Proposal on Feeding Support Application Software based on Research into the Effect of a "Fasting State" on "Mental Alertness"

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Abstract

This research aims to find academic evidence to support the following phenomenon: Most people seem to feel *sluggish in a fed state* and *feel mentally alert in a fasting state*. Based on prior research that shows that Brain-derived neurotrophic factor (BDNF) which is found to improve brain function is secreted in a fasting state, this research reveals: how much fasting results in alert state ; how much time it takes to enter an alert state; how long an alert state lasts. Also, we propose the development of smartphone application software, that can notify the user of how *clear* their state of mind is at any given time using the mathematical calculation, not by relying just on feeling as before.

1. Introduction

Everyone has a time in which one's mind is *mentally alert* or *sluggish*. For instance, there is no doubt that one is obviously in a sluggish state when they have a fever due to a cold. On the other hand, there are moments when one feels like they can make good progress with any kind of task thanks to an alert state.

In such moments, what kinds of phenomenon generates brain function? With regards to this question, a study was previously carried out by The National Cardiovascular Centre Research Institute: Department of Molecular pathogenesis: Laboratory of Biomolecular Research. The findings of this study show (1): "brain derived neurotrophic factor(BDNF) plays a beneficial role in improving brain function by increasing neurite outgrowth and synapse formation, ... Approximately a 30% restriction on eating (diet control) increases Brain-derived neurotrophic factor(BDNF) to become brain nourishment. In a related study, professor Shuzo Kumagai from Kyushu University claims that (2): "It seems that dietary restriction has the effect on neurogenesis and neuroprotection by increasing neurotrophic factor. ..... Dietary restriction has a great influence on the brain as well as on the increase of Brain-derived neurotrophic factor(BDNF) expression". Thus, it is becoming clear as a result of the scientific research, not just with experiential understanding, that one is *alert when BDNF increases*, namely, in a *fasting state*(3)(4). However, there are two difficulties with these preceding studies.

1. It is quite difficult to know if a person's level of BDNF is increasing or decreasing in their daily life. In short, the medical approach, which is to have blood drawn, is not a practical method for a daily use. This is not *an effective technique to provide a clear indication of the extent of a person's alert state* which would decrease the burden of everyday life.

2. They claim through the use of brain science that *Brain-derived neurotrophic factor increases at a fasting state of approximately 30%* and one becomes alert. However, their studies do not clarify, on a general or daily perceptive level *how much fasting results in alert state; how clear that state is, or how long this alert state lasts*.

2. Research on the Relationship between the Fasting State and Being Alert

2.1. The Survey Methodology

To fulfill this research we first carried out a questionnaire to clarify the common feelings associated with being *alert* or *sluggish*. The experiment was conducted on a group of 113 randomly chosen people aged in their teens to their fifties. Here is the survey overview: In this survey, respondents recorded the *fasting state* and *alertness* every 30 minutes from just after waking up to just before going to sleep for 2 days by using the survey sheet indicated in Figure 1.

The method of implementation is;

（Step.1） The survey participant records their age, gender, and the quantity of physical activity and exercise they do. Reference values of the quantity of physical activity and exercise are; *low* for *almost all day non-standing work*; *moderate* for *a lot of walking and physical activity*; *high* for *active in exercise*. This is implemented in line with the *Exercise and Physical Activity Guide for Health Promotion* by Ministry of Health, Labour and Welfare of Japan.

（Step.2） The survey participants start recording just after waking up. On the survey sheet, a 24 hour day is divided by 30 minutes. Every 30 minutes just after waking up, they record *fed/ fasting* state and *alert/ sluggish*.

There are three formats to record their perceived level. ○× form is applied to record the more intuitional judgment as indicated as below.

<Fed Level>	<Fasting Level>
・Fed a little : ○	・Fasting a little : ×
・Fed : ○○	・Fasting : ××
・Fed very much : ○○○	・Fasting very much : ×××
・Neither : Blank	・Neither : Blank

<Alert Level>	<Sluggish Level>
・A little alert : ○	・A little sluggish : ×
・Alert : ○○	・Sluggish : ××
・Very alert : ○○○	・Very sluggish : ×××
・Neither : Blank	・Neither : Blank

（Step.3） The participants accurately record the time they eat meals or snacks.

（Step.4） Repeat this up to just before going to sleep.

2.2. Survey Results Overview

In this paper, we have undertaken the survey indicated above, on 113 people chosen at random. A summary of results is shown in Fig.2

Total	Alert3	Alert2	Alert1	Neither	Sluggish1	Sluggish2	Sluggish3
Fasting3	19	37	34	19	18	20	22
Fasting2	27	93	88	35	49	34	29
Fasting1	24	132	136	73	93	47	37
Neither	119	284	345	257	143	94	83
Fed1	24	76	151	102	113	82	30
Fed2	18	45	56	51	93	94	30
Fed3	6	27	29	24	48	33	34

（Fig. A. Survey Result1 n=113）

The *level of fasting / fed* are on the vertical axis and the horizontal axis represents the *alert/ sluggish level*. 1, 2, 3 indicates the number of "○" or "×". Fig. A is a matrix in which all the participants are counted based on the recorded points for each 30 minutes.

For example, the top left cell of the matrix shows that there are 19 respondents who were *alert* ○○○ *(very alert)* when they were *fasting* ××× *(very fasting)*.

The same manner is adapted to the bottom left cell, which means that there were 34 respondents who were *sluggish* ○○○ *(very sluggish)* when they were *fed* ××× *(very fed)*.

	5:00	5:30	6:00	6:30	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00	12:30	13:00	13:30	14:00	14:30	15:00	15:30	16:00	16:30
Full○									×	×														
Fasting×					×	×	×	×	×	×									×	×				
					×	×	×	×	×	×	○	○	○	○			×	×	×	×	○			
Alert○					×	×	×	×	×	×	×	×												
Sluggish×					×	×	×	×	×	×	×	×							×	×	×	○	○	○
					×	×	×	×	×	×	×	×	×	×	○	○	○	○	×	×	×	○	○	○
Time																								

	17:00	17:30	18:00	18:30	19:00	19:30	20:00	20:30	21:00	21:30	22:00	22:30	23:00	23:30	24:00	24:30	1:00	1:30	2:00	2:30	3:00	3:30	4:00	4:30
Full○									○															
Fasting×								×	○	○														
			×	×	×	×	×	×	○	○	○													
Alert○							○	○	×	×	×	×	×	×										
Sluggish×	×	×			○	○	○	○	×	×	×	×	×	×										
	×	×	○	○	○	○	○	○	×	×	×	×	×	×										
Time																								

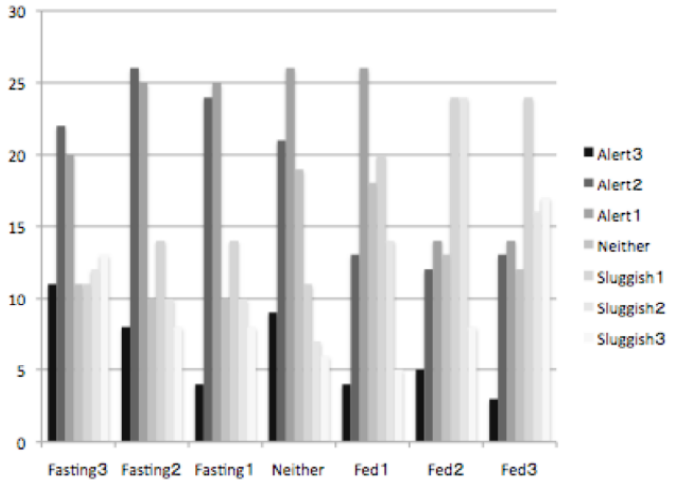
（Fig. 1. Survey Sheet）

2.3. Analysis of Survey Results

Survey result matrix on *fasting* and *mental alertness* indicated in Fig. A is shown in terms of percentages in (Fig.2) for better understanding and is graphically represented (Fig.3).

Total	Alert3	Alert2	Alert1	Neither	Sluggish1	Sluggish2	Sluggish3
Fasting3	11%	22%	20%	11%	11%	12%	13%
Fasting2	8%	26%	25%	10%	14%	10%	8%
Fasting1	4%	24%	25%	13%	17%	9%	7%
Neither	9%	21%	26%	19%	11%	7%	6%
Fed1	4%	13%	26%	18%	20%	14%	5%
Fed2	5%	12%	14%	13%	24%	24%	8%
Fed3	3%	13%	14%	12%	24%	16%	17%

(Fig.2. Survey Result Ratio)



(Fig.3. Survey Result Graph)

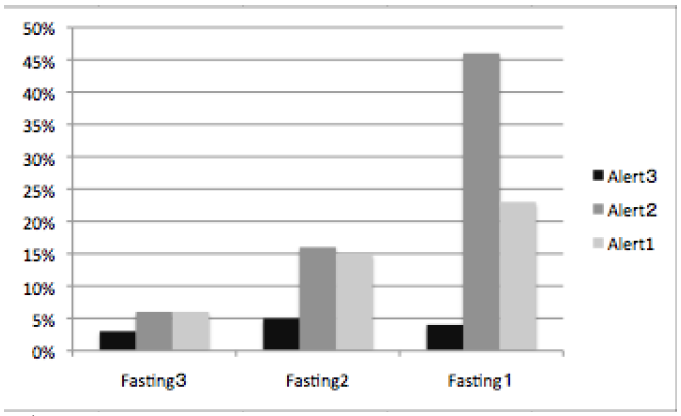
The dark colored bars represent a *mentally alert* state and the light colored bars on the graphs represent a *sluggish* state in Fig.3. It is clear from the graphs that in most cases the participants are "*alert*" in the *fasting state* and as they become full it is clear that they tend to become less alert.

Fig.4 and Fig.5 shows a direct correlation between a *fasting state* and *alertness*.

They explain that alertness specifically tends to appear in the *little fasting state* out of the range of the *fasting state* level.

Total	Alert3	Alert2	Alert1
Fasting3	3%	6%	6%
Fasting2	5%	16%	15%
Fasting1	4%	46%	23%

(Fig.4. Correlation between *Fasting state* and *Mental Alertness*)



(Fig.5. Graphs Showing the Correlation between *Fasting state* and *Mental Alertness*)

3. Lapse Time between Fed to Fasting State and Alertness Duration

3.1. Lapse time from fed to fasting state

Regarding the lapse time between the fed to fasting state, at what stage does the state of being *alert* occur? The survey results so far reveal that *alertness* tends to appear in *a little fasting state*. Accordingly, the lapse time from *fed* to *alert state* is shown in Fig.6.

The average lapse time recorded by the participants is indicated below: from each fed state there are three levels to the beginning of alert state

- Fed1 (Fed a little) : Average 85 min.
- Fed2 (Fed) : Average 151 min.
- Fed3 (Fed very much) : Average 126 min.

	30min	1h	1h30	2h	2h30	3h	3h30	4h	4h30	5h	5h30	6h	6h30	7h	7h30	8h	10h	average
Fed1	6	5	4	6	2	1	0	0	0	0	0	0	0	0	0	0	0	85min
Fed2	4	6	8	13	7	3	3	2	2	2	1	1	1	0	0	1	0	151min
Fed3	3	3	15	5	7	5	1	3	0	0	1	0	1	0	0	0	0	126min

(Fig.6. Lapse Time from *Fed* to *Alert State*)

	30min	1h	1h30	2h	2h30	3h	3h30	4h	4h30	5h	5h30	6h	6h30	7h	7h30	8h	10h	average
Fed1	2	5	5	2	1	2	3	2	0	1	1	1	0	0	0	0	0	146min
Fed2	3	13	5	4	7	3	4	3	6	1	2	0	0	1	0	1	0	159min
Fed3	4	11	6	3	4	5	1	0	0	1	4	1	1	0	1	1	1	165min

(Fig.7. Duration of *being alert*)

It takes a remarkably short time to reach to *the beginning of alertness* in a low level of fed state. Both *Fed* and *Fed very much* states require more than 2 hours to reach *the beginning of alertness*.

3.3. Alert State Duration

The average duration that the state of being *alert* is maintained is indicated below.

- Fed1（Fed a little）：Average 146 min.
- Fed2（Fed）：Average 159 min.
- Fed3（Fed very much）：Average 165 min.

As demonstrated above, the duration of time from *the beginning of alert state* to the end of that state is uniformly around 150 min. regardless of the fed status.

4. Proposal for Smart Phone Application Software to Notify the Alert State

4.1. Proposal for Application Software

According to the survey, it is clear that *fed a little* state tends to be equivalent to the *alert* state and it is reasonable to say that the length of time during which the alert state is maintained can be identified to a certain extent. Based on the analysis of the survey results, we propose the smartphone application software which enables the user to make the most of this state of *being alert*.

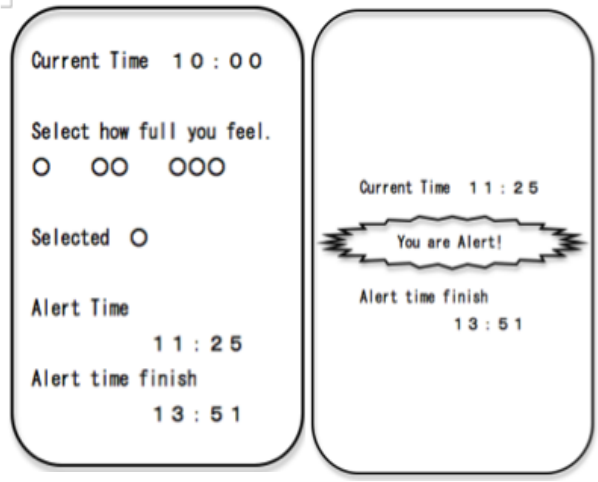
4.2. Application Configuration

In this paper we propose a smartphone application which has two main functions. The first is a function that displays the time in which the users are supposed to be in an *alert* state by calculating the meal-intake time and the fed level. The second function provides guidance related to meal-intake time and portion control so that the user can become *alert* at a specified time. Nowadays a large number of people carry their smartphone on them all the time, just as they do a wallet. It is effective to use this application on the smartphone, a device closely connected to our daily lives.

4.3. Alert Time Display Function

This function is utilized in conjunction with the built-in clock of the device. At first, the user inputs the *fed* level by using 1, 2, 3 every time they have had meal. 1 indicates the lowest fed level and 3 indicates the highest fed level.

The sign to notify that they have become alert will be displayed on the screen of the smartphone when it gets to the time, which is set in accordance with the length of time (Fed1: 85 min./ Fed2: 151 min./ Fed3: 126 min. later)from fed state to the beginning of the *alert* state presented in this research. *The approximate time the alert state ends* will also be displayed by adding the times (Fed1: 146 min. / Fed2: 159 min. / Fed3: 165 min. later) to the alert state beginning time.



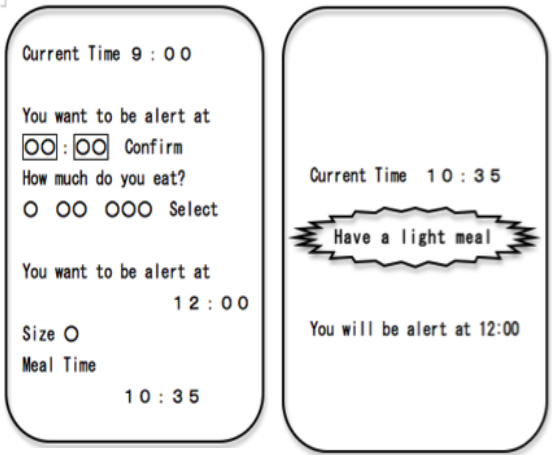
（Fig.8.Application Demo Image 1）

In short, this application aims to clearly indicate, by means of notifications, when a person is entering a state of being *alert* or *sluggish*. It allows the user to manage when they become alert. Up to now this state could only have been recognized intuitively by the individual.

4.4. Meal Time Guide Function to Create an Alert State

This function enables the user to enter an *alert state* by providing guidance on the meal times. This function aims to create the alert state intentionally by controlling the time and intake size of the meal in accordance with the targeted time, for instance, when there is *a particular time that you want to become alert* such as an important meeting. In the following example the user wants to become alert at noon.

If the meal size is *Fed1*, *alert state* will appear 85 min. after eating. Therefore it is ideal to intake the meal around 10:35AM, 85 min. before noon. In case of *Fed2*, *alert state* will appear 150 min. after eating. By using back calculation, this function suggests the user to intake the meal at 9:40AM, 150 min. before 12:00 noon by informing the user of the time.



（Fig.9. Application Demo Image 2）

5. Further Research

As for becoming alert, it goes without saying that in our daily lives there is a wide variety of factors other than fasting or fed states which affect this. For example, washing your face with cold water, exciting events, light exercise, taking a deep breath, etc. Indeed, the following cases are identified in the questionnaire; the case in which one becomes alert suddenly regardless of the fed of fasting state; the case in which even though alertness appears once, it disappears soon; the case in which alert time lasts longer than usual. There is room for further research in this area.

Furthermore, In relation to the research into the perception of each state, *alert* and *sluggish*, *the definitions used to indicate each state* are fundamentally vague. We would like to clarify what is meant by *alert* or *sluggish* and to explain the differences in the level of each state. Likewise, we would like to explain the definition of *fed* and *fasting* state as well as their degree of variation more clearly.

However, the present study has highlighted certain flaws in the prior studies especially in relation to its usage in daily life, and with regards to the relevance of fasting/fed state and alertness. Therefore, an application that can objectively notify users when they are in an *alert* state, something that could previously only be identified by an individual through their senses, is indeed profoundly significant.

(Note） The reference values for the quantity of the physical activity follow the *Exercise and Physical Activity Guide for Health Promotion* by Ministry of Health, Labour and Welfare of Japan.

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