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Mental, behavioural and physiological nonlocal correlations within the Generalized Quantum Theory framework: a review

Harald Walach*, Patrizio Tressoldi§ and Luciano Pederzoli°

* Institut für Transkulturelle Gesundheitswissenschaften
Europa Universität Viadrina, Germany

§ Dipartimento di Psicologia Generale, Università di Padova, Italy

°EvanLab, Firenze, Italy

Corresponding author:

Patrizio Tressoldi

Email: patrizio.tressoldi@unipd.it

Abstract

Generalized Quantum Theory (GQT) seeks to explain and predict quantum-like phenomena in areas usually outside the scope of quantum physics, such as biology and psychology. It draws on fundamental theories and uses the algebraic formalism of quantum theory that is used in the study of observable physical matter such as photons, electrons, etc.

In contrast to quantum theory proper, GQT is a very generalized form that does not allow for the full application of formalism. For instance neither a commutator, such as Planck's constant, nor any additive operations are defined, which precludes the usage of a full Hilbert-space formalism. But it is a formalized phenomenological theory that is applicable whenever the core element of a quantum theory needs to be captured, namely in the presence of incompatible or non-commuting operations. As a consequence, it also predicts nonlocal, generalized entanglement correlations in systems other than proper quantum systems.

In this review we summarize the specific scientific evidence relating to the quantum-like mental, behavioral and physiological nonlocal correlations. Such non-local, generalized entanglement correlations are expected, both in space and time, between subsystems of a larger system, whenever observables pertaining to the global system are incompatible or complementary to observables pertaining to subsystems, as predicted by GQT.

The result is a coherent explanation of a significant amount of controversial and seemingly weird occurrences that cannot be explained by classical physical laws. This review also offers a new perspective of the human mind's potential.

Keywords: Generalized Quantum Theory, entanglement, nonlocal correlation, mind-matter interaction, perception at distance

1.0 Generalized Quantum Theory

Quantum theory predicts a strange phenomenon, first described by Schrödinger (1935), called entanglement. This means that elements of a system behave in a correlated fashion even though they are spacelike or timelike separated and no classical signal can convey a causal influence. The first experiments pertaining to this phenomenon were performed by Aspect, Grangier, and Roger (1982) and by Aspect, Dalibard, and Roger (1982), forty-seven years after the publication of a famous paper by Einstein, Podolsky, and Rosen (1935) entitled "*Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?",* which described a "*Gedanken experiment*" (thought experiment) to rebut this theory, which Einstein et al. defined as "*spooky action at a distance*", where there is a correlation between two distant events that is not causally mediated, for instance through hidden variables. This is in stark contrast to the principle of locality, which states that only causes at the finite speed of light can convey influences. However, to date this phenomenon continues to pass all experimental tests, even though its interpretation is still the object of much heated debate (for a review see Genovese 2010, and Schlosshauer, Kofler & Zeilinger, 2013).

Non-local effects between entangled physical observables are predicted by the mathematical formalism that is at the base of quantum mechanics and constitutes one of modern physics' biggest successes.

Such a success could not remain unknown to researchers in other fields, who asked themselves questions like: "*Are non-local correlations specific only to the microscopic physical world or can they also be seen in biology, psychology, and other areas of our macroscopic lived world?*" and "*Can the statistical and mathematical formalism used in quantum mechanics also be used to explain phenomena in other domains?*" (e.g. Khrennikov, 2010; Vedral, 2010; Pothos and Busemeyer, 2013).

The motivation for GQT's creation arose from these fundamental questions (Atmanspacher, Römer & Walach, 2002; Atmanspacher, Filk & Römer, 2006; Walach & von Stillfried, 2011; Filk & Römer, 2011). More detailed descriptions can be found in the original presentations. As far as this review is concerned, we will concentrate on its basic assumptions.

Generalized Quantum Theory (GQT) seeks to explain and predict quantum-like phenomena in areas usually outside the scope of quantum physics, such as biology and psychology. It draws on fundamental theories and uses the algebraic formalism of quantum theory that is used in the study of observable physical matter such as photons, electrons, etc. In contrast to quantum theory proper, GQT is a very generalized form that does not allow the full application of the formalism. For instance, no commutator, such as Planck's constant, is defined, nor are additive operations, which precludes the usage of a full Hilbert-space formalism. But it is a formalized phenomenological theory that is applicable, whenever the core element of a quantum theory needs to be captured, namely the presence of incompatible or non-commuting operations. As a consequence, it also predicts nonlocal, generalized entanglement correlations in systems other than quantum systems proper.

1.1 Basic assumptions

"*Two observables **A** and **B** are called complementary or incompatible, if there are measured values of one of them, say value **a** of **A**, such that no eigenstate (observable characteristics) of **A** to the value a can be an eigenstate of **B**. **A** and **B** are justly called incompatible, because we cannot always define their values precisely at the same time. For incompatible observables **A** and **B** the order in which they are measured will matter. In this sense, **A** and **B** do not "commute" with each other. Observables **A** and **B** are called compatible if they are not complementary, i.e. if their measurements are interchangeable and do not disturb one another. In a classical setting every observable is compatible with all the others. In Generalized Quantum Theory, two observables need not be compatible but may be complementary. Whenever one of the two incompatible observables is precisely defined, our knowledge of the other observable may be reduced in precision*" (Walach et al. 2014, pp. 614).

As a consequence of these basic assumptions, a generalized entanglement correlation will be expected, if the following conditions are fulfilled:

"*1) A system is given, inside which subsystems can be identified. Entanglement phenomena will be best visible if the subsystems are sufficiently separated such that local observables pertaining to different subsystems are compatible.*

2) There is a global observable of the total system, which is complementary to local observables of the subsystems.

3) The total system is in an entangled state. For instance, eigenstates of the global observable are typically entangled states" (Walach et al. 2014, pp. 618).

The main characteristics and consequences of systems that are non-locally correlated within such a generalized framework are:

- The relationship or correlation between or among the subsystems is acausal. Regarding this characteristic, their correlation cannot be used to transfer information between or among the subsystems [Non Transmission (NT) axiom (Lucadou, Römer and Walach 2007)].

- This entails: Any attempt to use such systems in a causal way or to distil a causal signal out of them will lead to the breakdown of the entanglement correlation or to a reversal of expected outcomes. This is the reason, why experimental studies, that probe for causal stability often fail, and why a different, indirect kind of experimentation has to be employed that respects the framework conditions of such correlations.

- Entanglement correlations are not bound by space and time; that is, we may observe nonlocal correlations both in space and in time (Filk, 2013).

- Since within the generalized framework there is no precise definition of the commutator, which in quantum theory proper is ħ, theoretically and in principle non-local correlations might be quite strong and visible in the macro-world.

1.2 How to mentally entangle two subsystems

How such entangled systems can be produced, is a critical and not well investigated aspect. In physics, one of the most commonly used methods is the spontaneous parametric down-conversion to generate a pair of photons entangled in polarization. Other methods include the use of a fiber coupler to confine and mix photons, the use of quantum dots to trap electrons until decay occurs, etc. (Horodecki, et al. 2009). In simple words, entanglement is obtained by artificially inducing an interaction between certain physical properties of "objects" to be entangled.

But how is it possible to create an entanglement between human minds or entangle a human mind with a physical or biological object? The procedures used by researchers vary in the details (see sections 2 and 3), but they have two main types in common.

The first procedure type, which we will call Type **A**, is based on voluntary, intentional control by a person. Each 'mind', meaning each experimental participant, is asked to visualize an image of the mental, biological or physical 'object' to be entangled with, and maintain this connection to the object for a given time period so as to seemingly merge with it, simultaneously generating positive emotions related to the target object. For this type of entanglement procedure to be effective, the participants must have a certain ability to concentrate, either naturally, or accomplished by applying meditation techniques.

The second procedure type, we will call Type **B**, is characterized by the creation of an entanglement between the target object and the unconscious behaviour and/or the psychological and neurophysiological correlates of each participant's behaviour and mental activity, while attempting to maintain this implicit and unconscious connection as long as required. These two methods for creating a mental entanglement are shown schematically in Figure 1.

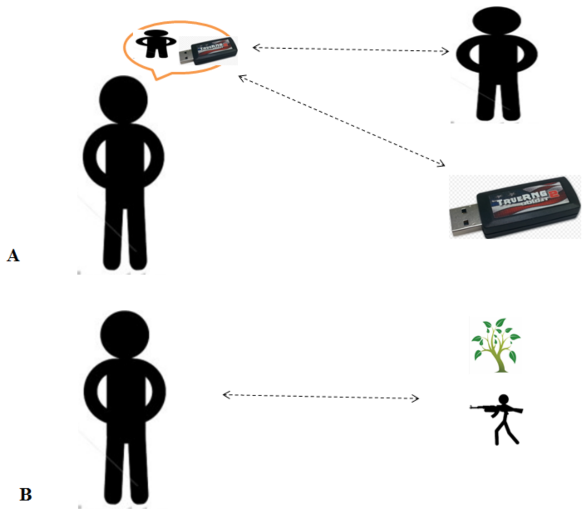

Figure 1: Schematic diagram of main methods for creating a mental entanglement. **A** = mental image and intentional control; **B** = unconscious connection.

Even the observables for studying the possible presence and level of non-local correlation among subsystems can be either Type **a** (e.g. verbal answers or conscious behavioural decisions from participants), or Type **b** (unconscious observables), such as mental or neurophysiological measurements and/or behavioural responses not resulting from conscious decisions. To summarize, by combining the two entanglement creation methods with the two types of observables used to determine a non-local correlation, we get four combinations as shown in Table 1.

Table 1: possible combinations of two methods for generating an entanglement with two types of observables from which a non-local correlation is analyzed.

		Entanglement type	
		A	**B**
Observable	**a**	Aa	Ab
	b	Ba	Bb

In the following sections 2 and 3 we will summarize all experimental evidence available regarding these four combinations of spatial and temporal entanglements and observables relating to quantum-like mental phenomena, of which the fundamental characteristic is represented by a total system of at least two entangled subsystems.

2.0 Quantum-like mental nonlocal correlations in space

Most of the experimental evidence presented in this section was conducted without referring to GQT or similar theoretical models, but came from classical experimental-inductive approaches. The purpose of this summary is to place them all within the context of this theory and highlighting the consistency with GQT's theoretical assumptions.

Of note, all the experiments discussed below have attempted to ensure that all possible correlations between the subsystems' observables were free of potential loopholes that would allow a correlation based on conventional local relationships.

For example, to avoid a local cause for an entanglement between two minds, the participant pairs were spatially isolated so as to prevent the possibility of conventional communication. Furthermore, to avoid the subsystems' correlation being due to local means – and therefore deterministic – various observables were chosen randomly. In the conclusion we will compare the precautions used to avoid loopholes in quantum mechanics experiments with those used in this field.

2.1 Mind-to-Mind and Mind-to-Information nonlocal correlation

This type of research is traditionally referred to as "telepathy" (mind-to-mind) or "clairvoyance" (mind-to-information) research. To create an entanglement between the mental activity of two individuals and/or between their respective electrophysiological correlates, Type **A** procedures were mainly used, whereas to measure the non-local correlation between them, both type **a** and type **b** observables were used.

Typical examples of studies that used Type **A** procedures and type **a** observables to create mental entanglement are those consisting of distant mental connection between two people, or between a person and a physical target such as an image on a computer or a geographical location, such as in Ganzfeld telepathy or remote viewing experiments.

The typical procedure to create mental entanglement consists of asking two people who are sensorially isolated to mentally connect with each other. One of them is then given some information, for example an image or sensory stimulation, which constitutes the variable used to observe the non-local correlation between the two partners by measuring the coincidences between what is given to one and what the other reports. A variation of this procedure is the absence of the second person, the one who perceives the information; this person is substituted with just information - such as a geographical location, a picture, or something else - to be described. In this case the establishment of entanglement between the single participant's mind and the target is required; the non-local correlation between what or how much the person is able to identify and the information contained in the target is measured. Such experiments are typically called "Remote Viewing" procedures.

The most recent summary of these studies can be found in Tressoldi (2011); Tressoldi and Khrennikov (2012), as well as Baptista, Derakhshani and Tressoldi (2015). In Tressoldi's (2011) meta-analysis, which reports the outcomes of 108 experiments in which the subject who had to mentally connect with distant information was placed in Ganzfeld sensorial conditions to improve the mental signal-to-noise- ratio, the observed non-local effect size, expressed as a correlation coefficient was r = 0.06 ± 0.01[1.] On the other hand, the observed non-local correlation value was r = 0.12 ± 0.02 (Baptista et al. 2015) in studies where a subject placed in normal sensorial conditions had to mentally connect with distant information, even when specific mental control precautions taken from various Remote Viewing techniques were applied. Obviously in this work it is not possible to provide all the details present in the original works, including those relating to the roles of experimental variations and diversity of participants.

Tressoldi and Khrennikov (2012) essentially analyze the same database as Tressoldi (2011), resorting to a formalism used in quantum mechanics to analyze a communication protocol called Remote State Preparation (RSP).

In Quantum Mechanics, RSP is a variant of teleportation. Here Alice, person A spatially separated and trying to convey a message using an entangled pair of photons, has full knowledge of the state she intends to prepare at Bob's location, the person B spatially separated, supposed to be the receiver of the information. Alice's goal is to prepare a quantum state at Bob's distant location without sending the actual state. Bob should need limited or zero knowledge about the state Alice aims to prepare from a distance.

If Alice is substituted with one of the pair, or the source of information, and Bob is substituted with the other person connected via entanglement, we have a mental RSP condition that Tressoldi and Khrennikov have designated Remote State Preparation of Mental Information (RSPMI). The results were measured using fidelity estimation and compared to the benchmark and experimental results using the following formula:

$$F = \Sigma_i \left[(p_i * q_i)^{1/2} + ((1- p_i) * (1-q_i))^{1/2}\right]$$

where p_i is the theoretical probability and q_i the experimental probability. The observed values are discordant with what would be expected from traditional communication (probability equal to 0.25); this discordance amounts to 41.5 standard units regarding data from the Mind-to-Mind protocol and 40.3 standard units for the Mind-to-Information protocol.

In these experimental protocols, the degree of correlation between observables of the two entangled subsystems can be made either by one or more independent judges, or by the participants themselves who, by choosing from the available options, must determine if there is a correlation between what was perceived and the information contained in the target. When the determination is made by an independent judge there do not seem to be problems regarding the correlation, if present, being due to a spatial entanglement. However, when it is made by the subjects themselves, it is possible that the correlation (if present) could be due to a temporal entanglement (see section 3.0) – that is, between the information available at time 1 and that available at time 2 – which is that used for measurement. Unfortunately, to date this perspective has not been carefully analyzed in the studies cited herein and currently remains uncertain.

2.1.1 Mind-to-Mind (Brain-to-Brain) nonlocal correlation

[1.] When measurements reported in original articles are not expressed in correlation units, such as for example Cohen's effect size ***d*** or Hedges' ***g***, they are converted to the correlation coefficient ***r*** using the formula: $r=[d^2/(d^2+4)]^{1/2}$.[1]

Another series of studies that used Type **A** procedure to create mental entanglement but type **b** observables examines distant mental entanglement between two people by observing the non-local correlation of neuro or psychophysiological activity.

These studies aimed to create volitional mental entanglement between a pair of subjects, still isolated and distanced from each other, while the variable used to observe the non-local correlation was EEG activity or some other psychophysiological parameter, such as skin resistance, heart rate or heart rate variability, etc. A recent example of a study that used EEG activity as an observable variable is Giroldini et al. (2015), which also contains a list of all similar studies. Unfortunately for this type of study it is not yet possible to quantitatively summarize all the collected data due to the large variation in data analysis techniques.

Also using Type **A** procedure and type **b** observables, Roe, Sonnex and Roxburgh (2014) produced a summary of 57 studies that examined the correlation between the intention to heal and variables dependent on one's state of health. The observed correlation was 0.20 ± 0.01. In this same study the authors also provide the non-local correlation value between intention to interact positively with biological targets, for example seeds, cell cultures, etc, and variables dependent on their reactions. The correlation obtained from 49 studies was 0.24 ± 0.01.

Schmidt (2012), moreover, reports a meta-analytic summary of all studies pertaining to the intention to modify electrodermal activity (EDA), or a distant partner's behaviour. The correlation obtained from 62 studies was 0.06 ± 0.01.

2.1.2. <u>Non-local correlation between the Mind in a dream state and Information</u>

An experimental protocol using Type **B** entanglement procedure and type **a** observables consists in attempting to connect information already available at a distance, or chosen in the future, with a subject's mind while in the dream state. According to the researchers who followed this line of research, dreaming is a mental state favorable to spatial and temporal entanglement with distant information, in that there is a better signal/noise ratio compared to wakefulness. The most recent summary of evidence in this area is given by Storm et al (submitted). The non-local correlation obtained from 38 studies attempting to create entanglement in space was 0.08 ± 0.03.

2.1.3. <u>Mind-to-Matter nonlocal correlation</u>

The entanglement procedures here are also Type **A** and type **b** observables. The difference to those described in the previous section is that in this case the entanglement is between a human mind and an electronic device, usually a random number generator (RNG), or more recently a photomultiplier (Tressoldi et al 2015). In these experimental protocols, non-local correlations are achieved between the mental state of the subject expressing intention and the actual changes in the device's operation with respect to the usual (e.g. for RNGs it is the deviation from a random state). A summary of collected evidence with a particular experimental protocol is found in Bösch, Steinkamp and Boller (2006), where data from 380 experiments up to 2004 were analyzed, showing a weak deviation of 2.47 standard units with respect to a null hypothesis.

Walach et al (in press) instead analyzed their experimental protocol's results by referring directly to GQT, particularly the NT theorem, and found confirmation. Basically, this theorem predicts that direct experimentation on systems that are based on non-local correlations will result in a breakdown of the correlations or in a channel switch, if repeated. The confirmed prediction was that experimental runs produced more significant correlations than control runs and chance expectation. They found a deviation of 5.64 standard units with respect to the null hypothesis.

An interesting research project directed by Dean Radin (2008; 2012; 2013; 2015) also regarding Type **A** entanglement procedures and type **b** observables aimed at studying the effects of mind-photon correlation, based directly on the Measurement Problem from QM (Henry, 2013). This problem originates from an apparent conflict between several principles of the quantum theory of measurement. In particular, the linear dynamics of quantum mechanics seem to conflict with the postulate that during measurement a non-linear collapse of the wave packet occurred.

The measurement problem becomes even more intriguing if we accept that some aspects of human consciousness such as awareness, attention, and intention, can be the determinants in this process, as theorized by some of the fathers of quantum mechanics such as Wolfgang Pauli, Eugene Wigner, and John von Neumann, to name a few. The typical procedure called for each participant to mentally connect, during brief periods of concentration, with a device that reproduced the classical double-slit experiment, and try to reduce the interference effects predicted by the wave-particle duality of light. The results highlighted a mental entanglement with a deviation of 2 to 4 standard units with respect to a null hypothesis.

Another interesting project, this time based on Type **B** entanglement procedures and type **b** observables is the Global Consciousness Project (http://global-mind.org). This project, launched in 1998 and still active, is based simply on the following premise: "*Periods of collective attention or emotion in widely distributed populations will correlate with deviations from expectation in a global network of physical random number generators (RNGs).*" The RNGs are placed in over 70 locations around the world, operate 24/7, and their data are transferred to a storage archive with open access to allow independent analysis. The consciousness coherence is determined by unpredictable events - such as natural disasters - or can be programmed (for example International Peace Day), which produce emotional coherence in a significant number of people and the ensuing Type **B** entanglement with the world-wide RNG net. The data from single events and complete summaries are available on its website and are continually updated. However, the most recent meta-analysis is that of Nelson and Bancel (2011), which examined 346 independent events and found a standard deviation of 6.2 with respect to the null hypothesis.

3.0 Quantum-like mental nonlocal correlations in time.

Entanglement correlations in quantum physics can not only be seen between physically separated systems but are also to be expected between time-like separated systems, i.e. across time spans back and forth in time . As regards non-local phenomena of time correlation, the only difference from those of non-local space correlation mentioned in the previous section is that the subsystems which constitute the whole system are entangled in time instead of space; that is to say, one of the two subsystems is in the present and the other in the future, according to the traditional time reference system.

In quantum physics time entanglement is a touchy subject (Olson and Ralph, 2013; Aharonov et al., 2014), and only recently have some authors attempted to verify its existence with mental observables. For example Atmanspacher and Filk (2010; 2013) postulated how to verify the presence of time entanglement using the Necker-Zeno model for bistable perception, asking participants to indicate exactly when the view of the Necker cube image changed, and recording this as a function of time. From a formal point of view, time entanglement can be verified if there is a violation of the temporal Bell inequality, formalized by the following equation:

$$p(t_3 - t_1) \leq p(t_2 - t_1) + p(t_3 - t_2)$$

where p = probability; t_1, t_2, t_3 = temporal sequence.

Tressoldi, Maier, Buechner and Khrennikov (2015) instead used the No-Signaling in Time (NSIT) inequality, as defined by Kofler e Bruckner (2013), to confirm the non-local time correlation between volitional motor actions at time1 (t_1) and presentation of subliminal images across the emotional spectrum at time2 (t_2).

NSIT requires only two measurements in time of two dichotomous observables, A and B, that may assume only two distinct states ±1. Hence, the basic scenario is:

$$At_1 = \pm 1,\ Bt_1 = \pm 1 \text{ and } At_2 = \pm 1,\ Bt_2 = \pm 1$$

In accordance with the principle of NSIT the outcome probabilities for one part must not depend on the outcome probabilities of the second part and it is expressed by the following formula:

$$P(Bt_2 = +1) = P(At_1 = -1, Bt_2 = +1) + P(At_1 = +1, Bt_2 = +1) \text{ and symmetrically}$$

$$P(Bt_2 = -1) = P(At_1 = +1, Bt_2 = -1) + P(At_1 = -1, Bt_2 = -1)$$

These authors found a violation of the NSIT conditions equal to 10.3 standard units, which suggests that the mental state evolution cannot be described classically and may be explained by temporally distinct cognitive states existing in a state of superposition.

Obviously these results require further confirmation as well as refinement of mathematical/statistical formalism to verify the existence of non-local time correlations, but these initial studies confirm that it is possible to verify non-local time correlation phenomena with behavioural and mental observables, either using or modifying QM formalism.

Regarding proof for non-local time correlation phenomena that use Type **B** entanglement procedures and type **b** observables and that do not refer to GQT nor use a modified formalism of QM, it can be summarized from two meta-analyses by Mossbridge, Tressoldi & Utts (2012) and Bem, Tressoldi, Rabyeron & Duggan (2015).

The former study outlines evidence relating to the relationship between neurological and psychophysiological variations at time1 and events of opposing emotional value (e.g. “happy” or “neutral” pictures) appearing at a later time2. The estimated average correlation from 26 selected studies is $r = 0.11 \pm 0.04$.

The latter meta-analysis by Bem et al (2015) outlines evidence concerning the relationship between behaviours – for example, choosing one of two keys or a response time – and future events of varying emotional or adaptive value, such as happy or unpleasant images. The estimated average correlation from an analysis of 69 studies of phenomena that don't require controlled cognitive activity was equal to r = 0.05 ± 0.01.

The aforementioned meta-analysis by Storm et al, which uses Type **B** entanglement procedures and type **a** observables, also analyzes correlations with information presented after the moment in which the participants reported the content of their dreams. The estimated correlation from examining 10 studies was equal to r = 0.04 ± 0.05.

4.0 Summary of evidence.

Table 2 presents an overview of mental non-local correlation phenomena, classified into type of entanglement and observable type. Table 3 is a summary of sources for quoted evidence, classified according to experimental protocols.

Table 2: Summary of non-local mental correlation phenomena, classified into types for entanglement and observables.

		Type of entanglement	
		A	**B**
Type of nonlocal correlation measurement	**a**	Mind-to-mind; Mind-to-Information;	Mind in Dream status-to-Information;
	b	Mind-to-Brain; Mind-to-Body physiology; Mind-to-Matter;	Behavior-to-future information; Brain and body physiology-to-future information; Mind-to-Matter (GCP)

Table 3: Summary of evidence related to quantum-like nonlocal correlation mental phenomena observed with different experimental protocols.

	Type of entanglement and type of observables	**References**	**Observed Correlation or number of SDs from the null effect**
ENTANGLEMENT IN SPACE			
Mind-to-mind or mind-to-inform. target	Type **A** - Type **a**	Tressoldi (2011); Tressoldi & Khrennikov (2012)	0.06 ± 0.01 41.5; 40.3
Mind-to-mind or mind-to-information target	Type **A** - Type **a**	Baptista et al. (2015)	0.12 ± 0.02
Mind-to-Brain	Type **A** - Type **b**	Giroldini et al. (2015)	0.03
Mind-to-Body & Mind-to-Biology	Type **A** - Type **b**	Schmidt (2012; Roe, Sonnex and Roxburgh, (2014)	0.06 ± 0.01 0.20 ± 0.01 0.24 ± 0.01
Mind-to-Matter	Type **A** - Type **b** Type **B** – Type **b**	Boller et al. (2006); Walach et al. (in press); Radin (2012; 2013; 2015); Nelson and Bancel (2011)	2.47 5.64 4.3;5.6;4.5 6.2

Mind in Dream status-to-inform. target	Type **B** - Type **a**	Storm et al. (submitted)	0.08 ± 0.03
ENTANGLEMENT IN TIME			
Body-to-future Information	Type **B** – Type **b**	Mossbridge et al. (2012); Bem et al. (2015); Tressoldi et al. (2015)	0.11 ± 0.04; 0.05 ± 0.01; 10.37
Mind-to-future Information	Type **A** – Type **a**	Atmaspacher et al. 2010; 2013.	
Mind in Dream state-to-future information	Type **B** - Type **a**	Storm et al. (submitted)	0.04 ± 0.05

One glance at these tables reveals a consistently large amount of evidence relative to all combinations of entanglement and observable types, along with different experimental protocols ranging from space or time Mind-to-Mind or Mind-Matter entanglements to Mind to Future Information.

However, it is important to remember once again that almost all the meta-analyses quoted here are related to research paths that do not explicitly refer to theoretical models drawn from QM, and least of all GQT. Only a limited number of studies – seven to be exact – refer to theoretical models and modified investigations from QM, and of these, four specifically refer to GQT. Quantitative measurements presented as proof should therefore be looked at cautiously, because they were taken from studies using a statistical formalism different to that used in QM to measure non-local correlations under entanglement conditions.

5.0 Conclusions and future developments.

The purpose of this review is essentially to present a summary of a series of phenomena that, if seen from the point of view of classical physics, would be considered impossible or at least weird, but appear logical if placed in the theoretical context of quantum-like spatial and temporal entanglement of GQT. Obviously, given the differences in both the examined observables – physical for QM, mental and behavioural for GQT, with their physiological correlates – and the formalism for measuring non-local correlations, we cannot expect to find phenomena identical to those seen in QM.

Nevertheless, if what is presented in this review withstands theoretical, methodological, and statistical criticism, the theory that our minds, our behaviours, and their physiological correlates can show quantum-like non-local correlations opens a new perspective on the human mind's potential. The phenomena investigated by the various research branches offer an interesting panorama, with great potential for application.

Furthermore, the similarities evident in phenomena that appear to obey normal laws regardless of the nature of the examined observables seem to support the theory that the laws underlying the micro- and macroscopic worlds are structurally uniform or isomorphic in the sense of a systems theoretical approach , thus unifying physics, biology, and psychology (e.g. Capra and Luisi, 2014). The model of reality that seems to unite these apparently diverse worlds is by nature inherently non-local, regardless of appearances, with fascinating characteristics such as being intrinsically non-deterministic (Gisin, 2014) and, to quote Anton Zeilinger (2005), "… *that reality and information* *are two sides of the same coin, that they are in a deep sense indistinguishable. If that is true, then what can be said in a given situation must, in some way, define, or at least put serious limitations on what can exist*."

As far as the future prospects of this theoretical approach are concerned, we hope that authors intending to involve themselves in the aforementioned, or similar phenomena that could be identified in the near future, refer specifically to GQT or to similar theories. We particularly hope that conditions are created within experimental protocols to specify its axioms with greater precision, even using (or adapting) the mathematical and statistical formalism of QM, as in the quoted studies by Tressoldi and Khrennikov (2012); Tressoldi, Mayer, Buechner and Khrennikov (2015); Atmanspacher and Filk (2010; 2013), and others such as, for example, the techniques suggested by Yearsley and Pothos (2014) to confirm so-called temporal Bell inequalities or those of Leggett-Garg, or adapting the formalism to other empirical questions as suggested by Uzan (2014) or Pothos and Busemeyer (2013).

In this way there is more control and several loopholes are minimized, some of which are also common to QM, for example the *locality or signaling* loophole, which concerns the possibility that the entangled subsystems might communicate among themselves via conventional methods. Two more loopholes that should be taken into consideration are the "detection" or "fair sampling loophole" and the "freedom of choice loophole". The *fair sampling loophole* (Giustina et al. 2013) concerns the efficiency of the correlation detectors among subsystems, which should be virtually perfect in order to eliminate any doubts that the data sample taken may show a false non-local correlation. The *freedom of choice* loophole (Sheidl et al. 2010), on the other hand, concerns the possibility that the parameters chosen to measure non-local correlations among subsystem properties are truly free, in that they are totally random, to prevent any transfer of local information. It is also necessary to further investigate entanglement quality. Even though in this review we have attempted to classify different phenomena as one of two types of entanglements, there is still little known about which conditions most favour its stability, both for Type **A** and **B**.

What appears to emerge from available evidence is that for both types of entanglement, cognitive activity associated exclusively with wakefulness must be avoided. This is founded on controlled information processing methods (analytical) based on verbal code – in other words, those features of System 2, using the classification from the dual-process model of information processing as described by Daniel Kahnemann (2011). It also seems that entanglement may be facilitated if the subsystems are part of a total system that is adaptive and has meaning to the individual, for example, giving differentiated and efficient responses to potentially positive or negative events (see studies related to Body to Future Information non local correlation), or that the entanglement is induced by pragmatic information, i.e., a reduction in informational entropy among the whole's subsystems (von Lucadou, 2015).

A fact that has been rarely discussed in the community of researchers is the theorem derived from GQT that entangled systems must not be used or usable to transmit classical, local signals. If they were used as such the correlation would break down (Lucadou, Römer and Walach, 2007). . This precludes replicability of anomalous effects per se in classical experimental settings. While in the physical case quantum entanglement has been proven experimentally by showing a deviation of empirical correlations against an expected boundary condition, set up by Bell's inequality, it is difficult to construct such frameworks for the generalized case, except for the conditions mentioned above. Hence, experimentation has to progress along indirect lines as pointed out by von Lucadou (2015) and as demonstrated by Walach et al. (in press). Most of the discussions around the alleged non-replicability of anomalous cognition studies (e.g. Alcock, 2003), revolves around the misunderstanding that such effects have to be conceived around classical concepts of signals and locality. We hope we have shown that this perspective is ill-conceived, and that paradoxes and empirical insufficiencies can be resolved if the phenomena in question are conceived as instantiations of a unitary class of phenomena, namely generalized non-local entanglement correlations. It remains to be explored precisely what the boundary conditions for the emergence of such phenomena have to be.

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