

Appendix for "Reinforcement Learning for Proposing Smoking Cessation Activities that Build Competencies: Combining Two Worldviews in a Virtual Coach"

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This document is the Appendix of the chapter "Reinforcement Learning for Proposing Smoking Cessation Activities that Build Competencies: A Pipeline for Combining Two Worldviews in a Virtual Coach" from the PhD thesis by Nele Albers. Using the same section names as in the chapter, we provide more information on:

- the preparatory activities for quitting smoking (Table S1),
- factors obtained in the repertory grid studies (Table S2 and Table S3),
- persuasive activities (Table S4 and Table S5),
- formulations for the smoker-identified competencies used to elicit people's beliefs about the usefulness of the competencies (Table S6),
- contributions of the preparatory activities to the expert competencies based on the data from our repertory grid study with experts (Table S7),
- structure of the conversational sessions with the virtual coach Mel (Figure S1),
- participant flow (Figure S2),
- participant characteristics (Table S8),
- changes in smoking frequency, quitter self-identity, and weekly exercise between the prescreening questionnaire, post-questionnaire, and follow-up questionnaire (Table S2),
- the number of samples and mean effort per preparatory activity cluster and persuasive activity based on our crowdsourcing study (Table S10),
- the mean effort per preparatory activity cluster and combination of values for the three selected binary user-inquired features (Figure S3),
- the number of samples per activity (cluster) and combination of values for the three selected binary user-inquired features (Figure S4), and
- the fraction of expert competencies built over time for different policies when sampling the effort people spend on their activities from a normal distribution (Figure S5).

METHODS

Step 1: Establishing competency-building activities

Table S1 shows the titles and formulations from the reminder messages for the 44 preparatory activities used in our study. There were two slightly different formulations for each activity, one for the conversational session and one for the reminder messages participants received on Prolific at the end of the session. 24 of the 44 formulations are very closely based on the ones by Albers et al. [2].

Table S1: Preparatory activities for quitting smoking. Titles and formulations from the reminder messages for the 44 preparatory activities for quitting smoking that were used in the study. 7 activities had another activity as a prerequisite in our data-gathering study. For the purpose of predicting the effort people spent on activities as well as the next user-inquired state features, the preparatory activities were grouped into five clusters.

	Title and Formulation	Prerequisite	Cluster	References
1	Creating motivational slogans/quotes for quitting smoking. Having strong motivation to quit smoking helps to quit successfully. Before the next session, I thus suggest you take some time to look for a motivational quote or write down something that motivates you to quit smoking. Place this somewhere you can see it every day, such as your fridge or closet door.		5	Michie et al. [12]

	Title and Formulation	Prerequisite	Cluster	References
2	Creating motivational slogans/quotes for becoming more physically active. Having strong motivation to become more physically active helps to succeed. Before the next session, I thus suggest you take some time to look for a motivational quote or write down something that motivates you to become more physically active. Place this somewhere you can see it every day, such as your fridge or closet door.		5	Michie et al. [12]
3	Testimonial on quitting smoking. When preparing for quitting smoking, it can help to learn from other people who have successfully quit smoking. What motivated them to quit? And what helped them to succeed? Before the next session, I thus recommend you watch two short videos with tips from former smokers. First, this 2-minute video in which Brett tells you about how he quit smoking for a healthier future: https://www.youtube.com/watch?v=SkxajRN4Fho&ab_channel=CentersforDiseaseControlandPrevention%28CDC%29 . And then this short video in which Tiffany tells you how she quit smoking: https://www.youtube.com/watch?v=6OZehKDHsj0&ab_channel=CentersforDiseaseControlandPrevention%28CDC%29 . What can you take away from these two examples for yourself? Take a few notes on your phone or a piece of paper.		4	https://www.cdc.gov/tobacco/campaign/tips/stories/index.html
4	Testimonial on becoming more physically active. When preparing for becoming more physically active, it can be useful to learn from other people who have succeeded in becoming more physically active. What goal did they set for themselves? And how did they reach it? Before the next session, I thus recommend you watch this short video in which 5 people describe how they reached their physical activity goals: https://youtu.be/m1MH09fCTG8 . What can you take away from the 5 examples for yourself? Take a few notes on a piece of paper or your phone.		4	Albers et al. [1], Hizli et al. [6]
5	Desired future self after quitting smoking - Writing. Having high aspiration to quit smoking may aid in quitting successfully. Thus, before the next session, I advise you to think about the person that you would like to be once you have successfully quit smoking. For example, you might want to be a "grandfather who can play football with his grandchildren" or a "nurse who can walk up the stairs to the fourth floor without getting out of breath." Write down everything that comes to your mind.		5	Albers et al. [2], Meijer et al. [10], Penfornis et al. [18]
6	Desired future self after becoming more physically active - Writing. Quitting smoking may be easier if you become more physically active (e.g., take walks, swim, or go running). One important step for this is to have a high ambition to become more physically active. Thus, before the next session, I advise you to think about the person that you would like to be once you have become more physically active. For example, you might want to be a "grandfather who can play football with his grandchildren" or a "nurse who can walk up the stairs to the fourth floor without getting out of breath." Write down everything that comes to your mind.		5	Albers et al. [2], Meijer et al. [10], Penfornis et al. [18]
7	Reasons for quitting smoking. Quitting smoking has many benefits. Think, for example, of improved physical fitness, healthier skin, and lower expenses. To help you quit smoking, it can be useful to write down why you want to quit. This can increase your aspiration to quit smoking, which may aid in quitting successfully. So, before the next session, I advise you to identify and write down reasons why you want to stop smoking. After writing them down, think about which reasons are most important to you and order them accordingly.		4	Albers et al. [2], Michie et al. [13], Trimbos Instituut [23]
8	Reasons for becoming more physically active. Quitting smoking may be easier if you become more physically active (e.g., take walks, swim, or go running). One crucial step for this is to have a strong desire to become more physically active. Therefore, before the next session, I advise you to identify and write down reasons why you want to become more physically active. After writing them down, think about which reasons are most important to you and order them accordingly.		4	Albers et al. [2], Michie et al. [13]
9	Personal rule for not smoking. Having strong determination to refrain from smoking may help to quit successfully. So, before the next session, I advise you to take some time to create a personal rule that helps you to refrain from smoking. Possible examples include "Not a puff - no matter what," "Say no to smoking, yes to life" or "Smoking is NOT an option." Write down your rule on a piece of paper and repeat it to yourself 3 times. Put the piece of paper with your rule somewhere you can see it every day.		4	Albers et al. [2], Michie et al. [13]

	Title and Formulation	Prerequisite	Cluster	References
10	Personal rule for becoming more physically active. Being more physically active (e.g., taking walks, swimming, or going running) may aid you to stop smoking. One important aspect for this is to have strong resolve to become more physically active. So, before the next session, I advise you to take some time to create a personal rule that helps you to become more physically active. Possible examples include "10 squats - no matter what," "Say no to sitting, yes to life" or "Driving to the grocery store is NOT an option." Write down your rule on a piece of paper and repeat it to yourself 3 times. Put the piece of paper with your rule somewhere you can see it every day.		4	Albers et al. [2], Michie et al. [13]
11	How friends and/or family will receive one's desired future self after quitting smoking. People are social creatures. This means that what we do is noticed by others around us, and they can react to it. To help you quit smoking, it can be useful to imagine how people who are important to you will receive your non-smoker future self. This can boost your confidence. The reactions of others, such as friends, colleagues, and family, to your future self can be positive, but they could also be negative. It is good to be prepared for both possibilities. Before the next session, I suggest you grab a pen and paper and answer these 4 questions: 1) How would the people who are important to you react to the new you, who has quit smoking? 2) How would you feel about their reactions? 3) How would you react if the people who are important to you react positively to the new you? 4) How would you react if the people who are important to you react negatively to the new you?	5 or 25	5	Mercken et al. [11], Perfect Fit project
12	How friends and/or family will receive one's desired future self after becoming more physically active. As social beings, our actions are observed by those around us, who may react in various ways. To boost your confidence when preparing for becoming more physically active, it can be beneficial to envision how those who are important to you will respond to your future physically active self. This can be your colleagues, friends, family, or neighbors, for example. While their reactions may be positive, they could also be negative. So it is wise to anticipate and prepare for both possible outcomes. Before the next session, I suggest you grab a pen and paper and answer these 4 questions: 1) How would the people who are important to you react to the new you, who has become more physically active? 2) How would you feel about their reactions? 3) How would you react if the people who are important to you react positively to the new you? 4) How would you react if the people who are important to you react negatively to the new you?	6 or 26	5	Mercken et al. [11], Perfect Fit project
13	Focusing on past successes for quitting smoking. To increase your confidence that you will succeed in quitting smoking, it can help to think back to previous successes. Have you ever quit smoking before or reduced the number of times you smoked? Maybe you once only had one instead of two cigarettes after dinner. Every success in quitting smoking counts! Before the next session, I suggest you take some time to think about your previous successes and make a list on a piece of paper. Take a few minutes to make your list before moving on. Then take a closer look at your list. Try to think about what strengths you have that helped you to achieve these things. Write these strengths down on your list so you do not forget them. You can also hang or place your list somewhere in your home so that you are reminded of your successes and strengths more often. The list shows that you can be proud of yourself.		4	Michie et al. [12], Perfect Fit project, Stichting Stop Be- wust [20]
14	Focusing on past successes for becoming more physically active. Reflecting on past successes can boost your confidence in successfully becoming more physically active. Before the next session, I suggest you think about when you succeeded in being more physically active. Have you ever taken the bike instead of the car, or taken the stairs instead of the escalator? Every small victory counts! Take a few minutes to make your list before moving on. Then take a closer look at your list. Try to think about what you did that helped you to achieve these things. Write it down on your list so you do not forget it. You can also hang or place your list somewhere in your home so you are reminded of your successes more often. These successes show that you can be proud of yourself.		4	Michie et al. [12], Perfect Fit project, Stichting Stop Be- wust [20]

	Title and Formulation	Prerequisite	Cluster	References
15	Role model for others by quitting smoking. Many people want to quit smoking for other people, such as children or friends. Thinking about how quitting smoking makes you a role model by doing something good for others can motivate you during difficult moments in your quitting journey. I, therefore, recommend you think about how quitting smoking makes you a role model for others before the next session. Grab a pen and a piece of paper and write down your thoughts. Or maybe a picture can help you capture your thoughts.		5	Perfect Fit project, Trimbos Instituut [23]
16	Role model for others by becoming more physically active. Many people want to become more physically active for other people, such as children or friends. Thinking about how becoming more physically active makes you a role model by doing something good for others can motivate you during difficult moments in your behavior change journey. I, therefore, recommend you think about how becoming more physically active makes you a role model for others before the next session. Grab a pen and a piece of paper and write down your thoughts. Or maybe a picture can help you capture your thoughts.		5	Perfect Fit project, Trimbos Instituut [23]
17	Tracking smoking behavior. Preparing for situations in which you commonly smoke may make it easier to successfully quit smoking. Therefore, I recommend that you record the situations in which you smoke before the next session. Take note of one or two keywords to describe the situation and the number of cigarettes that you smoked. For example, you might note "Lunch break, 2 cigarettes" or "TV, 5 cigarettes." It might be helpful to take these notes on your phone, or you could carry a small piece of paper and pen in your pocket.		3	Albers et al. [2], Michie et al. [13]
18	Tracking physical activity behavior. Becoming more physically active (e.g., taking walks, swimming, or boxing) may make it easier to successfully quit smoking. One important step for becoming more physically active is to know one's current level. This allows one to later set a precise goal and hence to feel more motivated. So, I recommend that you record your current behavior with regard to physical activity before the next session. Try to keep track of how much time you spend 1) sitting, 2) working out and 3) being moderately active (e.g., taking a walk, biking to the grocery store). For this, it might be helpful to keep a piece of paper and pen on your kitchen table, or maybe you have a smartwatch that can record these types of behavior for you.		3	Albers et al. [2], Michie et al. [13]
19	Feared future self when not quitting smoking - Writing. Having high motivation to quit smoking may aid in quitting successfully. Thus, before the next session, I advise you to think about who you do NOT want to be in the future but might become if you continue to smoke. For example, you might NOT want to be a "mother who dies early of coronary heart disease as her mother did," a "husband who is frowned upon by his wife" or a "man who is dependent on a substance." Write down everything that comes to your mind.		1	Albers et al. [2], Michie et al. [13]
20	Feared future self when not becoming more physically active - Writing. It may be easier to successfully quit smoking if you become more physically active (e.g., swim, take walks, or dance). One crucial step for this is to have high determination to become more physically active. Therefore, before the next session, I advise you to think about who you do NOT want to be in the future but might become if you fail to become more physically active. For example, you might NOT want to be a "mother who dies early of coronary heart disease as her father did," a "daughter who is frowned upon by her mother" or a "man who is dependent on his wife in his everyday life." Write down everything that comes to your mind.		1	Albers et al. [2], Meijer et al. [10], Penfornis et al. [18]
21	Feared future self when not quitting smoking - Picture. Having high motivation to quit smoking may help to quit successfully. So, before the next session, I advise you to think about who you do NOT want to be in the future but might become if you continue to smoke. For example, you might NOT want to be a "mother who dies early of coronary heart disease as her mother did," a "husband who is frowned upon by his wife" or a "man who is dependent on a substance." Then, look for or take a picture that best captures your feared future self. Save or print this picture so that you can see it every day.		1	Albers et al. [2], Meijer et al. [10], Penfornis et al. [18]

	Title and Formulation	Prerequisite	Cluster	References
22	Feared future self when not becoming more physically active - Picture. It may be easier to successfully quit smoking if you become more physically active (e.g. exercise, take walks, sit less). One crucial step for this is to have high determination to become more physically active. Therefore, before the next session, I advise you to think about who you do NOT want to be in the future but might become if you fail to become more physically active. For example, you might NOT want to be a "mother who dies early of coronary heart disease as her father did," a "daughter who is frowned upon by her mother" or a "man who is dependent on his wife in his everyday life." Then, look for or take a picture that best captures your feared future self. Save or print this picture so that you can see it every day.		1	Albers et al. [2], Meijer et al. [10], Penfornis et al. [18]
23	Visualizing smoking as a battle. Focusing on your goal of successfully quitting smoking may help you to quit. Thus, before the next session, I advise you to take some time to visualize smoking as a battle. For example, you might see yourself and a cigarette as two boxers in a fighting match. Then imagine yourself winning this battle. Visualize clearly how you win and what it feels like to be the winner. Write down a few words about your winning experience.		5	Albers et al. [2], Michie et al. [13]
24	Visualizing becoming more physically active as a battle. Becoming more physically active (e.g., swimming, taking walks, or dancing) may help you to successfully quit smoking. One important step for this is to focus on the goal of becoming more physically active. Thus, before the next session, I advise you to take some time to visualize becoming more physically active as a battle. For example, you might see yourself and a non-active version of yourself as two boxers in a fighting match. Then imagine yourself winning this battle. Visualize clearly how you win and what it feels like to be the winner. Write down a few words about your winning experience.		5	Albers et al. [2], Michie et al. [13]
25	Desired future self after quitting smoking - Picture. Having high aspiration to quit smoking may aid in quitting successfully. Thus, before the next session, I advise you to think about the person that you would like to be once you have successfully quit smoking. For example, you might want to be a "strong woman who lives a healthy life" or a "father who is a good role model for his children." Then look for or take a picture that best captures your desired future self. Save or print this picture so that you can see it every day.		5	Albers et al. [2], Meijer et al. [10], Penfornis et al. [18]
26	Desired future self after becoming more physically active - Picture. Quitting smoking may be easier if you become more physically active (e.g., take walks, dance, or swim). One crucial step for this is to have high motivation to become more physically active. Thus, before the next session, I advise you to think about the person that you would like to be once you have become more physically active. For example, you might want to be a "grandfather who can play football with his grandchildren" or a "nurse who can walk up the stairs to the fourth floor without getting out of breath." Then look for or take a picture that best captures your desired future self. Save or print this picture so that you can see it every day.		5	Albers et al. [2], Meijer et al. [10], Penfornis et al. [18]
27	Education on sleep. If you do not smoke, you sometimes sleep worse. This can make it more difficult to remain quit. You can sleep worse, for example, if you have the same caffeine intake (e.g., coffee, tea, energy drinks, chocolate) as before quitting because caffeine is metabolized less quickly once you quit. Before the next session, I thus recommend you watch this short video for a few tips for better sleep: https://www.youtube.com/watch?v=nysjq8VIwI8&ab_channel=EveryMindMatters . How do you plan to use these tips to improve your sleep after quitting smoking? Take a few notes on your phone or a piece of paper.		2	Perfect Fit project, Trimbos Instituut [23]
28	Education on the relationship between stress and smoking. Does smoking reduce stress? The answer to this question is "no." To feel more motivated to quit smoking, it can help to understand the relationship between smoking and stress. So I recommend watching this video before the next session: https://www.youtube.com/watch?v=GHZXsvrL270 . Afterward, think about what you have learned. What can you take away from the video for yourself? Grab a pen and paper and take a few notes.		2	https://jongvolwassenen.ikstopnu.nl/roken-en-stress/roken-vapen-tegen-stress/

	Title and Formulation	Prerequisite	Cluster	References
29	Routines that cause cravings. Getting fewer cravings to smoke may make it easier to successfully quit smoking. Therefore, before the next session, I advise you to think about routines in your daily life that often cause you to get cravings to smoke. For example, you might have experienced that if you go to bed very late and thus sleep less, you smoke more the next day. Or maybe you have noticed that if you skip your breakfast, you always smoke on your way to work but NOT otherwise. How could you change these routines to reduce or even avoid those cravings? Write down everything that comes to your mind.	17	3	Albers et al. [2], Michie et al. [13]
30	Thinking of high-risk situations and how to cope with them. Preparing for situations in which avoiding smoking is difficult may make it easier to successfully quit smoking. Thus, before the next session, I advise you to think about situations in which you might find it difficult to refrain from smoking. For example, this could be during your lunch break at work, when you meet your best friend, or when you watch TV. How could you deal with these situations so that you do NOT smoke? Write down your plans in a few words.	17	3	Albers et al. [2], Michie et al. [13]
31	Alternative behaviors for cravings. Planning how to resist urges to smoke may make it easier to successfully quit smoking. Therefore, before the next session, I advise you to think about activities that you could do to keep yourself busy when you feel the urge to smoke so that you do NOT smoke. These urges typically last a few minutes; think about something that you could do in the meantime until the urge has passed. For example, you could water your plants, eat a carrot, do 10 push-ups, or do something for another person in need. Write down everything that comes to your mind.		3	Albers et al. [2], Michie et al. [13]
32	Progressive muscle relaxation. Tensing and relaxing areas of the body can reduce cravings and withdrawal symptoms because it is very difficult to feel tense or uptight in a relaxed body. Thus, before the next session, I advise you to watch the following 15-minute video to learn progressive muscle relaxation (which is a way of relaxing your body): https://www.youtube.com/watch?v=ihO02wUzgkc&ab_channel=MarkConnelly . Even if you have already heard of this technique, it might be a good idea to refresh your memory.		2	Albers et al. [2], Michie et al. [13]
33	Breathing exercise. When you quit smoking, you may feel restless or irritable during the first days or weeks. To help you quit and stay quit, it can help to learn how to manage these nicotine withdrawal symptoms. One way to manage them is through breathing exercises. So, before the next session, I suggest you to watch this 3-minute video to learn how to do box breathing: https://www.youtube.com/watch?v=tEmt1Znux58&ab_channel=SunnybrookHospital . Even if you have already heard of this technique, it might be a good idea to refresh your memory.		2	National Cancer Institute [16]
34	Learning how to use a nicotine patch. When you quit smoking, you may experience nicotine withdrawal symptoms during the first days or weeks which can make it difficult to refrain from smoking. The symptoms can include anxiety, frustration, and nicotine cravings. One way to manage these symptoms is nicotine replacement therapy. For example, you can use a nicotine patch. To understand how to use a nicotine patch, I recommend watching this short video before the next session: https://www.youtube.com/watch?v=sgj5FJVqI5g&ab_channel=CentersforDiseaseControlandPrevention%28CDC%29 . What can you take away for yourself from this video? Note your thoughts on your phone or a piece of paper.	35	2	National Cancer Institute [16]
35	Learning about nicotine replacement therapy. Ceasing smoking can trigger nicotine withdrawal symptoms in the initial days or weeks. This can make it difficult to refrain from smoking. The symptoms can include anxiety, frustration, anger, and nicotine cravings. Nicotine replacement therapy, such as using a nicotine patch, is one approach to managing these symptoms. To understand what nicotine replacement therapy is and how it works, I recommend watching this 4-minute video before the next session: https://www.youtube.com/watch?v=g3Ar4v5K880&ab_channel=CentersforDiseaseControlandPrevention%28CDC%29 . What can you take away for yourself and your own quitting process from this video? Take a few notes on your phone or a piece of paper.		2	National Cancer Institute [16]

	Title and Formulation	Prerequisite	Cluster	References
36	Education on diet. It is possible that people who quit smoking gain some weight. Learning how you can maintain a healthy weight after quitting smoking can help you to quit and stay quit. I, therefore, recommend watching this short video with tips on how to prevent a large weight gain after quitting smoking before the next session: https://youtu.be/jseVEv9tVS8 . What can you take away from these tips for maintaining a healthy weight after quitting smoking for yourself? Grab a pen and piece of paper and note your takeaways.		2	Voedingscentrum [25]
37	Education about how the body starts repairing itself immediately once a person stops smoking. Having a strong desire to refrain from smoking may aid in quitting successfully. Thus, before the next session, I advise you to watch the following 12-minute video on how the body starts repairing itself immediately, as soon as a person stops smoking: https://www.youtube.com/watch?v=ZhTOC0T3P3c&ab_channel=RespiratoryTherapyZone . What information from the video is most relevant to you? Take a few notes.		4	Albers et al. [2], Michie et al. [13]
38	Exchanging a passive activity for an active one. Becoming more physically active (e.g., taking walks, going running, swimming) may help you to successfully quit smoking. One crucial part for this is to think about ways you can incorporate physical activity into your daily life. One way to do this is to exchange a passive activity for an active one. Therefore, before the next session, I advise you to think about ways you could exchange a passive activity for an active one. For example, you could take the stairs instead of the escalator, bike to work instead of taking the bus, or work at a standing desk. Grab a piece of paper or your phone and write down everything that comes to your mind. Which exchange do you want to focus on? Highlight this exchange.		3	Voedingscentrum [26]
39	Education about the possible positive impact of physical activity on dealing with cravings to smoke. Becoming more physically active (e.g., swimming, taking walks, boxing) may help you to successfully quit smoking. One crucial step for this is to have high aspiration to become more physically active. So, before the next session, I advise you to watch the following short video about the possible positive impact of physical activity on dealing with cravings to smoke: https://youtu.be/iakhFA-jPCc . What do you think about the information in the video? Write down your thoughts in a few words.		3	Albers et al. [2], National Cancer Institute [15]
40	Thinking of solutions to barriers to becoming physically active. Becoming more physically active (e.g., taking walks, boxing, dancing) may help you to successfully quit smoking. One important step for becoming more physically active is to remove possible obstacles. Thus, before the next session, I advise you to think about things that make it difficult for you to be physically active. For example, this could be that you do NOT have a raincoat to bike to the grocery store when it is raining, that you do NOT want to work out alone, or that you are at work all day and too exhausted by the time that you come home. What are possible solutions to your barriers? For instance, you could buy a raincoat, join a running group, or take a walk during your lunch break at work. Write down everything that comes to your mind.		3	Albers et al. [2], Al-faifi et al. [3]
41	Education on recommended physical activity. Quitting smoking may be easier if you become more physically active (e.g., swim, take walks, go running). One important step for becoming more physically active is to set a specific goal and thus to feel more aspiration. Therefore, before the next session, I advise you to watch the following 2-minute video on how much and which type of physical activity is recommended: https://www.youtube.com/watch?v=AAPhWbG_zLs&ab_channel=TREKGroup . Then, compare your physical activity behavior to the recommended amounts for the different types of physical activity. Write down which recommended amounts you meet or exceed, and which ones you do NOT meet.	18	3	Albers et al. [2]
42	Plan for becoming more physically active. Becoming more physically active (e.g., taking walks, dancing, swimming) may help you to successfully quit smoking. One crucial part for this is to create a plan for becoming more physically active. Therefore, before the next session, I advise you to think about what you could do to become more physically active. For example, you could get up from your desk after every 30 minutes of sitting, bike to the grocery store, do 10 squats every morning, or join a running group. Write down everything that comes to your mind. Which plan do you want to focus on? Highlight this plan.	18	3	Albers et al. [2]

	Title and Formulation	Prerequisite	Cluster	References
43	<p>Positive diary. This activity is called "Positive Diary" and helps you think positively and feel good. This can help you quit smoking and become more physically active. In the evening before going to bed, think about the day you had. Write down 2 or 3 things that happened that you are grateful for, happy about, or that went well. For example, "Someone smiled at me in the supermarket," "I did not smoke today," or "I took a nice walk with a friend." Writing down these positive moments can help you feel better, about yourself and about your day. You can write down anything! It does not have to be about being more physically active or quitting smoking, but can be any enjoyable moment from the day, big or small. This will help you to focus on positive things.</p>		4	Perfect Fit project, Sutton [21]
44	<p>Focusing on past success in general. To increase your confidence that you will succeed in changing your behavior (e.g., quitting smoking), it can help to think back to previous successes. Before the next session, I suggest you take a moment to reflect on times when you succeeded in something or felt satisfied. Have you ever won a competition? Did you cook something delicious recently? Or maybe you learned a new language? Grab a pen and paper and make a list of your success moments. No success is too small to write down! Take a few minutes to make your list before moving on. Then take a closer look at your list. Try to think about what you did that helped you to achieve your successes. Write it down on your list so you do not forget it. You can also hang or place your list somewhere in your home so that you are reminded of your successes more often. The list shows that you can be proud of yourself.</p>		4	Michie et al. [12], Perfect Fit project, Stichting Stop Bewust [20]

Step 2: Obtaining the views of health experts and smokers

Table S2: Factor loading, label, and explanation of the items with the most positive and most negative factor loadings¹ for the three factors describing expert-identified competencies. We created two individual competencies for each factor (i.e., one for each endpoint). The labels and explanations are direct, uncorrected quotes from participants.

Factor Loading	Label and Explanation
FACTOR 1: (+) PRACTICAL SKILLS – CLEAR FUTURE IDENTITY (–)	
0.85	practical skills: preparing practically for activities
0.80	strategies: through social learning the individual might find out strategies to successfully change behavior themselves
0.78	problem solving: This helps smokers to think ahead and come up with solutions for barriers
-0.63	Identity: These activities help to strengthen feared and ideal future selves
-0.63	identity: These activities help to envision the ideal and feared future selves
-0.64	Future-self: Future-selves can act as powerful motivators
FACTOR 2: (+) MOTIVATION – KNOWLEDGE (–)	
0.81	Increasing self-efficacy / confidence: By imagining oneself as a role model, the confidence and self-efficacy can increase
0.75	Boosting motivation and self-efficacy: By focusing on past successes and coming up with motivational quotes motivation and self-efficacy / confidence can be increased
0.64	boosting motivation: A personal rule and thinking about reasons to become more physically active can both boost a persons motivation to actually perform the behavior
-0.84	Education/Knowledge: Knowledge about a certain topic can be very valuable to change behavior
-0.89	knowledge: These activities aim to convey information and expand the smoker's knowledge
-0.94	Increasing knowledge: Watching an information video about the positive impact of physical activity on dealing with smoking cravings can increase knowledge on this topic.
FACTOR 3: (+) INSIGHTS INTO PERSONAL STRENGTHS – INSIGHTS INTO PERSONAL WEAKNESSES (–)	
0.63	strengthening: strengthening of personal power
-0.49	Identify barriers and facilitators: It is important that individuals recognize what stands in the way of/what facilitates achieving their goal
-0.58	measuring baseline: Measuring baseline in order to better adjust goals
-0.83	insight in current behavioral or thought patterns: The activities are about tracking and thereby gaining insight in current behavioral or thought patterns

¹Only factor loadings with a magnitude of at least 0.4 were considered.

Table S3: Factor loadings, labels, and explanations of the items with the most positive and most negative factor loadings for the five factors describing smoker-identified competencies. We created two individual competencies for each factor (i.e., one for each endpoint)¹. The labels and explanations are direct, uncorrected quotes from participants.

Factor Loading	Label and Explanation
FACTOR 1: (+) SELF-EFFICACY – PRACTICAL KNOWLEDGE (–)	
0.92	Self motivation: Activities that focus on motivation and planning
0.85	Mindset: Activities that will help you with the right mindset needed to quit smoking
0.79	Mindsets: getting into the right mindset
-0.75	Problem solving.: Quitting smoking and being more active can some times be hard and some barriers may show up, so being able to find a way around those is important.
-0.84	Knowledge: Consuming educational content, gaining knowledge
-0.86	Pratical: Learning real techniques to quit smoking
FACTOR 2: (+) AWARENESS OF POSITIVE OUTCOMES – AWARENESS OF NEGATIVE OUTCOMES (–)	
0.88	Positive outlook: Educating and exploring the positive steps you can take
0.88	Feeling godd about your day: Something positive to make you feel better about your day.
0.82	positivity: the activities in group 1 focus on the success of quitting
-0.68	Discouragement: Envisioning a feared future self might add to a self-fulfilling prophecy rather than act as a form of encouragement
-0.70	Negative reinforcement: Activity that provides a negative perceived outcome of the smoking
-0.86	Fears: Group 2 focuses on creating fear/guilt
FACTOR 3: (+) MOTIVATION TO CHANGE – KNOWLEDGE OF HOW TO MAINTAIN/ACHIEVE MENTAL WELL-BEING (–)	
0.77	Projection: I think the activities in Group 1 help the smoker project his/herself in his/her future life as a non-smoker.
0.61	motivation: group 1 refers to ways of motivating yourself to quit smoking
0.60	Future Self: Goals for the future, to obtain while pursuing the goal of quitting.
-0.49	Being mindful: This item more concerns mental well being
-0.50	Stress relief: This group teaches a method for relaxation
-0.50	mental: this activity is about improving mental health
FACTOR 4: (+) MINDSET THAT PHYSICAL ACTIVITY HELPS TO QUIT SMOKING	
0.85	Excercise: Both activities seek to enhance physical activity.
0.79	Physical activities help quitting: These activities are directly related to how physical activities can help someone quit
0.78	physical activity is relevant to quitting smoking: the activities focus on involvement in physical activity as helpful for building a role model
-0.41	Nucotine knowledge.: This is about the effects of nicotine.
-0.43	Situations and solutions for refraining from smoking: These are practical things to do in the now.
-0.44	Future without smoking: It shows what we fear when we do and do not quit smoking
FACTOR 5: (+) KNOWLEDGE OF HOW TO MAINTAIN/ACHIEVE WELL-BEING – AWARENESS OF SMOKING PATTERNS (–)	
0.61	Better sleep better health: This is focused on getting a good night sleep, for all health reasons
0.47	Team admiration: Here we focus on other people that have accomplished something great and we get inspired
0.45	Mental well-being: Activity that focusses on self-love and self-appreciation
-0.56	Patterns: Establishing patterns to one’s smoking habit.
-0.71	Direct activity: These activities are directly connected to the activity of quitting smoking.
-0.80	Planning: Create steps or envision ideas that help plan to quit smoking

¹The exception is factor 4 where the endpoints were negations of each other and we thus created a single competency.

Step 3: Creating persuasive activities

Table S4: Elements from protection motivation theory and how they were addressed in the persuasive activity for the smoker-identified competency "motivation to change."

Element	Way of Addressing the Element
Threat	Nicotine cravings, withdrawal symptoms, barriers to becoming more physically active
Threat vulnerability & severity	Number and diversity of situations that can cause cravings and of barriers to becoming more physically active, examples of common withdrawal symptoms
Response efficacy	Motivation can help overcome threats
Self-efficacy & response cost	Specific examples of simple ways to increase motivation (e.g., noting reasons for wanting to change)

Table S5: Persuasive activities. Smoker-identified competencies and formulations from the reminder messages (each activity had two formulations, one for the conversational session and one for the reminder message sent on Prolific at the end of the session) for the nine persuasive activities that were used in the study.

	Title and Formulation	References
1	Self-efficacy. Adopting the right mindset is crucial in altering one's behavior (e.g., quitting smoking). It involves identifying the desired end result and having faith in one's ability to attain it. Adequate motivation and self-confidence are crucial in this process. To understand why, I recommend watching this short video before the next session: https://youtu.be/CAQ_P4Z7z4Q . What do you think, how can self-confidence and motivation help you to reach your end goal? Write down your thoughts on a piece of paper or your phone.	Bandura [4], Michie et al. [14], Vlaams Instituut Gezond Leven [24]
2	Practical knowledge. Some very practical steps can aid in effectively changing your behavior (e.g., quitting smoking). This includes acquiring an understanding of your current behavior, exploring strategies to overcome possible obstacles, and preparing things that will motivate you. To understand why, I advise watching this short video before the next session: https://youtu.be/CM_u7oV7WXU . How do you think practical preparations can help you become more physically active and quit smoking? Write down your thoughts on a piece of paper or your phone.	Michie et al. [12], Michie et al. [13], Trimbos Instituut [22]
3	Awareness of positive outcomes. Keeping a positive outlook and being aware of positive outcomes of one's behavior change (e.g., quitting smoking) can help to overcome possible obstacles. To understand why, I recommend watching this short video before the next session: https://youtu.be/_BnMm3EKrDk . How do you think that thinking about "positive" things can help you to become more physically active and quit smoking? Note your thoughts on your phone or a piece of paper.	Grassi et al. [5], Hoepfner et al. [7], NHS inform [17], Penfornis et al. [18]
4	Awareness of negative outcomes. When preparing for changing your behavior (e.g., quitting smoking), it is helpful to think about 3 types of "negative" things. This includes obstacles, possible short-term adverse effects on your well-being, and things that could happen in the future if you do not change. To understand why, I advise watching this short video before the next session: https://youtu.be/28ggci50PvU . How can thinking about "negative" things help you to become more physically active and quit smoking? Note your thoughts on your phone or a piece of paper.	Alfaifi et al. [3], National Cancer Institute [16], Penfornis et al. [18], https://www.physio-pedia.com/Barriers_to_Physical_Activity
5	Motivation to change. Motivation is crucial when changing your behavior (e.g., quitting smoking). To understand why, I suggest watching this short video before the next session: https://youtu.be/kEadOY713qs . What do you think, how can (more) motivation help you quit smoking and become more physically active? Write down your thoughts on a piece of paper or your phone.	Trimbos Instituut [22]
6	Knowledge of how to maintain/achieve mental well-being. Knowledge of how to manage cravings and the often associated negative feelings such as anger, frustration, irritability, or anxiety helps to quit smoking successfully. To understand why, I suggest watching this short video before the next session: https://youtu.be/_pTTelaObHc . How do you think can knowledge of how to manage cravings and the resulting negative feelings help you quit smoking? Note your thoughts on a piece of paper or your phone.	National Cancer Institute [16]

	Title and Formulation	References
7	<p>Mindset that physical activity helps to quit smoking. Physical activity helps to quit smoking. To understand why, I suggest watching this short video before the next session: https://youtu.be/qoD2j_ITm9U. How do you think can physical activity help you to quit smoking? Collect your ideas on a piece of paper or your phone.</p>	<p>https://www.ikstopnu.nl/bibliotheek/sporten-helpt-bij-stoppen-met-roken/</p>
8	<p>Awareness of smoking patterns. It is common for individuals to encounter barriers or obstacles that make it more difficult for them to change their behavior (e.g., quit smoking). For example, a lack of support from one's friends for quitting smoking. Or not having running shoes. When preparing to change one's behavior, it is advantageous to consider potential obstacles to successfully changing one's behavior. To understand why, I suggest watching this short video before the next session: https://youtu.be/mdbC9q9pwFw. How do you think can thinking of possible obstacles help you to quit smoking and become more physically active? Collect your thoughts on your phone or a piece of paper.</p>	<p>https://www.physio-pedia.com/Barriers_to_Physical_Activity</p>
9	<p>Knowledge of how to maintain/achieve well-being. When changing one's behavior (e.g., quitting smoking), it is possible that in the short term, one's mental and/or physical well-being decline. For example, you may sleep worse for some time after quitting smoking. Such negative effects can make it challenging to both begin and sustain your behavior change. But there are steps that you can take to minimize or even prevent such negative effects. It is useful to think about such steps when preparing to change your behavior. To understand why, I advise watching this short video before the next session: https://youtu.be/3rSqLEgRHEo. What do you think, how can learning about steps to reduce short-term negative effects on your mental and physical well-being help you to quit smoking and become more physically active? Note your thoughts on your phone or a piece of paper.</p>	<p>Jaehne et al. [8], National Cancer Institute [16], Prosis et al. [19]</p>

Step 4: Designing the model

Table S6: Smoker-identified competencies and formulations of the corresponding factors used to elicit people's beliefs about the usefulness of the competencies.

	Competency	Factor Formulation
1	Self-efficacy	Self-confidence and motivation (e.g., right mindset, 'Yes, I can do it'-attitude, building motivation)
2	Practical knowledge	Practical preparation (e.g., learning how to relieve stress, knowing effects of nicotine, getting organized)
3	Awareness of positive outcomes	Keeping a positive outlook and being aware of positive outcomes (e.g., positive thinking, positive mindset, knowing benefits of quitting)
4	Awareness of negative outcomes	Thinking about 'negative' things (e.g., obstacles and how to deal with them, negative consequences of smoking, what life first looks like without smoking)
5	Motivation to change	Motivation (e.g., awareness of future non-smoker life, being motivated to quit, thinking of what you fear to happen when not quitting)
6	Knowledge of how to maintain/achieve mental well-being	Knowledge of how to manage cravings and the resultant negative feelings (e.g., improving one's mental health and well-being after quitting)
7	Mindset that physical activity helps to quit smoking	Knowledge of how physical activity helps to quit smoking
8	Awareness of smoking patterns	Thinking of possible obstacles (e.g., recognizing possible obstacles, envisioning ideas to overcome them, planning how to deal with them)
9	Knowledge of how to maintain/achieve well-being	Knowing how to maintain one's mental and physical well-being (e.g., knowing how to get good sleep and stay inspired)

Table S7: Contributions of the 44 preparatory activities to the six expert-identified competencies based on data from the repertory grid study with experts. Values of at least 0.9 are shown in bold to get an idea of which activities strongly contribute to the competencies. The activity with the highest total contribution of 2.32 is activity 10 (i.e., "personal rule for becoming more physically active").

Activity number	Practical skills	Clear future identity	Motivation	Knowledge	Insights into personal strengths	Insights into personal weaknesses
1	0.47	0.00	0.72	0.00	0.00	0.07
2	0.45	0.00	0.75	0.00	0.61	0.00
3	0.41	0.00	0.24	0.00	0.00	0.19
4	0.59	0.00	0.04	0.00	0.00	0.11
5	0.00	0.31	0.97	0.00	0.32	0.00
6	0.00	0.31	0.98	0.00	0.83	0.00
7	0.07	0.00	0.72	0.00	0.00	0.24
8	0.09	0.00	0.57	0.00	0.00	0.15
9	0.46	0.00	0.82	0.00	0.61	0.00
10	0.49	0.00	0.82	0.00	1.00	0.00
11	0.00	0.24	0.91	0.00	0.00	0.09
12	0.00	0.37	0.81	0.00	0.00	0.19
13	0.51	0.00	0.85	0.00	0.00	0.59
14	0.66	0.00	0.72	0.00	0.00	0.54
15	0.00	0.60	0.82	0.00	0.00	0.16
16	0.20	0.00	0.81	0.00	0.32	0.00
17	0.32	0.00	0.40	0.00	0.00	1.00
18	0.27	0.00	0.17	0.00	0.00	0.97
19	0.00	0.77	0.84	0.00	0.00	0.22
20	0.00	0.93	0.80	0.00	0.00	0.11
21	0.00	1.00	0.78	0.00	0.00	0.00
22	0.00	0.93	0.86	0.00	0.00	0.26
23	0.28	0.00	0.85	0.00	0.27	0.00
24	0.29	0.00	0.84	0.00	0.27	0.00
25	0.00	0.19	0.86	0.00	0.00	0.00
26	0.00	0.15	1.00	0.00	0.00	0.04
27	0.91	0.00	0.00	0.48	0.00	0.25
28	0.51	0.00	0.00	0.15	0.00	0.17
29	0.80	0.00	0.50	0.00	0.00	0.73
30	0.99	0.00	0.65	0.00	0.00	0.60
31	1.00	0.00	0.48	0.00	0.00	0.27
32	0.75	0.00	0.00	1.00	0.44	0.00
33	0.86	0.00	0.00	0.86	0.00	0.02
34	0.68	0.00	0.00	0.89	0.00	0.10
35	0.58	0.00	0.00	0.84	0.00	0.15
36	0.73	0.00	0.00	0.21	0.00	0.23
37	0.04	0.00	0.05	0.00	0.00	0.01
38	0.91	0.00	0.47	0.00	0.00	0.60
39	0.58	0.00	0.00	0.35	0.00	0.10
40	0.97	0.00	0.53	0.00	0.00	0.73
41	0.36	0.00	0.00	0.38	0.00	0.74
42	0.90	0.00	0.51	0.00	0.00	0.27
43	0.57	0.00	0.40	0.00	0.00	0.35
44	0.51	0.00	0.76	0.00	0.00	0.55

Step 5: Training the model

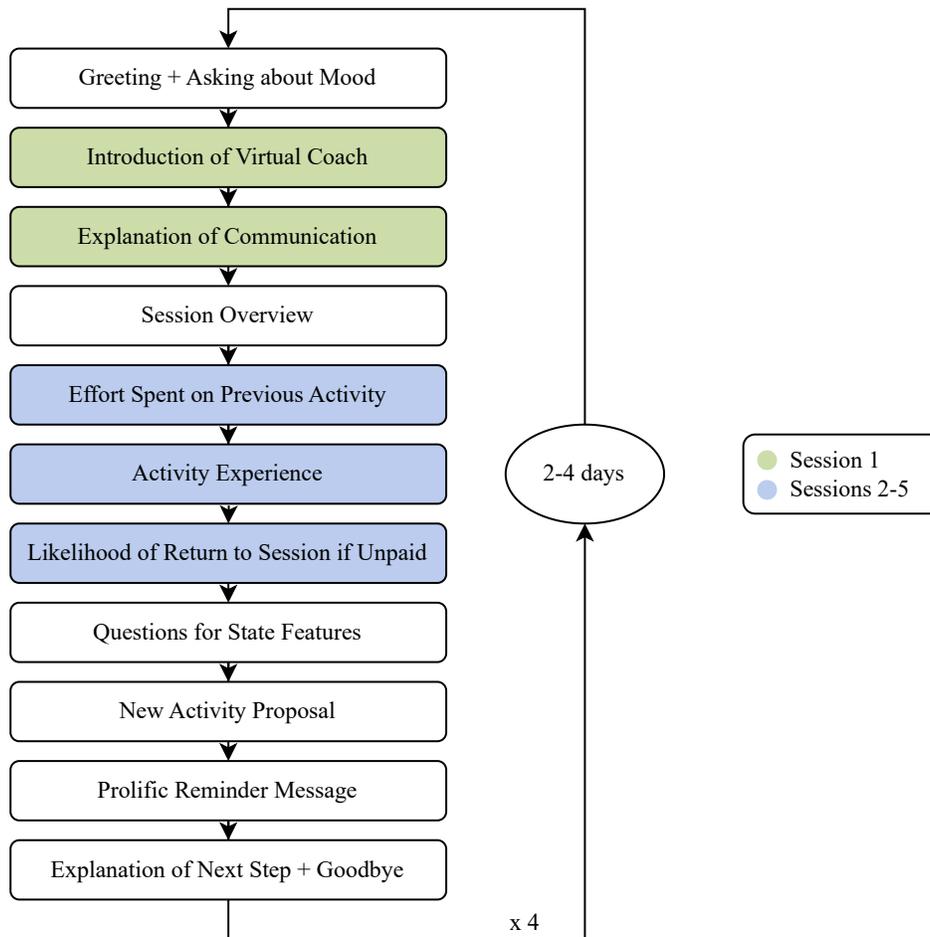


Figure S1: Structure of the five conversational sessions with Mel. Participants received reminder messages with the formulations of their new activities on the online crowdsourcing platform Prolific Academic, which is where participants were recruited.

Table S8: Characteristics of the 542 participants with at least one transition sample.

Characteristic	Value
AGE (IN YEARS)	
- Mean (SD)	38.89 (11.56)
- Range	20 – 85
GENDER	
- Female, n (%)	284 (52.40%)
- Male, n (%)	250 (46.13%)
- Other, n (%)	8 (1.48%)
HIGHEST COMPLETED EDUCATION LEVEL	
- No formal qualifications, n (%)	5 (0.92%)
- Secondary education (e.g. GED/GCSE), n (%)	61 (11.25%)
- High school diploma/A-levels, n (%)	135 (24.91%)
- Technical/community college, n (%)	89 (16.42%)
- Undergraduate degree (BA/BSc/other), n (%)	171 (31.55%)
- Graduate degree (MA/MSc/MPhil/other), n (%)	75 (13.84%)
- Doctorate degree (PhD/other), n (%)	5 (0.92%)
- Don't know/not applicable, n (%)	1 (0.18%)
SMOKING FREQUENCY	
- Once a day, n (%)	15 (2.77%)
- 2 – 5 times a day, n (%)	103 (19.00%)
- 6 – 10 times a day, n (%)	147 (27.12%)
- 11 – 19 times a day, n (%)	180 (33.21%)
- More than 20 times a day, n (%)	97 (17.90%)
TTM-STAGE FOR BECOMING PHYSICALLY ACTIVE	
- Precontemplation, n (%)	37 (6.83%)
- Contemplation, n (%)	162 (29.89%)
- Preparation, n (%)	94 (17.34%)
- Action, n (%)	68 (12.55%)
- Maintenance, n (%)	181 (33.39%)
WEEKLY EXERCISE AMOUNT	
- Never (0 – 60 minutes per week), n (%)	154 (28.41%)
- Sometimes (60 – 150 minutes per week), n (%)	251 (46.31%)
- Often (more than 150 minutes per week), n (%)	137 (25.28%)

Abbreviations: SD, Standard deviation; GED, General educational development; GCSE, General certificate of secondary education; BA, Bachelor of Arts; BSc, Bachelor of Science; MA, Master of Arts; MSc, Master of Science; MPhil, Master of Philosophy; PhD, Doctor of Philosophy; TTM, Transtheoretical model.

Table S9: Change in smoking frequency level¹, quitter self-identity², and weekly exercise level³ between the prescreening questionnaire (*T*₀), post-questionnaire sent two days after the last session (*T*₁), and follow-up questionnaire sent eight weeks after the last session (*T*₂).

Measure	<i>T</i> ₁ – <i>T</i> ₀		<i>T</i> ₂ – <i>T</i> ₀	
	Mean	95%-HDI	Mean	95%-HDI
Smoking frequency level	-0.67	[-0.96, -0.38]	-0.96	[-1.30, -0.63]
Quitter self-identity	0.21	[0.15, 0.27]	0.10	[0.01, 0.19]
Weekly exercise level	-0.16	[-0.51, 0.20]	0.19	[-0.25, 0.63]

Abbreviations: HDI, Highest density interval.

¹ Smoking frequency was measured with eight levels from “never” to “more than 20 times per day.”

² Quitter self-identity was assessed using three items based on Meijer et al. [9], each rated on a 5-point Likert scale from “disagree strongly” to “agree strongly.”

³ Weekly exercise was measured with three levels from “never (0–60 minutes per week)” to “often (more than 150 minutes per week).”

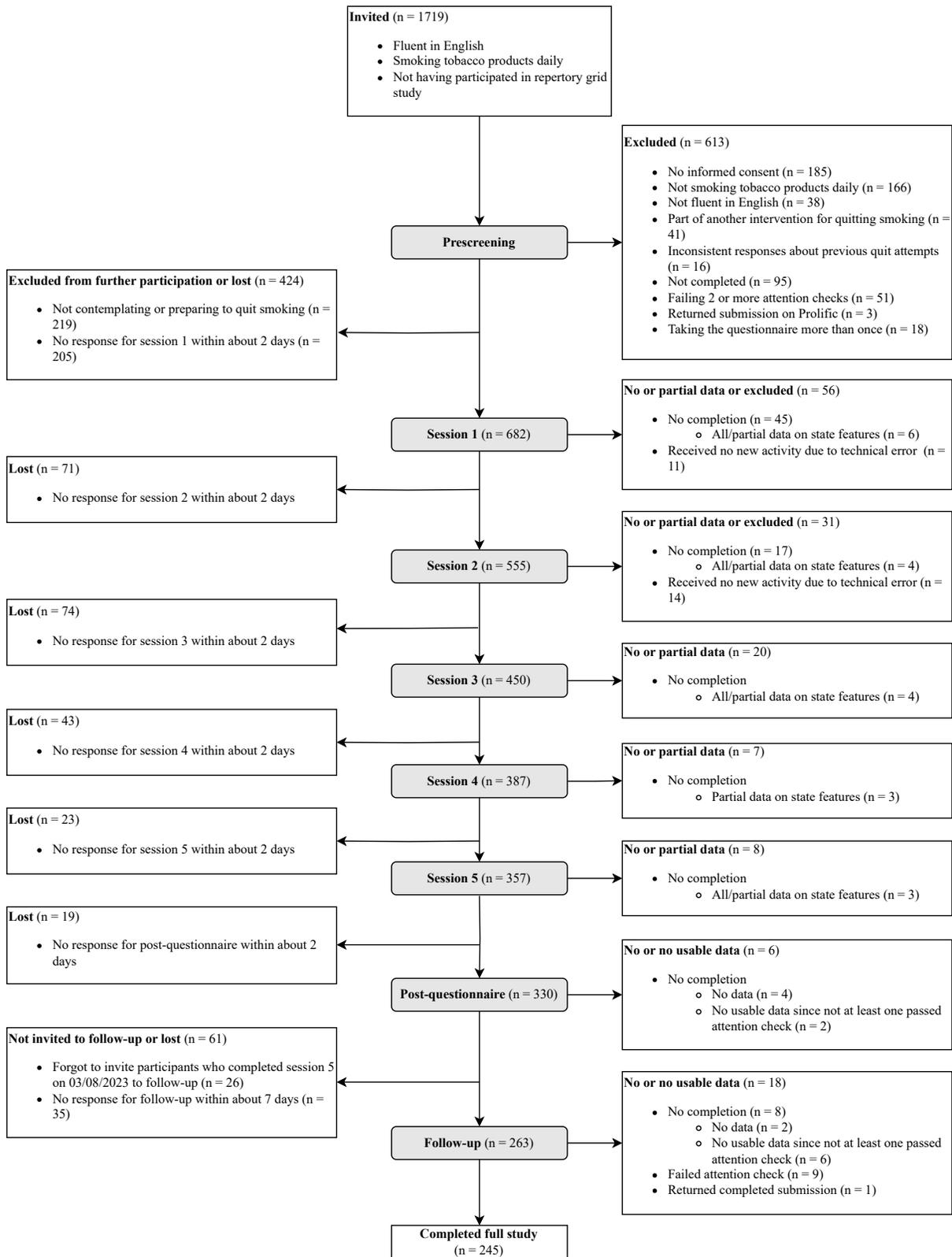


Figure S2: Participant flow through the study components. The numbers next to the component names denote how many people started the component. Participants on Prolific can return their submissions.

Table S10: Number of samples and mean effort per preparatory activity cluster and persuasive activity.

Activity (Cluster)	Number	Mean Effort (SD)
PREPARATORY ACTIVITY CLUSTERS		
Cluster 1 (e.g., feared future self when not quitting smoking, feared future self when not becoming more physically active)	113	5.68 (2.79)
Cluster 2 (e.g., education on sleep, education on the relationship between stress and smoking)	128	6.08 (3.04)
Cluster 3 (e.g., alternative behaviors for cravings, education about the possible positive impact of physical activity on dealing with cravings to smoke)	129	6.14 (2.72)
Cluster 4 (e.g., focusing on past successes for quitting smoking, personal rule for becoming more physically active)	120	5.48 (2.95)
Cluster 5 (e.g., desired future self after quitting smoking, creating motivational slogans/quotes for becoming more physically active)	143	5.30 (2.85)
PERSUASIVE ACTIVITIES		
Self-efficacy	120	5.36 (2.78)
Practical knowledge	121	5.34 (2.97)
Awareness of positive outcomes	124	5.86 (2.83)
Awareness of negative outcomes	121	5.52 (2.93)
Motivation to change	111	5.24 (2.82)
Knowledge of how to maintain/achieve mental well-being	111	5.95 (2.66)
Mindset that physical activity helps to quit smoking	124	5.68 (2.81)
Awareness of smoking patterns	124	5.24 (2.84)
Knowledge of how to maintain/achieve well-being	121	5.19 (2.94)
Total	1710	5.58 (2.86)

Abbreviations: SD, Standard deviation.

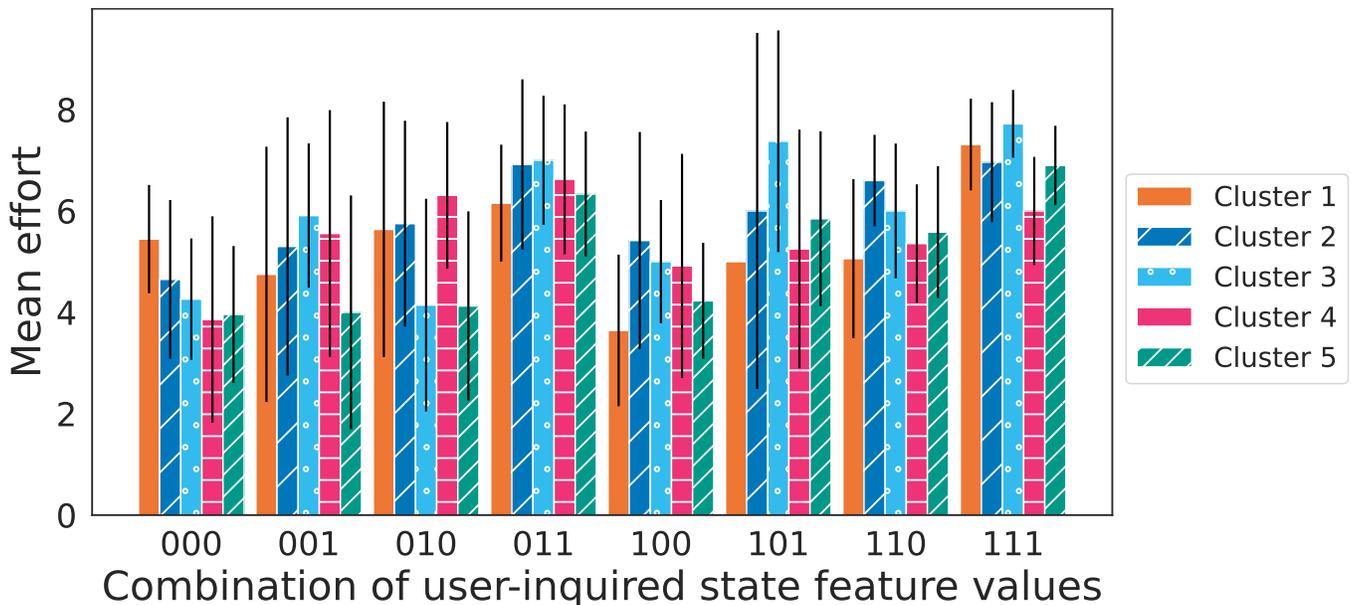


Figure S3: Mean effort with 95% credible intervals per preparatory activity cluster and combination of values for the three selected binary user-inquired features. We use binary strings to denote the values of the three binary features using this order: 1) belief about the usefulness of "self-efficacy," 2) belief about the usefulness of "mindset that physical activity helps to quit smoking," and 3) energy.

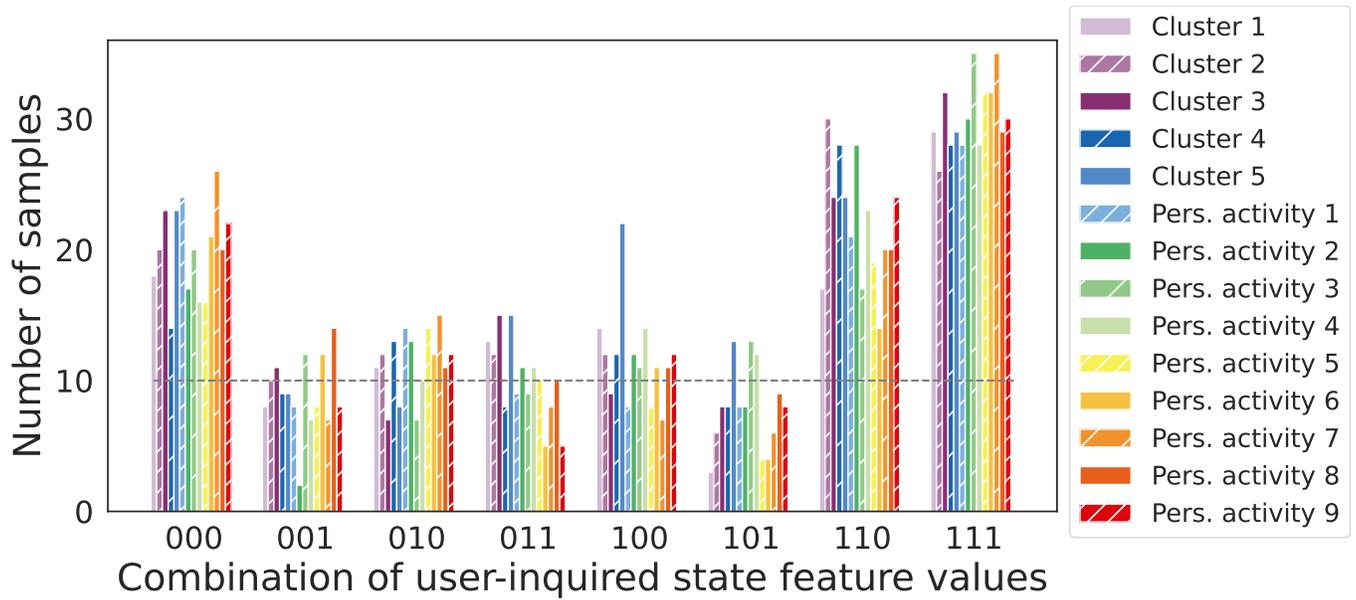


Figure S4: Number of samples per activity (cluster) and combination of values for the three selected binary user-inquired features. We use binary strings to denote the values of the three binary features using this order: 1) belief about the usefulness of "self-efficacy," 2) belief about the usefulness of "mindset that physical activity helps to quit smoking," and 3) energy. When we have less than 10 samples for a feature value combination and preparatory activity cluster, we impute with the mean effort spent on preparatory activities for the effort prediction. The effort spent on persuasive activities is not part of our model.

RESULTS

Figure S5 shows the fraction of expert competencies built after different numbers of proposed activities when sampling the effort people spend on their activities from a normal distribution whose mean and standard deviation are estimated from our collected data. Compared to our results presented in Figure 5.4 in the chapter, which is based on assuming that people spend the mean effort per preparatory activity cluster and combination of values for the three selected user-inquired state feature values, it takes longer to build expert competencies. The reason for this is that due to our binning of the expert competency levels into four possible values (i.e., 0, 0.33, 0.67, and 1), people who spend very little effort on their activity do not advance to the next level for a competency. If more bins were used, this effect would be less strong.

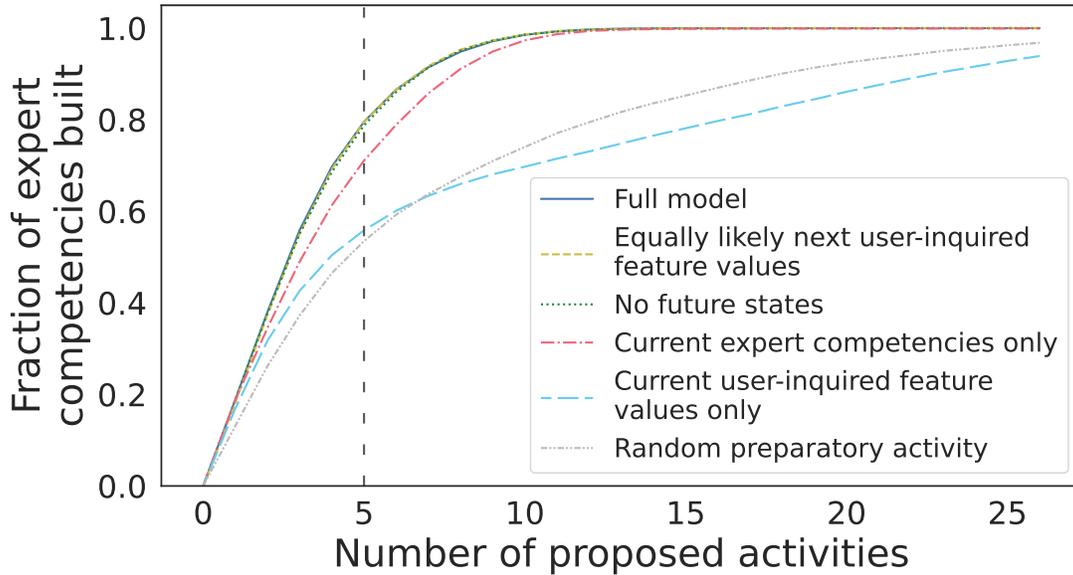


Figure S5: Fraction of expert competencies built after different numbers of proposed activities when using policies based on different models and sampling the effort people spend on their activities from a normal distribution. The lines for the first two policies almost overlap completely.

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