Quantum Walk Founds Over Dispersion of Field RNG Output: Mind Over Matter Through Quantum Processes

Takeshi Shimizu and Masato Ishikawa

ABSTRACT

Recent field RNG studies have reported that chi-square values of random number generator (RNG) outputs become highly significant when a large audience focuses on coherent events. Since the statistics are typically computed based on binomial distribution, RNG outputs are in a statistical state of over dispersion, lacking a framework for their interpretation. Notably, the Quantum Walk (QW) has the potential to detect such anomalies, since its distribution exhibits larger variances than binomial distribution. The current study focused on the distribution of QW and discusses several conditions. We assume that field consciousness unintentionally changes RNG output into chunks of Quanta that are mixed among the RNG output having its length. Using the concept of the quantum chunk, the proportions of test findings, which include the quantum chunk, are estimated. The current model estimates that about 1%-1.5% Qbits are mixed within a trial, based on results of previous significant field RNG experiments. Finally, several methodological tasks for the future are discussed.

Key Words: Hadamard matrix, over dispersion, field-RNG, psychokinesis

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Introduction

In recent decades, field studies using random number generators (RNGs) (Nelson *et al.,* 2002; Radin, 2006) have often reported that the RNG output exhibits high variance during coherent field events. It was suggested that field consciousness unintentionally influenced RNG behavior.

In these field RNG studies, targeted (analyzed) RNG outputs have t trials, corresponding to a certain length of a coherent event. Since each trial consists of n-bits generated per second, the probability distribution of the RNG output for 1 trial is described by classical random walk. With the random walk, a particle moves its position X_n at n-th step, with a probability of 1/2 of a step to the right, $X_n = X_{n-1} + 1$ or otherwise step to the left $X_n = X_{n-1} - 1$. The particle is initially located at position $X_0 = 0$. The probability is distributed binomially, with the standard deviation of the distribution $\sigma_{\mathrm{cls}} = \sqrt{n}$. Field RNG studies generate n bits per second, so the particle moves its position to X_n in a trial, which is standardized as $z = X_n/\sqrt{n}$ (even if only right steps are considered and all the left steps are discarded, the z-score becomes the same).

The large variance from field RNG studies, mentioned above, means that $\chi_t^2 = \sum_{i=1}^{t} z^2$ becomes significantly larger under a coherent

Corresponding author: Takeshi Shimizu
Address: Azuma4-9-6, 301-101, Tsukuba City, JAPAN (code 305-0031)
Phone: + 090-8057-1928
e-mail ✉ shim1zu@hotmail.com

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event, suggesting that the z-scores are distributed approximately $N(0,(1+\Delta_b)\sigma_{cls}^2)$, where Δ_b represents a coefficient for the over dispersion. The least ratio would be estimated, e.g the Global Consciousness Project (GCP) observed a coherent event with length of two hours, or 7,200 seconds, expecting by chance a chi-square value of 7200. When, the dataset becomes borderline significant $\chi^2_{(7\ 200)} = 7398.5$ ($\alpha = 0.05$), the ratio $\Delta_b = .028 (= 7398.5 / 7200 - 1)$ increased for all the z-square values on average. In addition to such single events, results from repetition designs also support these findings; e.g. at movie theaters (Shimizu & Ishikawa, 2010), in which 10 repetitions were conducted, generating for 90,000 seconds showing $\Delta_b = .008 (= 90698.99/90000 - 1)$, whereas short movie experiments (Shimizu & Ishikawa, 2012) generated about 12,500 seconds for experimental conditions, estimating $\Delta_b = .021$ $(= 12761.21/12500 - 1)$.

At any rate, we have no theoretical background to find these anomalies now, meaning the field RNG output remains in a state of over dispersion.

Noticeably discrete-time quantum walk (QW) on a line has been discussed as a quantum analogue of the random walk, having a possibility to detect these anomalistic over dispersions statistically, one reason is that its distribution is quite large compared with binomial distribution. The variance is proportion to step size n, and Konno (2008) discussed limit theorems for quantum walk, deriving that the standard deviation of the symmetric Hadamard walk (as noted below) becomes

$$\sigma_{q(n)}/n \to \sqrt{(2-\sqrt{2})/2} \cong 0.5412.$$

This is quite different from binomial distribution mentioned above, which is $\sigma_{cls(n)}/\sqrt{n} = 1$. Focusing on the QW distribution, the current study examined several conditions for the case of biased field RNG output, based on the assumption that field consciousness could alter the partial states of generated bits more or less into those derived from QW.

Definition of Quantum Walk

The quantum walk is a quantum generalization of the classical random walk in one dimension with an additional degree of freedom called the chirality (Konno 2003; 2008; Ide *et al.,* 2011). The chirality takes the values left and right, and represents the direction of motion of the particle. At each time step, if the walker exhibits left chirality, it moves one step to the left, and if it exhibits right chirality, it moves one step to the right. Let define $|L\rangle = [1 \quad 0]^T$ and $|R\rangle = [0 \quad 1]^T$, where L and R refer to the left and right chirality states, respectively, T is the transposed operator. At the origin for the QW, the initial Qbit states that φ is given by

$$\Phi = \left\{\varphi = \begin{bmatrix}\alpha \\ \beta\end{bmatrix} = \alpha|L\rangle + \beta|R\rangle \in \mathbb{C}^2 : \|\varphi\|^2 = |\alpha|^2 + |\beta|^2 = 1\right\}. \quad (1)$$

where $\mathbb{C}$ is the set of complex numbers. Let X_n be the QW at step n starting from the initial Qbit state $\varphi \in \Phi$. Initially, the probability of a particle at position 0 is $p(X_0 = 0) = 1$ (e.g. $\|\varphi\|^2 = \left|1/\sqrt{2}\right|^2 + \left|i/\sqrt{2}\right|^2 = 1/2 + 1/2 = 1$).

The time evolution of the QW on $\mathbb{Z}$ is determined by a set of 2 × 2 unitary matrices

$$U = \begin{bmatrix} a & b \\ c & d \end{bmatrix}, \quad (2)$$

where $a, b, c, d \in \mathbb{C}$, U is a unitary matrix, the conjugate transposed matrix U^* satisfied $UU^* = U^*U = I$. In order to define the dynamics of the model, we divide U into two matrices:

$$P = \begin{bmatrix} a & b \\ 0 & 0 \end{bmatrix}, Q = \begin{bmatrix} 0 & 0 \\ c & d \end{bmatrix} \quad (3)$$

with U = P + Q. The matrix P represents that the particle moves to the left, whereas Q represents moves to the right, at each time step. This corresponds to p + q = 1 in binomial distribution. In particular,

$$U = \frac{1}{\sqrt{2}}\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}, \quad (4)$$

the QW is called the Hadamard walk, which can be considered the most typical QW.

Over time, the probability that a particle is in position x at time n starting from the origin with $\varphi \in \Phi$ is defined by

$$p(X_n = x) = (\Xi_n(l,m)\varphi) \times (\Xi_n(l,m)\varphi) = \left|\left|\Xi_n(l,m)\varphi\right|\right|^2, \quad (5)$$

where $\Xi_n(l,m)$ denote the sum of all paths starting from the origin in the trajectory consisting of l steps left and m steps right. In fact, for time $n = l + m$ and position $x = -l + m$, we have

$$\Xi_n(l,m) = \sum_{l_j,m_j} P^{l1}Q^{m1}P^{l2}Q^{m2}\cdots P^{l_{n-1}}Q^{m_{n-1}}P^{l_{n-1}}Q^{m_n}, \quad (6)$$

where the summation is taken over all integers $l_j, m_j \geq 0$ satisfying $l_1 + \cdots + l_n = l, m_1 + \cdots + m_n = m,\ l_j + m_j = 1$. We should note that the definition gives

$$\Xi_{n+1}(l,m) = P\,\Xi_n(l-1,m) + Q\,\Xi_n(l,m-1) \quad (7)$$

to compute the probability easily. Further details have been discussed previously (Konno, 2003; 2008).

Since no mean biases were necessary to detect over dispersion of field RNG output, we focused on symmetric QW distribution with initial amplitude $\varphi = [1/\sqrt{2} \quad i/\sqrt{2}]^T$. Figure 1 presents the distributions of the Hadamard walk over time. After step 4, the Hadamard walk showed twin peaks, which was distinct from binomial distribution.

Mixed distribution model for field RNG output

Additional issues include how would the degree of the QW mix with classical distributions during coherent events. Herein, we hypothesize the concept of 'quantum chunk (QC)' with the operative short length c, which behaves as QW by step c. While each chunk starts at step zero, the QCs are independent of each other. We consider that such QCs exist among binary RNGs, thus increasing variance.

First consider the construction of chi-square values among trials. Anomalistic large chi square values during a coherent event are expressed by over dispersion ratio Δ_b throughout all t trials

$$(1+\Delta_b)E[\chi_t^2] = (1+\Delta_{w(n,c)})E[\chi_{rt}^2] + E[\chi_{(1-r)t}^2] \quad (8)$$

where the first term on the right side represents the chi square values of the trial, which includes QC (QC trial), $\Delta_{w(n,c)}$ is the over dispersion ratio within a QC trial, n is the bit size of all trials, c is chunk length in the QC trial, r is the QC trial ratio toward the number of trials t (r = number of QC trial / t), and the second term represents the chi square values of the non-QC trial. These are independent of t, $(1+\Delta_b)t = (1+\Delta_{w(n,c)})rt + (1-r)\,t$, showing a relation $\Delta_{w(n,c)} = \Delta_b / r$.

Next consider the variance within a QC trial. Consider that the variance of the QC trial with bit size n, $(1+\Delta_{w(n,c)})n$, is constructed in two parts; (1) QC variance $\sigma_{q(c)}^2$ with chunk length c, and (2) binomial distribution with $n-c$, as follows,

$$(1+\Delta_{w(n,c)})n = \sigma_{q(c)}^2 + (n-c) \quad (9)$$

Thus, the relation between over dispersion coefficients is

$$\Delta_{w(n,c)} = \Delta_b / r = (\sigma_{q(c)}^2 - c)/n. \quad (10)$$

Relation between QC trial ratio and chunk length

Since the QC trial ratio depends both on n and Δ_b, no fixed value is available, but rather lines relative to conditions. Figure 2, with a fixed $\Delta_b = .021$, shows the relations between QC trial ratio 'r' and QC length 'c', with three conditions of n=512, 256, and 64 bits per trial, assuming that one QC trial included only one QC. The QC trial ratio 'r' is proportion to the trial bit size, n.

The estimation line at condition n=512, shows that the QC trial ratio (r) is 96.6% when the QC length (c) is fixed at 8. The QC trial ratio decreases to 18.1% when the QC length (c) is fixed longer at 16, since the QC variance $\sigma_{q(c)}^2$ increases approximately in proportion to c^2, refereeing the limit theorem $\sigma_{q(c)}^2 \cong c^2(2-\sqrt{2})/2$ (Konno, 2008). In Figure 2, we draw blanks for longer quantum chunks, which makes 1.5 times variance ($\Delta_{w(n,c)}$>.50) as the original variance (n), since such QC variance soon becomes large with chunk length c, (e.g. n=512, c=32, 780.38(=$\sigma_{q(32)}^2$ + $(512-32)) > 1.50 \times 512$). Furthermore, if the QC trial includes two or more chunks, we can refer half the value on the vertical axis (e.g. n=512, c=8, and the QC trial has two chunks within it, which is equal to the case that n=256, c=8, where the QC trial has one chunk within it; r=.483(=.966/2)).

Figure 3 shows the estimation lines with fixed n=512 using the results of two field RNG experiments, $\Delta_b = .021$ (Shimizu & Ishikawa, 2012) and $\Delta_b = .008$ (Shimizu & Ishikawa, 2010). Under the assumption r=1.00 (all of the trials including QC), previous field RNG experiments showed that the Qbits/n-bits ratio is quite small 0.015 (=c/n = 8/512) (Shimizu & Ishikawa, 2012) or 0.010 (=5/512).

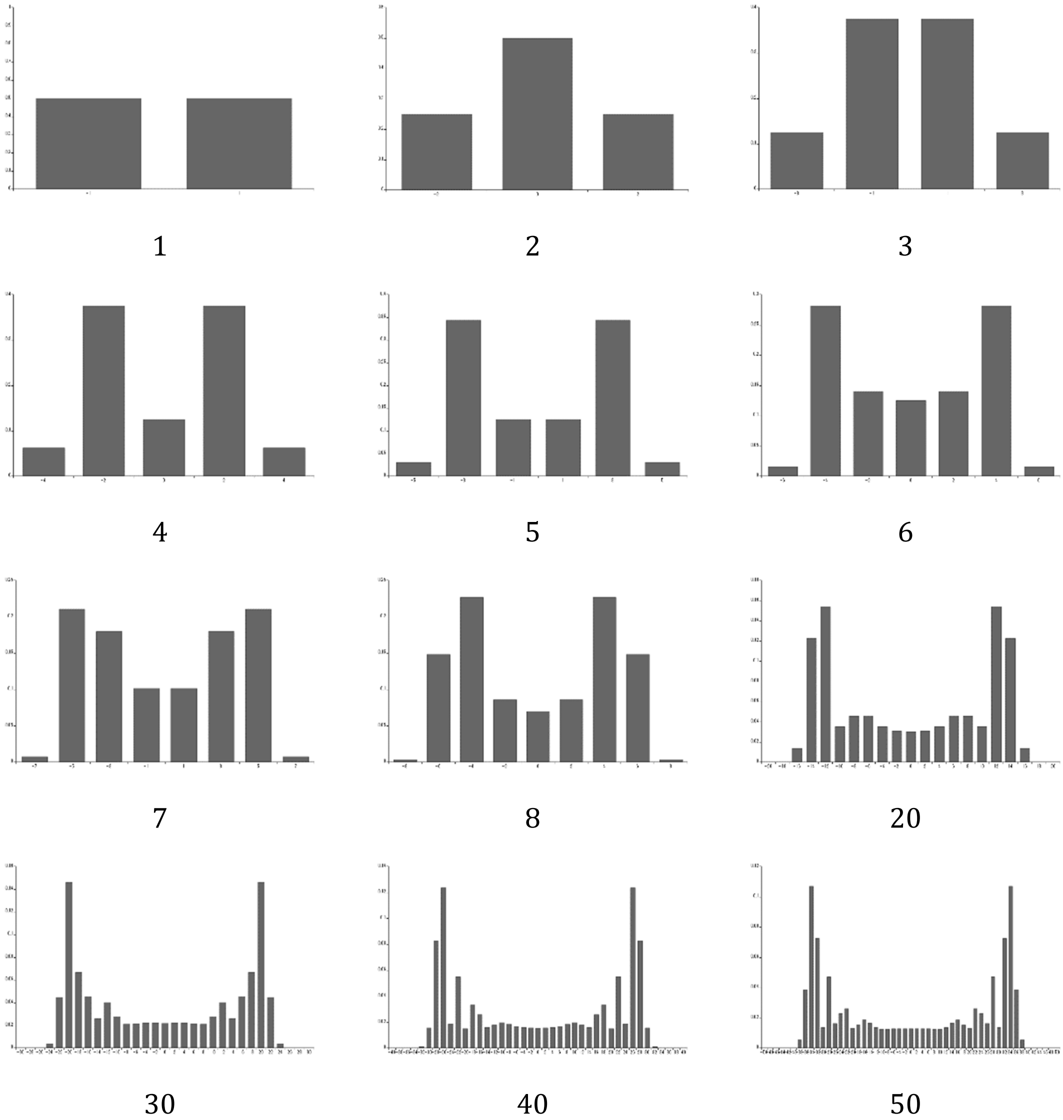

Figure 1. Evolution of quantum walk distribution with step.

Future tasks

Above all, the current estimation showed that it is theoretically possible to determine the field RNG over dispersion, with the assumption that coherent field consciousness enhances the variance of RNG output, since the output includes Qbits with the length of QC even if it is invisible, as well as classical bits (i.e. C-bits). It is likely that human consciousness or psychological state exerts some anomalistic effects to maintain or prolong the state of quantum entanglement. Noticeably, RNG has the potential to measure and explore such anomalistic behavior.

Under the assumption of QW and the concept of quantum chunk (QC), it is necessary to assume that the length of the quantum chunk itself would be a variable that is influenced by PK strength. A new challenging task will be to estimate quantum hidden states using methods, such as Markov chain or Hidden Markov Model. Moreover, a unitary matrix would extend generally. The definition of unitary matrix is expressed as $U = \begin{bmatrix} cos\theta & sin\theta \\ sin\theta & -cos\theta \end{bmatrix}$. Current decomposition of the unitary matrix is referred to the Hadamard matrix (Ambainis, et al., 2001), which is one of the most discussed case. Along with current Hadamard ($\theta = \pi/4$), in future more discussion will be necessary for range $0 < \theta < \pi / 2$.

If there is no over dispersion, $\Delta_b = .000$, all the estimated ratios on the line approach zero horizontally.

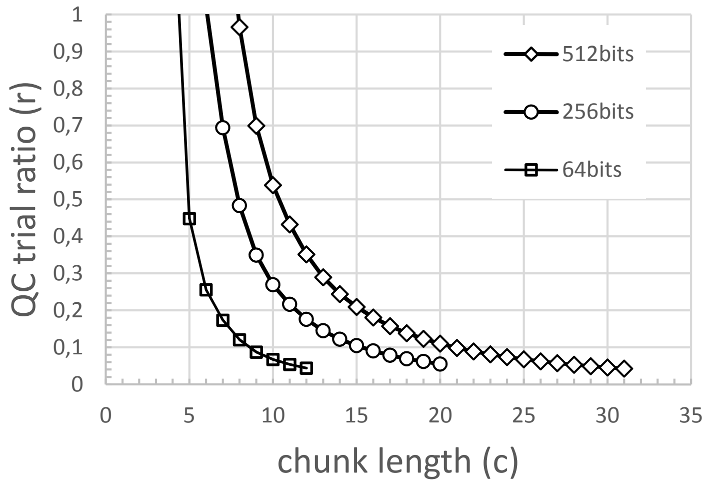

Figure 2. Relation between the QC length within trial and the QC trial mixed ratio at $\Delta = .021$.

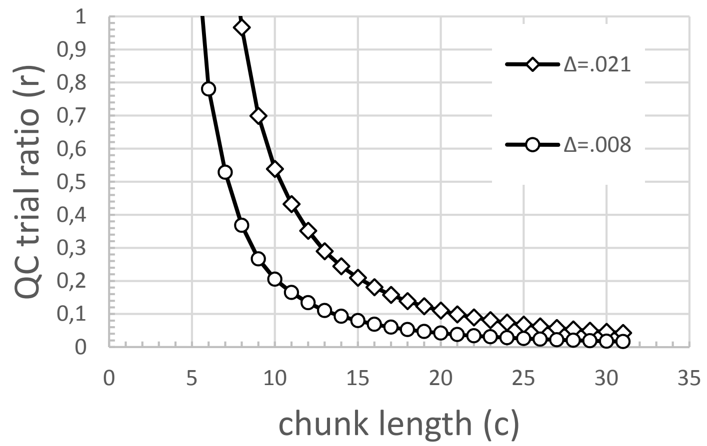

Figure 3. Relation between the QC length within trial and the QC trial mixed ratio at n=512.

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