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COLLEGE OF INFORMATION SCIENCES AND TECHNOLOGY

DEVELOPMENT AND ANALYSIS OF AI GENERATED MOTIVATIONAL HEALTH
INTERVENTION CONTENT USING PROMPT ENGINEERING ARCHITECTURE

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Abstract

Over 70% of adults in the United States are insufficiently active. While effective interventions often require personalization, current approaches to motivational messaging mostly rely on manual generation of intervention messages, which is not scalable. To address this pitfall, this thesis investigates the generation and effectiveness of AI-generated motivational health messages through the lens of GAIMPLAY (Generative AI to Motivate Physical ActivitY), a novel, theory-informed prompt engineering methodology designed for the tailored creation of motivational content. This research utilizes natural language processing (NLP) tools for a quantitative analysis of sentiment, readability, and text comparisons, assessing the effectiveness of prompt chaining in generating tailored motivational content. Additionally, the thesis evaluates the utility of quantitative NLP metrics in the analysis of AI-generated health messaging, aiming to bridge the gap between the need for personalization in health interventions and the scalability challenges of manual message generation.

Table of Contents

List of Figures	iv
List of Tables	v
Acknowledgements	vi
1 Introduction	1
1.1 Introduction	2
1.2 Research Objectives	2
2 Background	3
2.1 Motivational Health Messages	4
2.1.1 PAMF Framework	4
2.1.2 Potential of Generative AI	4
2.1.3 Personalization	4
2.1.4 Prompt Chaining	4
2.2 Analyzing Text Generated Messages	5
2.2.1 Existing Research	5
3 Methods	6
3.1 GAIMPLAY Architecture	7
3.1.1 Theory-Driven Generation	7
3.1.2 Personalized Message Generation	8
3.1.3 Chaining	8
3.2 Message Analysis	8
3.2.1 Overall Message Analysis	8
3.2.2 Chaining Message Analysis	10
4 Findings/Results	11
4.1 Overall Message Analysis Results	12
4.1.1 Motivation Effectiveness Results	12
4.1.2 Sentiment Analysis Results	14
4.1.3 Readability Analysis Results	18
4.2 Chaining Message Analysis Results	24
4.2.1 Content Generation (Prompt 1, Prompt 2) Analysis Results	24

4.2.2	Content Rewriting (Prompt 2 to Prompt 3) Analysis Results	25
4.2.3	Tailoring Rewriting (Prompt 3 to Prompt 4) Analysis Results	26
4.3	Summary of Results	29
5	Discussion and Implications	30
5.1	Research Intentions	31
5.2	Motivational Messages Implications	31
5.2.1	Unchained vs. Chained with respect to PAMF Framework Discussion . . .	31
5.2.2	Sentiment	31
5.2.3	Readability	32
5.2.4	Chaining Overall	32
5.3	NLP Scoring Effectiveness	32
5.3.1	Positive Takeaways	32
5.3.2	Negative Takeaways	33
5.3.3	Analysis of Metrics	33
5.4	Future Work	34
6	Conclusion	35
6.1	Conclusion	36
	Bibliography	37
	Appendix	39

List of Figures

3.1	Visualization of GAIMPLAY Architecture	7
4.1	Positive Sentiment Word Cloud	15
4.2	Negative Sentiment Word Cloud	15
4.3	Comparison of Sentiment Scores in Unchained and Chained Messages	16
4.4	Comparison of Sentiment Scores Among Tailoring Groups for Unchained Messages	17
4.5	Elementary Flesch-Kincaid Grade Levels Word Cloud (3 to 8)	20
4.6	High School Flesch-Kincaid Grade Levels Word Cloud (8 to 12)	20
4.7	College Flesch-Kincaid Grade Levels Word Cloud (12 and up)	20
4.8	Comparison of Flesch Reading Ease Scores in Unchained and Chained Messages .	21
4.9	Comparison of Flesch-Kincaid Grade Level Scores in Unchained and Chained Messages	21
4.10	Comparison of Flesch Reading Ease Scores Among Tailoring Groups for Un- chained Messages	22
4.11	Comparison of Flesch-Kincaid Grade Level Scores Among Tailoring Groups for All Messages	23
4.12	Comparison of Flesch-Kincaid Grade Level Scores Among Tailoring Groups for Chained Messages	23
4.13	Comparison of Flesch-Kincaid Grade Level Scores Among Tailoring Groups for Unchained Messages	24
4.14	Prompt 1 Word Cloud	25
4.15	Prompt 2 - Prompt 1 Word Cloud	25
4.16	Comparison of Prompt 1 to Prompt 2 and Prompt 2 to Prompt 3 Scores	26
4.17	Cosine Similarity Tailoring Scores	27
4.18	Bert F1 Tailoring Scores	28
4.19	Jaccard Index Tailoring Scores	28
4.20	BLEU F1 Tailoring Scores	29

List of Tables

4.1	PAMF Analysis of Motivational Messages, Chained	12
4.2	PAMF Analysis of Motivational Messages, Chained	13
4.3	PAMF Analysis of Tailored Motivational Messages, Unchained	14
4.4	Comparison of Sentiment Scores for Unchained and Chained Messages with respect to Tailoring	15
4.5	Comparison of Flesch Reading Ease Scores for Unchained and Chained Messages with respect to Tailoring	18
4.6	Comparison of Flesch-Kincaid Reading Level Scores for Unchained and Chained Messages with respect to Tailoring	19
4.7	Prompt 1 to Prompt 2 Difference Scores	25
4.8	Prompt 2 to Prompt 3 Difference Scores	26
4.9	Prompt 3 to Prompt 4 Difference Scores	27
A.1	Chained Final Messages	39
A.2	Unchained Final Messages	50
A.3	Word clouds analysis with respect to Demographics/Chaining	62

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Chapter 1

Introduction

1.1 Introduction

In recent years, the field of generative Artificial Intelligence (AI) has seen a significant surge in popularity and application, particularly in the realms of chatbots and image-generation tools [1]. This growing trend has not only transformed the way we interact with technology but has also opened up new avenues for scalable tailored care in healthcare. Among these, the use of AI for crafting tailored motivational messaging stands out as a promising development. However, despite its potential, due to its novel nature, applying generative AI to motivational messaging has yet to be explored thoroughly.

Traditional evaluation of motivational messages relies heavily on human surveys [17]. This thesis, however, proposes an innovative approach: using advanced Natural Language Processing (NLP) for a quantitative evaluation of AI-generated motivational messages. This methodology offers a thorough assessment of the effectiveness of AI systems in delivering personalized and impactful motivational content.

Currently, there is a notable gap in quantitative analysis in the research surrounding AI generated content and its application in motivational messaging. This paper aims to bridge this gap, highlighting the potential of generative AI as a means to enhance mental and emotional well-being in the digital era while underscoring the feasibility of using computational analysis to evaluate such technologies.

1.2 Research Objectives

In the United States, over 70% of adults fall short of meeting the recommended guidelines for physical activity [17], presenting a critical public health issue. Motivational health messaging has emerged as a key strategy to combat this issue. Yet, the development of such messages often encounters a significant challenge: they must either be designed to broadly resonate, sacrificing individual relevance, or be custom-tailored to each individual, a process that proves to be exceedingly demanding for experts.

The digitization of motivational health messaging introduces additional hurdles, including the burden on users and the complexities of personalization. This study aims to leverage generative AI's capabilities to establish a theoretically informed prompt architecture. This architecture is intended to facilitate the zero-shot generation of motivational health messages, customized for each recipient. The overarching goal is to enhance the accessibility of digital health interventions across varied segments of the adult population by automating content personalization through AI [12].

Chapter 2

Background

2.1 Motivational Health Messages

2.1.1 PAMF Framework

In this research, we used the Physical Activity Messaging Framework (PAMF) [18] to guide our content generation. The PAMF is a validated tool designed to support the creation and evaluation of physical activity messages. It was developed using concepts identified in a scoping review of PA messaging [17], drawing from relevant theory and existing frameworks [3, 13] and through consultation with researchers, policymakers and practitioners. The PAMF specifies that messages should include information about what type of physical activity to do as well as why and how an individual might do it.

2.1.2 Potential of Generative AI

Generative AI has emerged as a promising tool for curating health intervention content at-scale. Prior work has demonstrated the feasibility of using generative AI models to write messages to persuade people to receive the COVID19 vaccine [8] and promote health awareness [9, 15]. Cox et al. [4] also investigated crowd-sourced and zero-shot prompting approaches to generate diverse motivational messages to promote physical activity. This research builds upon these foundations, aiming to combine generative AI with theory-driven prompts to generate impactful motivational messages.

2.1.3 Personalization

The existing body of work underscores the capabilities of generative AI in health content creation, primarily through few-shot prompting techniques that rely on pre-existing examples of human-written messages. Furthermore, limited work has investigated the ability of generative AI models to personalize content based on recipient characteristics [11] despite there being a large body of evidence to support the value of personalization in improving outcomes of health interventions [17, 16].

2.1.4 Prompt Chaining

As the field of generative AI grows, so does research behind prompting techniques for this technology. Prompt chaining, as explored by Wu et al., is a novel technique that offers a structured approach that could significantly enhance the generation and customization of health-related messages. The process of chaining involves sequentially linking prompts, where the output of one step informs the input of the next, thereby creating a logical and coherent progression of ideas. This method leverages the inherent capabilities of generative artificial intelligence (AI), enabling the system to produce more contextually relevant and personalized messages [19].

One of the key benefits of employing prompt chaining in this context is the ability to intricately tailor messages to specific audiences or individuals. By breaking down the message generation process into smaller, manageable tasks, each focused on a specific aspect of the motivational message (e.g., identifying the audience, specifying the activity, highlighting benefits, and providing actionable advice), it is possible to achieve a higher degree of personalization. Additionally, it

provides a transparent framework for message generation, where the logic and reasoning behind each step are explicit, making it easier to adjust and optimize the messages based on feedback or additional insights [19].

2.2 Analyzing Text Generated Messages

Previous research on evaluating motivational health messages has predominantly utilized human surveys to assess their effectiveness. While these surveys are instrumental in gauging motivational impact, the process of developing surveys, obtaining approvals, distributing them, and then collecting responses can be considerably time-consuming. Furthermore, when the sample sizes are limited, there's a potential for bias in the findings. Recent studies, however, have illustrated the feasibility of employing natural language processing (NLP) metrics to analyze AI-generated content [10, 6]. These quantitative assessments offer a faster means of evaluation, avoiding the delays and potential biases associated with smaller participant pools.

2.2.1 Existing Research

In a study that explored the use of AI to foster health awareness, the evaluation of both human-generated and AI-generated content was facilitated through the application of various quantitative metrics, including N-gram analysis, semantic analysis, readability analysis, topic modeling, and sentiment analysis [10]. This demonstrates the efficacy of such metrics in scrutinizing and contrasting AI-generated materials, albeit in a distinct context. Additionally, another research investigating the comparison between human and AI-generated radiology reports employed metrics such as Cosine Similarity, Sequence Matcher Similarity, Different Token Count, BLEU (Bilingual Evaluation Understudy), and BERTscore (Bidirectional Encoder Representations from Transformers score) [6], underscoring the potential of quantitative measures in the analysis of AI-produced content.

Chapter 3

Methods

3.1 GAIMPLAY Architecture

In this paper, we present GAIMPLAY (Generative AI to Motivate Physical Activity) – a novel, theory-informed prompt engineering architecture to develop personalized, principle-based messages to promote physical activity. We developed a prompt engineering architecture to structure queries that can develop intervention content with fidelity to a theory of behavior change that is acceptable to representatives of the targeted sub-population and free of bias. We borrow from recent advances using AI chains [19] to develop transparent and controllable human-AI interactions by identifying primitive tasks for content generation and progressively building on them to develop content. In our text generation architecture, the primitive tasks consist of 1) identifying a short-term benefit of physical activity (e.g., feeling revitalized, improving cognitive function), 2) adding a self-regulatory prompt for physical activity (e.g., set a goal for today, make a plan, or contact a friend who will encourage you), 3) formatting in the style of a text message, and 4) personalizing based on the intended recipient’s age, gender, and health concern [12].

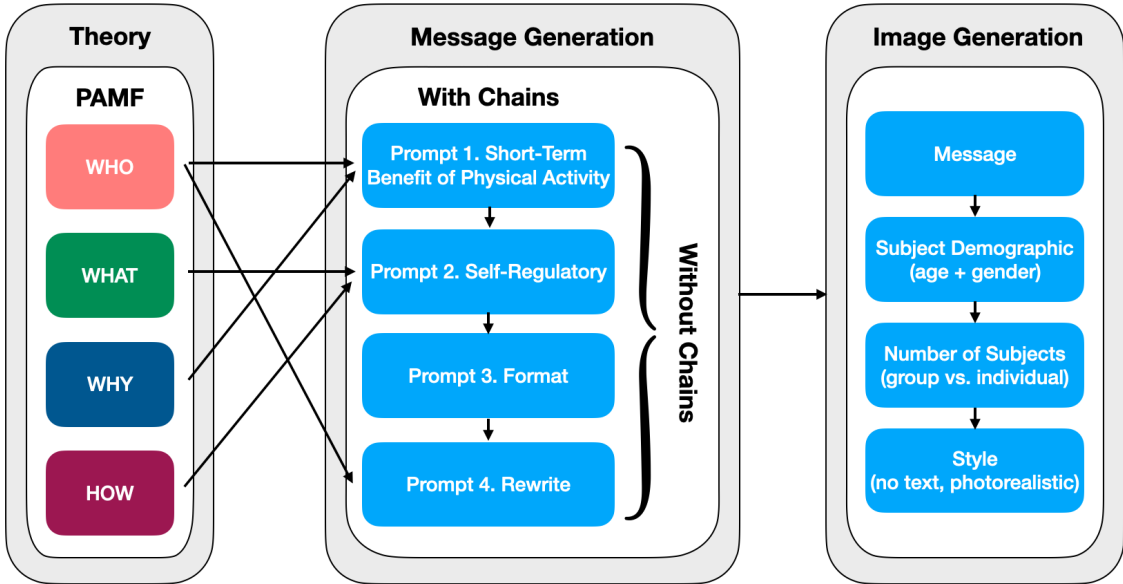


Figure 3.1: Visualization of GAIMPLAY Architecture: GAIMPLAY uses a theory-informed approach to generate personalized messages to motivate physical activity. We used PAMF [18] to identify requirements for message content and inform our message generation process. For message generation, we prompted GPT-4 using two different approaches (with and without chaining) to understand the utility of AI chains for this application. For image generation, while it is not detailed in this thesis, we used DALL-E 3.

3.1.1 Theory-Driven Generation

We used the Physical Activity Messaging Framework (PAMF) [18] to guide our content generation. The PAMF is a validated tool designed to support the creation and evaluation of physical activity messages. It was developed using concepts identified in a scoping review of PA messaging [17], drawing from relevant theory and existing frameworks [3, 13] and through consultation with researchers, policymakers and practitioners. The PAMF specifies that messages should include

information about what type of physical activity to do as well as why and how an individual might do it. We followed these guidelines from PAMF for our message generation steps [12]

3.1.2 Personalized Message Generation

The primary motivation of this work is to capitalize on the potential of generative AI to rapidly generate personalized content for health message libraries on a large scale. There is a large body of evidence to support the value of personalization in improving outcomes of health interventions [16, 17]. To inform our generation of personalized messages, we selected relevant variables identified in prior work [17]. Specifically, we personalized content based on age (young, middle-aged, senior), gender identity (man, woman), and health concern (healthy, diabetes, cardiovascular disease, cancer) [12].

3.1.3 Chaining

Building on recent work on AI chaining [19], we wanted to compare messages generated using a chaining approach (i.e. the output of each prompt is used as input for the next prompt in the sequence) vs. without chaining (i.e. all prompts are provided as a single instruction with no breaks in between). We developed the following prompts in alignment with our guiding theoretical framework (i.e. PAMF) and personalization dimensions:

- **Prompt 1:** Write 30 messages that identify a short-term benefit of physical activity.
- **Prompt 2:** Add a self-regulatory prompt for physical activity to each message. The self-regulatory prompt can involve setting a goal to be active that day or encouraging the recipient to contact a friend who will encourage them to be active.
- **Prompt 3:** Add a hook to make the messages interesting, and fit each message in less than 200 characters.
- **Prompt 4:** Rewrite these messages in the style of a {age} {gender}.

All messages were generated using GPT-4 with temperature set to 0. This choice was made in an effort to support the replicability of our approach despite the non-deterministic nature of generative AI models. Due to the exploratory nature of this work, we limited generation to 10 messages per age/gender sub-group [12].

3.2 Message Analysis

3.2.1 Overall Message Analysis

The comprehensive analysis of the generated messages was conducted through multiple lenses to ensure a robust evaluation. Initially, each message was scrutinized to verify its adherence to the input prompts, with a specific focus on crafting motivational health messages. This step involved a meticulous comparison against the Physical Activity Messaging Framework (PAMF) [18], aiming to validate the integrity of zero-shot message generation based on this theoretical foundation.

Additionally, the study employed word clouds to visually depict the frequency of words within each message category, delineated by their chained or unchained nature, as well as by the specific tailoring applied (Generic, Young man, Young woman, Middle-aged man, Middle-aged woman, Senior man, Senior woman). This approach facilitated an exploration of linguistic patterns and thematic shifts across the different groupings.

Sentiment Analysis

Modeling off Hasani et al. [6], we chose to analyze the sentiment of motivational messages created. To do this, we utilized the `SentimentIntensityAnalyzer` function from the Python package, `nltk` (version: 3.8.1). This function utilizes the VADER sentiment dictionary [7]. With these scores, we created word clouds to identify which words were associated with positive and negative sentiments.

To further dissect the emotional undertones of the generated motivational messages, the sentiment compound score from the `SentimentIntensityAnalyzer` function in the `nltk` Python package (version 3.8.1) was utilized. This function leverages the VADER sentiment lexicon, as introduced by Hutto and Gilbert (2014) [7], to quantify sentiment valence scores. The analysis extended to the creation of word clouds representing words associated with positive and negative sentiments, providing a graphical representation of the emotional weight of the words used in the messages.

The assessment of sentiment distribution employed the Shapiro-Wilk normality test, confirming the non-normal distribution of the data. This finding necessitated the application of the Mann-Whitney U test to discern statistically significant differences in sentiment scores between chained and unchained messages. Furthermore, to explore sentiment disparities across tailored messages with respect to age and gender, the Kruskal-Wallis test was executed. This non-parametric method assessed whether sentiment varied significantly among the different tailoring categories for both chained and unchained messages. Subsequent pairwise comparisons via the Dunn test pinpointed specific groups that exhibited significantly higher sentiment scores relative to others, enriching the analysis with a detailed exploration of sentiment dynamics across the variously tailored messages.

Readability Analysis

Again with Hasani et al. [6] in mind we also decided to analyze the readability of each message. To complete this, we leveraged the readability Python package (version: 0.3.1) to quantify the comprehensibility of each generated text. This analysis utilized the Fleish Kincaid reading ease and reading level metrics, popular for their efficacy in estimated text readability. The Fleish Kincaid reading ease scores range from 0 to 100 with scores closer to 100 indicating the message is easier to read while the reading level scores correspond to the reading grade level directly.

To enrich our understanding of the factors influencing readability scores, word clouds were generated, showing the words and word types that predominantly affect the determination of a message's reading level. This process involved the categorization of messages into three distinct readability brackets: elementary (grades 3-8), high school (grades 9-12), and college (grade 12 and above).

The Shapiro-Wilk normality test was employed to examine the distribution of the Flesch-Kincaid Reading Ease scores, ensuring the appropriateness of subsequent statistical tests. Upon

establishing the non-normal distribution of these scores, the Mann-Whitney U test was applied to explore statistically significant differences in readability between chained and unchained messages.

Further statistical examination was conducted using the Kruskal-Wallis test to assess variability in readability across seven different message tailoring conditions, evaluating the hypothesis that readability scores would vary based on tailored content. This non-parametric test was selected for its suitability in handling non-normally distributed data across multiple groups. For conditions where the Kruskal-Wallis test indicated significant differences, pairwise Dunn tests were conducted to identify specific contrasts between tailoring conditions, offering a nuanced view of how each tailoring approach influences the readability of messages in terms of both reading ease and grade level.

3.2.2 Chaining Message Analysis

Content Generation (Prompt 1 to Prompt 2) Analysis

In our chaining architecture, prompt 1 and prompt 2 both ended up being content generation steps where prompt 1 would generate the initial message and prompt 2 would simply add a sentence to the end of prompt 1. Therefore to analyze the first two prompts, created word clouds for prompt 1 and the content that was added to the end of prompt 1 in prompt 2 (prompt 2 - prompt 1).

Rewriting (Prompt 2 to Prompt 3) and Tailoring (Prompt 3 to Prompt 4) Analysis

In our investigation of the rewriting processes inherent to our architectural framework—specifically, the transitions from Prompt 2 to Prompt 3, and from Prompt 3 to Prompt 4—we adopted a suite of analytical metrics paralleling the methodologies employed by Schmälzle and Wilcox [15]. This approach facilitated a rigorous examination of the textual transformations and similarities between consecutive prompts, providing insights into the effectiveness and nuances of our rewriting steps.

The metrics selected for this analysis encompassed Cosine Similarity, Jaccard Index, BLEU Score, and BERT F1 Score, each chosen for its relevance and capacity to offer distinct perspectives on text similarity and quality of the rewriting process. All of these metrics range from 0 to 1 with scores closer to 1 indicating the messages are more similar.

For the computation of Cosine Similarity, we leveraged the Scikit-learn Python package (version 1.4.1.post1), which facilitated the measurement of semantic proximity between text vectors derived from our message prompts.

The Jaccard Index and BLEU scores were calculated using the nltk package (version 3.8.1), allowing us to assess the lexical overlap and translation quality between the rewritten texts, respectively. These metrics provided a quantitative basis to gauge the extent of modification and the preservation of semantic content throughout the rewriting process.

Finally, to ascertain the BERT F1 Score, we utilized the bert_score Python package (version 0.3.13) with the 'bert-large-uncased' model. This metric enabled a sophisticated evaluation of rewriting quality through the lens of contextual embeddings, offering a nuanced understanding of text similarity that accounts for the complex semantic relationships encoded in the BERT representations.

Chapter 4

Findings/Results

4.1 Overall Message Analysis Results

4.1.1 Motivation Effectiveness Results

Chained Messages

In our initial analysis of the effectiveness of our zero-shot chaining approach to generating motivational health messages with AI, we found our chained messages to be mostly effective at addressing the key points of that PAMF framework: who, what, how, and why [18]. Notably, we found the first prompt ("Write 30 messages that identify a short-term benefit of physical activity.") was very effective at identifying **WHY** the recipient should engage in physical activity. Furthermore, we found Prompt 2 (Add a self-regulatory prompt for physical activity to each message. The self-regulatory prompt can involve setting a goal to be active that day or encouraging the recipient to contact a friend who will encourage them to be active.) and Prompt 3 (Add a hook to make the messages interesting, and fit each message in less than 200 characters.) to both be effective at adding **WHAT** the message is asking the recipient to do and **HOW** the recipient might follow through with the recommendation (see Table 4.1).

At this stage for the chained messages, we did not find any notable differences that indicated the tailoring of the messages using only age and gender was effective at changing the messages to make them resonate with its audience better (see Table 4.2).

Prompt 1	Prompt 2	Prompt 3
Regular exercise can improve your skin health .	Regular exercise can improve your skin health . Plan to take a brisk walk during your lunch break to get your blood pumping .	Want glowing skin ? A brisk walk during lunch can do wonders. Get your blood pumping!

Table 4.1: PAMF (Physical Activity Messaging Framework) Analysis of Motivational Messages, Chained (Message #8): Each message is color-coded to reflect the integration of PAMF concepts (i.e. **WHAT** the message is asking the recipient to do, **WHY** the recipient should engage in physical activity, and **HOW** the recipient might follow through with the recommendation)

Tailoring	Message
Young man	Craving radiant skin ? A quick walk during your lunch break can work miracles. Get your circulation going!
Young woman	Desire radiant skin ? A quick walk during your lunch break can work miracles. Get your circulation going!
Middle-aged man	Desire radiant skin ? A quick stroll during your lunch break can work miracles. Get your circulation going!
Middle-aged woman	Desire radiant skin ? A quick stroll during your lunch break can work miracles. Get your circulation going!
Senior man	Desire a radiant complexion ? A brisk midday stroll can work miracles. Get your circulation going!
Senior woman	Desire radiant skin ? A brisk midday walk can work miracles. Get your circulation going!

Table 4.2: PAMF (Physical Activity Messaging Framework) Analysis of Motivational Messages, Chained (Message #12): Each message is color-coded to reflect the integration of PAMF concepts (i.e. **WHAT** the message is asking the recipient to do, **WHY** the recipient should engage in physical activity, and **HOW** the recipient might follow through with the recommendation)

Unchained Messages

In our first analysis of the zero-shot unchained motivational messages, we found the messages to be more effective at generating messages following the PAMF framework of addressing the who, what, why, and how in each message. We found similar results to the chained messages at addressing the **WHAT**, **WHY**, and **HOW** in each message, but the unchained messages did a better job at incorporating the **WHO** of each message. As seen in table 4.3, message #22 in our unchained corpus shows how for each tailoring the suggested activity changes based on who the message is tailored to. For example, a young woman is instructed to go cycling while a senior man is suggested to play shuffleboard, an exercise that could potentially be more attractive for each age group.

Tailoring	Message
Generic	"Physical activity can improve your mood . Plan a dance session and shake off the blues. Dance for delight!"
Young man	" Boost your productivity with a rowing session . Plan a row and pull your weight. Row, row, row your boat!"
Young woman	" Boost your heart health with a cycling session ! Set a goal to cycle for 30 minutes today . Pedal for your heart!"
Middle-aged man	"Physical activity can improve your mental health . Plan a walk in the park . Step into serenity!"
Middle-aged woman	"A swim can help you feel more rejuvenated . Set a goal to swim twice a week . Dive into wellness!"
Senior man	" Invite a friend for a game of shuffleboard . It's a fun way to stay active and socialize ."
Senior woman	" Pilates can help improve your balance . Schedule a session today . Balance your way to health!"

Table 4.3: PAMF (Physical Activity Messaging Framework) Analysis of Tailored Motivational Messages, Unchained (Message #22): Each message is color-coded to reflect the integration of PAMF concepts (i.e. **WHAT** the message is asking the recipient to do, **WHY** the recipient should engage in physical activity, and **HOW** the recipient might follow through with the recommendation)

4.1.2 Sentiment Analysis Results

Word Differences in Positive and Negative Sentiment Messages

After computing the sentiment score for each message, we compiled word clouds to show the words that were most common in the positive sentiment scores (0 to +1) and those with negative sentiment scores (-1 to 0) (see Figures 4.1 and 4.2). We found that the most common words in positive sentiment messages included words we would associate as being positive such as "improve", "boost", "friend", and "help". While in the negative sentiment messages it featured words that have more of a negative connotation such as "feeling", "anxiety", "stroke", "depression", "risk", and "lower". Despite many of the messages encouraging the recipient to combat or help prevent these negative terms, just having those words in the message decreases the overall sentiment of the message in the sentiment package from nltk.



Figure 4.1: Positive Sentiment Word Cloud: Word cloud showing the most common words from messages with sentiment scores from 0 to +1. Some of the most common words in positive sentiment messages included words commonly associated with being positive such as "improve", "boost", "friend", and "help".



Figure 4.2: Negative Sentiment Word Cloud: Word cloud showing the most common words from messages with sentiment scores from -1 to 0. Some of the most common words in the negative sentiment messages include words that typically have more of a negative connotation such as "feeling", "anxiety", "stroke", "depression", "risk", and "lower".

Unchained v. Chained Sentiment Results

Tailoring	Unchained, mean (SD)	Chained, mean (SD)
Generic	0.56 (0.35)	0.38 (0.44)
Young man	0.54 (0.24)	0.22 (0.45)
Young woman	0.55 (0.31)	0.27 (0.46)
Middle-aged man	0.58 (0.23)	0.16 (0.50)
Middle-aged woman	0.68 (0.19)	0.23 (0.49)
Senior man	0.81 (0.10)	0.14 (0.47)
Senior woman	0.69 (0.28)	0.35 (0.45)

Table 4.4: Comparison of Sentiment Scores for Unchained and Chained Messages with respect to Tailoring: Unchained messages contained significantly higher sentiment than chained messages ($W = 33014$, $p < 0.001$). Additionally, sentiment was not significantly different across tailoring groups for chained messages ($\chi^2 = 7.31$, $p = 0.29$, $df = 6$), but was significantly different for unchained messages ($\chi^2 = 44.96$, $p < 0.001$, $df = 6$).

After confirming that the data (see Table 4.4) was not normally distributed using the Shapiro-Wilk normality test ($W = 0.86$, $p < 0.001$), we used a Mann-Whitney U test to measure statistically significant differences in sentiment between chained vs. unchained messages (see Figure 4.3). Our results indicate a significant difference between the two groups ($W = 33014$, $p < 0.001$) where unchained messages contain higher sentiment than chained messages.

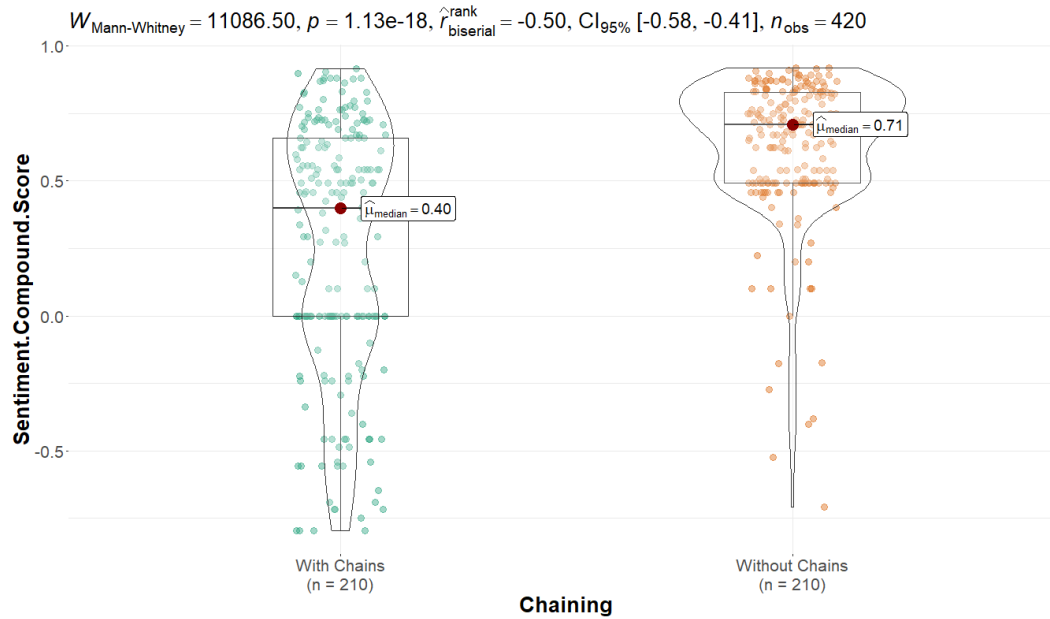


Figure 4.3: Comparison of Sentiment Scores in Unchained and Chained Messages: Unchained messages contained significantly higher sentiment than chained messages ($W = 33014$, $p < 0.001$). This figure was generated using the ‘ggstatsplot’ package in R [14].

Tailoring Sentiment Results

Using a Kruskal-Wallis test, we found that sentiment was not significantly different across age/gender groups for chained messages ($\chi^2 = 7.31$, $p = 0.29$, $df = 6$), but IS significantly different for unchained messages ($\chi^2 = 44.96$, $p < 0.001$, $df = 6$; see Figure 4.4). A pairwise Dunn test revealed that messages for senior men had significantly higher sentiment compared to every other group except senior women. Messages for senior women also had significantly higher sentiment than messages for young men.

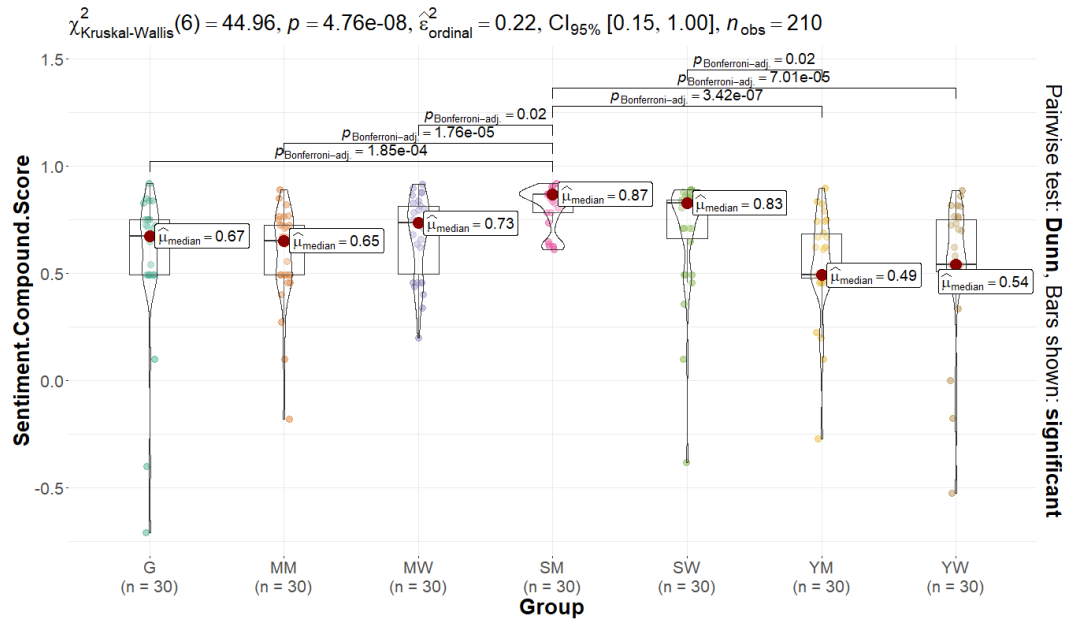


Figure 4.4: Comparison of Sentiment Scores Among Tailoring Groups for Unchained Messages: Sentiment was significantly different across tailoring groups for unchained messages ($\chi^2 = 44.96, p < 0.001, df = 6$). With respect to pairwise differences, messages for senior men had significantly higher sentiment compared to messages for every other group except senior women. Additionally, messages for senior women had significantly higher sentiment than messages for young men. This figure was generated using the ‘ggstatsplot’ package in R [14].

4.1.3 Readability Analysis Results

Readability of Messages Overall

We evaluated the readability of our message corpus using the Flesch reading ease (table 4.5) and Flesch-Kincaid grade level (table 4.6) scores. We found no messages in our corpus scored lower than 59 in terms of reading ease, indicating acceptable readability [5]. After confirming that the data for the Flesch Reading Ease scores was not normally distributed using the Shapiro-Wilk normality test ($W = 0.98$, $p < 0.001$), we used a Mann-Whitney U test to measure statistically significant differences in sentiment between chained vs. unchained messages. Our results indicate a significant difference between the two groups ($W = 28556$, $p < 0.001$) where unchained messages scored higher in terms of readability compared to chained messages. We also used a Kruskal-Wallis test to compare readability across the seven different tailoring conditions (i.e. age/gender groups). We found no significant differences across age/gender groups for chained messages ($\chi^2 = 8.23$, $p = 0.22$, $df = 6$). However, we observed significant differences across age/gender groups for unchained messages ($\chi^2 = 26.65$, $p < 0.001$, $df = 6$). A pairwise Dunn test revealed significant differences between messages for middle-aged men as compared to messages for young or senior men. Specifically, messages for young and senior men scored significantly higher in terms of reading ease compared to messages for middle-aged men. We also found that messages for young men were significantly more readable than generic messages.

Tailoring	Unchained, mean (SD)	Chained, mean (SD)
Generic	64.62 (20.47)	70.12 (15.34)
Young man	80.79 (9.11)	63.09 (13.50)
Young woman	72.89 (11.21)	65.96 (16.21)
Middle-aged man	60.46 (18.64)	64.27 (15.62)
Middle-aged woman	73.73 (11.26)	61.83 (16.15)
Senior man	76.38 (14.25)	59.69 (16.15)
Senior woman	72.17 (12.68)	60.29 (17.18)

Table 4.5: Comparison of Flesch Reading Ease Scores for Unchained and Chained Messages with respect to Tailoring: All messages scored above 59, indicating acceptable readability across the entire corpus [5]. Unchained messages scored higher in terms of readability compared to chained messages ($W = 28556$, $p < 0.001$). There were no significant differences across age/gender groups for chained messages ($\chi^2 = 8.23$, $p = 0.22$, $df = 6$). However, there were significant differences across age/gender groups for unchained messages ($\chi^2 = 26.65$, $p < 0.001$, $df = 6$).

With respect to the Flesch-Kincaid Grade Level scores, we found that our messages are readable as a whole with no message with a reading level higher than the 9th grade. Furthermore, we found a significant difference between the two groups with respect to Flesch-Kincaid Grade Level ($W = 15662$, $p < 0.001$) where unchained messages scored lower than chained messages. (c.) We used a Kruskal-Wallis test to compare readability grade level across the seven different tailoring conditions (i.e. age/gender groups). We found a significant difference in grade level for the chained ($\chi^2 = 16.61$, $p = 0.01$, $df = 6$), unchained ($\chi^2 = 31.55$, $p < 0.001$, $df = 6$), and com-

bined ($\chi^2 = 13.66$, $p = 0.03$, $df = 6$) message corpora. Results from a pairwise Dunn test reveal that, in the context of the combined message corpus, messages for middle-aged men were written at a significantly higher grade level compared to messages for young men. Pairwise Dunn for the chained message corpus revealed that generic messages scored significantly lower in terms of reading grade level as compared to messages for senior men and women as well as middle-aged women. Finally, unchained messages for middle-aged men scored significantly higher on reading grade level compared to unchained messages for middle-aged women, and senior men. Conversely, unchained messages for young men scored significantly lower on reading grade level compared to generic messages and those written for middle-aged men.

Tailoring	Unchained, mean (SD)	Chained, mean (SD)
Generic	8.42 (2.81)	7.24 (2.09)
Young man	6.45 (1.29)	8.59 (1.72)
Young woman	7.44 (1.47)	8.36 (2.03)
Middle-aged man	9.12 (2.17)	8.59 (1.96)
Middle-aged woman	7.17 (1.21)	9.02 (2.19)
Senior man	6.82 (1.88)	9.29 (2.23)
Senior woman	7.45 (1.61)	9.28 (2.38)

Table 4.6: Comparison of Flesch-Kincaid Reading Level Scores for Unchained and Chained Messages with respect to Tailoring: All messages scored at a 9th grade level or below, indicating acceptable readability [2]. Unchained messages scored significantly lower than chained messages with respect to Flesch-Kincaid Grade Level ($W = 15662$, $p < 0.001$). We found also significant differences in grade level between different age/gender subgroups for the chained ($\chi^2 = 16.61$, $p = 0.01$, $df = 6$), unchained ($\chi^2 = 31.55$, $p < 0.001$, $df = 6$), and combined ($\chi^2 = 13.66$, $p = 0.03$, $df = 6$) message corpora.

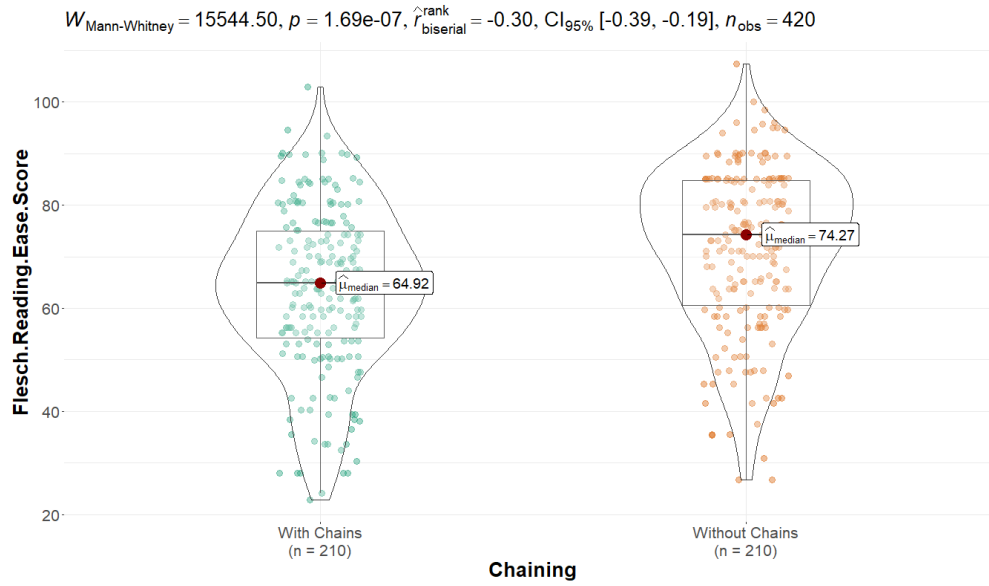


Figure 4.8: Comparison of Flesch Reading Ease Scores in Unchained and Chained Messages: Unchained messages scored significantly higher in terms of Flesch Reading Ease compared to chained messages ($W = 28556, p < 0.001$). This figure was generated using the ‘ggstatsplot’ package in R [14].

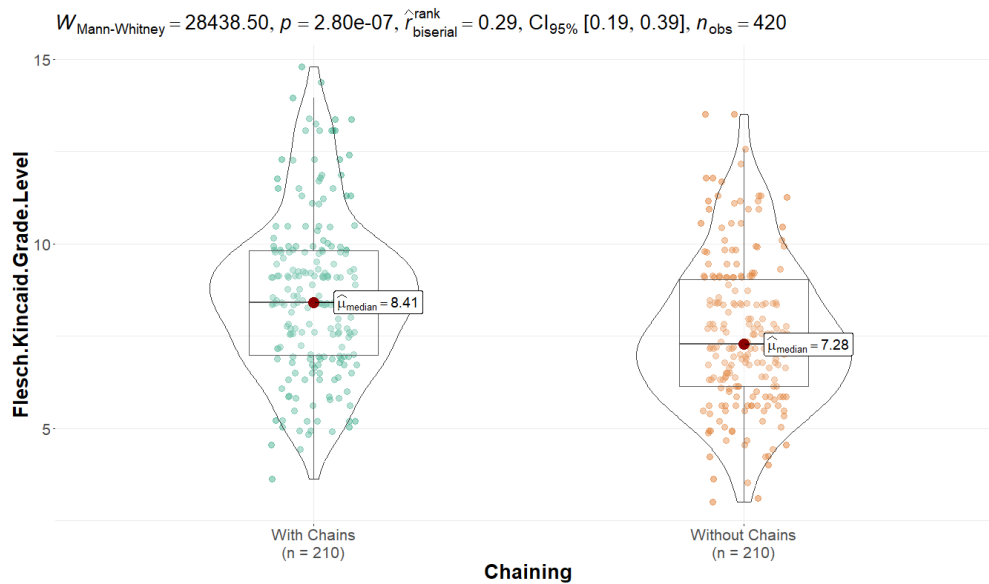


Figure 4.9: Comparison of Flesch-Kincaid Grade Level Scores in Unchained and Chained Messages: Unchained messages scored lower in terms of Flesch-Kincaid Grade Level compared to chained messages ($W = 15662, p < 0.001$). This figure was generated using the ‘ggstatsplot’ package in R [14].

Tailoring Readability Results

We used a Kruskal-Wallis test to compare readability across the seven different tailoring conditions (i.e. age/gender groups). We found no significant differences across age/gender groups for chained messages ($\chi^2 = 8.23$, $p = 0.22$, $df = 6$). However, we observed significant differences across age/gender groups for unchained messages ($\chi^2 = 26.65$, $p < 0.001$, $df = 6$; see Figure 4.10). A pairwise Dunn test revealed significant differences between messages for middle-aged men as compared to messages for young or senior men. Specifically, messages for young and senior men scored significantly higher in terms of reading ease compared to messages for middle-aged men. We also found that messages for young men were significantly more readable than generic messages.

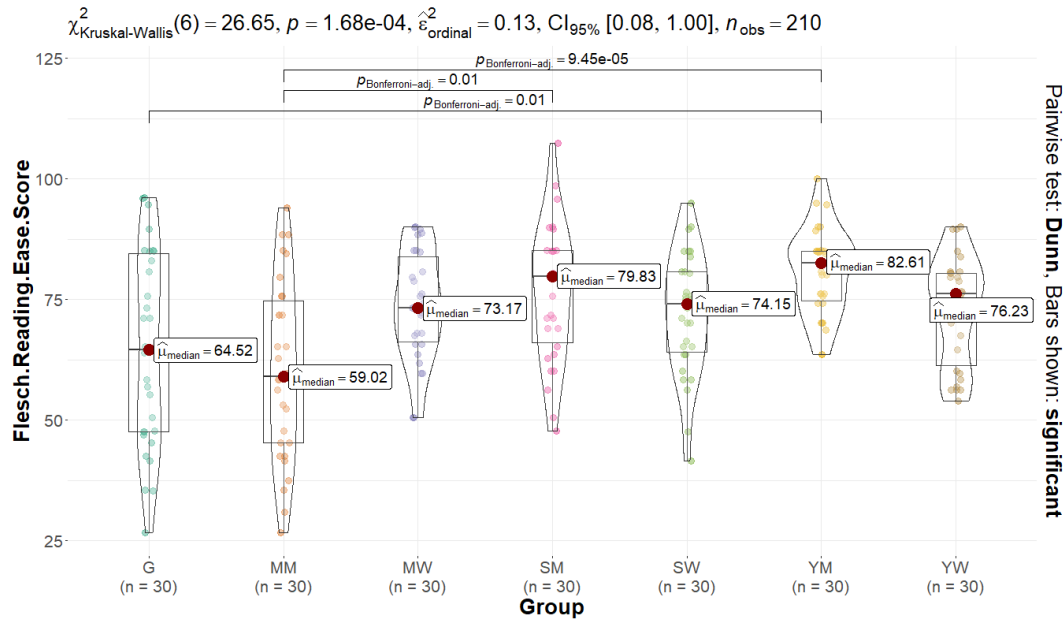


Figure 4.10: Comparison of Flesch Reading Ease Scores Among Tailoring Groups for Unchained Messages: We observed significant differences across age/gender groups for unchained messages ($\chi^2 = 26.65$, $p < 0.001$, $df = 6$). Specifically, unchained messages for young and senior men scored significantly higher in terms of reading ease compared to unchained messages for middle-aged men. We also found that unchained messages for young men scored significantly higher than generic messages. This figure was generated using the ‘ggstatsplot’ package in R [14].

We used a Kruskal-Wallis test to compare readability grade level across the seven different age/gender groups (see Figures 4.12, 4.13). We found a significant difference in grade level for the chained ($\chi^2 = 16.61$, $p = 0.01$, $df = 6$), unchained ($\chi^2 = 31.55$, $p < 0.001$, $df = 6$), and combined ($\chi^2 = 13.66$, $p = 0.034$, $df = 6$) message corpora. Results from a pairwise Dunn test reveal that, in the context of the combined message corpus, messages for middle-aged men were written at a significantly higher grade level compared to messages for young men (see Figure 4.11).

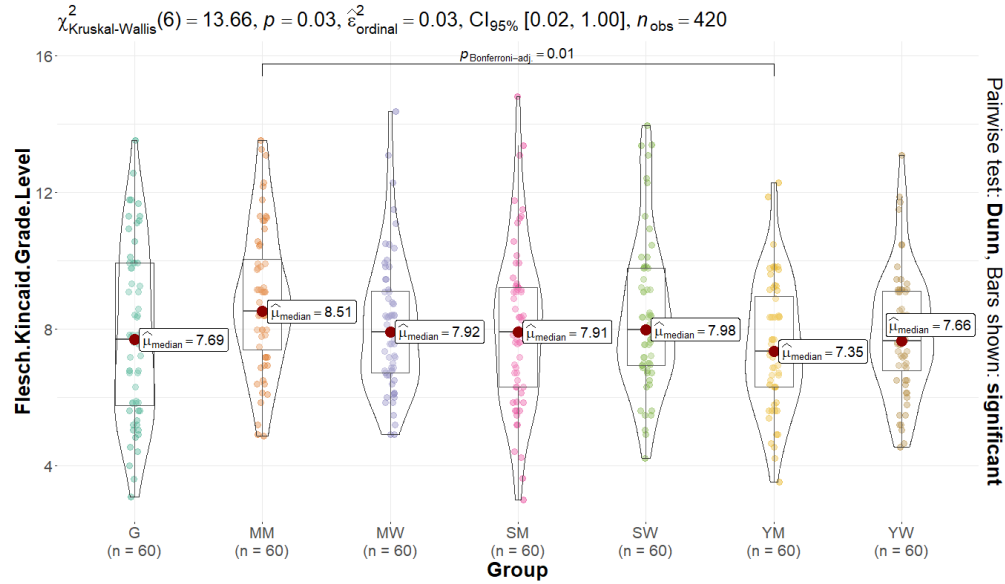


Figure 4.11: Comparison of Flesch-Kincaid Grade Level Scores Among Tailoring Groups for All Messages: Within the combined message corpus, messages for middle-aged men scored significantly higher in terms of Flesch-Kincaid Grade Level compared to messages for young men. This figure was generated using the ‘ggstatsplot’ package in R [14].

Pairwise Dunn for the chained message corpus revealed that generic messages scored significantly lower in terms of reading grade level as compared to messages for senior men and women as well as middle-aged women.

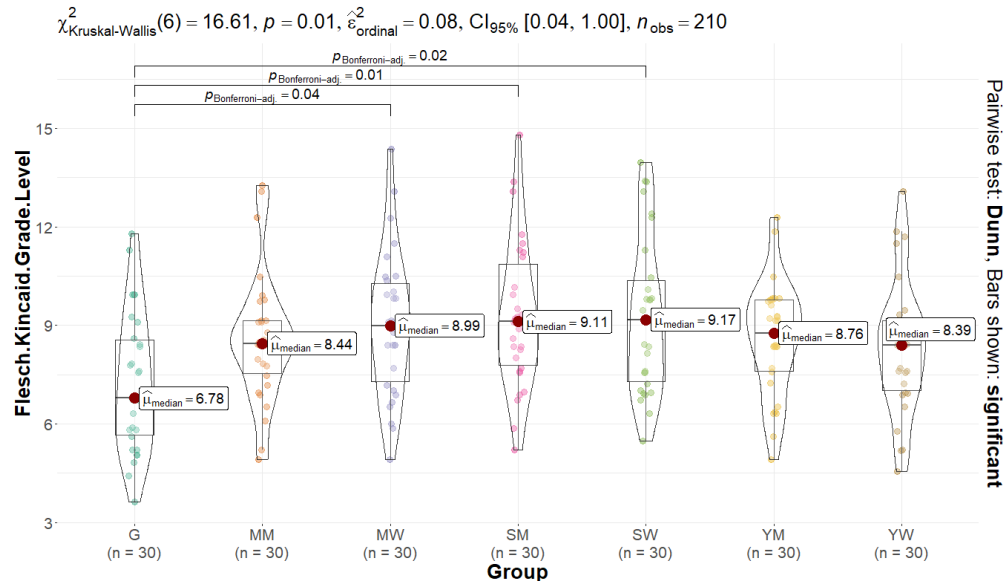


Figure 4.12: Comparison of Flesch-Kincaid Grade Level Scores Among Tailoring Groups for Chained Messages: Chained generic messages scored significantly lower in terms of Flesch-Kincaid Grade Level compared to chained messages for middle-aged women, senior men, and senior women. This figure was generated using the ‘ggstatsplot’ package in R [14].

Finally, unchained messages for middle-aged men scored significantly higher on reading grade level compared to unchained messages middle-aged women, and senior men. Conversely, unchained messages for young men scored significantly lower on reading grade level compared to generic messages and those written for middle-aged men.

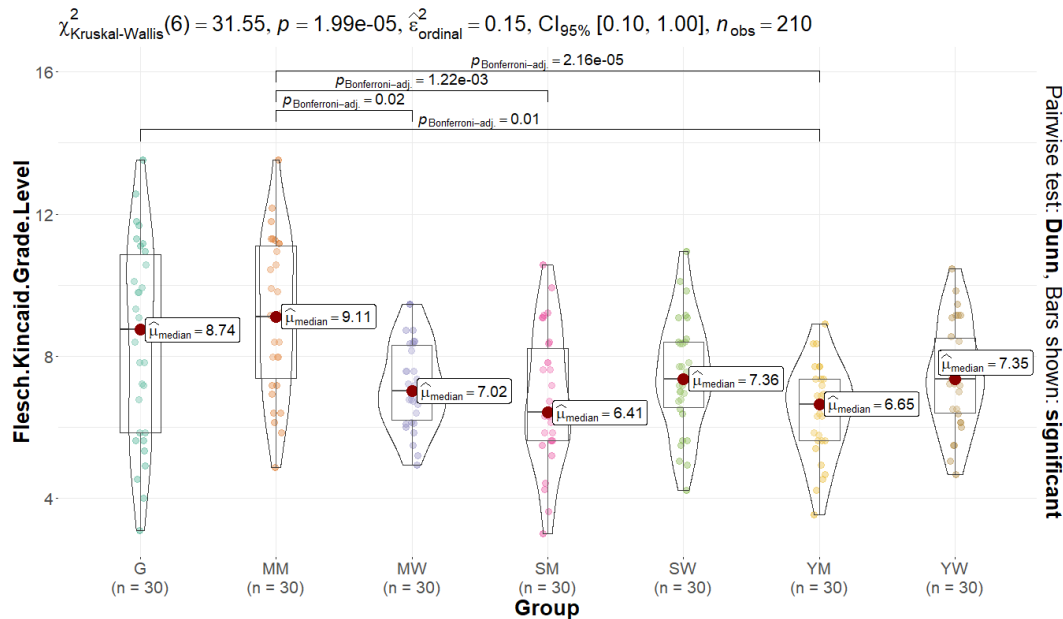


Figure 4.13: Comparison of Flesch-Kincaid Grade Level Scores Among Tailoring Groups for Unchained Messages: Unchained messages for middle-aged men scored significantly higher in terms of Flesch-Kincaid Grade Level compared to unchained messages for middle-aged women and senior men. Conversely, unchained messages for young men scored significantly lower in terms of Flesch-Kincaid Grade Level compared to generic unchained messages and unchained messages for middle-aged men. This figure was generated using the ‘ggstatsplot’ package in R [14].

4.2 Chaining Message Analysis Results

4.2.1 Content Generation (Prompt 1, Prompt 2) Analysis Results

In our chaining architecture, both prompt 1 (Write 30 messages that identify a short-term benefit of physical activity.) and prompt 2 (Add a self-regulatory prompt for physical activity to each message. The self-regulatory prompt can involve setting a goal to be active that day or encouraging the recipient to contact a friend who will encourage them to be active) ended up being content generation steps. We analyzed these results to determine the differences between prompt 1 and prompt 2 as seen in table 4.7, but upon further examination of the messages, we realized in each of the 30 messages, prompt 2 ended up simply adding a sentence or two to the end of prompt 1. To better analyze the differences in content added in prompt 1 to the content generated in prompt 2, word clouds of prompt 1 and the content added in prompt 2 (see Figures 4.14 and 4.15). It was found that prompt 1 generated more basic exercise advice with common words being "physical activity",

Value, mean (SD)			
Cosine Similarity	BERT Score	Jaccard Index	BLEU Score
0.52 (0.14)	0.71 (0.05)	0.38 (0.09)	0.14 (0.11)

Table 4.8: Prompt 2 to Prompt 3 Difference Scores: Cosine Similarity and BERT Score both showed that prompt 2 and prompt 3 were similar to each other, while Jaccard Index and BLEU Score surprisingly showed that the messages were not similar even though this step was simply a rewriting step. Cosine Similarity, BERT Score, Jaccard Index, and BLEU scores range from 0 to 1. Scores closer to 1 indicate the messages are more similar.

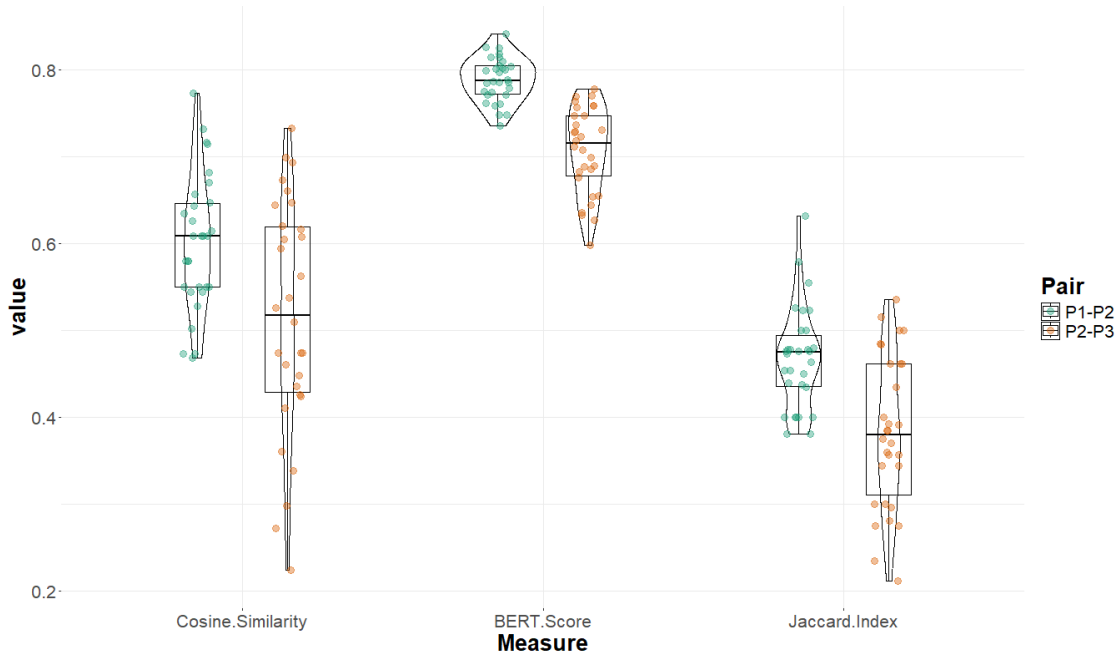


Figure 4.16: Comparison of Prompt 1 to Prompt 2 and Prompt 2 to Prompt 3 Scores: From prompt 1 to prompt 2 the comparison scores for cosine similarity and BERT score show that the messages were more similar than the messages from prompt 2 to prompt 3. Similarly, Jaccard index scores indicated that messages from prompt 2 to prompt 3 were more distinct compared to messages from prompt 1 to prompt 2. Cosine Similarity, BERT Score, Jaccard index, and BLEU scores range from 0 to 1. Scores closer to 1 indicate the messages are more similar.

4.2.3 Tailoring Rewriting (Prompt 3 to Prompt 4) Analysis Results

To analyze the tailoring rewriting step of our chaining architecture, prompt 3 to prompt 4 (Rewrite these messages in the style of a age gender.), we once again used the Cosine Similarity, Bert Score, Jaccard index, and BLUE Score metrics to analyze how much each message was changed from the previous results (see Table 4.9). We found no significant difference between any of the tailorings, but similar to our results in the content rewriting analysis, we found BERT score to be higher than the rest of the metrics and BLEU score to be lower than the rest of the results (see Figures 4.17, 4.18, 4.19, and 4.20).

Tailoring	Value, mean (SD)			
	Cosine Similarity	BERT Score	Jaccard Index	BLEU Score
Young man	0.40 (0.14)	0.84 (0.06)	0.50 (0.11)	0.29 (0.21)
Young woman	0.48 (0.18)	0.85 (0.06)	0.52 (0.11)	0.29 (0.23)
Middle-aged man	0.47 (0.19)	0.84 (0.06)	0.70 (0.22)	0.49 (0.12)
Middle-aged woman	0.52 (0.16)	0.86 (0.06)	0.56 (0.12)	0.41 (0.23)
Senior man	0.43 (0.16)	0.84 (0.06)	0.49 (0.11)	0.30 (0.20)
Senior woman	0.52 (0.21)	0.84 (0.07)	0.54 (0.16)	0.38 (0.24)

Table 4.9: Prompt 3 to Prompt 4 Difference Scores: Cosine Similarity, BERT Score, Jaccard index, and BLEU scores all showed no significant difference in scores for each tailoring group. Cosine Similarity, BERT Score, Jaccard index, and BLEU scores range from 0 to 1. Scores closer to 1 indicate the messages are more similar.

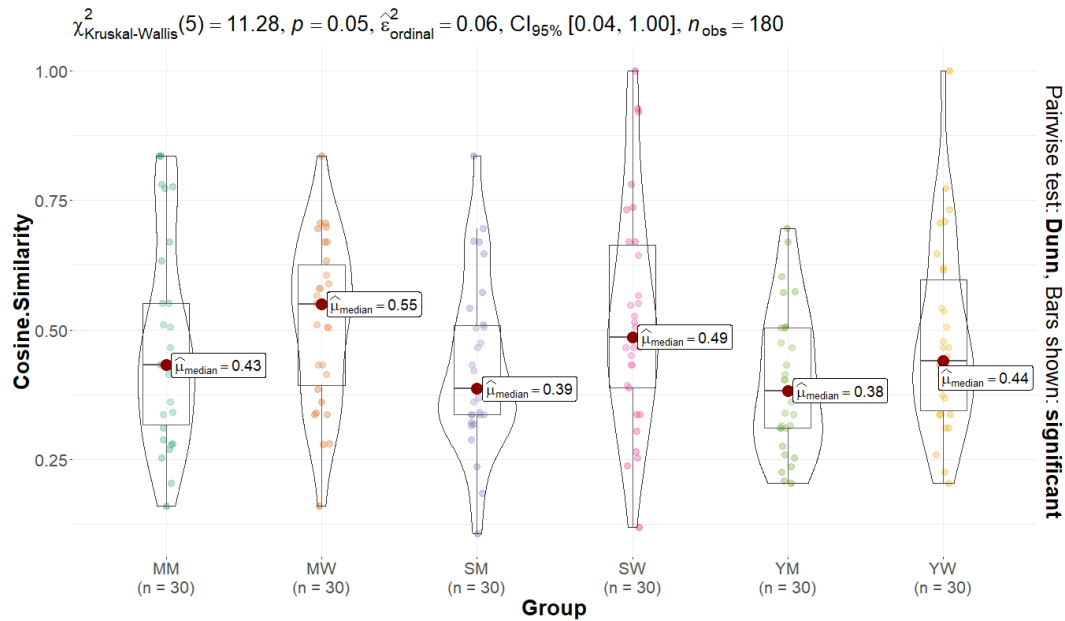


Figure 4.17: Cosine Similarity Tailoring Scores: There were no significant differences between the tailoring groups in terms of cosine similarity. This figure was generated using the ‘ggstatsplot’ package in R [14].

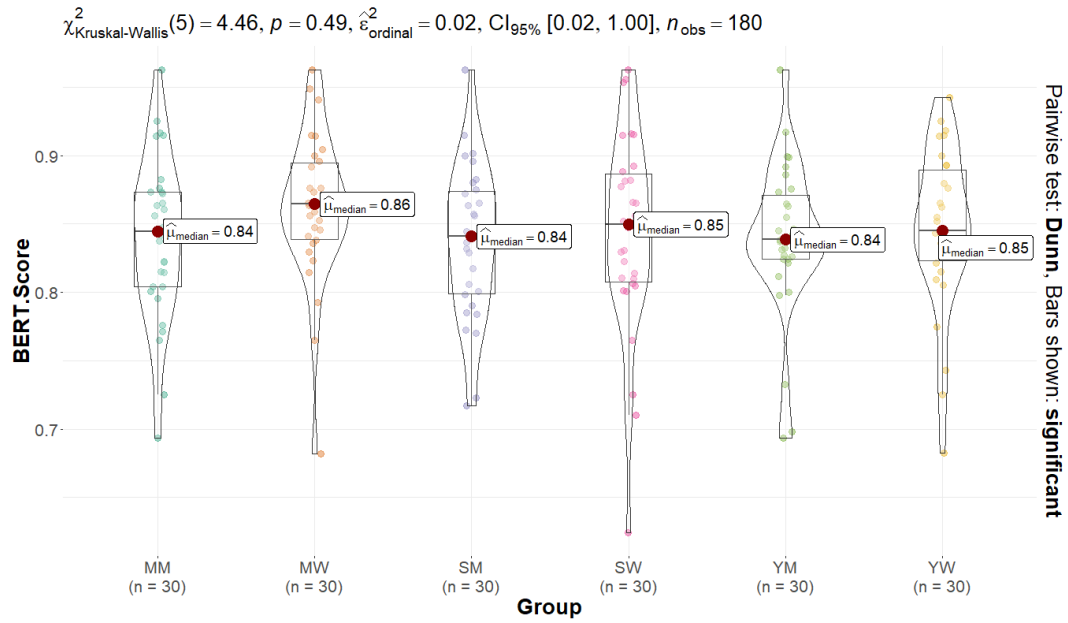


Figure 4.18: Bert F1 Tailoring Scores: There were no significant differences between the tailoring groups in terms of BERT score. [14]

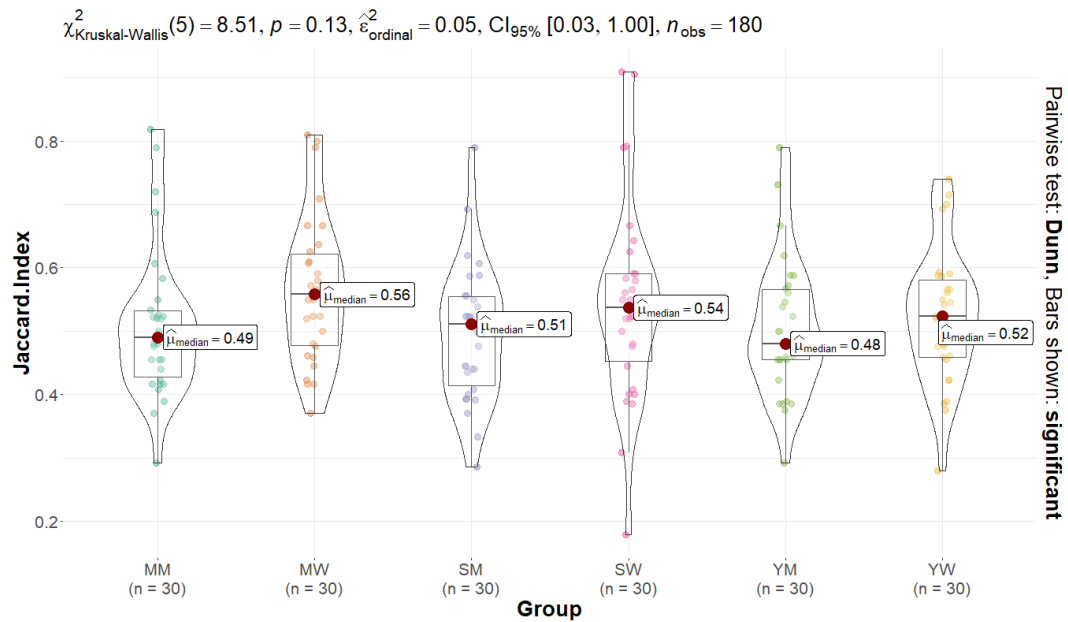


Figure 4.19: Jaccard Index Tailoring Scores: There were no significant differences between the tailoring groups in terms of Jaccard distance. This figure was generated using the ‘ggstatsplot’ package in R [14].

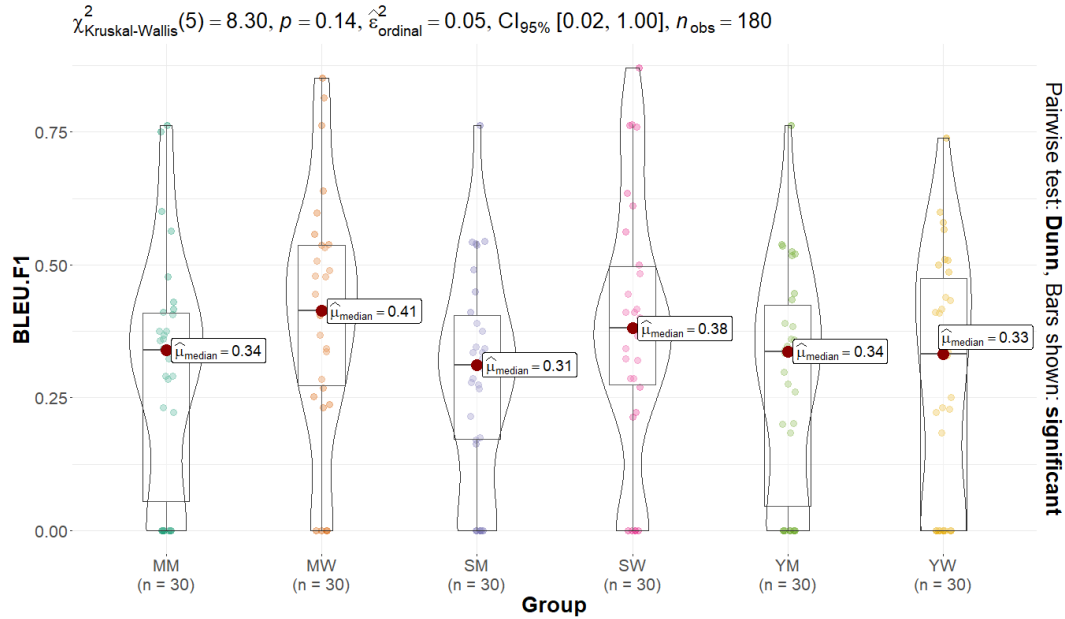


Figure 4.20: BLEU Score F1 Tailoring Scores: There were no significant differences between the tailoring groups in terms of BLEU F1 score. [14]This figure was generated using the ‘ggstatplot’ package in R [14].

4.3 Summary of Results

Overall, unchained messages were found to excel in tailoring activities to specific demographics, showcasing a superior capability to customize messages according to the target audience’s needs. Moreover, these messages were distinguished by significantly higher sentiment scores compared to their chained counterparts, alongside elevated readability metrics.

In the realm of message chaining, a noteworthy divergence was observed in the transition from the second to the third prompt, particularly in terms of BLEU scores. This discrepancy highlighted a diminished computational similarity between messages across the rewriting phase within the chaining process, suggesting issues with the BLEU score metric or how our messages are being rewritten.

We also found that sentiment analysis was adversely influenced by the presence of words commonly associated with negative connotations, such as "cancer," "anxiety," and "depression". This occurred despite their context within positively framed sentences aimed at addressing or preventing these health conditions. Furthermore, readability assessments were significantly affected by the inclusion of longer words and terms bearing complex definitions, including "cardiovascular," "stroke," and "depression".

Concerning comparative metrics, cosine similarity and Jaccard distance emerged as the most reliable indicators of message similarity. Conversely, BERT scores tended to produce overly generous similarity evaluations, while BLEU scores consistently yielded low similarity ratings. This disparity underscores the necessity for a critical appraisal of metric selection in evaluating the consistency and effectiveness of health messaging strategies.

Chapter 5

Discussion and Implications

5.1 Research Intentions

The objective of this research was to harness the potential of generative artificial intelligence to design a theoretically grounded prompt structure that enables the zero-shot generation of bespoke motivational health messages. Guided by the principles of the Physical Activity Messaging Framework (PAMF), our goal was to produce motivational health communications that are both effective and devoid of bias. Additionally, this study explored the utility of natural language processing (NLP) tools in evaluating the efficacy of motivational health messages and the broader scope of AI-generated content.

5.2 Motivational Messages Implications

5.2.1 Unchained vs. Chained with respect to PAMF Framework Discussion

In the comparative analysis of unchained and chained messages within the context of the Physical Activity Messaging Framework (PAMF), both methodologies demonstrated high efficacy in generating diversified responses pertaining to the 'what', 'why', and 'how' components of each message. This observation underscores their capacity to create nuanced and varied motivational content. However, a discernible differentiation was noted in their approach to addressing the 'who' aspect of messaging.

Chained messages exhibited a tendency towards consistency, with minimal alterations made to tailor messages to specific audience demographics. This rigidity contrasts with the adaptability observed in unchained messages, where there was a significant emphasis on customizing the activity recommendations to suit the preferences and capabilities of the targeted demographic. For instance, in tailoring messages for a senior man, activities such as shuffleboard were suggested, whereas recommendations for a young man demographic leaned towards more vigorous activities like boxing. This strategic customization in unchained messages illustrates a deliberate effort to align the activity suggestions with the physical and social preferences of each demographic group, thereby enhancing the relevance and potential impact of the messages.

5.2.2 Sentiment

In the comparative analysis of unchained versus chained messaging within the Physical Activity Messaging Framework (PAMF), a noteworthy distinction emerged in sentiment levels. Unchained messages demonstrated a significantly higher sentiment compared to their chained counterparts. This distinction was particularly pronounced in the context of message tailoring, where no significant variation was observed in the chained messages' adaptability. Conversely, unchained messages exhibited a discernible differentiation in sentiment; senior men's sentiment ratings were significantly higher than those for all other demographic tailoring, except for senior women. Similarly, senior women's sentiment scores were significantly elevated when compared to those tailored for young men.

This pattern suggests that the inherent flexibility of unchained messages to undergo adjustments based on a variety of factors—not merely confined to reiterating the preceding message—contributes to an overall more positive sentiment. Furthermore, this adaptability enables unchained messages

to fine-tune their sentiment more effectively for specific demographic tailoring. This strategic flexibility is what likely facilitated the significantly higher sentiment levels observed in messages tailored for senior men and women.

5.2.3 Readability

In evaluating the Flesch-Kincaid Readability metrics, it was observed that messages produced via the unchained approach demonstrated superior readability, characterized by higher ease-of-reading scores and lower grade-level requirements. Specifically, within the unchained message framework, the readability scores for young and senior men surpassed those for middle-aged men, suggesting that texts intended for the former groups were more accessible. This discrepancy hints at an underlying assumption that middle-aged men possess a higher capacity for processing complex texts, a form of age-based bias. Conversely, in the context of chained messaging, generic messages were noted to require a reading level significantly lower than those tailored for senior men and women, as well as middle-aged women. This trend, evident across both prompting strategies, implies a potential bias toward assigning more challenging texts to older demographics.

5.2.4 Chaining Overall

In the analysis of message chaining, a notable discrepancy emerged when examining the BLEU scores from prompt 2 to prompt 3, indicating a lack of computational similarity between messages. This divergence may be attributed to several factors. Firstly, the BLEU metric's effectiveness might be compromised by the brevity of our texts, which did not exceed 200 characters. Additionally, the substantial modification of messages to incorporate engaging hooks may have further distanced the messages in terms of this particular metric.

Conversely, the BERT-based similarity assessments across successive chaining steps suggested a higher degree of message congruence compared to other evaluated metrics. This observation could stem from various factors. Given that BERT is a pre-trained model, its effectiveness for shorter texts might be inherently limited. However, its architecture allows for a nuanced understanding of textual similarity, potentially explaining the observed trend of greater message similarity.

5.3 NLP Scoring Effectiveness

5.3.1 Positive Takeaways

The employment of natural language processing (NLP) techniques for the analysis of AI-generated content, especially in the context of motivational health messaging, holds significant promise. NLP facilitates the rapid and uniform evaluation of large amounts of content. With the continuous advancements in the NLP domain, the repertoire of metrics for scrutinizing AI-produced material is expected to enhance further. This approach effectively addresses the challenges associated with securing large research samples and mitigates the biases typically associated with smaller research survey studies.

In this study, the application of sentiment analysis, readability assessments, and text comparison metrics has yielded valuable insights into a domain that poses substantial challenges for traditional survey creation and approval processes within academic institutions.

5.3.2 Negative Takeaways

While NLP offers substantial promise in analyzing motivational health messages designed for human recipients, the definitive assessment of their impact ultimately relies on human feedback. Quantitative evaluations derived from algorithmic computations provide valuable insights but are inherently limited in capturing the nuanced effectiveness of such messages.

Moreover, selecting the most reliable metrics for analysis presents its own challenges, as different metrics may exhibit biases influenced by the specific characteristics of the dataset under consideration.

5.3.3 Analysis of Metrics

Sentiment

The examination of sentiment word clouds, which delineate the lexical distinctions between messages of positive and negative sentiment (refer to figures 4.1 and 4.2), reveals that the negative sentiment word clouds predominantly feature terms such as "anxiety," "depression," "cancer," and "stroke." Despite these terms appearing within contexts that propose methods for addressing and improving the respective conditions, their presence seems to contribute to an overall negative sentiment of the messages. This observation raises a fundamental question for further investigation: whether the mere inclusion of terms typically associated with negative sentiment suffices to categorize the entire message as negative.

Readability

The analysis of readability metrics across messages, illustrated through word clouds highlighting lexical variations among elementary, high school, and college reading levels, indicated that words associated with higher grade levels were generally longer. See figures 4.5, 4.6, and 4.7. Furthermore, terms encompassing more complex subjects, such as "depression," "cancer," "stroke," and "cardiovascular," were observed to elevate the reading level scores. This suggests a correlation between the complexity of the topic and the required reading proficiency to comprehend the message.

Comparison Metrics

In this study, various text comparison metrics were employed, including cosine similarity, BERT score, Jaccard Index, and BLEU score, each offering valuable insights along with their respective advantages and limitations. Cosine similarity and Jaccard Index emerged as particularly reliable metrics, consistently providing intermediate values among the four assessed metrics. Their effectiveness is partly attributed to their independence from pre-trained models, enhancing their suitability for analyzing the generated motivational messages within this research context.

Conversely, the BERT score, reliant on a pre-trained model, often yielded higher values compared to other metrics, suggesting a potential positive bias inherent to this approach. The BLEU score, in contrast, frequently registered the lowest values among the metrics evaluated, a phenomenon that may be attributed to the brevity of the messages analyzed.

5.4 Future Work

The outcomes of this study indicate that the inherent flexibility of unchained messages, despite potentially leading to variations in customization efficacy, offers the potential for achieving enhanced tailoring of health messages.

Future research should aim at refining the customization process to better match the individual preferences and requirements of recipients. This could involve the incorporation of factors such as specific health conditions, preferred types of physical activity, existing levels of fitness, and personal health goals. It would be valuable to investigate whether the inclusion of these additional factors for customization could enhance the effectiveness of the chained messaging strategy, particularly given its potential for higher consistency relative to the unchained approach.

Additionally, it is suggested that future studies should blend the computational analysis conducted in this research with evaluations conducted by humans to assess the motivational impact of these messages. Comparing AI-generated messages with those crafted by humans could provide deeper insights into their relative effectiveness.

Moreover, the integration of AI-generated messages with visually compelling images should be explored. With the rapid advancements in tools such as DALL-E 3 and similar technologies, the potential for these tools to complement AI-generated textual content in creating comprehensive health-focused materials warrants further exploration.

Chapter 6

Conclusion

6.1 Conclusion

Generative AI has emerged as a promising technological tool for scaling content generation. Recent work has applied generative AI to healthcare tasks. However, limited work has focused on its application to motivational physical activity messages. In this thesis, the efficacy of AI-generated health intervention content, derived from a theoretically informed prompt structure, was rigorously assessed through natural language processing (NLP) techniques. The analysis revealed that generative AI can proficiently produce motivational health messages, with unchained messages exhibiting superior sentiment and readability, alongside enhanced tailoring specificity compared to their chained counterparts, which, while slightly inferior, demonstrated notable consistency in tailoring outcomes. Furthermore, it was established that NLP metrics serve as an effective means for evaluating AI-generated content, though the integration of human feedback would significantly enrich the research findings. This research sheds light on the potential of generative AI in crafting theory-based health content, highlighting its valuable role in promoting well-being.

Bibliography

- [1] 2023. Top Generative AI Statistics for 2024. <https://www.salesforce.com/news/stories/generative-ai-statistics/> Last accessed 10 March 2024.
- [2] 2024. Flesch Reading Ease and the Flesch-Kincaid Grade Level. <https://readable.com/readability/flesch-reading-ease-flesch-kincaid-grade-level/>. Accessed: 2024-03-28.
- [3] Lauren E Connell, Rachel N Carey, Marijn De Bruin, Alexander J Rothman, Marie Johnston, Michael P Kelly, and Susan Michie. 2019. Links between behavior change techniques and mechanisms of action: an expert consensus study. *Annals of behavioral medicine* 53, 8 (2019), 708–720.
- [4] Samuel Rhys Cox, Ashraf Abdul, and Wei Tsang Ooi. 2023. Prompting a Large Language Model to Generate Diverse Motivational Messages: A Comparison with Human-Written Messages. In *International Conference on Human-Agent Interaction*. ACM, 378–380.
- [5] Rudolph Flesch. 1948. A new readability yardstick. *Journal of applied psychology* 32, 3 (1948), 221.
- [6] Amir M. Hasani, Shiva Singh, Aryan Zahergivar, Beth Ryan, Daniel Nethala, Gabriela Bravomontenegro, Neil Mendhiratta, Mark Ball, Faraz Farhadi, and Ashkan Malayeri. [n. d.]. Evaluating the performance of Generative Pre-trained Transformer-4 (GPT-4) in standardizing radiology reports. ([n. d.]). <https://doi.org/10.1007/s00330-023-10384-x>
- [7] C.J. Hutto and E.E. Gilbert. 2014. VADER: A Parsimonious Rule-based Model for Sentiment Analysis of Social Media Text. In *Eighth International Conference on Weblogs and Social Media (ICWSM-14)*. Ann Arbor, MI.
- [8] Elise Karinshak, Sunny Xun Liu, Joon Sung Park, and Jeffrey T. Hancock. 2023. Working With AI to Persuade: Examining a Large Language Model’s Ability to Generate Pro-Vaccination Messages. *Proceedings of the ACM on Human-Computer Interaction* 7, CSCW1 (2023), 1–29.
- [9] Sue Lim and Ralf Schmälzle. 2023. Artificial Intelligence for Health Message Generation: An Empirical Study Using a Large Language Model (LLM) and Prompt Engineering. *Frontiers in Communication* 8 (2023), 1129082.

- [10] Sue Lim and Ralf Schmälzle. [n. d.]. Artificial intelligence for health message generation: an empirical study using a large language model (LLM) and prompt engineering. 8 ([n. d.]), 1129082. <https://doi.org/10.3389/fcomm.2023.1129082>
- [11] Sandra Matz, Jake Teeny, Sumer Sumeet Vaid, Gabriella M. Harari, and Moran Cerf. 2023. The Potential of Generative AI for Personalized Persuasion at Scale.
- [12] Sanjana Mendu, Nolan Pye, David Conroy, and Saeed Abdullah. 2024. GAIMPLAY: A Theory-Informed Prompt Engineering Architecture for Personalized Motivational Message Generation to Promote Physical Activity. In *Designing (with) AI for Wellbeing Workshop @ CHI Conference on Human Factors in Computing Systems* (Honolulu, Hawaii, USA, May 12, 2024). ACM, New York, NY, USA, 10.
- [13] Susan Michie, Maartje M Van Stralen, and Robert West. 2011. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation science* 6, 1 (2011), 1–12.
- [14] Indrajeet Patil. 2021. Visualizations with statistical details: The 'ggstatsplot' approach. *Journal of Open Source Software* 6, 61 (2021), 3167. <https://doi.org/10.21105/joss.03167>
- [15] Ralf Schmälzle and Shelby Wilcox. 2022. Harnessing Artificial Intelligence for Health Message Generation: The Folic Acid Message Engine. *Journal of Medical Internet Research* 24, 1 (2022), e28858.
- [16] Kristina L Schmid, Susan E Rivers, Amy E Latimer, and Peter Salovey. 2009. Targeting or Tailoring? Maximizing Resources to Create Effective Health Communications. (2009).
- [17] Chloë Williamson, Graham Baker, Nanette Mutrie, Ailsa Niven, and Paul Kelly. 2020. Get the Message? A Scoping Review of Physical Activity Messaging. *International Journal of Behavioral Nutrition and Physical Activity* 17, 1 (2020), 51.
- [18] Chloë Williamson, Graham Baker, Jennifer R. Tomasone, Adrian Bauman, Nanette Mutrie, Ailsa Niven, Justin Richards, Adewale Oyeyemi, Beelin Baxter, Benjamin Rigby, Benny Cullen, Brendan Paddy, Brett Smith, Charlie Foster, Clare Drummy, Corneel Vandelanotte, Emily Oliver, Fatwa Sari Tetra Dewi, Fran McEwen, Frances Bain, Guy Faulkner, Hamish McEwen, Hayley Mills, Jack Brazier, James Nobles, Jennifer Hall, Kaleigh Maclaren, Karen Milton, Kate Olscamp, Lisbeth Villalobos Campos, Louise Bursle, Marie Murphy, Nick Cavill, Nora J. Johnston, Paul McCrorie, Rakhmat Ari Wibowo, Rebecca Bassett-Gunter, Rebecca Jones, Sarah Ruane, Trevor Shilton, and Paul Kelly. 2021. The Physical Activity Messaging Framework (PAMF) and Checklist (PAMC): International Consensus Statement and User Guide. *International Journal of Behavioral Nutrition and Physical Activity* 18, 1 (2021), 164.
- [19] Tongshuang Wu, Michael Terry, and Carrie Jun Cai. 2022. AI Chains: Transparent and Controllable Human-AI Interaction by Chaining Large Language Model Prompts. In *CHI Conference on Human Factors in Computing Systems*. ACM, 1–22.

Appendix

Table A.1: Chained Final Messages

Tailoring Type	Message #	Message
Generic	1	"Feeling down? A 30-minute workout can boost your mood instantly. Set a goal today!"
Generic	2	"Stressed? A quick 15-minute workout during lunch can help. Plan it today!"
Generic	3	"Struggling to sleep? A 20-minute walk after dinner can improve your sleep quality. Try it!"
Generic	4	"Need an energy boost? A morning workout tomorrow can do the trick. Set a goal!"
Generic	5	"Need to focus? A 30-minute yoga session before work can help. Plan it now!"
Generic	6	"Want to manage your weight? A short walk with a friend in the park can help. Invite them today!"
Generic	7	"Want to maintain healthy blood pressure? A 30-minute cardio workout thrice a week can help. Set a goal!"
Generic	8	"Want to improve digestion? A 20-minute jog after dinner can aid. Plan it today!"
Generic	9	"Want to maintain a healthy BMI? A 45-minute workout five times a week can help. Set a goal!"
Generic	10	"Want to feel confident about your body? Join a fitness class with a friend this weekend. Invite them today!"
Generic	11	"Beat depression & anxiety with a 30-minute workout! Set a goal today and feel the difference."
Generic	12	"Want glowing skin? A brisk walk during lunch can do wonders. Get your blood pumping!"
Generic	13	"Stay strong with a buddy workout! Physical activity strengthens bones and muscles. Plan a session today."
Generic	14	"Improve balance & coordination with yoga or tai chi. Try a new exercise today and feel the change."
Generic	15	"Manage chronic health conditions with daily physical activity. Make a plan and stick to it."
Generic	16	"Keep your heart healthy with cardio exercises. Set a goal today for a healthier tomorrow."
Generic	17	"Boost your lung capacity with deep breathing exercises or a brisk walk. Plan it today!"
Generic	18	"Want to be more flexible? Try a new stretching routine today and feel the difference."
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Generic	19	"Manage your blood sugar levels with a 30-minute workout. Make a plan today and stay healthy."
Generic	20	"Boost your immune system with a friend. Plan a workout session together and stay fit."
Generic	21	"Want to fight cancer? 30 minutes of physical activity can help. Get moving today!"
Generic	22	"Boost your mental health with a walk in the park after work. Exercise is the best medicine!"
Generic	23	"Keep cholesterol in check with a jog. Call a friend and make it a fun evening run!"
Generic	24	"Spice up your love life with regular exercise. Join a fitness class this week!"
Generic	25	"Say no to heart disease. Take the stairs instead of the elevator today!"
Generic	26	"Boost your memory with a bike ride. Plan one with a friend this weekend!"
Generic	27	"Reduce stroke risk with some gardening or housework today. Make physical activity a habit!"
Generic	28	"Improve your life quality with yoga before bed tonight. Regular exercise is the key!"
Generic	29	"Dance away osteoporosis risk. Invite a friend to a dance class this week!"
Generic	30	"Walk to work tomorrow for a healthier you. Exercise for overall well-being!"
Young Man	1	"Feeling a bit low? Pump up your spirits with a 30-minute workout. Make it your goal for today!"
Young Man	2	"Under pressure? A swift 15-minute workout during your lunch break can be your stress-buster. Schedule it today!"
Young Man	3	"Having trouble sleeping? A 20-minute post-dinner stroll can enhance your sleep quality. Give it a shot!"
Young Man	4	"In need of an energy kick? A morning workout tomorrow can do wonders. Make it your goal!"
Young Man	5	"Struggling to concentrate? A 30-minute yoga session before work can be your solution. Schedule it right away!"
Young Man	6	"Looking to manage your weight? A casual walk with a buddy in the park can be beneficial. Ask them to join you today!"
Young Man	7	"Aiming to maintain healthy blood pressure? A 30-minute cardio workout three times a week can be your answer. Make it your goal!"
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Young Man	8	"Looking to boost digestion? A 20-minute jog after dinner can help. Schedule it today!"
Young Man	9	"Aiming for a healthy BMI? A 45-minute workout five times a week can be your solution. Make it your goal!"
Young Man	10	"Want to feel more confident about your physique? Join a fitness class with a friend this weekend. Ask them to join you today!"
Young Man	11	"Conquer depression & anxiety with a half-hour sweat session! Set your fitness goal today and experience the transformation."
Young Man	12	"Craving radiant skin? A quick walk during your lunch break can work miracles. Get your circulation going!"
Young Man	13	"Maintain your strength with a partner workout! Exercise fortifies your bones and muscles. Schedule a workout today."
Young Man	14	"Enhance your balance & coordination with yoga or tai chi. Experiment with a new workout today and notice the shift."
Young Man	15	"Control chronic health issues with regular physical activity. Devise a routine and adhere to it."
Young Man	16	"Preserve your heart's health with cardio workouts. Establish a fitness goal today for a healthier future."
Young Man	17	"Increase your lung capacity with deep breathing exercises or a brisk walk. Schedule it today!"
Young Man	18	"Aspiring to be more flexible? Experiment with a new stretching routine today and observe the difference."
Young Man	19	"Regulate your blood sugar levels with a half-hour workout. Set a fitness plan today and maintain your health."
Young Man	20	"Enhance your immune system with a workout buddy. Organize a fitness session together and stay in shape."
Young Man	21	"Combat cancer with 30 minutes of exercise. Start your fitness journey today!"
Young Man	22	"Enhance your mental well-being with a post-work park stroll. Remember, exercise is the best therapy!"
Young Man	23	"Maintain your cholesterol levels with a jog. Make it a fun evening run with a buddy!"
Young Man	24	"Add some zest to your romantic life with regular workouts. Enroll in a fitness class this week!"
Young Man	25	"Reject heart disease by choosing stairs over the elevator today!"
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Young Man	26	"Improve your memory with a weekend bike ride. Make plans with a friend!"
Young Man	27	"Lower your stroke risk with some gardening or housework today. Make being active a daily routine!"
Young Man	28	"Elevate your quality of life with some bedtime yoga. Consistent exercise is the secret!"
Young Man	29	"Ward off osteoporosis with dance. Ask a friend to join a dance class with you this week!"
Young Man	30	"Opt for a walk to work tomorrow for a healthier lifestyle. Exercise for complete well-being!"
Young Woman	1	"Feeling a bit low? A quick 30-minute workout can instantly lift your spirits. Why not set a goal for today?"
Young Woman	2	"Feeling stressed? A swift 15-minute workout during your lunch break can help. Why not plan it for today?"
Young Woman	3	"Having trouble sleeping? A 20-minute stroll after dinner can enhance your sleep quality. Give it a try!"
Young Woman	4	"In need of an energy boost? A morning workout tomorrow could be just the thing. Set a goal!"
Young Woman	5	"Struggling to concentrate? A 30-minute yoga session before work could be the solution. Plan it now!"
Young Woman	6	"Looking to manage your weight? A short walk with a friend in the park could be beneficial. Why not invite them today?"
Young Woman	7	"Want to keep your blood pressure in check? A 30-minute cardio workout three times a week could help. Set a goal!"
Young Woman	8	"Looking to improve your digestion? A 20-minute jog after dinner could aid. Plan it for today!"
Young Woman	9	"Want to maintain a healthy BMI? A 45-minute workout five times a week could be the answer. Set a goal!"
Young Woman	10	"Want to feel more confident in your body? Join a fitness class with a friend this weekend. Why not invite them today?"
Young Woman	11	"Overcome depression and anxiety with a half-hour workout! Set a fitness goal today and experience the transformation."
Young Woman	12	"Desire radiant skin? A quick walk during your lunch break can work miracles. Get your circulation going!"
Young Woman	13	"Maintain your strength with a partner workout! Exercise fortifies your bones and muscles. Schedule a workout today."
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Young Woman	14	"Enhance your balance and coordination with yoga or tai chi. Experiment with a new workout today and notice the shift."
Young Woman	15	"Control chronic health issues with regular physical activity. Devise a plan and adhere to it."
Young Woman	16	"Preserve your heart's health with cardiovascular exercises. Establish a goal today for a healthier future."
Young Woman	17	"Increase your lung capacity with deep breathing exercises or a quick walk. Schedule it today!"
Young Woman	18	"Aspire to be more flexible? Experiment with a new stretching routine today and notice the transformation."
Young Woman	19	"Regulate your blood sugar levels with a half-hour workout. Devise a plan today and maintain your health."
Young Woman	20	"Enhance your immune system with a friend. Schedule a joint workout session and stay in shape."
Young Woman	21	"Combat cancer with just 30 minutes of exercise. Start your fitness journey today!"
Young Woman	22	"Enhance your mental well-being with a post-work stroll in the park. Remember, exercise is the best therapy!"
Young Woman	23	"Maintain your cholesterol levels with a fun jog. Why not make it a social event and invite a friend?"
Young Woman	24	"Add some zest to your love life with regular workouts. Sign up for a fitness class this week!"
Young Woman	25	"Prevent heart disease by choosing the stairs over the elevator today!"
Young Woman	26	"Improve your memory with a weekend bike ride. Make it more enjoyable by inviting a friend!"
Young Woman	27	"Lower your risk of stroke with some gardening or house chores today. Make physical activity a part of your daily routine!"
Young Woman	28	"Enhance your quality of life with some bedtime yoga. Consistent exercise is the secret!"
Young Woman	29	"Ward off the risk of osteoporosis with dance. Ask a friend to join a dance class with you this week!"
Young Woman	30	"Opt for a walk to work tomorrow for a healthier lifestyle. Exercise for overall wellness!"
Middle-Aged Man	1	"Feeling a bit low? A half-hour workout can instantly lift your spirits. Why not set a goal today?"
Middle-Aged Man	2	"Under pressure? A swift 15-minute workout during your lunch break can be a great stress-buster. Make a plan for it today!"
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Middle-Aged Man	3	"Having trouble sleeping? A 20-minute stroll after dinner can enhance your sleep quality. Give it a shot!"
Middle-Aged Man	4	"In need of a pick-me-up? A morning workout tomorrow could be just the ticket. Set a goal!"
Middle-Aged Man	5	"Struggling to concentrate? A 30-minute yoga session before starting work can be a big help. Make a plan now!"
Middle-Aged Man	6	"Looking to manage your weight? A brief walk with a buddy in the park can be beneficial. Why not invite them today?"
Middle-Aged Man	7	"Keen to maintain healthy blood pressure? A 30-minute cardio workout three times a week can be a great help. Set a goal!"
Middle-Aged Man	8	"Looking to improve your digestion? A 20-minute jog after dinner can assist. Make a plan for it today!"
Middle-Aged Man	9	"Aiming to maintain a healthy BMI? A 45-minute workout five times a week can be a big help. Set a goal!"
Middle-Aged Man	10	"Want to feel more confident in your own skin? Join a fitness class with a friend this weekend. Why not invite them today?"
Middle-Aged Man	11	"Combat depression and anxiety with a half-hour exercise routine! Set a target today and notice the transformation."
Middle-Aged Man	12	"Desire radiant skin? A quick stroll during your lunch break can work miracles. Get your circulation going!"
Middle-Aged Man	13	"Maintain your strength with a partner workout! Exercise fortifies your bones and muscles. Schedule a session today."
Middle-Aged Man	14	"Enhance your balance and coordination with yoga or tai chi. Experiment with a new workout today and experience the shift."
Middle-Aged Man	15	"Control chronic health issues with regular physical activity. Devise a routine and adhere to it."
Middle-Aged Man	16	"Preserve your heart's health with cardiovascular exercises. Establish a goal today for a healthier future."
Middle-Aged Man	17	"Increase your lung capacity with deep breathing exercises or a brisk walk. Schedule it today!"
Middle-Aged Man	18	"Aspire to be more limber? Experiment with a new stretching regimen today and notice the difference."
Middle-Aged Man	19	"Regulate your blood sugar levels with a half-hour workout. Devise a plan today and maintain your health."
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Middle-Aged Man	20	"Enhance your immune system with a friend. Organize a joint workout session and stay in shape."
Middle-Aged Man	21	"Combat cancer with 30 minutes of exercise. Start your fitness journey today!"
Middle-Aged Man	22	"Enhance your mental well-being with a post-work stroll in the park. Remember, exercise is the best medicine!"
Middle-Aged Man	23	"Maintain your cholesterol levels with a jog. Why not make it a fun evening run with a buddy?"
Middle-Aged Man	24	"Add some zest to your romantic life with regular workouts. Sign up for a fitness class this week!"
Middle-Aged Man	25	"Prevent heart disease by choosing the stairs over the elevator today!"
Middle-Aged Man	26	"Improve your memory with a weekend bike ride. Why not plan one with a friend?"
Middle-Aged Man	27	"Lower your risk of stroke with some gardening or housework today. Make being active a daily routine!"
Middle-Aged Man	28	"Enhance your quality of life with some bedtime yoga. Consistent exercise is the secret!"
Middle-Aged Man	29	"Lower your risk of osteoporosis with dance. Why not invite a friend to a dance class this week?"
Middle-Aged Man	30	"Opt for a walk to work tomorrow for a healthier lifestyle. Exercise for overall well-being!"
Middle-Aged Woman	1	"Feeling a bit low? A 30-minute workout can instantly lift your spirits. Why not set a goal today?"
Middle-Aged Woman	2	"Feeling the pressure? A swift 15-minute workout during your lunch break can help alleviate stress. Make a plan for it today!"
Middle-Aged Woman	3	"Having trouble sleeping? A 20-minute stroll after dinner can enhance your sleep quality. Give it a shot!"
Middle-Aged Woman	4	"In need of a pick-me-up? A morning workout tomorrow could be just the ticket. Set a goal!"
Middle-Aged Woman	5	"Struggling to concentrate? A 30-minute yoga session before work can aid focus. Why not plan it now?"
Middle-Aged Woman	6	"Looking to manage your weight? A leisurely walk with a friend in the park can help. Why not invite them today?"
Middle-Aged Woman	7	"Aiming to maintain healthy blood pressure? A 30-minute cardio workout three times a week can assist. Set a goal!"
Middle-Aged Woman	8	"Looking to improve digestion? A 20-minute jog after dinner can help. Make a plan for it today!"
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Middle-Aged Woman	9	"Aiming to maintain a healthy BMI? A 45-minute workout five times a week can assist. Set a goal!"
Middle-Aged Woman	10	"Want to feel more confident in your own skin? Join a fitness class with a friend this weekend. Why not invite them today?"
Middle-Aged Woman	11	"Overcome depression and anxiety with a half-hour exercise routine! Set a personal goal today and experience the transformation."
Middle-Aged Woman	12	"Desire radiant skin? A quick stroll during your lunch break can work miracles. Get your circulation going!"
Middle-Aged Woman	13	"Maintain your strength with a partner workout! Exercise fortifies your bones and muscles. Schedule a session today."
Middle-Aged Woman	14	"Enhance your balance and coordination with yoga or tai chi. Experiment with a new workout today and notice the improvement."
Middle-Aged Woman	15	"Control chronic health issues with regular physical activity. Devise a plan and adhere to it."
Middle-Aged Woman	16	"Preserve your heart's health with cardiovascular exercises. Establish a goal today for a healthier future."
Middle-Aged Woman	17	"Increase your lung capacity with deep breathing exercises or a brisk walk. Schedule it today!"
Middle-Aged Woman	18	"Aspire to be more flexible? Experiment with a new stretching routine today and notice the difference."
Middle-Aged Woman	19	"Regulate your blood sugar levels with a half-hour workout. Devise a plan today and maintain your health."
Middle-Aged Woman	20	"Enhance your immune system with a friend. Schedule a joint workout session and stay in shape."
Middle-Aged Woman	21	"Combat cancer with just 30 minutes of physical activity. Start your journey to health today!"
Middle-Aged Woman	22	"Enhance your mental well-being with a peaceful walk in the park after work. Remember, exercise is the best medicine!"
Middle-Aged Woman	23	"Maintain a healthy cholesterol level with a fun jog. Why not call a friend and make it an enjoyable evening run?"
Middle-Aged Woman	24	"Add some zest to your love life with regular exercise. Consider joining a fitness class this week!"
Middle-Aged Woman	25	"Take a stand against heart disease. Opt for the stairs instead of the elevator today!"
Middle-Aged Woman	26	"Improve your memory with a leisurely bike ride. Why not plan one with a friend this weekend?"
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Middle-Aged Woman	27	"Lower your risk of stroke with some gardening or house-work today. Make physical activity a part of your daily routine!"
Middle-Aged Woman	28	"Enhance your quality of life with some yoga before bed tonight. Regular exercise is the secret to a healthy life!"
Middle-Aged Woman	29	"Ward off the risk of osteoporosis with some dancing. Invite a friend to a dance class this week!"
Middle-Aged Woman	30	"Consider walking to work tomorrow for a healthier you. Exercise for overall well-being!"
Senior Man	1	"Feeling a bit low? A half-hour exercise routine can instantly lift your spirits. Why not set a goal today?"
Senior Man	2	"Feeling the pressure? A brisk 15-minute workout during your lunch break can help alleviate stress. Make a plan for it today!"
Senior Man	3	"Having trouble sleeping? A 20-minute stroll after your evening meal can enhance your sleep quality. Give it a shot!"
Senior Man	4	"In need of a pick-me-up? A morning exercise session tomorrow could be just the ticket. Set a goal for it!"
Senior Man	5	"Struggling to concentrate? A half-hour yoga session before starting your day can aid focus. Why not plan for it now?"
Senior Man	6	"Looking to manage your weight? A leisurely walk with a friend in the park can be beneficial. Why not invite them today?"
Senior Man	7	"Aiming to maintain a healthy blood pressure? A half-hour cardio workout three times a week can be of help. Set a goal for it!"
Senior Man	8	"Looking to enhance digestion? A 20-minute jog post-dinner can assist. Make a plan for it today!"
Senior Man	9	"Aiming to maintain a healthy BMI? A 45-minute workout five times a week can be beneficial. Why not set a goal for it?"
Senior Man	10	"Want to feel more confident about your physique? Join a fitness class with a friend this weekend. Why not invite them today?"
Senior Man	11	"Combat feelings of depression and anxiety with a half-hour exercise routine! Set a goal for yourself today and notice the positive impact."
Senior Man	12	"Desire a radiant complexion? A brisk midday stroll can work miracles. Get your circulation going!"
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Senior Man	13	"Maintain your strength with a partner exercise routine! Physical activity fortifies your bones and muscles. Schedule a session today."
Senior Man	14	"Enhance your balance and coordination with yoga or tai chi. Experiment with a new form of exercise today and observe the transformation."
Senior Man	15	"Control chronic health issues with regular physical activity. Devise a plan and adhere to it."
Senior Man	16	"Preserve your heart's health with cardiovascular exercises. Establish a goal today for a healthier future."
Senior Man	17	"Increase your lung capacity with deep breathing exercises or a brisk walk. Schedule it today!"
Senior Man	18	"Aspire to be more limber? Experiment with a new stretching regimen today and notice the difference."
Senior Man	19	"Regulate your blood sugar levels with a half-hour exercise routine. Devise a plan today and maintain your health."
Senior Man	20	"Enhance your immune system with a friend. Schedule a joint workout session and stay in shape."
Senior Man	21	"Combat cancer with 30 minutes of physical activity. Start moving today!"
Senior Man	22	"Enhance your mental well-being with an after-work stroll in the park. Exercise is the ultimate remedy!"
Senior Man	23	"Maintain your cholesterol levels with a jog. Invite a buddy for a fun evening run!"
Senior Man	24	"Add some zest to your romantic life with regular exercise. Enroll in a fitness class this week!"
Senior Man	25	"Reject heart disease. Opt for the stairs over the elevator today!"
Senior Man	26	"Enhance your memory with a cycling session. Schedule one with a friend this weekend!"
Senior Man	27	"Lower your stroke risk with some gardening or house chores today. Make physical activity a routine!"
Senior Man	28	"Elevate your quality of life with some bedtime yoga. Regular exercise is the secret!"
Senior Man	29	"Ward off the risk of osteoporosis with dance. Ask a friend to join a dance class this week!"
Senior Man	30	"Opt for a walk to work tomorrow for a healthier self. Exercise for comprehensive well-being!"
Senior Woman	1	"Feeling a bit low? A gentle 30-minute workout can instantly lift your spirits. Why not set a goal today, dear?"
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Senior Woman	2	"Feeling stressed, my dear? A quick 15-minute workout during your lunch break can help. Why not plan it today?"
Senior Woman	3	"Having trouble sleeping? A leisurely 20-minute walk after dinner can improve your sleep quality. Give it a try!"
Senior Woman	4	"In need of an energy boost? A morning workout tomorrow can do wonders. Set a goal, dear!"
Senior Woman	5	"Finding it hard to focus? A 30-minute yoga session before starting your day can help. Why not plan it now?"
Senior Woman	6	"Looking to manage your weight? A short walk with a friend in the park can be beneficial. Why not invite them today?"
Senior Woman	7	"Want to maintain a healthy blood pressure? A 30-minute cardio workout thrice a week can help. Set a goal, dear!"
Senior Woman	8	"Looking to improve digestion? A 20-minute jog after dinner can aid. Why not plan it today?"
Senior Woman	9	"Want to maintain a healthy BMI? A 45-minute workout five times a week can help. Set a goal, dear!"
Senior Woman	10	"Want to feel confident about your body? Join a fitness class with a friend this weekend. Why not invite them today?"
Senior Woman	11	"Combat feelings of depression and anxiety with a half-hour exercise routine! Set a personal goal today and notice the positive impact."
Senior Woman	12	"Desire radiant skin? A brisk midday walk can work miracles. Get your circulation going!"
Senior Woman	13	"Maintain your strength with a partner workout! Regular exercise fortifies your bones and muscles. Schedule a session today."
Senior Woman	14	"Enhance your balance and coordination with yoga or tai chi. Experiment with a new physical activity today and observe the transformation."
Senior Woman	15	"Control chronic health issues with consistent physical activity. Formulate a plan and adhere to it."
Senior Woman	16	"Preserve your heart's health with cardiovascular exercises. Establish a goal today for a healthier future."
Senior Woman	17	"Increase your lung capacity with deep breathing exercises or a brisk walk. Schedule it today!"
Senior Woman	18	"Aspire to be more limber? Experiment with a new stretching routine today and notice the difference."
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Table A.1 Chained Messages, Continued from previous page

Tailoring Type	Message #	Message
Senior Woman	19	"Regulate your blood sugar levels with a half-hour workout. Formulate a plan today and maintain your health."
Senior Woman	20	"Enhance your immune system with a friend. Organize a joint workout session and stay in shape."
Senior Woman	21	"Combat cancer with a 30-minute daily exercise routine. Start your journey to health today!"
Senior Woman	22	"Enhance your mental well-being with a peaceful walk in the park after work. Remember, exercise is the best therapy!"
Senior Woman	23	"Maintain a healthy cholesterol level with a leisurely jog. Why not make it a social event with a friend?"
Senior Woman	24	"Add a dash of excitement to your love life with regular exercise. Consider joining a fitness class this week!"
Senior Woman	25	"Prevent heart disease by choosing the stairs over the elevator today!"
Senior Woman	26	"Improve your memory with a scenic bike ride. Why not arrange one with a friend this weekend?"
Senior Woman	27	"Lower your risk of stroke by engaging in some gardening or housework today. Make physical activity a part of your daily routine!"
Senior Woman	28	"Enhance your quality of life with some calming yoga before bed tonight. Consistent exercise is the secret!"
Senior Woman	29	"Ward off the risk of osteoporosis with some fun dancing. Why not invite a friend to a dance class this week?"
Senior Woman	30	"Consider walking to work tomorrow for a healthier lifestyle. Exercise is the key to overall well-being!"

Table A.2: Unchained Final Messages

Tailoring Type	Message #	Message
Generic	1	"Boost your mood with a quick jog today. Set a goal, lace up your shoes, and hit the road. Ready, set, go!"
Generic	2	"Did you know a brisk walk can improve your sleep? Plan a walk before bedtime and sleep like a baby tonight."
Generic	3	"A 20-minute workout can increase your energy. Set a reminder for a midday workout. Your future self will thank you."
Generic	4	"Physical activity can reduce stress. Plan a yoga session today and say goodbye to stress. Namaste!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Generic	5	"A quick swim can improve your heart health. Dive in today and feel the difference. Make a splash!"
Generic	6	"Physical activity can boost your creativity. Plan a bike ride and let your mind wander. Pedal your way to inspiration!"
Generic	7	"A morning workout can kickstart your metabolism. Set your alarm and start your day right. Rise and shine!"
Generic	8	"Physical activity can improve your memory. Plan a hike and enjoy the benefits. Remember, every step counts!"
Generic	9	"A dance class can improve your coordination. Schedule one today and dance your worries away. Let's boogie!"
Generic	10	"Physical activity can improve your skin health. Plan a run and glow from within. Run for radiance!"
Generic	11	"A quick workout can boost your confidence. Set a goal and crush it today. You've got this!"
Generic	12	"Physical activity can improve your posture. Plan a Pilates session and stand tall. Embrace your inner strength!"
Generic	13	"A game of tennis can improve your reflexes. Schedule a match today. Game, set, match!"
Generic	14	"Physical activity can boost your immune system. Plan a workout and stay healthy. Fight off germs with fitness!"
Generic	15	"A bike ride can improve your lung health. Plan a ride and breathe easy. Pedal for your lungs!"
Generic	16	"Physical activity can improve your digestion. Plan a walk after dinner. Walk your way to wellness!"
Generic	17	"A yoga session can improve your flexibility. Schedule a session today. Stretch for success!"
Generic	18	"Physical activity can improve your bone health. Plan a weightlifting session. Lift for longevity!"
Generic	19	"A run can improve your mental health. Set a goal and run for your mind. Run for resilience!"
Generic	20	"Physical activity can improve your focus. Plan a workout before work. Focus with fitness!"
Generic	21	"A swim can improve your muscle tone. Dive in today. Swim for strength!"
Generic	22	"Physical activity can improve your mood. Plan a dance session and shake off the blues. Dance for delight!"
Generic	23	"A hike can improve your endurance. Plan a hike today. Hike for health!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Generic	24	"Physical activity can improve your sleep. Plan a yoga session before bed. Yoga for your zzz's!"
Generic	25	"A workout can improve your self-esteem. Set a goal and crush it today. Work out for worth!"
Generic	26	"Physical activity can improve your balance. Plan a Tai Chi session. Balance with Tai Chi!"
Generic	27	"A run can improve your cardiovascular health. Set a goal and run for your heart. Run for life!"
Generic	28	"Physical activity can improve your mental clarity. Plan a workout and clear your mind. Clear mind, better life!"
Generic	29	"A swim can improve your joint health. Dive in today. Swim for suppleness!"
Generic	30	"Physical activity can improve your overall wellbeing. Plan a workout and feel the difference. Wellness awaits!"
Young Man	1	"Boost your mood with a quick jog today. Set a goal, lace up, and hit the pavement. Ready, set, go!"
Young Man	2	"Did you know? A quick workout can improve your focus. Plan a gym session after work. Your brain will thank you!"
Young Man	3	"Crush stress with a boxing session. Set a goal to hit the bag today. Float like a butterfly, sting like a bee!"
Young Man	4	"Boost your energy with a bike ride. Plan a route and pedal away. Feel the wind in your hair!"
Young Man	5	"Improve your sleep with yoga. Set a goal to try a new pose tonight. Namaste, my friend!"
Young Man	6	"Boost your creativity with a hike. Plan a trail and let nature inspire you. Adventure awaits!"
Young Man	7	"Improve your memory with swimming. Set a goal to do 20 laps today. Dive in, the water's fine!"
Young Man	8	"Boost your confidence with weightlifting. Plan a session and feel the power. You're stronger than you think!"
Young Man	9	"Improve your digestion with a walk. Set a goal to stroll after dinner. Walk it off, champ!"
Young Man	10	"Boost your immunity with a dance class. Plan to bust a move today. Dance like nobody's watching!"
Young Man	11	"Improve your skin with a sweat session. Set a goal to glow today. Sweat now, shine later!"
Young Man	12	"Boost your productivity with a run. Plan a route and hit your stride. Run the day, don't let it run you!"
Young Man	13	"Improve your mood with a basketball game. Set a goal to shoot some hoops. Ball is life!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Young Man	14	"Boost your focus with a climbing session. Plan a climb and reach new heights. The sky's the limit!"
Young Man	15	"Improve your sleep with a tai chi class. Set a goal to flow tonight. Find your zen!"
Young Man	16	"Boost your energy with a soccer game. Plan a match and score a goal. Game on!"
Young Man	17	"Improve your memory with a tennis match. Set a goal to serve an ace. Game, set, match!"
Young Man	18	"Boost your confidence with a martial arts class. Plan a session and unleash your power. Be a warrior, not a worrier!"
Young Man	19	"Improve your digestion with a paddleboarding session. Set a goal to balance today. Ride the wave!"
Young Man	20	"Boost your immunity with a Zumba class. Plan to shake it off today. Dance your worries away!"
Young Man	21	"Improve your skin with a sauna session. Set a goal to sweat today. Heat it up!"
Young Man	22	"Boost your productivity with a rowing session. Plan a row and pull your weight. Row, row, row your boat!"
Young Man	23	"Improve your mood with a rugby game. Set a goal to tackle today. Get in the scrum!"
Young Man	24	"Boost your focus with a pilates class. Plan a session and find your core. Stretch it out!"
Young Man	25	"Improve your sleep with a meditation session. Set a goal to breathe tonight. Inhale the future, exhale the past!"
Young Man	26	"Boost your energy with a frisbee game. Plan a match and let it fly. Catch you on the flip side!"
Young Man	27	"Improve your memory with a chess game. Set a goal to checkmate today. Make your move!"
Young Man	28	"Boost your confidence with a parkour session. Plan a run and leap into action. The world is your playground!"
Young Man	29	"Improve your digestion with a trampoline session. Set a goal to bounce today. Jump for joy!"
Young Man	30	"Boost your immunity with a kickboxing class. Plan a session and kick some butt. Fight for your health!"
Young Woman	1	"Boost your mood with a quick jog! Set a goal to run for 20 minutes today. Ready, set, go!"
Young Woman	2	"Dance your stress away! Plan a 30-minute dance session tonight. It's fun and healthy!"
Young Woman	3	"Get that post-workout glow! Schedule a yoga session for tomorrow morning. Shine on!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Young Woman	4	"Boost your brainpower with a bike ride! Set a goal to cycle for 15 minutes today. Pedal to the metal!"
Young Woman	5	"Feel the burn, enjoy the reward! Plan a HIIT session for this evening. You've got this!"
Young Woman	6	"Get a natural energy boost with a brisk walk! Set a goal to walk for 30 minutes today. Step it up!"
Young Woman	7	"Improve your sleep with a swim! Plan a swimming session for tomorrow. Dive into health!"
Young Woman	8	"Boost your confidence with a boxing session! Set a goal to box for 20 minutes today. Punch it out!"
Young Woman	9	"Relieve anxiety with a Pilates class! Plan a session for this evening. Stretch and breathe!"
Young Woman	10	"Improve your focus with a hike! Set a goal to hike for an hour this weekend. Adventure awaits!"
Young Woman	11	"Feel happier with a Zumba class! Plan a session for tomorrow. Dance like nobody's watching!"
Young Woman	12	"Boost your creativity with a run! Set a goal to run for 30 minutes today. Unleash your potential!"
Young Woman	13	"Improve your memory with a yoga session! Plan a class for this evening. Namaste!"
Young Woman	14	"Boost your self-esteem with a weightlifting session! Set a goal to lift for 20 minutes today. Strong is beautiful!"
Young Woman	15	"Reduce stress with a Tai Chi class! Plan a session for tomorrow. Flow with the movements!"
Young Woman	16	"Feel more relaxed with a meditation session! Set a goal to meditate for 10 minutes today. Find your zen!"
Young Woman	17	"Improve your skin with a sweat session! Plan a cardio workout for this evening. Glow from within!"
Young Woman	18	"Boost your metabolism with a kickboxing class! Set a goal to kickbox for 30 minutes today. Kick it up a notch!"
Young Woman	19	"Improve your posture with a ballet class! Plan a session for tomorrow. Stand tall and proud!"
Young Woman	20	"Boost your immune system with a swim! Set a goal to swim for 20 minutes today. Dive into wellness!"
Young Woman	21	"Improve your digestion with a walk! Plan a 30-minute walk for this evening. Walk your way to health!"
Young Woman	22	"Boost your heart health with a cycling session! Set a goal to cycle for 30 minutes today. Pedal for your heart!"
Young Woman	23	"Improve your flexibility with a yoga class! Plan a session for tomorrow. Stretch for success!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Young Woman	24	"Boost your lung capacity with a run! Set a goal to run for 20 minutes today. Breathe easy!"
Young Woman	25	"Improve your bone density with a weightlifting session! Plan a workout for this evening. Lift for life!"
Young Woman	26	"Boost your endurance with a HIIT class! Set a goal to HIIT for 30 minutes today. Push your limits!"
Young Woman	27	"Improve your balance with a Pilates class! Plan a session for tomorrow. Balance is key!"
Young Woman	28	"Boost your mental health with a dance class! Set a goal to dance for 20 minutes today. Dance your worries away!"
Young Woman	29	"Improve your muscle tone with a boxing session! Plan a workout for this evening. Punch for power!"
Young Woman	30	"Boost your overall health with a hike! Set a goal to hike for an hour this weekend. Hike for health!"
Middle-aged Man	1	"Boost your mood with a quick jog today. Set a goal, lace up those shoes and hit the pavement. Ready, set, go!"
Middle-aged Man	2	"Did you know a brisk walk can improve your focus? Plan a walk during your lunch break. Your mind will thank you."
Middle-aged Man	3	"Physical activity can help you sleep better. Try a workout before bed. Sweet dreams are waiting!"
Middle-aged Man	4	"Feeling stressed? A quick workout can help. Set a goal to hit the gym after work. You've got this!"
Middle-aged Man	5	"Boost your energy with a morning workout. Set your alarm and start your day right. Rise and shine!"
Middle-aged Man	6	"Physical activity can improve your mood. Plan a bike ride this evening. Pedal your worries away!"
Middle-aged Man	7	"Did you know exercise can help control weight? Set a goal to hit the gym today. Your future self will thank you."
Middle-aged Man	8	"Physical activity can boost your creativity. Plan a hike this weekend. Inspiration awaits!"
Middle-aged Man	9	"Exercise can improve your memory. Set a goal to swim a few laps today. Dive into better brain health!"
Middle-aged Man	10	"Physical activity can reduce anxiety. Plan a yoga session tonight. Find your zen."
Middle-aged Man	11	"Boost your self-esteem with a workout. Set a goal to lift weights today. Feel the power!"
Middle-aged Man	12	"Physical activity can improve your skin health. Plan a run this afternoon. Glow from within!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Middle-aged Man	13	"Did you know exercise can boost your immune system? Set a goal to play basketball today. Score for health!"
Middle-aged Man	14	"Physical activity can improve your sex life. Plan a dance class with your partner. Spice things up!"
Middle-aged Man	15	"Exercise can help manage stress. Set a goal to do some gardening today. Dig into relaxation!"
Middle-aged Man	16	"Physical activity can improve your digestion. Plan a bike ride after dinner. Pedal for better health!"
Middle-aged Man	17	"Boost your brain health with a workout. Set a goal to do some yoga today. Stretch for success!"
Middle-aged Man	18	"Physical activity can improve your heart health. Plan a hike this weekend. Climb to a healthier heart!"
Middle-aged Man	19	"Did you know exercise can improve your bone health? Set a goal to lift weights today. Strengthen your skeleton!"
Middle-aged Man	20	"Physical activity can improve your lung health. Plan a swim session this evening. Dive into better breathing!"
Middle-aged Man	21	"Boost your metabolism with a workout. Set a goal to run a few miles today. Race towards better health!"
Middle-aged Man	22	"Physical activity can improve your mental health. Plan a walk in the park. Step into serenity!"
Middle-aged Man	23	"Did you know exercise can improve your vision? Set a goal to play tennis today. Swing for sight!"
Middle-aged Man	24	"Physical activity can improve your posture. Plan a Pilates class this weekend. Stand tall!"
Middle-aged Man	25	"Boost your productivity with a workout. Set a goal to do some aerobics today. Jump into efficiency!"
Middle-aged Man	26	"Physical activity can improve your balance. Plan a Tai Chi session this evening. Flow into stability!"
Middle-aged Man	27	"Did you know exercise can improve your flexibility? Set a goal to do some stretching today. Reach for better health!"
Middle-aged Man	28	"Physical activity can improve your muscle strength. Plan a weightlifting session. Lift for longevity!"
Middle-aged Man	29	"Boost your endurance with a workout. Set a goal to cycle a few miles today. Pedal towards perseverance!"
Middle-aged Man	30	"Physical activity can improve your lifespan. Plan a jog this weekend. Run towards a longer life!"
Middle-aged Woman	1	"Boost your mood with a brisk walk today. Plan it during your lunch break. You'll feel great!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Middle-aged Woman	2	"A quick jog can help you sleep better tonight. Set a goal to run for 20 minutes today."
Middle-aged Woman	3	"Dance your stress away! Schedule a fun dance session this evening. You'll feel lighter."
Middle-aged Woman	4	"Boost your energy with a morning yoga session. Set your alarm and start your day right."
Middle-aged Woman	5	"Improve your focus with a midday workout. Plan it and see the difference in your productivity."
Middle-aged Woman	6	"A bike ride can help you feel more relaxed. Set a goal to cycle for 30 minutes today."
Middle-aged Woman	7	"A swim can help you feel refreshed. Plan a swim session this afternoon. You'll love it!"
Middle-aged Woman	8	"Boost your creativity with a hike. Set a goal to hike this weekend. Nature inspires!"
Middle-aged Woman	9	"A Pilates session can help improve your posture. Schedule one today. Stand tall and proud!"
Middle-aged Woman	10	"A Zumba class can help you feel happier. Set a goal to join one this week. Dance and smile!"
Middle-aged Woman	11	"Boost your memory with a strength training session. Plan one today. Strong body, strong mind!"
Middle-aged Woman	12	"A tennis match can help you feel more alert. Set a goal to play this weekend. Game, set, match!"
Middle-aged Woman	13	"Boost your confidence with a kickboxing class. Schedule one this week. Feel empowered!"
Middle-aged Woman	14	"A walk in the park can help you feel more peaceful. Set a goal to walk daily. Peace begins with a step."
Middle-aged Woman	15	"Boost your metabolism with a HIIT workout. Plan one today. Burn calories, not time!"
Middle-aged Woman	16	"A yoga session can help you feel more balanced. Set a goal to practice daily. Find your zen."
Middle-aged Woman	17	"Boost your flexibility with a stretching routine. Schedule one today. Bend, don't break!"
Middle-aged Woman	18	"A run can help you feel more positive. Set a goal to run 3 times a week. Run towards positivity!"
Middle-aged Woman	19	"Boost your endurance with a cycling session. Plan one this weekend. Pedal towards fitness!"
Middle-aged Woman	20	"A dance class can help you feel more joyful. Set a goal to join one this week. Dance like nobody's watching!"
Middle-aged Woman	21	"Boost your concentration with a Tai Chi class. Schedule one today. Focus and flow!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Middle-aged Woman	22	"A swim can help you feel more rejuvenated. Set a goal to swim twice a week. Dive into wellness!"
Middle-aged Woman	23	"Boost your strength with a weightlifting session. Plan one today. Lift weights, lift your spirits!"
Middle-aged Woman	24	"A walk can help you feel more connected to nature. Set a goal to walk daily. Connect with Mother Earth!"
Middle-aged Woman	25	"Boost your agility with a badminton match. Schedule one this weekend. Swift and strong!"
Middle-aged Woman	26	"A run can help you feel more accomplished. Set a goal to run a 5k this month. Run towards your goals!"
Middle-aged Woman	27	"Boost your balance with a yoga session. Plan one today. Balance your body and mind!"
Middle-aged Woman	28	"A dance class can help you feel more expressive. Set a goal to join one this week. Express yourself through dance!"
Middle-aged Woman	29	"Boost your stamina with a boxing class. Schedule one today. Punch your way to fitness!"
Middle-aged Woman	30	"A swim can help you feel more invigorated. Set a goal to swim 3 times a week. Swim towards vitality!"
Senior Man	1	"Boost your mood with a brisk walk today. Set a goal to walk for 30 minutes. You'll feel great!"
Senior Man	2	"Plan a bike ride this afternoon. It's a fun way to improve your heart health."
Senior Man	3	"Call a friend and plan a tennis match. It's a great way to stay active and socialize."
Senior Man	4	"Did you know gardening can improve your flexibility? Plan to spend some time in your garden today."
Senior Man	5	"Set a goal to swim for 20 minutes today. It's a great low-impact exercise for seniors."
Senior Man	6	"Plan a hike this weekend. It's a great way to improve your balance and enjoy nature."
Senior Man	7	"Invite a friend for a round of golf. It's a fun way to stay active and enjoy the outdoors."
Senior Man	8	"Set a goal to do some strength training today. It's great for maintaining muscle mass."
Senior Man	9	"Plan to do some yoga this evening. It's a great way to improve your flexibility and relax."
Senior Man	10	"Invite a friend for a walk in the park. It's a great way to stay active and catch up."
Senior Man	11	"Set a goal to do some light jogging today. It's great for improving your cardiovascular health."
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Senior Man	12	"Plan to do some tai chi this afternoon. It's a great way to improve your balance and relax."
Senior Man	13	"Invite a friend for a game of badminton. It's a fun way to stay active and socialize."
Senior Man	14	"Set a goal to do some stretching exercises today. It's great for improving your flexibility."
Senior Man	15	"Plan to do some water aerobics this weekend. It's a great low-impact exercise for seniors."
Senior Man	16	"Invite a friend for a game of table tennis. It's a fun way to stay active and socialize."
Senior Man	17	"Set a goal to do some resistance band exercises today. It's great for maintaining muscle mass."
Senior Man	18	"Plan to do some pilates this evening. It's a great way to improve your core strength and balance."
Senior Man	19	"Invite a friend for a game of lawn bowls. It's a fun way to stay active and socialize."
Senior Man	20	"Set a goal to do some balance exercises today. It's great for preventing falls."
Senior Man	21	"Plan to do some deep breathing exercises this afternoon. It's a great way to relax and reduce stress."
Senior Man	22	"Invite a friend for a game of shuffleboard. It's a fun way to stay active and socialize."
Senior Man	23	"Set a goal to do some chair exercises today. It's great for improving your strength and flexibility."
Senior Man	24	"Plan to do some meditation this evening. It's a great way to relax and improve your mental health."
Senior Man	25	"Invite a friend for a game of horseshoes. It's a fun way to stay active and socialize."
Senior Man	26	"Set a goal to do some walking exercises today. It's great for improving your cardiovascular health."
Senior Man	27	"Plan to do some qi gong this afternoon. It's a great way to improve your balance and relax."
Senior Man	28	"Invite a friend for a game of bocce. It's a fun way to stay active and socialize."
Senior Man	29	"Set a goal to do some leg lifts today. It's great for improving your lower body strength."
Senior Man	30	"Plan to do some mindfulness exercises this evening. It's a great way to relax and improve your mental health."
Senior Woman	1	"Boost your mood with a brisk walk today. Set a goal to walk for 30 minutes. You'll feel great!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Senior Woman	2	"Did you know dancing can improve your balance? Plan a dance session at home today. Let's groove!"
Senior Woman	3	"A short swim can do wonders for your heart health. Schedule a swim today. Dive into wellness!"
Senior Woman	4	"Gardening can help lower stress levels. Spend some time in your garden today. Nature is calling!"
Senior Woman	5	"A bike ride can improve your joint mobility. Plan a ride in the park today. Pedal your way to health!"
Senior Woman	6	"Yoga can help improve your flexibility. Set a goal to do 15 minutes of yoga today. Stretch and relax!"
Senior Woman	7	"A game of tennis can boost your energy levels. Schedule a game with a friend today. Serve up some fun!"
Senior Woman	8	"Walking can help improve your sleep. Plan a walk after dinner today. Walk your way to sweet dreams!"
Senior Woman	9	"Did you know Tai Chi can improve your mental clarity? Try a session today. Find your inner peace!"
Senior Woman	10	"Aerobics can help improve your lung health. Set a goal to do 20 minutes today. Breathe easy!"
Senior Woman	11	"Pilates can help strengthen your core. Schedule a session today. Power up your posture!"
Senior Woman	12	"A hike can help lower your blood pressure. Plan a hike in the local park today. Step into wellness!"
Senior Woman	13	"Did you know dancing can improve your memory? Plan a dance session today. Dance your worries away!"
Senior Woman	14	"A game of golf can help improve your hand-eye coordination. Schedule a game today. Swing into health!"
Senior Woman	15	"A bike ride can help improve your digestion. Plan a ride today. Cycle your way to wellness!"
Senior Woman	16	"A swim can help improve your muscle strength. Schedule a swim today. Make a splash for health!"
Senior Woman	17	"Gardening can help improve your bone density. Spend some time in your garden today. Dig into wellness!"
Senior Woman	18	"Walking can help improve your mood. Plan a walk in the morning today. Start your day on a positive note!"
Senior Woman	19	"Yoga can help lower your anxiety levels. Set a goal to do yoga today. Unwind and relax!"
Senior Woman	20	"A game of badminton can help improve your reflexes. Schedule a game today. Smash your way to health!"
Senior Woman	21	"Aerobics can help improve your heart health. Set a goal to do 20 minutes today. Jumpstart your wellness!"
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Table A.2 Unchained Messages, Continued from previous page

Tailoring Type	Message #	Message
Senior Woman	22	"Pilates can help improve your balance. Schedule a session today. Balance your way to health!"
Senior Woman	23	"A hike can help improve your endurance. Plan a hike today. Conquer your wellness goals!"
Senior Woman	24	"Dancing can help improve your flexibility. Plan a dance session today. Dance your way to health!"
Senior Woman	25	"A game of golf can help improve your concentration. Schedule a game today. Focus on your health!"
Senior Woman	26	"A bike ride can help improve your mood. Plan a ride today. Cycle your way to happiness!"
Senior Woman	27	"A swim can help improve your flexibility. Schedule a swim today. Dive into flexibility!"
Senior Woman	28	"Gardening can help improve your mental health. Spend some time in your garden today. Cultivate wellness!"
Senior Woman	29	"Walking can help improve your bone health. Plan a walk today. Step into strength!"
Senior Woman	30	"Yoga can help improve your posture. Set a goal to do yoga today. Stretch your way to health!"

