a) E. Prideaux. - Exp. of Emotion in cases of Mental Disorders as shown by the Psychogalvanic Reflex. In *Brit.Jr. of Psychology. Med.Sec.* Oct.1921, p.23.

(3) Waller denies the value of these tests.In his view atropine can only affect secretion currents, which are in no way related to Fere phenomena. He has offered tracings of psychogalvanic deflexion after atropine. Bancroft maintains that Waller's experiments in no way disprove the hypothesis that the sebacious glands are responsible for the phenomenon, given that a subliminal activity persists in these and is not altogether done away by the atropine

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(10) Needless to say that fluctuations in attention coincide with fluctuations of conscious mental activity.

*(*11) V. Joseph Frobes - Lehrbuch der Experimentellen Psychologie. Freiburg in Breslau, Zwelter Bd.s.82, 1920.

(12) W,M.Bayliss - Principles of General PHysiology. pp.484-691. London, Longmans, Green and Co.,1920.

(13) I am indebted to Dr. Wayemburg for bringing to my attention the work of his colleague Dr. Jong, only published in part, and quoted in Reference #*6.* His well grounded objections to my previous work, in the 2nd International Conference of Psychometrics in Vocational Guidance, have prompted us to undertake research on the local changes in blood pressure brought about by the cuff, at different levels of pression which has allowed us to eliminate what was an important potencial cause of error.

(14) The apex in the respiratory tracing must coincide with the apex in the oscilographic tracing.

(15) It is essential to check that the tubes are in their corresponding position (the one connecting capsule and cuff must connect with the box of the capsule and the cuff); otherwise, the tracings could be inverted.

(16) The name chosen for the waves does not imply that they can be seen as exclusively the result of changes in minimal tension The same applies to the the remaining waves.

*(*17) Both words are the surname of two doctors in Barcelona.