Introducing Complex Numbers into Basic Growth Functions (4) : Hypothetic Appearance of Exponential Function with Base e from the Complex Representation of '0+(-1)+1'

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Introducing Complex Numbers into Basic Growth Functions – (IV) Hypothetic Appearance of Exponential Function with Base *e* from the Complex Representation of '0=(–1)+1' –

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This study was designed to investigate the hypothetic appearance of exponential function with base e from the complex representation of '0=(–1)+1' and phase shifts. The results obtained were as follows. There was a hypothetic appearance of $\exp(i\theta)$ from the complex representation of '–1' in '0=(–1)+1' when subjected to the hypothetic breakdown of multiplication form connecting complex numbers constructing '0=(–1)+1'. The clockwise $\pi/2$ rotation of θ in $\exp(i\theta)$ led to $\exp(\theta)$. If there were many different complex numbers with their replicas to be left, then this would be given by an equation with continuous phase shift of θ in $\exp(i\theta)$. The hypothetic inheritance of phase shift of θ in $\exp(i\theta)$ to the change in θ in $\exp(\theta)$ might lead to the calculation of definite integral of $\exp(\theta)$. Might the change in θ in $\exp(i\theta)$ and/or $\exp(\theta)$ be related to the passage of time (t) in $\exp(t)$?

INTRODUCTION

The exponential function with base e is a function of importance to the basic growth analysis of ruminants (Brody, 1945) and forages (Watson, 1952; Radford, 1967; Hunt, 1990). It was shown hypothetically by Shimojo *et al.* (2003) that the exponential function with base e was obtained by $\pm\pi/2$ rotation of axes of variable described using Euler's formula. Shimojo *et al.* (2004a, b, c) reported that '0=(–1)+1' was described using the product of complex numbers and the hypothetic breakdown of multiplication form caused incomplete pair disappearances of them to leave some sorts of complex numbers. These two hypothetic phenomena might be related to suggest the appearance of exponential

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function with base e from '0 = (−1) + 1'.

This fourth study was designed to investigate the hypothetic appearance of exponential function with base e from the complex representation of '0 = (−1) + 1' and phase shifts.

COMPLEX REPRESENTATION OF '0 = (−1) + 1'

Complex representation of '−1' to leave complex numbers

The following equation is taken up as an example of complex representation of '0 = (−1) + 1' according to reports by Shimojo *et al.* (2004a, b, c). Thus,

$$\begin{aligned}
0 &= (-1)+1 \\
&= [\exp(\boldsymbol{i}\theta)\cdot \boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot \boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta)) \\
&\quad \cdot\{-(-\exp(\boldsymbol{i}\theta))\}\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta)] \\
&\quad + [\exp(\boldsymbol{i}\theta)\cdot \boldsymbol{i}\exp(-\boldsymbol{i}\theta)\cdot \boldsymbol{i}\exp(\boldsymbol{i}\theta)\cdot(-\exp(-\boldsymbol{i}\theta)) \\
&\quad \cdot(-\exp(\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))\cdot(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))\cdot\exp(-\boldsymbol{i}\theta)].
\end{aligned} \tag{1}$$

The hypothetic breakdown of multiplication form in (1) leaves a sort of complex number,

$$\begin{aligned}
&[\exp(\boldsymbol{i}\theta)+\boldsymbol{i}\exp(-\boldsymbol{i}\theta)+\boldsymbol{i}\exp(\boldsymbol{i}\theta)+(-\exp(-\boldsymbol{i}\theta)) \\
&\quad +\{-(-\exp(\boldsymbol{i}\theta))\}+(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))+(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))+\exp(-\boldsymbol{i}\theta)] \\
&\quad +[\exp(\boldsymbol{i}\theta)+\boldsymbol{i}\exp(-\boldsymbol{i}\theta)+\boldsymbol{i}\exp(\boldsymbol{i}\theta)+(-\exp(-\boldsymbol{i}\theta)) \\
&\quad +(-\exp(\boldsymbol{i}\theta))+(-\boldsymbol{i}\exp(-\boldsymbol{i}\theta))+(-\boldsymbol{i}\exp(\boldsymbol{i}\theta))+\exp(-\boldsymbol{i}\theta)] \\
&= 2\exp(\boldsymbol{i}\theta),
\end{aligned} \tag{2}$$

where the complex representation of '1' vanishes due to complete pair disappearances of complex numbers constructing '1'.
Each of the other seven complex numbers will be left according to other ways of breakdown, as shown by Shimojo *et al.* (2004c).

If there are many different complex numbers with their replicas to be left, then the following equation will be given after the hypothetic breakdown of multiplication form connecting complex numbers constructing '−1',

$$\begin{aligned}
&\sum_{h=1}^{m}\Bigl[\sum_{k=0}^{n}\{\exp(\boldsymbol{i}(\theta_h+2k\pi))+\boldsymbol{i}\exp(-\boldsymbol{i}(\theta_h+2k\pi))+\boldsymbol{i}\exp(\boldsymbol{i}(\theta_h+2k\pi)) \\
&\quad +(-\exp(-\boldsymbol{i}(\theta_h+2k\pi)))+(-(-\exp(\boldsymbol{i}(\theta_h+2k\pi))))+(-\boldsymbol{i}\exp(-\boldsymbol{i}(\theta_h+2k\pi))) \\
&\quad +(-\boldsymbol{i}\exp(\boldsymbol{i}(\theta_h+2k\pi)))+\exp(-\boldsymbol{i}(\theta_h+2k\pi))\}\Bigr] \\
&= 2\sum_{h=1}^{m}\Bigl[\sum_{k=0}^{n}\exp(\boldsymbol{i}(\theta_h+2k\pi))\Bigr],
\end{aligned} \tag{3}$$

where $0<\theta_1<\theta_2<\cdots<\theta_h<\cdots<\theta_m<\pi/2$.
Thus, there is a hypothetic appearance of $\exp(\boldsymbol{i}\theta)$ from the complex representation of

'0=(−1)+1', namely from '−1'. It is suggested hypothetically from equation (3) that $\exp(\boldsymbol{i}\theta_1)$ is the starting point and the phase shift of θ will lead to the other complex numbers, $\exp(\boldsymbol{i}(\theta_m+2n\pi))$ as the last point. If m and n are extremely large, then there will be the continuous phase shift of a micro-scale. Broadly speaking at the risk of making mistakes, equation (3) suggests that $\exp(\boldsymbol{i}\theta)$ with continuous micro-scale phase shift appears hypothetically from the complex representation of '0=(−1)+1'.

Hypothetic conversion of $\exp(\boldsymbol{i}\theta)$ into $\exp(\theta)$

As shown in the preceding section, there was a product of $\pm\boldsymbol{i}$ and $\exp(\pm\boldsymbol{i}\theta)$ in the complex representation of '0=(−1)+1'. However, it was reported by Shimojo *et al.* (2003) that $\exp(\theta)$ was given by the product of $-\boldsymbol{i}$ and variable in $\exp(\boldsymbol{i}\theta)$. Thus,

$$\exp((-\boldsymbol{i})\cdot(\boldsymbol{i}\theta))=\exp(\theta). \tag{4}$$

This is a kind of conversion from the world of complex numbers [$\exp(\boldsymbol{i}\theta)$] into the world of real numbers [$\exp(\theta)$].

If the phase shift of θ in $\exp(\boldsymbol{i}\theta)$ is inherited hypothetically to the change in θ in $\exp(\theta)$, then the calculation of definite integral of $\exp(\theta)$ will be allowed.

Definite integral of $\exp(\theta)$ expanded into infinite series

The definite integral of $\exp(\theta)$ expanded into infinite series is given by

$$\begin{aligned}\int_{\theta_1}^{\theta_2}\exp(\theta)d\theta&=\int_{\theta_1}^{\theta_2}\left(1+\frac{\theta}{1!}+\frac{\theta^2}{2!}+\cdots+\frac{\theta^n}{n!}+\cdots\right)d\theta\\&=\left[\frac{\theta}{1!}+\frac{\theta^2}{2!}+\cdots+\frac{\theta^n}{n!}+\cdots\right]_{\theta_1}^{\theta_2}\\&=\left[\left(1+\frac{\theta}{1!}+\frac{\theta^2}{2!}+\cdots+\frac{\theta^n}{n!}+\cdots\right)+(-1)\right]_{\theta_1}^{\theta_2}\\&=\left[\exp(\theta)+(-1)\right]_{\theta_1}^{\theta_2}\\&=\exp(\theta_2)-\exp(\theta_1).\end{aligned} \tag{5}$$

Another hypothetic description of definite integral of $\exp(\theta)$ suggested by Shimojo *et al.* (2004b, c) is

$$\begin{aligned}\int_{\theta_1}^{\theta_2}\exp(\theta)d\theta&=\int_{\theta_1}^{\theta_2}\left(1+\frac{\theta}{1!}+\frac{\theta^2}{2!}+\cdots+\frac{\theta^n}{n!}+\cdots\right)d\theta\\&=\left[\frac{\theta}{1!}+\frac{\theta^2}{2!}+\cdots+\frac{\theta^n}{n!}+\cdots\right]_{\theta_1}^{\theta_2}+\{(-1)+1\}-\{(-1)+1\}.\end{aligned} \tag{6}$$

If the complex representation of two sets of '(−1)+1' is followed by the hypothetic breakdown of multiplication form connecting complex numbers constructing '(−1)+1', then the following will be given (Shimojo *et al.*, 2004b, c)

$$\int_{\theta_1}^{\theta_2} \exp(\theta)d\theta = \left[\frac{\theta}{1!} + \frac{\theta^2}{2!} + \cdots + \frac{\theta^n}{n!} + \cdots\right]_{\theta_1}^{\theta_2} + \{(-1)+1\} - \{(-1)+1\}$$

$$= \left[\frac{\theta}{1!} + \frac{\theta^2}{2!} + \cdots + \frac{\theta^n}{n!} + \cdots\right]_{\theta_1}^{\theta_2}$$

$$+ \left[\exp(\boldsymbol{i}\theta) + \boldsymbol{i}\exp(-\boldsymbol{i}\theta) + \boldsymbol{i}\exp(\boldsymbol{i}\theta) + (-\exp(-\boldsymbol{i}\theta)) + \{-(-\exp(\boldsymbol{i}\theta))\} + (-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)) + (-\boldsymbol{i}\exp(\boldsymbol{i}\theta)) + \exp(-\boldsymbol{i}\theta)\right]$$

$$- \left[\exp(\boldsymbol{i}\theta) + \boldsymbol{i}\exp(-\boldsymbol{i}\theta) + \boldsymbol{i}\exp(\boldsymbol{i}\theta) + (-\exp(-\boldsymbol{i}\theta)) + \{-(-\exp(\boldsymbol{i}\theta))\} + (-\boldsymbol{i}\exp(-\boldsymbol{i}\theta)) + (-\boldsymbol{i}\exp(\boldsymbol{i}\theta)) + \exp(-\boldsymbol{i}\theta)\right]$$

$$= \left[\frac{\theta}{1!} + \frac{\theta^2}{2!} + \cdots + \frac{\theta^n}{n!} + \cdots\right]_{\theta_1}^{\theta_2} + 2\exp(\boldsymbol{i}\theta) - 2\exp(\boldsymbol{i}\theta)$$

$$= \exp(\theta_2) - \exp(\theta_1), \quad (7)$$

where the complex representation of '1' is not shown due to complete pair disappearances of complex numbers with their opposites.
In equation (7) there are two types of changes in θ ; (i) the change from θ_1 to θ_2 for the definite integral of $\exp(\theta)$, (ii) a series of $\pm\pi/2$ phase shifts of θ in $\exp(\pm\boldsymbol{i}\theta)$ occurring due to the hypothetic breakdown of multiplication form connecting complex numbers to construct '−1'.

Conclusions and suggestions from the present study

It is shown hypothetically from equations (1)~(7) that $\exp(\boldsymbol{i}\theta)$ appears from '−1' in '0=(−1)+1' when described using complex numbers and subjected to the hypothetic breakdown of multiplication form connecting them to construct '0=(−1)+1'. The clockwise $\pi/2$ rotation of the variable in $\exp(\boldsymbol{i}\theta)$ gives $\exp(\theta)$. The hypothetic inheritance of phase shift in $\exp(\boldsymbol{i}\theta)$ to $\exp(\theta)$ might lead to the calculation of definite integral of $\exp(\theta)$ under the change in θ. Might the change in θ in $\exp(\boldsymbol{i}\theta)$ and/or $\exp(\theta)$ be related to the passage of time (t) in $\exp(t)$? However, what causes these hypothetic phenomena to occur is not known.

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