

Natural Language Stage of Change Modelling for "Motivationally-driven" Weight Loss Support

Selina Meyer

selina.meyer@ur.de Chair for Information Science, University of Regensburg Regensburg, Bavaria, Germany

ABSTRACT

Motivational factors play a significant role in weight loss. Providing appropriate support based on an individual's motivational level could be a deciding factor in weight loss success. Considering the high cost of obesity to public health care, a system with the ability to assess motivation could benefit individuals and the public alike. As self-report measures are not always available and would be tedious to use on a regular basis, one way to achieve this understanding could be the interpretation of natural language. This project studies the feasibility of using conversational agents to measure motivation by engaging users in natural conversation during weight loss. This approach could be a good means of tracking motivation, as it is cheap and accessible and can model motivation in a more natural and engaging way than self-report measures.

CCS CONCEPTS

Human-centered computing → Natural language interfaces;
 Computing methodologies → Information extraction; • Applied computing → Sociology.

KEYWORDS

Conversational AI, Empathetic Dialogue, Weight Loss, Motivation

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1 INTRODUCTION

In recent decades, overweight and obesity have become a growing societal problem. According to the World Health Organization's most recent estimates, 39% of the world's population are overweight and 13% are obese [36]. At the current rate, we can expect the global obesity rate to rise to 20% by 2025 [37]. Weight problems can decrease quality of life and put individuals at increased risk for various other diseases such as coronary heart disease, type 2 diabetes and cancer and increase overall mortality [5]. As a result,



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ICMI '21, October 18–22, 2021, Montréal, QC, Canada © 2021 Copyright held by the owner/author(s). ACM ISBN 978-1-4503-8481-0/21/10. https://doi.org/10.1145/3462244.3481279 more than 13% of global total healthcare expenditure is attributable to high BMI [37].

While a wide variety of treatment options and weight loss programmes exist [13, 15, 33], most non-surgical treatments tend to suffer from a high dropout rate, resulting in relatively low success rates [2, 16, 20]. Even though factors that influence weight and weight loss are manifold and cannot be reduced to a single predictor [5, 10], we know that motivational factors, such as a person's readiness to change and self-efficacy, are crucial elements to weight loss success [21, 31, 32, 35]. Motivational intervention is showing promise in weight loss treatment [29] and counselling approaches such as Motivational Interviewing (MI) have been used in the context of physical activity and nutrition for some time [6].

Depending on a person's level of motivation and stage of change, different treatment methods are best suited to support behavioural changes [1]. For instance, to encourage people with lower motivation levels and high degrees of ambivalence, the first priority should be to resolve this ambivalence, while individuals with higher levels of motivation and in later stages of change will benefit more from developing specific skills and planning further steps in their behaviour change [1, 6, 23]. However, motivation and related concepts undergo frequent fluctuations during prolonged behaviour change as it is required in weight loss, which can often result in relapses or retrograde steps [3, 27, 32]. In clinical studies exploring the relationship between motivation and weight loss success, motivation is usually measured using one or several multi-item self-report questionnaires, i.e. [8, 29, 34]. This approach is not feasible in practice, however, as behaviour change is inherently difficult [3] and additional workload should arguably be kept to a minimum. Expecting clients to fill out long questionnaires on a regular basis may thus in itself become an inhibitor to motivation and sustainable behaviour change.

Traditional counselling approaches such as MI successfully rely on natural conversation as a means to recognize motivation and readiness to change [6, 23]. Thus, natural language together with the framework provided by such a counselling approach could offer valuable clues to an individual's level of motivation. Consequently, a conversational agent (CA) that maintains dialogue with individuals during weight loss may be a good means of tracking motivational levels in a naturalistic and engaging way, hence eliciting useful information that can enable the CA to provide appropriate support and interventions.

In order to build such a system, it is first necessary to learn how exactly motivational levels and stages of change can be mapped to natural written conversation. To achieve this, different features of natural language may be explored as predictor variables for motivation. It will also be important to explore differences between human-human conversation and human-chatbot conversation in this context. While research shows, that self-disclosure to a chatbot has the same effects as to a person [18], we also know that human-chatbot communication is typically expressed in a different way than human-human communication [17]. Consequently, this project is driven by the following research questions:

- *RQ1*: How is weight loss motivation voiced in written conversation?
- *RQ2*: How much and what context is necessary to understand individuals' motivational levels during weight loss, or more specifically:
 - a. What features help predict a person's current motivation for and thoughts about weight loss?
 - b. Can a person's motivational level and stage of change be predicted by their utterances?
- *RQ3*: How can fluctuation in motivation over time be modeled, measured and recognized?
- *RQ4*: In what ways does written articulation of motivation change in human-chatbot interaction?

2 BACKGROUND AND RELATED WORK

Most technology-delivered weight loss support systems focus on meal and activity tracking, information initiatives or gamification strategies [4, 19, 24, 26]. However, such systems do not aim at understanding the user or the emotional and motivational processes involved in weight loss. As such, they are unable to adapt to a user's individual needs and deal with common fluctuation in motivation. They mainly aim at facilitating weight loss as long as the user is "on-track" and largely disregard the problem of attrition common in most weight loss programmes.

In contrast, MI heavily relies on understanding and supporting individuals in the process of change [23]. Originally developed for addiction treatment, it has since been successfully applied to a large number of contexts, including weight loss therapy [6]. Its goal is to help the client to identify individual reasons for change by resolving ambivalence and thus increasing motivation and readiness to change [6, 23]. Ambivalence can be recognized by looking out for two opposing signals that help to contextualize the client's motivations and give experienced counsellors clues about the client's stage of change. The first signal, "change talk", includes all utterances, that are positively associated with the change, e.g. reasons why it is necessary, recognition of strengths that might help, trust in ability to change, concrete strategies, plans and successes, etc. As such, change talk can be seen to be a positive marker for a person's willingness to change and should be actively elicited by the qualified counsellor [6, 23]. In opposition to change talk, users may also express "sustain talk", meaning comments "that support the status quo" [6, p. 15]. This kind of talk encompasses doubts and fears associated with the change, expectations of failure, reasons or excuses why change cannot be pursued, references to past failures and attempts to play down the problem, among other things (see table 1 for examples). When ambivalence is strong, change and sustain talk often occur closely together, symbolizing the client's conflict of emotions about the impending behaviour change [23]. The transtheoretical model ties in with the concept of MI and further conceptualizes the process of behaviour change. It suggests

that people undergo different stages of change, starting with precontemplation, where a person is not aware of the necessity to change their behaviour, over contemplation, where first intents of behaviour change form and ending in maintenance and termination, where changed behaviour has been stable for a certain amount of time [27]. While the original model encompasses 6 stages of change, in the literature and corresponding questionnaires, it is sometimes reduced to 3 - 5 stages depending on the context, with precontemplation, contemplation and action as essential phases which are always present [9, 14, 23]. Being able to recognize the opposing patterns of change and sustain talk in a conversation around change and contextualize them within the transtheoretical model could be a first step towards modelling motivation.

Table 1: Examples of change talk, sustain talk and ambivalence in naturalistic written conversation data (Translated from German by the author. Data available on request.)

	Example	
change talk	"I'm worth feeling this way and I'll be damned if	
	<i>I'll ever forget it. I'm worth it.</i> " (utterance 291/10)	
	"this shapeless thick body, I just find it disgusting."	
	(utterance 671/5)	
	"Starting tomorrow, I'll be cooking for myself	
	again, so I can plan for more vegetables." (ut-	
	terance 722/14)	
sustain talk	"I just can't manage to cook healthily with the	
	money I have" (utterance 261/4)	
	"the month is not even over, but I have already	
	written it off" (utterance 869/8)	
ambivalence	"I am a regular carbohydrate junkie. I do not want	
	it myself, but just can't get it together." (utter-	
	ances 333/3-4)	

There has been research on the effects of MI administered by CAs, which generally showed positive impacts on participants [7, 11, 25, 28]. However, so far this approach has largely been used to guide CAs actions. We believe, that in order to successfully deliver automated MI and helping people in their behaviour changes and weight loss journeys, it is important to gain an in-depth understanding of the processes involved in behaviour change and how different states of mind and motivational levels are communicated by the individuals undergoing the change. To achieve this, we plan to employ concepts from MI in such a way, that we can reach a true understanding of a user's motivational level and current stage of change through their interaction with a CA. To the author's knowledge there is currently very little research focusing on recognizing and interpreting motivational levels via natural language processing. In fact, we could only find very little research on the automatic modelling of motivation in general, regardless of context and used predictors [12, 22]. In a study exploring natural language processing methods to code MI, classification of change talk and sustain talk was unreliable, with kappa agreement between algorithms and humans ranging only between 0.2 and 0.3 [30]. Improving on these results and finding a way to reliably code user utterances automatically would be a first step towards understanding the user

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and thus towards being able to offer emotional support tailored to the user in a given situation.

3 RECOGNIZING MOTIVATION AND STAGES OF CHANGE

We hypothesize that, given enough information, it is possible to automatically deduct a person's level of motivation and stage of change by interpreting their utterances, for example by the presence and absence of change and sustain talk. As a first step towards recognizing such utterances, we crawled naturalistic written conversation data from Germany's largest weight loss forum "adipositas24.de" ¹. The posts were written between May1st, 2006 and July 31st 2020 and sourced from two sub-forums related to weight loss without surgery. Detailed examination of the posts revealed two main purposes of posting in the forum:

- P1. To share and receive practical and factual information and strategies
- P2. To seek or provide emotional support, and share motivation, success and setbacks

We first identified posts, which were related to motivation, meaning that they contained at least one instance of change talk or sustain talk. Only 17% of posts (1.222) were found to relate to motivation. The other posts were largely part of P1. In some cases, they had nothing to do with weight loss at all and were thus deemed as irrelevant for this research.

In order to address *RQ1*, the remaining "motivation posts" will be annotated on a sentence to sentence basis using four first-level categories: *1. Change Talk, 2. Sustain Talk, 3. Nothing, 4. Both/Ambivalence.*

3.1 Change talk recognition and scaling

Once enough posts have been annotated, we plan on applying machine learning algorithms as a means to recognize change and sustain talk in written conversation. In this, we aim to improve on [30]'s approaches and results, by applying up-to-date transformer models, which are likely to yield better results than the RNN and DSF tested in the cited work. Additionally, by solely focusing on client codes (change and sustain talk) and leaving out counsellor codes, which were also subject of annotation in [30], we limit the algorithm's scope and the number of labels, which is likely to increase prediction accuracy. The classifier will also be tested on content from other sub-forums, to ensure a certain degree of context independence. We are also considering semi-supervised learning as a way to achieve scalability of our dataset. Having a larger dataset for reference will help with user utterance classification in later stages of the project and also serve as a control sample that identifies the system's ability to correctly classify utterances outside of our small initial dataset.

3.2 Mapping utterances to motivational levels

To explore if and how a person's stage of change can be estimated by their utterances, we are planning a crowd-sourcing study in which overweight and obese participants will be required to complete a questionnaire measuring their stage of change [14], after which they will be presented with sentences of the annotated forum data and asked to what extend they agree with the statements and how likely it is that they would write something similar in their specific situation. This step will help to address RQ2 as we will gain insight on what kind of utterances are likely to be voiced in the different stages of change.

3.3 Modelling fluctuations in motivation and providing "motivationally-driven" support

Results from the study could help us estimate a person's stage of change by interpreting their utterances. The information gained can be put to use by creating a rule-based chatbot that has two main purposes:

• Measure motivation and its fluctuations over time

Each user utterance could be allocated a motivation-score. When calculating this score, we could take into account how likely it is that a person in a certain stage of change voices such an utterance, as indicated by the results of the study outlined in 3.2 as well as how the utterance is classified. As a simple example if the user writes "this shapeless thick body, I just find it disgusting." (see table 1), the system would first check, for which stage this is a typical sentence and then for instance attribute it to the contemplation phase, thus giving it 0 points (see table 2). Next, it would classify the statement as change talk and add 2 points, to get a motivation score of 2. The weighted mean of all user-utterances, where more current

Table 2: Example motivation score calculation

likely stage	+	type of utterance
precontemplation (-1)		sustain talk (-1)
contemplation (0)		nothing (0)
action (+1)		both (+1)
		change talk (+2)

utterances are weighted stronger than less recent ones, can then be used to estimate the user's stage of change or motivational level. How many points to allocate to the different stages and utterance types will be defined later on. We will have to consider whether the stage and type of utterance should be weighted differently and how fine-grained the motivation score should be. This highly depends on the results of the crowd-sourcing study. Once functional, this approach could yield information about motivational fluctuations over time and, if tested on enough users over some time, might allow us to identify different "change-types" and thus help to answer *RQ3*.

• **Provide motivationally-driven weight loss support** Based on the estimated stage of change, and how motivation has been developing, the chatbot could then employ different support strategies (see table 3). This requires the motivational level to constantly be re-evaluated by the system.

4 CONCLUSION

This abstract outlines doctoral research in its beginning stages. We described a tentative research plan and the initial data collection which mainly serves as preparation for the remaining project. Our goal is to gain a deeper understanding of motivation and use this understanding to provide motivationally-driven support in the specific context of weight loss. To achieve this, we are planning to apply

¹https://www.adipositas24.de

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Table 3: Strategies to use in different motivational stages

Stage	Strategy	
low motivation/	Raise awareness	
precontemplation	Get Person to talk about prob-	
	lems their weight causes them	
increasing motivation/	Reinforce change talk	
contemplation	Give examples of benefits losing	
	weight could have	
high motivation/	Set goals	
action	Track achievements	
	Plan weight loss strategies	
decreasing motivation/	Raise awareness	
relapse	Remind of past achievements	
	and current successes	
	Reinforce change talk	

concepts from established counselling methods to natural language processing. We hope that this new approach can add to the existing research and improve the efficiency and capacity for empathy of automated weight loss support by adding a deeper understanding of motivation and its underlying processes and fluctuations.

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