I received some feed-back from a psychologist, and from others, and apparently my earlier description was less transparent than I thought. I have added some further details.

OUTLINE of lecture at Perrott-Warrick Conference
(Cambridge UK, April 2, 2000)
(Audience mainly of Psychologists, with some physicists.)

Topic: Quantum Theory of Mind-Brain Interaction.

Two Main Points:

1. Quantum theory is formulated as a theory of the INTERACTION between PARTICIPANT-OBSERVERS and PHYSICAL SYSTEMS, whereas classical physical theory leaves out interactions with participant-observers.

2. Copenhagen vs von Neumann-Wigner quantum theory:

** Copenhagen makes quantum theory into a mere computational scheme: it renounces the aspiration to describe reality, or mind-brain connection..

** von Neumann-Wigner makes quantum theory into a theory of reality that provides the basis for a theory of the mind-brain interaction.

A Main Problem: "Environmental Decoherence"

This is the effect of the interaction of a system with its environment. It reduces the brain to a classical system, IN A CERTAIN SPECIFIC SENSE.

It is claimed that this decoherence effect entails that QM cannot be important to mind-brain interaction.

That argument is incorrect.

The Solution:

The QUANTUM ZENO EFFECT allows a person's mental effort to guide the activities of his brain.

The FIRST MAIN AIM of this talk:

TO ACTUALLY SHOW FROM SCRATCH, to non physicists, how the Quantum Zeno Effect allows the activities of a person's brain to be quided by his mental effort.

I intend dispel the idea that QM of mind-brain interaction is some obscure abstruse idea,

or that you must know some physics in order to understand and use it.

Quantum theory is actually much SIMPLER than classical mechanics: a child can do it. There is no need to solve differential equations to get certain key results

I shall ACTUALLY DERIVE the two key main conclusions FROM SCRATCH.

Classical physics permits no such explicit DERIVATION of features of the mind-brain connection. That's because mental qualities do not even enter the classical-physics dynamical equations.

QUANTUM THEORY FROM SCRATCH.

1. Quantum theory is (can be) formulated in terms of square arrays of numbers, called MATRICES: Example of a 3-by-3 matrix: (3 rows r, and 3 colums c)

$$\text{Matrix } A = \begin{matrix} 9 & 4 & 7 \\ 2 & 1 & 6 \\ 8 & 8 & 5 \end{matrix}$$

$\langle r|A|c\rangle$ is the number in row r and column c

e.g. $\langle 1|A|3\rangle = 7$

Matrices can be added:

$A+B=C \quad \langle r|C|c\rangle = \langle r|A|c\rangle + \langle r|B|c\rangle$,

A matrix can be multiplied by a number n

$nA = C \quad \langle r|C|c\rangle = n\langle r|A|c\rangle$.

Two matrices can be multiplied to give a new Matrix:

$AB = C \quad \langle r|C|c\rangle =$ Sum over i of $\langle r|A|i\rangle\langle i|B|c\rangle$

What is “i” and what does it mean here? Give an example like you did for $\langle r|A|c\rangle$ above.

(Sometimes AB=BA; sometimes not)

Let a trace over A = Tr A

A basic operation: Tr A = Sum of the diagonal elements of A

Tr A = Sum over i of <i|A|i>   [= 9+1+5 = 15 in the example}

What is “i” and what does it mean here? The example is good.

As opposed to the property of matrices (as just mentioned)

A key property of Tr: Tr AB = Tr BA (for bounded A and B)

define bounded (if it is not important for them to know it leave it out -- if it is important define it)

Sum over i, Sum over j <i|A|j><j|B|i>
is independent of the ordering of A and B.

What is “i” and what does it mean here?

Many general conclusions can be deduced without actually writing down any actual **matrices**: Just knowing certain **properties** is enough.

Left the “r” out of matrices and the “t” out of properties

I shall ACTUALLY DERIVE, here, the TWO KEY RESULTS, just from the ideas given above, without writing down any matrix explicitly.

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2. Quantum Theory is a STATISTICAL THEORY: it allows the computation of probabilities of outcomes, but not the computation of the individual outcomes.

Moved sentence to Details

3. Quantum theory is a theory of INTERACTION between PARTICIPANT-OBSERVERS and PHYSICAL SYSTEMS.

The dynamics consists of three processes:

I. At certain times a participant-observer asks a Yes-No question.
II. "Nature" returns an answer, Yes or No,
III. Between these interventions by participant-observers the state evolves deterministically according to a specified rule.

Details:

I. The state of the system at time t is represented by a matrix S(t), called the "density matrix".

(I moved this because it is preferable for the definition of S(t) to be in the same section in which it is first used)

II. Each Yes-No question is ALSO represented by a matrix “P” (P=1 for a YES answer and P=0 for a NO answer) The Yes-No question matrix satisfies the relation PP=P. BECAUSE

????

"Asking P" is represented by "the von Neumann process 1":

If P=0
The state of the system at time t [the density matrix S(t)] =
the NO question PS(t-0)P
+ the YES question (1-P)S(t-0)(1-P)

If P=1
The state of the system at time t [the density matrix S(t)] =
the YES question PS(t-0)P
+ the NO question (1-P)S(t-0)(1-P)

That is in general:
S(t)= PS(t-0)P + (1-P)S(t-0)(1-P)

[S(t-0) is limit of S(t') as t'-->t from below]
from below what ???

Typical questions: Is the pointer moving to the right?
Is my arm rising?

II. If P=1 then Nature answers Yes:
S(t+0)= PS(t) with probability Tr PS(t)/TrS(t)
or
If P=0 then Nature answers No:
S(t+0)=(1-P)S(t) with probability Tr (1-P)S(t)/TrS(t)

III. Between jumps S(t') evolves via
[They (the psychologists) won't know what you mean by "jumps"]
S(t')=exp(-iH(t'-t)) S(t) exp(-iH(t-t'))
This equation needs to be first stated in plain English, as I demonstrated in the "Details" section. What is H? What is the meaning of exp. Explain how "i" here is different than how you used it above.

For "small" (t'-t), S(t') ~= (1-iH(t'-t)) S(t) (1-iH(t-t'))

BECAUSE ???

THE QUANTUM ZENO EFFECT.

QZE is caused by Rapid Repetitive asking of same question P;

Consider S(t') after two closely spaced "Asking question P".
Suppose the answers are not known: i.e., suppose we want
to represent just the resulting statistical properties:

The state of the system at time t' ~=
P (1-iH(t'-t)) [PS(t)P
+ (1-P)S(t)(1-P)] (1-iH(t-t')) P
+ (1-P) (1-iH(t'-t)) [PS(t)P
+ (1-P)S(t)(1-P)] (1-iH(t-t')) (1-P)

The meaning of this is not clear because the meaning of III above was not made clear

that is:

S(t') ~= P (1-iH(t'-t)) [PS(t)P + (1-P)S(t)(1-P)] (1-iH(t-t')) P

+ (1-P) (1-iH(t'-t)) [PS(t)P + (1-P)S(t)(1-P)] (1-iH(t-t')) (1-P)

Because this is not clear starting with III above, the following highlighted in blue is totally incomprehensible to the average educated layman or psychologist. What you end up saying IN EFFECT is "*TRUST ME, I KNOW WHAT I AM DOING*". This is not consistent with your aim in this lecture.

H enters in four ways: PHP, (1-P)H(1-P), PH(1-P), & (1-P)HP.
Look at terms containing PH(1-P) or (1-P)HP.

Note that P(1-P)=(1-P)P =0

Thus each of these terms appears with AT LEAST TWO powers of (t'-t). But PHP and (1-P)H(1-P) appear with a first power of (t'-t).

Consider a long interval T.
Divide it into n intervals of length T/n.

The contributions LINEAR in T/n give n contribution T/n:
n/n is zeroth order in n.

But n contributions of second order in T/n give n/nn:
As n-->large n/nn --> Zero

The cross terms PH(1-P) and (1-P)HP drop out in limit:

Effect: H-->PHP + (1-P)H(1-P).

No P <--> (1-P) transitions.

The system gets trapped either in the subspace where $P=1$ or in the subspace where $(1-P)=1$ (i.e., in the subspace where $P=0$).

This is the Quantum Zeno Effect.

I have derived it from scratch.

It works just as well for a "decoherent mixture"
$S(t)$= Sum of "classical" contributions,
as for a pure state $S(t)$.

QZE keeps the STATISTICAL SYSTEM from speading out (diffusing) in the way that it would without the "ASKING OF QUESTIONS" by the participant-observer.

The second key property is LOCALITY.

> In the following sentence highlighted by blue
> what exactly do P_1 and P_2 represent here?
> How are they different from P and $1-P$?

Suppose there are participant/observers in two well separated regions.
Suppose the first asks YES or NO represented by P_1, and the second asks YES or NO represented by P_2 at the same time.
Then the rules of (relativistic) quantum field theory demand

$$P_1 P_2 = P_2 P_1.$$

> How does this relate to the aforementioned fact that for matrix multiplication AB does not always equal BA?

KEY LOCALITY RESULT:

> Because the following (highlighted in green) follows from the incomprehensible highlighted blue sentence above it is also incomprehensible.

The probabilty $\langle P_1\rangle$ for outcome $P_1 = 1$ is not
affected/changed by just "ASKING THE QUSTION P_2":

> For example is $\langle P_1\rangle$ the same or different from P_1 as used just preceeding? Say it in ordinary English

$$\langle P_1\rangle = \mathrm{Tr}\, P_1[P_2 S P_2 +(1-P_2)S(1-P_2)/ \mathrm{Tr}\, [P_2 S P_2 + (1-P_2)S(1-P_2)]$$
$$= \mathrm{Tr}\, P_1[P_2 S + (1-P_2)S]/\mathrm{Tr}[P_2 S + (1-P_2)S]$$

= Tr P_1 S/Tr S.

Say this equation in ordinary English like I did in the “Detail” section above.

{For each term use Tr AB = Tr BA, P_2 P_1 = P_1 P_2,
and P_2 P_2=P_2 (which entails (1-P_2)(1-P_2)=(1-P_2)).}

This is the key locality result: I have derived it from scratch.
They will all be scratching their heads at this point

This locality result justifies interpreting "asking **question**" [left the “e” out of question]
(represented by S-->PSP + (1-P)S(1-P)) as a local process
governed by the participant-observer who is asking the question.

The above results are interpretation independent. That is, the predictions are the same whether the von Neumann/Wigner interpretation is being used (as in the above examples involving P) or whether the Copenhagen interpretation is being used.

The advantage of using the von Neumann/Wigner interpretation (as in the above examples involving P) derives from the following two paragraphs.

In Copenhagen quantum theory the system S(t) being acted on and observed
is some tiny "atomic" system, and the participant-observer is the
psycho-physical agent plus the devices that he uses to prepare the system S(t),
and later to probe it in a particular way that he chooses.

To deal with cosmological and mind-brain questions I follow von Neumann
and Wigner and bring the entire physical world into the system S(t):
S(t) represents the aggregation of all atoms and their constituents.
Thus the body-brain aspect of the participant-observer is represented in S(t).
But the participant-observer has also aspects that are described in
psychological terms: ideas, consents and vetoes, and effort.

CONCLUSION I.

According to the theory, the only way the psychological aspects
of the participant-observer can enter into the physical dynamics
is via "asking questions":

He can enter only via the von Neumann process 1.:
S(t)= PS(t-0)P + (1-P)S(t-0)(1-P).

To aid their memories refer them to the above section entitled “QM derived from scratch", subsection 3-II above

This is a local process: it does not affect far-away probabilities!

[On the other hand, NATURE'S choice of nearby outcome DOES affect far-away probabilities, in general.]

MAXIMALLY PREDICTIVE FORM OF THE THEORY.

To make the theory maximally predictive we must curtail maximally the freedom of the uncontrolled licence of the participant-observer.

I assume that each participant-observer (quantum processor) has at any time just a finite set of P's that he/she/it can ask.

Doesn't this contradict the assumption utilized in attacking the frame problem?

These P's act on the physical degrees of freedom of the participant-observer (the quantum processor).

For a given quantum processor let P(t) be defined as follows:

P(t)= The P that maximizes Tr P S(t).
Explain in what way Tr P S(t) is maximized. i.e temporally, spatially, quantitatively, etc.

Suppose the processor at time t is allowed only to consent to or to veto P(t).

And suppose the timing and rapidity of the accepted questions is controlled by "mental effort": increasing mental effort shortens the interval between the "askings".

And suppose that, for each processor, each P in the set of allowed P's tends to create, if PSP is actualized, a subsequent P that is very similar to P. If the rapidity of asking P is sufficient then QZE will kick in, and the system will tend to remain confined to the subspace P for a long time, as a consequence of the continued focus of mental attention on the question P.

In this scheme the brain does most of the work, but the mind can influence brain activity via QZE by applying consent-veto and mental effort.

Tie-in to Psychology.

Wm. James. in "Psychology: The Briefer Course"

Ch. Attention: Sect. Attention and Free Will.

``I have spoken as if our attention were wholly determined by neural conditions. I believe that the array of {\it things} we can attend to is so determined. No object can {\it catch} our attention except by the neural machinery. But the {\it amount} of the attention which an object receives after it has caught our attention is another question. It often takes effort to keep mind upon it. We feel that we can make more or less of the effort as we choose. If this feeling be not deceptive, if our effort be a spiritual force, and an indeterminant one, then of course it contributes coequally with the cerebral conditions to the result. Though it introduce no new idea, it will deepen and prolong the stay in consciousness of innumerable ideas which else would fade more quickly away. The delay thus gained might not be more than a second in duration--- but that second may be critical; for in the rising and falling considerations in the mind, where two associated systems of them are nearly in equilibrium it is often a matter of but a second more or less of attention at the outset, whether one system shall gain force to occupy the field and develop itself and exclude the other, or be excluded itself by the other. When developed it may make us act, and that act may seal our doom. When we come to the chapter on the Will we shall see that the whole drama of the voluntary life hinges on the attention, slightly more or slightly less, which rival motor ideas may receive. ..."

Posing a question is the act of attending. In the chapter on Will, in the section entitled ``Volitional effort is effort of attention" James writes:

``Thus we find that {\it we reach the heart of our inquiry into volition when we ask by what process is it that the thought of any given action comes to prevail stably in the mind.}"

and later

``{\it The essential achievement of the will, in short, when it is most `voluntary,' is to attend to a difficult object and hold it fast before the mind. ... Effort of attention is thus the essential phenomenon of will."}

Still later, James says:

{\it ``Consent to the idea's undivided presence, this is effort's sole achievement."} ...``Everywhere, then, the function of effort is the same: to keep affirming and adopting the thought which, if left to itself, would slip away."

The vN/W theory, with the Quantum Zeno Effect incorporated, explains the mind-brain features that are the basis of James's conception of the action of human volition on brain process.

EXAMPLE: How does your mental action raise your arm?

The set or sequence of P(t)'s is being offered to the mental aspect of the participant-observer by his body-brain. If raising the arm might be appropriate in the current circumstance then the possibility of attending to the question "Is my arm rising?" is likely to be posed. If consented to, not vetoed, this question will be posed. If effort is applied the same question will be asked in rapid succession. Attention will become focussed on the idea of the rising arm. According to James's ideo-motor theory, the action of raising the arm will be initiated (in the brain) by this fixing of attention.

The answer given by nature might be No! Then there will be some more searching. But if raising the arm is by far the most appropriate action under the circumstance, then the probability for a Yes answer--- with this probability ground out by the mechanical (survival-honed) evolution ---should be high.

If the initial answer is No, and all other alternatives are "bad", on the basis of the mechanically conditioned criteria, then the question should get posed again soon. Maybe this time it will get caught by QZE.

Thus von Neumann-Wigner quantum theory provides the rudiments of a neat and simple framework for studying mind-brain interaction. It has significant explanatory power: it explains immediately the essential features of volition described by Wm. James.

This conference is examining reports of paranormal phenomena from the perspective of normal physical theory.

But the first requirement on an adequate normal theory is that it explain the NORMAL action of mind upon matter that is at the basis of our daily lives.

vN/W QM provides such a theory.

What does it say about paranormal phenomena?

An immediate conclusion is the locality result:

CONCLUSION II.

PROBABILITIES for distant outcomes cannot be influenced by mental effort here, insofar as normal relativistic quantum field theory holds.

Example 1:

Suppose P_1 and P_2 are correlated at time t:

S(t) = a(t)(P_1)(P_2) + b(t)(1-P_1)(1-P_2).

C = ((P_1)-(1-P_1))((P_2)-(1-P_2)) = Correlation Operator

<C(t)> = Tr C S(t)/Tr S(t) = 1.

Suppose HS(t') = (H_1 + H_2)S(t') t'>t

and S(t')H = S(t')(H_1 + H_2) t'>t

Suppose S--> P_2 S P_2 + (1-P_2)S(1-P_2) ~ mental effort by processor 2 for t'>t.

CONCLUSION: You have "conclusion I" followed by "conclusion II" followed by "conclusion"

This cannot effect <P_1>(t') for t'>t

Thus in the experiment described by Fotini Pallikari, a mental effort that stablizes P_2 can affect things in the region, of processor 2, but cannot change the probabilities pertaining to what another observer sees.

CONCLUSION II: You have "conclusion I" followed by "conclusion II" followed by "conclusion" followed by "conclusion II" Perhaps MODIFICATIONS OF CONCLUSION II would be better.

But distant effects can be obtained by modifying the theory slightly:

Mental Effort: S--> [(1+s)PSP + (1-P)S(1-P)] , small s

This violates normal quantum theory.

It would permit SIGNALS to be sent faster-than-light, in violation
of ideas from the theory of relativity.

The orthodox theory automatically excludes FTL signalling.

But if experiments really conflict with this conclusion, then the modification
proposed above seems to be the simplest way out.

It would mean that mental process can influence not only which questions are
asked, and when they are asked---which appears to be all that is needed to
explain the NORMAL effects of mind on matter---but also can bias the
probabilities for the alternative outcomes away from what quantum theory
specifies. That would be a violation of quantum theory, but at least
a well defined and calculable variation of the normal rules.
