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Intervention Reflecting Motivation to Achieve Long-term Goals

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Abstract

This study proposes a method to identify interventions appropriate to each motivation to achieve goals. People must stay motivated to engage themselves in working hard over a long time toward goals. Some kinds of intervention work well, while others fail. This method requests them to express their reflections on the engagement in daily behavior toward the goals. It converts the expression into a vector representing their motivational state using the word embedding technology. The method sends messages that reflect the motivational states to examine changes in the motivation when people receive messages. It identifies what types of messages encourage/discourage people with different motivations. In a 6-week experiment with 14 undergraduate and graduate students, intervention with messages is sent to their smartphones. The experiment results reveal messages improving/degrading motivation depending on the current motivational states of subjects, which enable us to provide more effective interventions for users trying to achieve a big goal in a long time.

Keywords: goal setting, motivation, message intervention, the Harada Method, word embedding

1. Introduction

It is important to engage in sustained behavior to achieve high-level goals, such as improving a healthy life and acquiring advanced qualifications (Lindner, Menzies, Kelly, Taylor, & Shearer, 2003). For example, daily tooth brushing is important for oral health (Attin & Hornecker, 2005), and regular physical activity can reduce the risk of lifestyle-related diseases such as heart disease and diabetes (Physical Activity, n.d.). However, it is difficult for individuals to maintain motivation to sustain behavior (Xu et al., 2013).

It is effective to employ goal setting along with its periodical reflection to encourage behavior change. Consolvo et al. report that it is effective to evaluate the achievement of self-set goals every week (Consolvo et al., 2009). Liao (Liao, 2019) also points out that assessment in a short period brings high performance in change. In addition, goal setting is strongly related to human motivation. Byan et al. have mentioned that providing specific goals improves motivation for tasks (Bryan & Locke, 1967). Gary et al. have proven that short-term goals are more motivating and perform better on tasks than long-term goals (Latham & Seijts, 1999). On the other hand, it is also known that unattainable goals reduce motivation (Erez & Zidon, 1984). It is important to set appropriate goals to maintain and improve motivation.

There are several types of motivation. In the MSLQ (Pintrich, Smith, Garc á, & McKeachie, 1991), a questionnaire proposed by Pintrich et al. to investigate motivations for learning in the field of education, motivations are classified into 6 categories: internal goal orientation, which is a sense of fulfillment, external goal orientation, which is the desire to be valued by others, work value, which depends on whether target tasks are important, belief control, which corresponds to a belief that the effort will produce positive results, self-efficacy, which is the confidence that one can achieve goals, and test anxiety, which is anxiety occurring in evaluative situations. Self-determination theory (Ryan & Deci, 2000) also classifies motivations into three categories according to the degree of self-determination or autonomy. From the viewpoint of behavior change, each kind of motivation appears as a different behavior depending on the characteristics of people. The motivation related to internal goal orientation often comes from responsibility, which leads to the spontaneous achievement of difficult tasks, while that related to external goal orientation aims to get rewards from outside (Brynjarsdottir et al., 2012). Competition with others works well for young people (Oyibo et al.,

2017), because it stimulates their motivation from external goal orientation.

To achieve the goals, one must stay motivated and continue to work hard over the long term. However, it is difficult for people to stay motivated. As Fogg (Fogg, 2009) points out, to persuade people to sustain behavior for goal achievement, it is necessary to provide them with intervention at the right time (Choi et al., 2019), taking their abilities and motivation into account.

Wang et al. reveal that the use of subjective data collected using smartphones is effective to know the appropriate timing (Wang et al., 2014) because it provides detailed information about changes in the state of individual subjects. Various efforts have been made to support human behavior with intervention from agents working on smartphones. Examples are studies that support human behavior through text messages from agents (Suffoletto et al., 2015; Graham et al., 2021; Patrick et al., 2009; Tomislava, Gordana, & Jelena, 2020). Most of these studies focus on developing effective messages for users. Of course, it is important to develop a message that will cause the user to take behavior. However, interventions using agents require some ingenuity. What people want from agents is not long conversations to establish a good relationship, but short conversations to get proper information (Clark et al., 2019). ChatGPT has high expectations as a conversational agent (Skjuve et al, 2023), but additional research is required for ChatGPT to be applied to change behavior. The reactions of message receivers not only depend on their goal settings but also vary with their motivational states. It is necessary to obtain detailed information on the internal states of the receivers to create proper messages (Zhong, 2023). It is necessary to consider the goal-setting and motivational state of the user receiving the message. Currently, no research on behavioral support takes into account users' goal-setting and types of motivation.

Based on the subject's goal setting, this study investigates what kinds of messages improve/degrade motivation toward the achievement of goals. The study adopts the Harada method (Bodek & Harada, 2012) because it addresses goal-setting and reflection on its achievement. The analysis of reflection in a short period is a promising way to lead people to achieve their goals. The method lets users dictate reflections on how they regard their behavior toward the goals. Making the best use of text analysis technologies, this study based on the Harada method estimates motivational states periodically from the reflection. Using the estimated motivational states, it intervenes with users by sending messages to examine the motivation change. An experiment conducted for 6 weeks for more than 10 users reveals what kinds of messages are effective for users with specific motivational states. The paper discusses the effects in a quantitative way powered by text analysis technologies.

2. Goal Setting and Motivation

2.1 The Harada Method

The Harada Method (BodeK & Harada, 2012) is a method to make goals more feasible. The Harada Method aims at fostering self-reliant individuals who can reliably demonstrate achievement and performance through forming excellent personality and human skills. It is used in a wide range of situations, including for celebrities, athletes, and human resource development for large corporations. Professional baseball player Shohei Otani also used the method in high school age to attain his respectful character and excellent human skills.

The Harada Method consists of the following three components.

- Open Window 64 (OW64)
- Diary
- Routine check sheet

First, OW64 is a goal hierarchy. The main goal to be achieved is placed in its center, surrounded with its 8 subgoals, each of which is broken into 8 small goals. The center represents the ultimate goal of a person, while goals at the lowest level should be concrete ones whose achievement the person can assess. The person sets goals at a lower level to achieve the upper goal. Lower goals remind the person of continuous efforts to accomplish the upper one.OW64 promotes the users' motivation and continuation of efforts by setting up a total of 64 goals that are embodied in two stages toward a major goal. The Harada Method emphasizes not only improving one's ability, but also training one's personality. To this end, sub-goals are set from the four perspectives of mind, technique, physical, and life. Subgoals can be divided into two types: routine goals to be achieved repeatedly every day, and time-bound goals to be achieved by a due date.

Next, the Harada Method uses a diary where the person specifies a plan to achieve goals the next day. One day later, the person records achievements as well as the differences from the plan. The diary entries enable the person to review the plan day by day. There are four items to reflect on in the diary.

- Things that go well on the day
- Actions or experiences regarded to lead the personal growth and appreciation from others

- Something the person wants to try if the day could come again (if there were no limitations)
- Words or events that inspired the person to achieve the goals

Finally, the Harada Method provides a routine check sheet. It is a chart showing routine goals repeated daily. At the end of the day, the person should check how many goals have been accomplished on the day. This allows the person to check the degree of the goal achievement. The daily check contributes to fostering a sense of self-efficacy through a series of successes.

2.2 Self-Determination Theory

Self-Determination Theory (SDT) (Ryan & Deci, 2000) is a psychological model that classifies types of motivation according to the degree of self-determination or autonomy. SDT classifies motivation as shown in Figure 2.1.

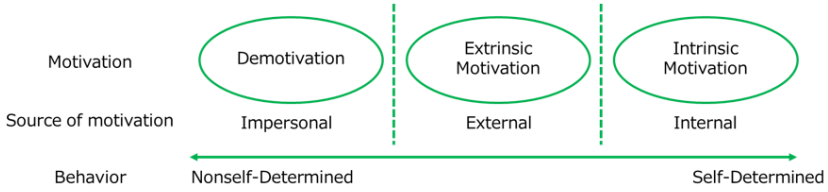

Figure 2.1. Classification of motivation in self-determination theory

Figure 2.1 shows that demotivation is the state of being totally unmotivated. Extrinsic motivation is motivation that is generated by external influences such as rewards, evaluations, and punishments. Intrinsic motivation is motivation that stems from one's own emotions, such as interest, curiosity, and concern. Thus, there is no demotivation in the location of motivation; extrinsic motivation is external and intrinsic motivation is internal. The degree of self-determinism was highest for intrinsic motivation and lowest for demotivation.

Furthermore, self-determination theory has three fundamental needs: autonomy, competence, and relatedness. It is believed that by increasing these three needs, motivation changes to intrinsic motivation. Autonomy is the need to determine one's own behavior for oneself. Competence is the need to feel that one is capable. Relatedness is the need to establish a spiritual relatedness with others. For example, these three needs are explained assuming a situation in which a goal is set to "do daily walking to maintain a healthy state. Autonomy is the need to set goals for oneself without being forced by others to walk. Competence refers to the need to have confidence in one's ability to continue walking for a period of time or to be able to walk a certain distance. Relatedness is the need to build a spiritual relatedness, such as trust, with the people one walks with.

Many studies (Eisenberger, Rhoades, & Cameron, 1999; Gagné & Deci, 2005; Grant, 2008; Kuvaas, Buch, Weibel, Dysvik, & Nerstad, 2017) have found that people with intrinsic motivation have better performance and satisfaction with the tasks they work on than people with other types of motivation. Therefore, it is very important to motivate people and lead them to intrinsic motivation in behavioral support.

2.3 Word2Vec

Since motivation is an internal state, it cannot be observed. In addition, its quantitative evaluation is difficult. The study quantitatively estimates motivation based on what persons write in their diaries. To quantitatively evaluate texts, we need a method that deals with words quantitatively.

Word2Vec is a method to obtain distributed representations of words using a neural network (Géron, 2019). Word2Vec is based on the distribution hypothesis. The distribution hypothesis states that the meaning of a word is formed by the surrounding words. It assumes the meaning of any word can be inferred from the context before and after it.

Skip-gram is a learning algorithm of a neural network to derive a distributed representation of a specific word from the probabilities of multiple words that would appear around the word. Skip-grams can obtain accurate distributed representations of words through training with plenty of labeled data. Skip-gram can get accurate distributed representations, although its training is expensive (Xing, Wang, Zhang, & Liu, 2014). The distributed representations are presented in an intermediate layer, which is a vector representation of words with a specified number of dimensions. The vector representation is used to vectorize arbitrary words.

Word2Vec represents words as multi-dimensional feature vectors. If each feature dimension is appropriate, the representation will take into account the relationships between words. For example, words are represented with 4 dimensional vectors. Assuming that the 0th, 1st, 2nd, and 3rd elements of the vectors correspond to genderness, adultness, royalty, and other characteristics, respectively, the words can be represented as in Table 2.1.

Table 2.1. Examples of vector representations of words

Word	Vector representation	0th element (genderness)	1st element (adultness)	2nd element (royalty)	3rd element (others)
Prince	(0.9, 0.1, 0.8, 0.0)	0.9	0.1	0.8	0.0
Princess	(0.1, 0.1, 0.8, 0.0)	0.1	0.1	0.8	0.0
Female	(1.0, 0.0, 0.0, 0.0)	1.0	0.0	0.0	0.0
Male	(0.1, 0.0, 0.0, 0.0)	0.1	0.0	0.0	0.0

When words are represented as vectors, reflecting the relationships among them. The relationships can be computed in terms of operations. For example, if we compute "princess - female + male," the answer is prince according to human intuition. From Table 2.1, we compute the vectors, which roughly correspond to the vectors representing the princes, as shown in Equation (1).

$$Princess - Female + Male = (0.1, 0.1, 0.8, 0.0) - (1.0, 0.0, 0.0, 0.0) + (0.1, 0.0, 0.0, 0.0)$$
$$= (1.0, 0.1, 0.8, 0.0) \approx (0.9, 0.1, 0.8, 0.0) = Prince \quad (1)$$

Each word represented with appropriate feature dimensions enables its vector to adequately represent the relationships among other words.

2.4 TF-IDF

If words related to a motivating factor are specific to the diary of a person, it is plausible that the person has the motivation factor. TF-IDF (Sklearn.Feature_extraction.Text.TfidfVectorizer., 2007) is a method to identify words specific to a document. It is calculated based on two values: Term Frequency (TF) and Inverse Document Frequency (IDF).

Term Frequency is the frequency with which a word appears in a document. For some documents, the more frequently a word appears in a document, the more likely it is to be important.

Inverse Document Frequency, on the other hand, indicates how many documents use the word, indicating the rarity of the word. Words frequently used in various documents are rated as less important, which lowers their IDF values. Conversely, words appearing only in particular documents get higher IDF values.

These two values are multiplied together to obtain TF-IDF values. In other words, the TF-IDF value of a word is the product of its frequency in documents and its rarity among documents. TF-IDF enables us to find important words in documents, which means document features can be captured.

3. Goal Setting and Motivation Estimation

3.1 Behavioral Support Considering Types of Motivation

This paper proposes a method to support users to achieve their goals taking into account the types of their motivations. The proposed method utilizes message intervention. Figure 3.1 shows a schematic diagram of the proposed method.

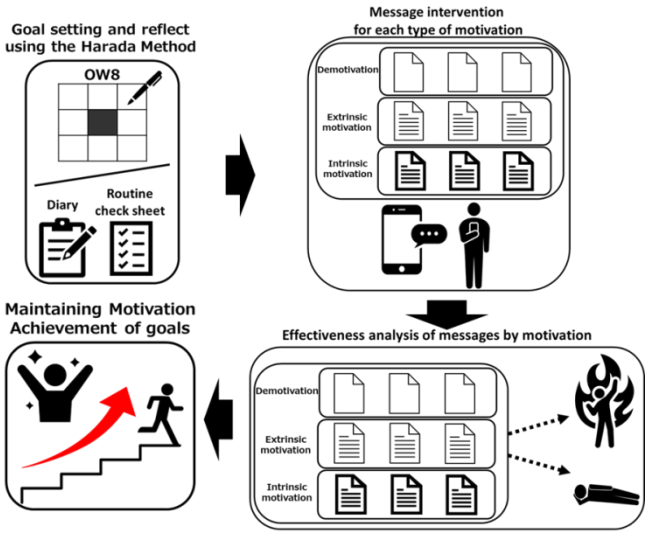

Figure 3.1. Proposed Method

In the proposed method, users set goals according to the Harada Method. They also look back on their behavior with their diaries. The types of user motivations are estimated from the contents of their diaries using natural language processing. User motivations are divided into three types: demotivation, extrinsic motivation, and intrinsic motivation. It depends on the motivations of users how they react to receiving a message. The method sends messages that match their motivation to promote users to achieve their goals.

To examine the effect of the message intervention on users of each motivation, the method checks the change in motivation before and after the message intervention. The method provides two types of messages: external ones and internal ones. Table 3.1 provides an overview of intervention messages.

Table 3.1. Two Types of Intervention Messages

Message Type	Contents
Extrinsic Message	Reward, Praise, and Scolding
Intrinsic Message	Self-Determination Theory's Three Needs (Autonomy, Competence, and Relatedness)

Extrinsic messages are founded on extrinsic factors such as rewards, punishments, praise, or scolding. The messages reflect reviews referring to past diaries and routine check sheets. For example, the method will intervene with engineers who have failed to survey relevant technologies sending a message saying, “Enough survey would help you gain trust from your company." On the other hand, intrinsic messages aim to enhance the user's interest and motivation. Specifically, the messages reflect the three needs proposed by self-determination theory: autonomy, competence, and relatedness.

Identification of messages effective for each motivation enable us to provide interventions that encourage users to maintain or increase their motivation. As a result, it can help users achieve their goals.

3.2 Goal Setting and Reflection Using Harada Method

The study uses the Harada Method to have users set and reflect on their goals. The Harada Method emphasizes not only the improvement of work-related abilities but also the improvement of personality. The Harada Method enables users to cultivate technical skills and mental strength to achieve their goals.

The user uses OW64 to set goals. Determined users can accomplish many subgoals, ultimately achieving the larger final goal. However, for more users to experience goal achievement, it is important to lower the hurdles to achieve subgoals to make the final goal easier to achieve. While the Harada Method obliged users to set 64 subgoals in total, the proposed method makes users aim 8 subgoals. This allows users to identify specific actions and ideas to achieve familiar final goals. Based on the actions and ideas, users develop a plan to achieve their final goals.

In addition, the Harada Method has users periodically record their behavior on diaries and assess their behavior with routine check sheets. The proposed method introduces the same process to make look back users on their behavior. It lets users write down small text to represent how they feel on looking back on their behavior. It brings users a detailed review of executing the plans to achieve the goals. Users can reassess the degree to which they have achieved their plan, looking back on records of the results. In addition, the accumulation of small plan accomplishments fosters self-efficacy that they are capable of carrying out their plans to achieve their goals.

3.3 Vectorization of Text in Diary

To estimate the user's motivation, the sentences in the diaries are vectorized using natural language processing. The proposed method regards the user's daily state is expressed with specific words in the diary. Words in the diary are vectorized using Word2Vec.

Furthermore, the proposed method uses the Behavioral Regulation in Exercise Questionnaire-3 (BREQ-3) developed by Mullan et al. as a sentence to express each motivation (Mullan, Markland, & Ingledew, 1997). The BREQ-3 is a scale to measure motivation for exercise based on self-determination theory. Though it targets exercise, items in the questionnaire can be applied to any activities that need motivations. In the proposed method, some sentences have been rewritten to be more relevant to target activities. Each sentence in the questionnaire is related to one of the following three types of motivations.

- Demotivation
- Extrinsic Motivation
- Intrinsic Motivation

The words of each sentence are converted into vectors. Vectors in sentences of a specific type of motivation are summed

up to get a vector specifying the direction of the motivation type. The proposed method refers to the vector as a motivation axis. Consequently, there are three motivation axes: the demotivation axis, the extrinsic motivation axis, and the intrinsic motivation axis.

Word2Vec uses the following 9 parts of speech of words in the diary and the questionnaire, because they are independent words.

- Verbs
- Adjectives
- Adjective Verbs
- Nouns
- Pronouns
- Adverbs
- Conjunctions
- Emotive words
- Continuous words

3.4 Estimation of User Motivation

Estimating user motivation from the journal's reflection sentences. The journal has four long descriptive items: "Things that went well that day", "An action or experience that you believe led to your personal growth and thank you", "If you could do today over again (if there were no limitations)" and "Words or events that inspired you to achieve your goals". All of these sentences are added together for each diary, and feature words are extracted from them.

TF-IDF is used to select feature words. TF-IDF is a method for estimating characteristic words by considering both words that appear frequently in a text and rare words that do not appear in other texts. The TF-IDF values are calculated, and the top five TF-IDF words are defined as the feature words of the diary, and the vectors of the feature words are converted into vectors using Word2Vec and added together for each diary. This added vector is considered the "feature vector," which is a vector representing the state of the user who wrote the journal.

The user's motivation is estimated from the similarity between the feature vector calculated for each diary and the motivation axis calculated from the questionnaire sentences. In this study, Euclidean distance is used as the method for calculating vector similarity. For example, if the distance between the feature vector and the intrinsic motivation axis is large, the user is in a state of weak intrinsic motivation. Conversely, if the distance between the feature vector and the intrinsic motivation axis is small, the user is in a state of strong intrinsic motivation. The type of motivation with the smallest distance between the feature vector and the motivation axis is the type of motivation that was highest for the user when he/she filled out the diary. By checking the change in motivation before and after the message intervention, we identify the type of message that is effective for each motivation.

4. Experiments and Results of Message Intervention

4.1 Outline of Experiment

In this experiment, subjects worked toward a final goal of "presenting their research results to many researchers of outside." Each of them set their subgoals, which was succeeded by reflection on the subgoals using the Harada Method. The subjects are a total of 14 bachelor and master students engaging in research themes related to data science. For the experiment, OW64 is changed to OW8 with 8 squares instead of 64 squares. Subjects use OW8 to set goals at the beginning of the experimental period. In addition, subjects reflect daily using a diary and a routine check sheet. Since the number of sub-goals is small, the routine check sheet contains not only routine goals but also time-bound goals. The actual contents of OW8 filled out by a subject, the contents of the diary, and the contents of the routine check sheet are shown in Figure 4.1, Figure 4.2, and Figure 4.3, respectively.

Have confidence in my research activities	Prepare presentation materials by the day before the seminar	Conduct research based on logical thinking
Read 5 references per week	To present research in an open lab	The paper must be completed by the end of December
Exercise at least twice a week for at least 30 minutes each time	Use my phone no more than 3 hours a day	At least 15 hours of research each week

Figure 4.1. OW8 actually completed by subjects

Things that go well on the day
I am glad that I was able to take time to do research.

Actions or experiences regarded to lead the personal growth and appreciation from others.
I was able to take time to do research well without overextending our free time.

Something the person wants to try if the day could come again (if there were no limitations)
I went to bed a little early and was not able to study English, which I had decided to do, and to do the analysis I had planned to finish, so I wanted to redo those two things.

Words or events that inspired the person to achieve the goals
The study sessions in the lab gave me a great deal of motivation to do research, and I was reminded that I had quite a bit of time before the presentation until the open lab.

Figure 4.2. Actual diaries filled out by subjects

Daily routines goals	November 19th	November 20th	November 21st
Have confidence in my research activities		✓	✓
Conduct research based on logical thinking	✓	✓	
Exercise at least twice a week for at least 30 minutes each time	✓		✓
Use my phone no more than 3 hours a day			✓
Time-bound goals	November 19th	November 20th	November 21st
Prepare presentation materials by the day before the seminar	✓	✓	
Read 5 references per week			
The paper must be completed by the end of December			✓
At least 15 hours of research each week			✓

Figure 4.3. Routine check sheet actually completed by the subject

Subjects receive messages via e-mail. Messages were sent twice a week on Tuesdays and Thursdays at 8:00 a.m. There are two types of messages: extrinsic and intrinsic messages, as described in section 3.1.

The purpose of this experiment is to examine effective interventions for each type of subject's motivation. For this purpose, the experiment divided the duration of the experiment into two types. The duration of the experiment is shown in Figure 4.4.

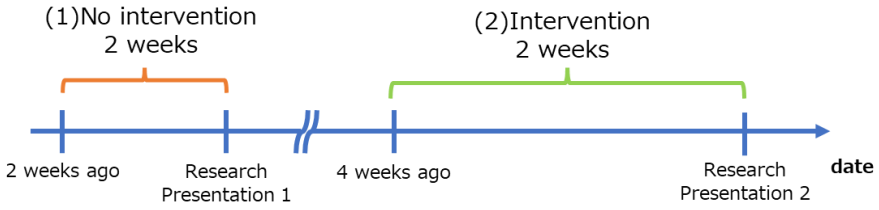

Figure 4.4. Duration of the experiment

The experiment consists of two durations: (1) two weeks with no message intervention and (2) four weeks with message intervention. In Period (1), subjects did not receive any message but engaged in reflection toward goals set based on the Harada Method. Sentences specifying the reflections are used as part of the training data for the Word2Vec model. In Period (2), two types of messages were randomly sent to the subjects in addition to the Harada Method. Some examples of messages used in the experiment are shown in Table 4.1.

Table 4.1. Examples of messages used in the experiment

Message Type	Contents	Example of message
Extrinsic Message	Reward	If you work hard on your research now, you may have a chance to go abroad for an international conference!
		You can go abroad which costs 300,000 JPY with expense from official budgets.
	Praise	You seem to be accomplishing slides very well these days.
		Your steady efforts are paving the way for your own growth and success.
		Keep up the good work!
	Scolding	You haven't been able to accomplish much in the way of data analysis recently.
		At this rate, you may end up writing papers and preparing presentation materials just in time for the term!
		Why don't you start working a little harder now?
Intrinsic Message	Autonomy	Knowing what you are doing and what you are not doing will increase your chances of achieving your goals.
		Please take a look at your OW8 once again.
	Competence	When you check your routine check sheet, you can look back at the items you have accomplished so far.
		You have the ability to continuously work on even the tedious goals you set for yourself.
	Relatedness	Discussions with lab students and professors can be a good stimulus for your research ideas and motivation.
		Why don't you talk to someone today about the purpose of your research or the difficulties you had in your experiments?

For each period, feature words are extracted from the diaries using TF-IDF. In this experiment, the top five words with the highest TF-IDF value for each diary are used as feature words.

Training of a Word2Vec model uses all sentences in diaries for Period (1) and Period (2) but also ones in questionnaires. Feature words are vectorized using the Word2Vec model to compute feature vectors. The similarity between the feature vector of the diary and the motivation axis calculated from the questionnaire is used to estimate the subject's motivation and the effect of the message on that day.

4.2 Motivation Estimation Results

In the experiment, Word2Vec converts words in the diary and questionnaire into 20-dimensional vectors. Some of the actual questions in the questionnaire are shown in Table 4.2.

Table 4.2. Examples of questionnaire questions

Items to be measured in the survey	Question
Demotivation	I don't understand why I bother to engage in research activities.
Extrinsic Motivation	I do research because I am told by others that I should do research.
Intrinsic Motivation	I feel pleasure and satisfaction from doing research.

There are 168 diaries for 12 days for 14 subjects in total. Since motivation varies from day to day even for the same subject, motivation is estimated for each diary entry. The motivation of each diary is estimated with the smallest Euclidean distance of the feature vector from the motivation axis. Table 4.3 shows the results in the estimation of the motivation for each subject.

Table 4.3. Results of motivation estimation

Highest Motivation	Number of Diary
Demotivation	114
Extrinsic Motivation	20
Intrinsic Motivation	34

4.3 Motivation Change

The change in subjects' motivation before and after receiving the message is examined to know effective interventions for each motivation. The change is aggregated for every highest motivation before subjects receive the message. It means to examine the change in the Euclidean distance between the feature vector and each axis of the motivation axes at 2 time points: time *t-1* before the message receipt, and at time *t* after the message receipt. For example, if the distance between the extrinsic motivation axis and the feature vector decreases after receiving the message, it can be said that extrinsic motivation is enhanced by the message.

Suppose subjects of the same motivation receive a message related to a specific motivation. If plenty of them get nearer to a specific motivation axis, we can say the message strengthens the motivation for those subjects. We can find a message weakens a specific type of motivation in the same way.

From the viewpoint above, the likelihood for a message to weaken a specific type of motivation is examined in the following way.

(likelihood of weakening) = (percent of those who increased distance)
- (percent of those who decreased distance)

The examinee's percentages of changes in motivation are shown in Table 4.4.

Table 4.4. Motivation Change

Highest Motivation	Type of message	Motivation axis	% of those who increased distance	% of those who decreased distance	Likelihood of weakening	p-value
Demotivation	Extrinsic message	Demotivation	0.596	0.404	0.192	0.057**
		Extrinsic motivation	0.519	0.481	0.038	0.806
		Intrinsic motivation	0.481	0.519	-0.038	0.649
	Intrinsic message	Demotivation	0.458	0.542	-0.084	0.922
		Extrinsic motivation	0.625	0.375	0.25	0.277
		Intrinsic motivation	0.375	0.625	-0.25	0.331
Extrinsic Motivation	Extrinsic message	Demotivation	0.000	1.000	-1	0.008*
		Extrinsic motivation	1.000	0.000	1	0.008*

		Intrinsic motivation	0.000	1.000	-1	0.008*
	Intrinsic message	Demotivation	0.000	1.000	-1	0.125
		Extrinsic motivation	1.000	0.000	1	0.125
		Intrinsic motivation	0.000	1.000	-1	0.125
Intrinsic Motivation	Extrinsic message	Demotivation	0.375	0.625	-0.25	0.375
		Extrinsic motivation	0.125	0.875	-0.75	0.001*
		Intrinsic motivation	0.688	0.313	0.375	0.039*
	Intrinsic message	Demotivation	0.250	0.750	-0.5	0.547
		Extrinsic motivation	0.250	0.750	-0.5	0.039*
		Intrinsic motivation	0.875	0.125	0.75	0.016*

A statistical test is necessary to confirm whether a message causes a significant difference in strengthening/weakening a specific type of motivation.

Since the population does not follow a normal distribution and there is a correspondence between samples, the Wilcoxon signed rank test is used as the testing method. The null hypothesis is that there is no significant difference in motivation before and after receiving the message. The null hypothesis is rejected when the p-value is below the significance level.

In Table 4.4, * and ** indicate that the null hypothesis is rejected when the significance level is set at 5% and 10%, respectively.

The results in Table 4.4 confirm the differences in the change for each of the subjects' motivational states. The likelihood of weakening reveals the direction in motivation change for each subject's state. For example, the likelihood of weakening close to 1.0 indicates that most subjects with a particular motivation have increased their distance from the motivation axis, which means they get farther from the axis. On the other hand, when the likelihood of weakening is close to -1.0, the distance from the motivation axis decreases, that is, they get closer to the axis. Figure 4.5 shows the likelihood of the distance to every axis for each kind of subject's motivation.

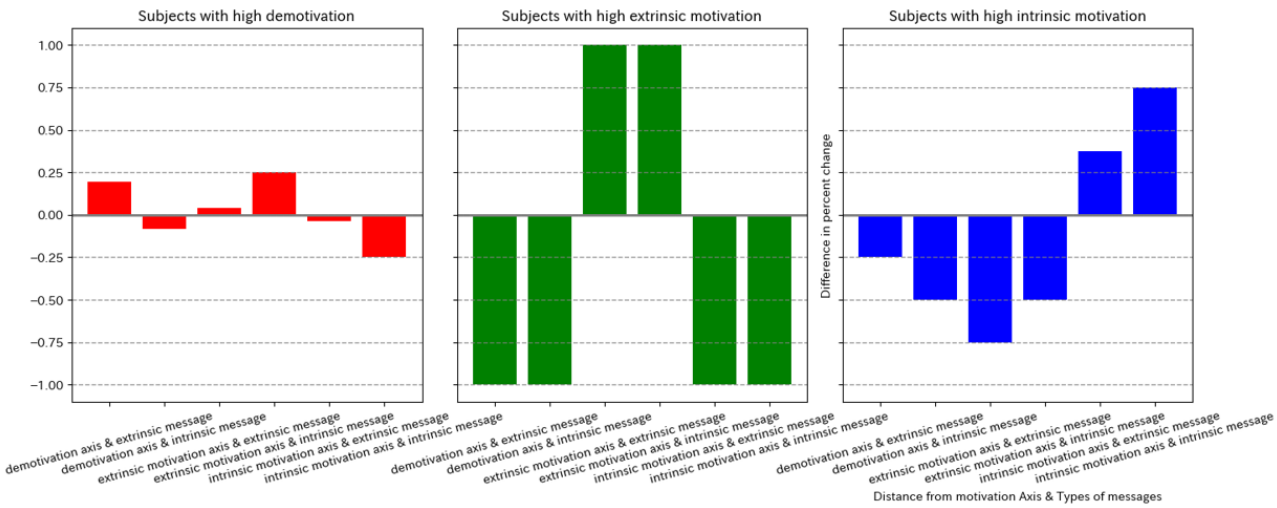

Figure 4.5 Difference in the rate of change for each subject's motivation

Figure 4.5 and Table 4.4 show that significant differences in motivation before and after the message intervention appear in the following cases.

- When extrinsic messages are sent to subjects with high extrinsic motivation,

- the distance from the extrinsic motivation axis increases, and
- the distance from both the demotivation axis and the intrinsic motivation axis decreases.

- When either type of message is sent to subjects with high intrinsic motivation,
  - the distance from the extrinsic motivation axis decreases, and
  - the distance from the intrinsic motivation axis increases.
- When subjects with low motivation receive extrinsic messages,
  - the distance from the demotivation axis increases (with a significance level of 10%)

5. Discussion

5.1 Consideration of Motivation Axis

The 3 motivation axes correspond to demotivation, extrinsic motivation, and intrinsic motivation. Each of them consists of a 20-dimensional vector. The norm for each of the motivation axes is shown in Table 5.1. The cosine similarity and the Euclidean distances between the motivation axes are shown in Table 5.2.

Table 5.1. Motivation axis norms

Types of Motivation Axes	Norm
Demotivation Axis	0.696
Extrinsic Motivation Axis	2.870
Intrinsic Motivation Axis	0.259

Table 5.2. cos similarity and Euclidean distance between motivation axes

Types of motivation Axis	cos similarity	Euclidean distance
Demotivation and Extrinsic Motivation Axes	0.973	2.198
Demotivation and Intrinsic Motivation Axes	0.715	0.542
Extrinsic and Intrinsic Motivation Axes	0.756	2.680

From Tables 5.1 and 5.2, we can see the following relationships for each motivation axis.

- The angle between the demotivation axis and the extrinsic motivation axis is the smallest while the distance between them is large.
- The angle between the demotivation axis and the intrinsic motivation axis is the largest among the three axes, while the distance is the smallest.
- The angle between the extrinsic motivation axis and the intrinsic motivation axis is small, but the distance is the largest among the three axes.

From the above, we can image an example of relationships among the motivation axes shown in Figure 5.1.

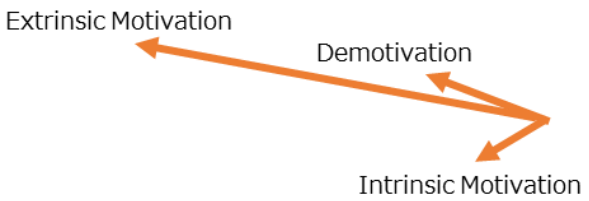

Figure 5.1. Example of Relationships among Motivation Axes

Figure 4.5 shows that the difference in the likelihood of weakening each motivation is 1 or -1 for subjects with high extrinsic motivation. It means subjects with high extrinsic motivation always experience the same change when they receive the message. Furthermore, the distance from the extrinsic motivation axes increases, while that from the demotivation and intrinsic motivation axes decreases. Given the norm of the extrinsic motivation is largest in Figure 5.1, it might be caused because the norm of the feature vector of subjects with high extrinsic motivation is reduced by the intervention of the message. Figure 5.2 shows an example of a change in the feature vector caused by the intervention for a subject with high extrinsic motivation.

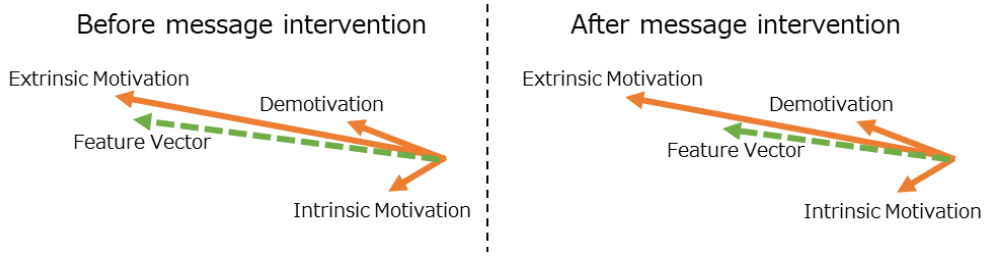

Figure 5.2. Feature Vector of Subjects with High Extrinsic Motivation Before and After Intervention

5.2 Subjects with Low Motivation

The results in section 4.3 show that extrinsic messages put subjects with low motivation away from the demotivation axis. However, there is no significant difference in the distance between the extrinsic and intrinsic motivation axes before and after the message intervention. Thus, the low-motivation subjects cannot be said to have been strengthened in either extrinsic or intrinsic motivation by the extrinsic messages, but their demotivation is weakened. It indicates their motivation is strengthened in some way.

5.3 Subjects with High Extrinsic Motivation

The results in section 4.3 indicate subjects with high extrinsic motivation get away from the extrinsic motivation axis when they receive extrinsic messages. In addition, their distance from the demotivation and the intrinsic motivation axes decreases. Therefore, their extrinsic motivation is weakened while they get demotivated or strengthen their intrinsic motivation.

To check whether they put themselves near to the demotivation or the intrinsic motivation, let us calculate the mean values of motivation difference at receiving the message. The mean values shown in Figure 5.3 indicate that the mean difference decreases larger in the intrinsic motivation than in the demotivation. The extrinsic message intervention weakens extrinsic motivation and strengthens intrinsic motivation.

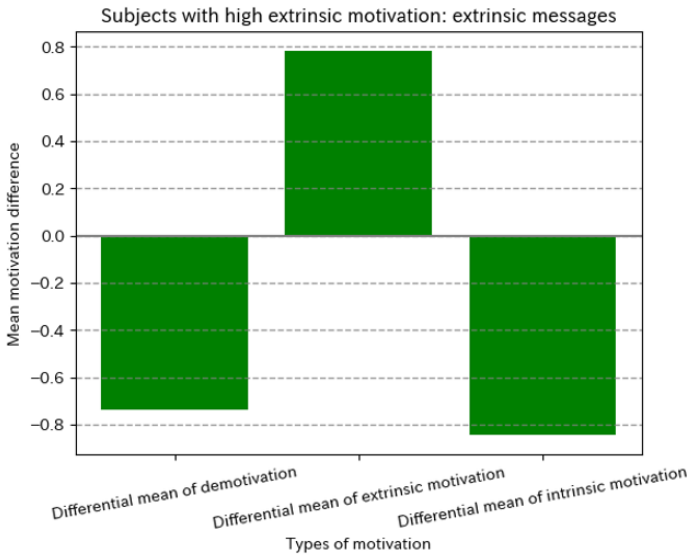

Figure 5.3. Average of each motivational difference

These results suggest that the extrinsic messages from agents have caused enhancing effects, which coincide with the previous works using stimuli from humans (Deci, 1971; Anderson, Manoogian, & Reznick, 1976; Swann & Pittman, 1977) on subjects with high extrinsic motivation. The effect is the enhancement of intrinsic motivation by external stimuli. Deci et al. proved experimentally that positive verbal rewards produce an enhancing effect (Deci, 1971). The results using agent messages in this study have shown that an enhancing effect occurs by external stimuli, regardless of whether they are positive or negative. Clark et al. point out agents are expected to play roles of concise information exchange, different from human messages expected to deepen interpersonal relationships (Clark et al., 2019). Short agent messages are likely to enhance intrinsic motivation, either they are positive or negative.

5.4 Subjects with High Intrinsic Motivation

According to the experiment results in Section 4.3, with either extrinsic or intrinsic messages, subjects having high

intrinsic motivation increases the distance from the intrinsic motivation axis. On the other hand, the distance from the extrinsic motivation axis decreases. It can be said that subjects with high intrinsic motivation weaken their intrinsic motivation while strengthen their extrinsic motivation by the message intervention.

The message intervention causes undermining effects (Deci & Ryan, 1985; Mueller & Dweck, 1998) on subjects with high intrinsic motivation. The undermining effect is the reduction of intrinsic motivation held initially by providing external rewards. In this experiment, undermining effects occurs not only in extrinsic messages but also in intrinsic messages. It suggests that the message intervention itself may be an external factor, regardless of the content of the message.

5.5 Dealing with Each Motivation

From the discussion in section 5.2, extrinsic message intervention could have slight effects on unmotivated people. Extrinsic messages have a possibility to motivate people who is weak in motivation.

From the discussion, extrinsic message intervention is effective for those with high extrinsic motivation. Extrinsic messages have enhancing effects to strengthen their intrinsic motivation. Note that, from Figure 5.3, the distance has decreased not only from the intrinsic motivation axis but also from the demotivated axis. It implies either they get stronger in intrinsic motivation or they weaken motivation. Therefore, it is necessary to carefully monitor the progress of individuals with high extrinsic motivation when they are intervened with messages. In the monitoring, it is one way to provide direct guidance when motivation disappears.

The discussion in section 5.4 implies it is effective to avoid the message intervention itself for those who have high intrinsic motivation. The message intervention might have undermining effects on highly intrinsically motivated individuals, weakening their intrinsic motivation.

Individuals have different types of effective interventions depending on their motivational states. The experiment allows us to identify the intervention method appropriate for each motivation. It is important to understand an individual motivational state to intervene according to the state when providing support through messages.

Since appropriate interventions with messages will lead people to desired motivational states, we can let them take preferable behavior without excessive effort. For example, let us consider agents generating messages, such as ChatGPT, to motivate huge people according to the motivation in each of them. To make agents generate preferable messages, fine tuning is indispensable (Zhong, 2023). Agents that understand the motivational state of individuals to provide messages are expected to bring about behavioral changes in individuals. The results of this study provide guidelines to plan instruction tuning so that agents can generate preferable messages.

5.6 Limitation

This study examines motivation, which is the internal state of the subject at a specific point in time. It focuses on what kind of messages improve/degrade the state. The study only examines the effects of messages in a short time. It considers only the instantaneous motivational states of target people.

Human motivation is thought to vary depending on messages given over a long time. Messages that are strategically presented over a long time are expected to reduce fluctuations in the motivation of the target people. This study does not take the long-term perspective into account. This is a limitation of the proposed method.

6. Conclusion

This paper proposes a method to estimate the types of motivation based on user's reflections to provide effective interventions for each motivation.

In the proposed method, users set goals and reflect on them according to the Harada Method. The feature words are calculated for each sentence of their diaries using TF-IDF for the sentences of the reflective content. The method converts feature words into feature vectors using Word2Vec. Feature vectors represent the motivational states of the users at the time they write diary entries. The motivation axis, which is a vector representing each motivation, is created based on the content of the sentences in the motivation questionnaire. The similarity between the motivation axis and the feature vector is used to estimate the subject's motivational state.

To verify the types of interventions that are effective for each user condition, the study has conducted a message intervention experiment. Two types of messages, extrinsic and intrinsic messages, are sent to the subjects. Changes in motivation are checked before and after the message intervention.

The results of the experiment have shown that it is possible to determine the type of effective messages for each user's motivational state. It implies we can lead people to the desired motivation by understanding their motivational state and providing interventions according to that motivation.

In the future, it is planned to check whether extending the duration of the experiment or increasing the number of subjects would change the results of the experiment, especially from viewpoints of messages provided according to long-term strategies. In addition, although the primary goal is limited to research activities in this study, it is necessary to verify whether effective interventions differ when other primary goals are used, such as well-being.

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Authors contributions

Mr.Rintaro Kataoka was responsible for study design, data analysis, and the draft of the manuscript. Prof.Hiromitsu Shimakawa and Prof.Fumiko Harada revised the study and the draft. All authors read and approved the final manuscript. All authors contributed equally to the study, discussing in a daily manner.

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Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Obtained.

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The Publication Ethics Committee of the Redfame Publishing.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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