

# MEDICAL SHARED DECISION MAKING WITH EMBODIED CONVERSATIONAL AGENTS

A dissertation presented

by

Zessie (Zhe) Zhang

to the Faculty of the Graduate School

of the Khoury College of Computer Sciences

in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

Northeastern University

Boston, Massachusetts

March 2020

Thesis Title: Medical Shared Decision Making with Embodied Conversational Agents

Author: Zhe Zhang

PhD Thesis Approval to complete all degree requirements for the PhD in Computer Science.

[Signature] Thesis Advisor      2/21/20 Date

[Signature] Thesis Reader      2/21/20 Date

[Signature] Thesis Reader      2/21/20 Date

\_\_\_\_\_  
Thesis Reader      Date

\_\_\_\_\_  
Thesis Reader      Date

**KHOURY COLLEGE APPROVAL:**

[Signature] Associate Dean for Graduate Programs      3/1/20 Date

**COPY RECEIVED BY GRADUATE STUDENT SERVICES:**

[Signature] Recipient's Signature      3/6/20 Date

Distribution: Once completed, this form should be scanned and attached to the front of the electronic dissertation document (page 1). An electronic version of the document can then be uploaded to the Northeastern University-UMI Website.

## ABSTRACT

Shared decision making (SDM) is a process in which clinicians and patients work together to make decisions about the patient's care using the best available evidence while accounting for patient personal values and preferences. SDM has been increasingly advocated as the ideal model for patient decision making in healthcare. In practice, however, SDM is seen to occur to a limited extent only. Significant barriers that have prevented patients from participating in SDM include insufficient time to interact with clinicians, fear of asking questions or disagreeing with clinicians' recommendations, and inadequate health literacy and numeracy to understand and act on complex health information. Previous research has shown that decision coaching by a healthcare professional can effectively address these barriers and support patient participation in SDM. However, decision coaching is rarely used in practice due to the limited availability of time and healthcare professionals trained in these techniques.

Embodied conversational agents (ECAs) represent a promising alternative to the provision of decision coaching for SDM. Previous work on ECAs has shown that they are capable of providing health counseling and coaching and have a positive impact on patient satisfaction and health outcomes. In this dissertation, I develop and evaluate an ECA that acts as a virtual decision coach to automatically provide patients with guidance and coaching on the main tasks of the SDM process. The goal of this system is to support patients to actively participate in medical decisions and to ensure that decisions are informed by the best available evidence and consistent with their

personal values. I describe three studies to evaluate the ability of the ECA-based decision coach in facilitating SDM and improving patient decision quality. This work contributes to the field of Human Computer Interaction and Medical Decision Making by providing a simulation of a human decision coach using an ECA to support patient participation in SDM and by providing researchers with opportunities to compare different decision-making approaches in a perfectly controlled setting by using an ECA.

## ACKNOWLEDGEMENTS

I'd like to thank my advisor for providing me with the opportunity to enter the research world and with the guidance and support throughout my entire PhD journey. I would also like to thank Karen Sepucha and Carey Noland for being on my PhD committee and for the invaluable feedback they have given me on my work.

I would also like to thank all the incredible mates that I have been working with in the lab throughout the years, including Lazlo Ring, Juan Fernandez, Ameneh Shamekhi, Shuo Zhou, Dina Utami, Stefan Olafasson, Eve Kimani, Teresa O'Leary, Prasanth Murali, Dhavel Parmar, and Lin Shi.

Finally, I would like to give a special thanks to my husband, my parents, and my life-long friends, for their continuous love and support. None of this would have been possible without it.

# TABLE OF CONTENTS

|  |    |
|--|----|
| ABSTRACT .....   | I  |
| ACKNOWLEDGEMENTS.....  | IV |
| TABLE OF CONTENTS .....  | V  |
| 1 INTRODUCTION .....   | 1  |
| 2 RELATED WORK .....   | 6  |
| 2.1 SHARED DECISION MAKING IN HEALTHCARE .....                   | 6  |
| 2.2 PROCESS MODELS OF SDM .....                                  | 10 |
| 2.3 DECISION SUPPORT FRAMEWORKS.....                             | 12 |
| 2.4 DECISION THEORIES .....                                      | 16 |
| 2.4.1 Normative Theories .....                                   | 16 |
| 2.4.2 Descriptive Theories.....                                  | 17 |
| 2.4.3 Prescriptive Theories.....                                 | 19 |
| 2.5 CONSTRUCTS AND MEASURES FOR SDM.....                         | 26 |
| 2.5.1 Decision Antecedents.....                                  | 27 |
| 2.5.2 Decision Making Process .....                              | 28 |
| 2.5.3 Decision Outcomes .....                                    | 29 |
| 2.6 DECISION SUPPORT TECHNIQUES.....                             | 30 |
| 2.6.1 Patient Decision Aids .....                                | 30 |
| 2.6.2 Decision Coaching.....                                     | 32 |
| 2.7 COMPUTERIZED TOOLS FOR SDM.....                              | 35 |
| 2.8 EMBODIED CONVERSATIONAL AGENTS FOR HEALTH COUNSELING .....   | 39 |
| 2.9 SUMMARY OF RELATED WORK .....                                | 42 |
| 3 A VIRTUAL DECISION COACH FOR MEDICAL SHARED DECISION MAKING .. | 44 |
| 3.1 PRIMARY SDM TASKS .....                                      | 45 |
| 3.2 CONVERSATIONAL STRUCTURE .....                               | 47 |

|  |     |
|--|-----|
| 3.3 IMPLEMENTATION.....  | 50  |
| 4 EVALUATING THE ACCEPTABILITY OF A VIRTUAL DECISION COACH.....                        | 52  |
| 4.1 PROTOTYPE SYSTEM.....  | 53  |
| 4.2 PILOT STUDY.....   | 56  |
| 4.2.1 Participants.....  | 57  |
| 4.2.2 Procedure.....   | 57  |
| 4.2.3 Measures.....  | 58  |
| 4.2.4 Results.....   | 59  |
| 4.3 CONCLUSION.....  | 65  |
| 5 COMPARATIVE EVALUATION OF VALUE CLARIFICATION PREFERENCE<br>ELICITATION METHODS..... | 66  |
| 5.1 STUDY CONDITIONS AND SYSTEMS.....  | 67  |
| 5.2 COMPARATIVE EVALUATION STUDY.....  | 70  |
| 5.2.1 Participants.....  | 71  |
| 5.2.2 Procedure.....   | 71  |
| 5.2.3 Measures.....  | 71  |
| 5.2.4 Results.....   | 73  |
| 5.3 CONCLUSION.....  | 80  |
| 6 EVALUATING A VIRTUAL SHARED DECISION-MAKING COACH FOR COLON<br>CANCER SCREENING..... | 82  |
| 6.1 VIRTUAL SDM SYSTEM FOR CRC SCREENING.....  | 83  |
| 6.2 EVALUATION STUDY.....  | 87  |
| 6.2.1 Participants.....  | 88  |
| 6.2.2 Procedures.....  | 88  |
| 6.2.3 Measures.....  | 89  |
| 6.2.4 Results.....   | 91  |
| 6.3 CONCLUSION.....  | 102 |

|   |     |
|---|-----|
| 7 CONCLUSIONS.....  | 105 |
| REFERENCE.....  | 112 |
| APPENDIX A: BASELINE QUESTIONNAIRE (STUDY I, II, III).....            | 127 |
| APPENDIX B: NEED FOR COGNITION SCALE (STUDY II, III) .....            | 129 |
| APPENDIX C: HEALTH LOCUS OF CONTROL SCALE (STUDY I) .....             | 132 |
| APPENDIX D: CONTROL PREFERENCE SCALE (STUDY I, II, III).....          | 135 |
| APPENDIX E: NUMERACY SCALE (STUDY I, II, III) .....                   | 136 |
| APPENDIX F: KNOWLEDGE TEST FOR PRENATAL TESTING (STUDY I).....        | 138 |
| APPENDIX G: KNOWLEDGE TEST FOR CRC SCREENING (STUDY III) .....        | 140 |
| APPENDIX H: SYSTEM USABILITY (STUDY II) .....                         | 142 |
| APPENDIX I: DECISIONAL CONFLICT SCALE (STUDY I, II, III) .....        | 143 |
| APPENDIX J: DECISION REGRET SCALE (STUDY I).....                      | 146 |
| APPENDIX K: SATISFACTION WITH DECISION SCALE (STUDY I, II, III) ..... | 147 |
| APPENDIX L: INTENTION FOR CRC SCREENING (STUDY III) .....             | 148 |
| APPENDIX M: PREPARATION FOR DECISION MAKING SCALE (STUDY III).....    | 149 |
| APPENDIX N: DECISION MAKING EXPERIENCE (STUDY I, II, III) .....       | 151 |
| APPENDIX O: ATTITUDES TOWARDS DECISION COACH (STUDY I, II, III) ..... | 152 |
| APPENDIX P: SDM-Q-9 (STUDY III) .....                                 | 153 |
| APPENDIX P: COLORECTAL CANCER BROCHURE (STUDY III).....               | 155 |
| APPENDIX Q: COLON CANCER SCREENING COUNSELING TRANSCRIPTS .....       | 164 |

# 1 INTRODUCTION

In the practice of healthcare, clinicians and patients frequently face situations in which a decision must be made about prevention, diagnosis, or treatment. Traditionally, medical decision making has followed a "paternalistic" model, in which the clinician acts as the patient's guardian, determining what is best for the patient, with limited patient participation [1]. This model assumes that the clinician can accurately discern what is in the patient's best interest and recommend the optimal course of action for the patient. Yet, studies show that clinicians often misjudge patient preferences [2-4], and patients can make very different choices than their clinicians when they are fully informed about their options [2, 5].

Over the past few decades, healthcare researchers and organizations have encouraged patients to play an active role in making treatment decisions [6]. Patients have also shown a desire to be involved in medical decision making that affects them [7, 8]. Research suggests that patients are the best judges of their values concerning health [9], and patients who are involved in their own healthcare decisions are more satisfied

with the care they receive and often experience better outcomes [10-12]. Given these findings, researchers in health communication have developed techniques for "shared decision making" (SDM), allowing patients to participate in decision making and receive care that matches their personal needs and goals. SDM is a process in which clinicians and patients work together to make decisions about tests, treatments, and care plans [13, 14]. It takes into account the best available medical evidence plus patient values and preferences to make optimal personalized choices.

SDM has been increasingly advocated as the ideal model for engaging patients in decision making [15, 16], especially when more than one medically-acceptable option is available and the best choice depends strongly on patient values and preferences [17-20]. However, SDM only occurs to a limited extent in routine practice. National Health Service (NHS) inpatient surveys from United Kingdom show that 40%-50% of their patients want to be more involved in their medical decision making [21]. Barriers for patients to participate in SDM include insufficient time to interact with their clinicians [22], fear of asking questions and disagreeing with their clinicians' recommendations [23, 24], and inadequate health literacy to understand and act on complex health information [25-27].

Several attempts have been made to support patient participation in SDM. One effort has been developing tools, such as educational pamphlets and computer programs, for patients to use outside of clinical encounters to learn about their options, so they do not have to rely on time-constrained clinical consultations to get the information they need to make a shared decision [28-33]. While these tools address the

time barrier and help patients fill in information gaps, it has been argued that these tools alone are not enough to ensure SDM, because they focus heavily on information provision with little support to clarify patient values and preferences related to the options available, and they do not help integrate medical evidence with these values and preferences [34]. Other efforts include health professionals providing coaching and education to patients to help them weigh options, clarify values, and prepare for discussions with their healthcare providers [35, 36]. Although decision coaching can provide additional support on value clarification and information integration, it requires a significant amount of time and skill from the healthcare provider doing it, so it has not been widely adopted in routine care.

Embodied conversational agents (ECAs) are computer animated characters designed to simulate face-to-face conversation [37], and represent a promising alternative approach to supporting patient participation in SDM. ECAs provide a pressure-free environment in which the users can take as much time as they need to absorb information and ask questions [38]. They can ensure a thorough understanding by consistently evaluating their users' comprehension of the information being presented, and by repeating information or explaining it in different ways, as needed. Additionally, ECAs have a nonjudgmental attitude, allowing users to voice their concerns or disagreement without fear or embarrassment. ECAs can also provide health information in a consistent manner and adapt the information to users' particular needs, and they have been proven to be particularly effective in conveying complex health information to people with low health literacy [38-42]. Last but not the least,

ECAs can use verbal and non-verbal behaviors to elicit trust and build rapport with their users, enabling better communication and increasing user satisfaction [43].

In this dissertation, I develop an ECA to simulate the decision coaching process provided by a human decision coach. The ECA acts as a virtual decision coach to automatically provide guidance and coaching to patients on the main tasks of SDM, including problem identification, choice education, value clarification and preference elicitation (VC/PE) defined as a process to clarify patient values related to their decision making, helping them form a preference, and final decision making.

Specifically, in my work I answer the following research questions:

- RQ1. Will people accept an ECA in the role of decision coach to guide them through the SDM process?
- RQ2. What is the best decision-making framework for a virtual decision coach to use to support SDM?
- RQ3. How well can a virtual decision coach be generalized to support SDM across different decision problems?
- RQ4. Is a virtual decision coach more effective than standard patient education materials for improving the decision-making process and decision quality?

The work presented in this dissertation contributes to the field of Human Computer Interaction (HCI) and Medical Decision Making (MDM) by providing a simulation of a human decision coach using an ECA to support patient participation in SDM. Another contribution of this work is that it provides researchers with

opportunities to compare different decision-making approaches in a perfectly controlled setting by using an ECA.

This dissertation is organized as follows. In Chapter 2, I discuss related work that explores the barriers to SDM, process models for SDM, as well as previous work in designing decision aids to support patient participation in SDM. In Chapter 3, I describe the "virtual decision coach", a simulation of human decision coaching using an ECA to provide guidance and coaching to patients to promote and facilitate their participation in SDM activities. In Chapter 4, I present an evaluation of the virtual decision coach in supporting women making a hypothetical decision on prenatal testing to answer RQ1. I then answer RQ2 and RQ3 in Chapter 5 by presenting an empirical study comparing three VC/PE approaches for three hypothetical medical decisions. In Chapter 6, I present a randomized controlled trial designed to evaluate the Virtual Shared Decision-Making System guided by the virtual decision coach in helping older adults make a shared decision on colorectal cancer screening, in which I show the efficacy of the system, answering RQ4. In Chapter 7, I conclude the dissertation and discuss directions for future research.

# 2 RELATED WORK

## 2.1 SHARED DECISION MAKING IN HEALTHCARE

SDM is defined as "an approach where clinicians and patients share the best available evidence when faced with the task of making decisions, and where patients are supported to consider options, to achieve informed preferences" [13, 14]. SDM is characterized by information sharing between two or more parties, at a minimum including a clinician and a patient, with both parties taking steps to build a consensus about the preferred healthcare option and implementation plan [18, 44]. These characteristics distinguish SDM from other decision-making models such as the "paternalistic" and "informed" models. In those models, information is transferred from one party to another and the decision is made independently by either the clinician ("paternalistic") or patient ("informed") [1]. In SDM, information is exchanged in both

directions and the clinician and patient are both assumed to possess expertise that is important to decision making [18, 44]. The clinician's expertise includes medical knowledge of the disease, prognosis, and available options for treatment. This includes potential benefits and risks to the patient, and possible outcomes. The patient's expertise lies in knowledge of their personal beliefs, priorities, and current situation.

Some researchers have suggested that SDM should be applied to all medical decision making [15, 16]. However, others have argued that it is particularly useful in situations of equipoise, where more than one medically-acceptable intervention exists but little information is available to suggest that one intervention is superior to another [18-20, 44]. In some cases, there is a lack of evidence about the outcomes of certain medical interventions. In an analysis of 3000 currently available interventions by BMJ Clinical Evidence, an estimated 50% of these interventions are classified as having insufficient evidence for effectiveness [45]. In other cases, the existing evidence does not allow differentiation between interventions. For example, women with early stage breast cancer can usually choose mastectomy (complete removal of the breast) or lumpectomy followed by radiation (a local excision of the tumor) as their treatment options, with both offering an equivalent survival benefit [46]. However, women who choose mastectomy will lose the entire breast and may undergo reconstructive surgery, while women who choose lumpectomy will have radiation and live with a slightly higher risk of recurrence in the treated breast [46]. In situations where equipoise exists, the "best" choice depends strongly on patient personal values and preferences. These decisions are considered "preference-sensitive" [17], and should be made only when

patients are fully informed and have explored their values and preferences to make a choice that is best for them.

Although SDM has been increasingly advocated as the ideal model for medical decision making, particularly for preference-sensitive decisions [18-20], its use in current clinical practice is limited [21]. Several factors can prevent health professionals from engaging in SDM. First, health professionals lack the time to follow the best practices of SDM during their brief interactions with patients. Given the limited time they have with patients, it is unlikely that clinicians can communicate with each patient about all available decision options in great detail, as well as eliciting patient personal values and preferences. Second, health professionals may lack the appropriate skills needed to facilitate an SDM interaction. It has been found that clinicians tend to use more authoritative communication styles rather than collaborative approaches in clinical practices [23, 47]. Research has also indicated that health professionals fail to recognize patient decisional conflict and focus mainly on providing information without addressing patient values and preferences [48-52]. These studies have highlighted the growing need for professional training among health professionals on how to perform SDM in clinical practice [13, 35]. Finally, health professionals can misjudge patient preferences. For example, clinicians often assume that women with early stage breast cancer prefer lumpectomy over mastectomy. However, in a study of 125 women with early stage breast cancer, approximately 1/3 of the women chose to have a mastectomy [2]. Additionally, clinicians often consider the length of a patient's life to be the top priority, while some patients prioritize quality of life as their primary

goal [3, 4]. Misjudgment of patient values and priorities can lead to misunderstandings between patients and health professionals, which can result in frustration and mistrust.

There are also challenges for patients to participate in SDM. First, it can be difficult for patients, especially for those who prefer to delegate decision making to their clinicians, to accept that there is no medically preferred option. Second, patient preferred level of involvement in SDM may significantly differ depending on the type of decision, patient personality, and the skills of their healthcare providers [7, 53-56]. Patients may feel worried, upset or even abandoned when being asked to play an active role in decision making [54, 57]. They may also be reluctant to discuss their choices or ask questions of their clinician, due to fear of being labeled as "difficult" patients [23]. Third, many patients have inadequate health literacy, which can hinder their participation in SDM. Health literacy is defined as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" [58]. Agency for Healthcare Research and Quality (AHRQ) estimated that 36 percent of the adult population in the U.S. have limited health literacy. This is more prevalent in certain subgroups, such as older adults, racial and ethnic minorities, people who have not completed high school, and people who live in poverty [27]. Limited health literacy not only affects patient comprehension of medical information, but also prevents them from effectively communicating with their healthcare providers [25-27]. Even if a patient has a high level of health literacy, they may still feel overwhelmed by the amount of information that the clinician is trying to deliver during an SDM interaction. Patients can have

substantially different expectations regarding the amount of information they need to make a shared decision: some patients want to know as much as possible, while some do not want any information [59].

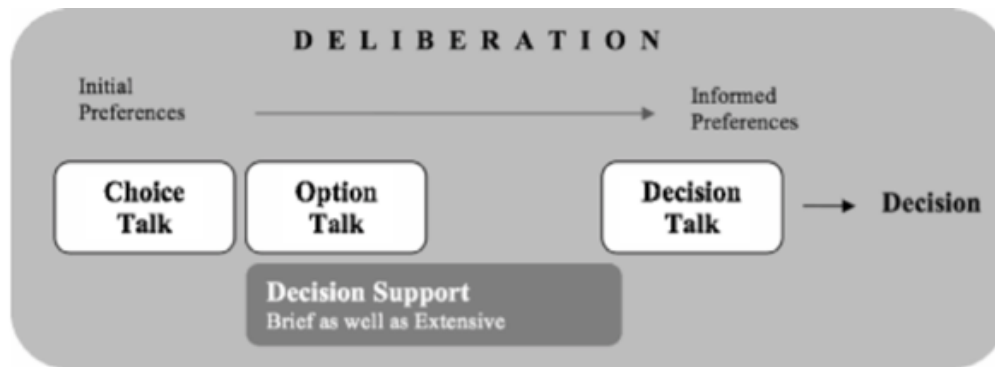
## 2.2 PROCESS MODELS OF SDM

A number of theoretical models have been developed to conceptualize the process of SDM. In 1997, Charles et al. presented a model for SDM, which suggests as key characteristics of SDM : (1) that it involves at least two participants—the clinician and the patient; (2) that both parties share information; (3) that both parties take steps to build a consensus about the preferred care plan, and (4) that a decision is made based on agreement between both parties [18].

In 2006, Makoul and Clayman conducted a systematic review of SDM literature in the context of physician-patient encounters and identified nine "essential elements" of an SDM process [19], including defining the problem, presenting the options, discussing the pros and cons for each option, clarifying patient values and preferences, assessing patient self-efficacy, providing doctor knowledge or recommendations, checking patient understanding, making or deferring a decision, and arranging follow-ups.

More recently in 2012, Elwyn et al. translated the concept of SDM into a practical model, which can be used to guide SDM in clinical practice [14]. This model describes SDM as a step-wise process (Figure 2-1): (1) choice talk in which patients are made aware that reasonable options exist; (2) option talk in which patients are informed about

all options in sufficient detail; (3) decision talk in which patients are supported to explore their personal preferences and decide what is best. The details of each step are summarized in Table 1. The model also introduces the concept of "deliberation" and describes it as "a process of considering information about the pros and cons of their options, to assess their implications, and to consider a range of possible futures, practical as well as emotional" [14]. According to this model, deliberation begins as soon as patients develop an awareness of their options and ends when informed decisions are made.



**Figure 2-1: The Three Talk Model**

**Table 2-1: Key Components of The Three-Talk Model**

| Steps              | Key Components     | Descriptions  |
|--------------------|--------------------|---|
| <b>Choice Talk</b> | (a) Step back      | Identify the problem and clarify the decision   |
|                    | (b) Offer choice   | Help patient develop awareness of alternative options   |
|                    | (c) Justify choice | Emphasize<br>(1) the importance of respecting individual preferences<br>(2) the role of uncertainty |

|                      |                                      |  |
|----------------------|--------------------------------------|--|
|                      | (d) Check reaction                   | Check if the patient has any concerns about the choice of options  |
|                      | (e) Defer closure                    | Defer closure when the patients react by asking "tell me what to do"<br>Reassure that you are willing to support the process |
| <b>Option Talk</b>   | (a) Check knowledge                  | Check the knowledge base of the patient regarding options  |
|                      | (b) List options                     | List all options before getting into more detail   |
|                      | (c) Describe options                 | Describe options, their pros and cons in practical terms   |
|                      | (d) Provide patient decision support | Provide tools to help patients understand and compare options  |
|                      | (e) Summarize                        | Summarize the information and assess patient understanding   |
| <b>Decision Talk</b> | (a) Focus on preferences             | Guide the patient to form their preferences  |
|                      | (b) Elicit a preference              | Help the patient to identify the most favored option(s)  |
|                      | (c) Moving to a decision             | Check for the need to make a decision or defer a decision  |
|                      | (d) Offer review                     | Offer the opportunity to review the information and the decision   |

## 2.3 DECISION SUPPORT FRAMEWORKS

There have been frameworks developed to guide the development and evaluation of decision support to help patients participate in SDM and improve decision outcomes.

The Ottawa Decision Support Framework (ODSF) developed by O’Conner et al. describes three primary elements that are important to decision making and their relationships to each other. According to this framework, unresolved decision needs negatively affect decision outcomes, and decision support can improve decision outcomes by addressing unresolved decisional needs. The details of the three elements are summarized in table 2.

**Table 2-2: Elements of Ottawa Decision Support Framework**

|   |
|---|
| <p><b>Decisional Needs</b></p> <p>They are defined as “gaps between what is and what should be”.</p> <p>Examples include:</p> <ul style="list-style-type: none"><li>○ decisional conflict about the best course of action (personal uncertainty about the best course of action)</li><li>○ inadequate knowledge of condition, options, benefits, risks, scientific uncertainties</li><li>○ unrealistic expectations of the likelihood of benefits and risks</li><li>○ unclear values or personal importance of benefits, risks, scientific uncertainties</li><li>○ inadequate support from others or resources</li><li>○ decision characteristics such as decision type, timing, and stage and leaning to a specific option</li><li>○ special needs from patients’ personal or clinical characteristics</li></ul> |
| <p><b>Decision Outcomes</b></p> <p>Decision quality: a “high-quality” decision is one that is</p> <ul style="list-style-type: none"><li>○ informed with best available evidence</li><li>○ informed with the patient values</li></ul>  |

Other outcomes include:

- actions or behaviors (e.g., make or defer a decision, adherence to the chosen option)
- values-based health outcomes
- emotions such as regret or blame
- the appropriate use of health services and related costs

### **Decision Support**

It is defined as “structured assistance in deliberating on the options communicating with others that is tailored to the patient's decisional needs”.

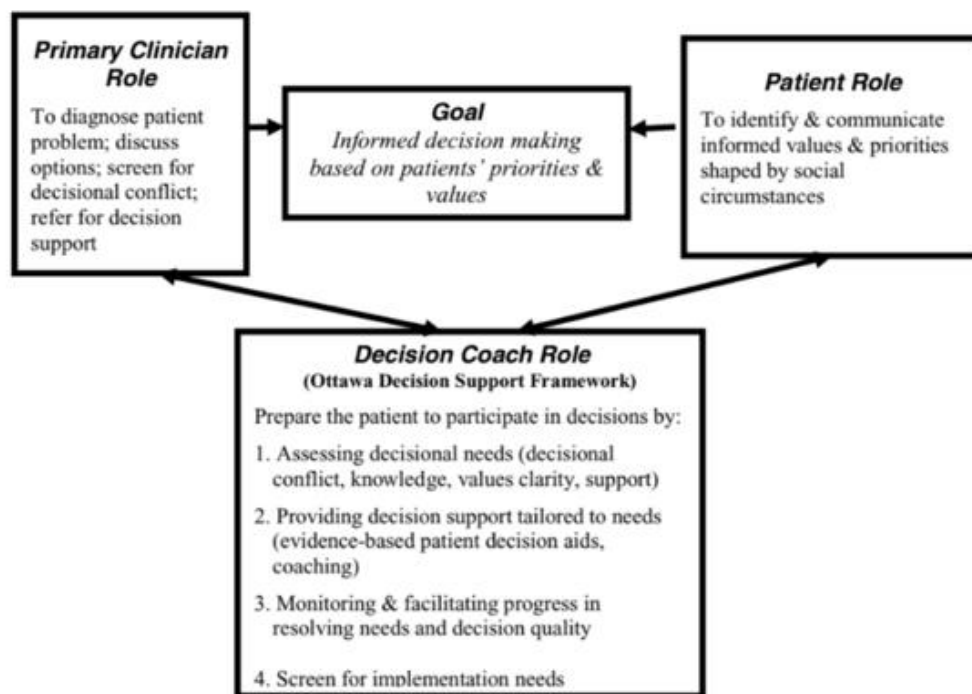
It can be provided in the form of clinical counseling, decision aids and/or decision coaching.

The process involves:

- clarifying the decision
- assessing the patient's decisional needs
- providing information to address knowledge deficits and unrealistic expectations
- clarifying the patient's values by describing other patients' experiences or asking them to rate the personal importance of benefits, harms, or side effects
- enhancing support from others and resources;
- monitoring and facilitating progress in decision making.

Based upon ODSF, Stacey et al. developed the Decision Coach-Mediated SDM Framework (Figure 2-2), expanding the traditional patient-clinician dyad to include the role of decision coach to better facilitate SDM [35]. This framework outlined the general responsibility of the clinician role, the patient role, and the decision coach in the process of SDM. The practitioner is primarily responsible for diagnosing the problem, providing the options, screening for patient decisional conflict, and referring for decision support

if necessary. The patient is expected to share their values and priorities shaped by personal situations and social circumstances. The decision coach recognizes patient decisional conflict and intervenes by providing guidance and support throughout the SDM process. The coach can help the patient understand the best evidence about the health condition and treatment options, clarify their values, build skills in deliberation, communicate with others involved in the decision, and break down barriers to implementation of the preferred choice. A decision coach should be a well-trained health professional who has a neutral attitude towards the decision under discussion. In clinical settings, the role of decision coach is often fulfilled by nurses, social workers, psychologists, or genetic counselors. The idea of using an ECA to perform the role of decision coach to facilitate SDM is primarily inspired by this framework.



**Figure 2-2: Decision Coach-Mediated SDM Framework**

## 2.4 DECISION THEORIES

There are several theories on the topics of choice and decision-making, explaining how people cognitively approach and achieve a decision. These theories can be divided into three general branches: (1) normative theories, (2) descriptive theories, and (3) prescriptive theories [60].

### 2.4.1 NORMATIVE THEORIES

Normative theories are concerned with how individuals should make decision under ideal conditions. They were developed under the assumption that humans are ideal decision makers who are informed, rational, and cognitively capable of computing complex information with accuracy. The central normative principle proposes that an individual who is faced with a range of options should choose the one that maximizes the overall value of decision outcomes.

Expected Utility Theory (EUT) is the most widely recognized normative theory [61], which provides a model of rational behavior under conditions of uncertainty. It suggests that individuals should always choose the option that leads to the maximum expected utility. The expected utility is calculated by the sum of the utilities for all possible outcomes multiplied by the respective probabilities of these outcomes occurring. In this context "utility" provides a numeric measure of an individual's strength of preference for each particular outcome relative to other potential outcomes. The "probability" represents the uncertainty related to each of the decision outcomes.

Another well-known normative theory is the Subjective Expected Utility Theory (SEUT), which is also referred to the Bayesian Decision Theory [62]. SEUT adheres to the same paradigm of decision making as EUT except that in EUT, probabilities of possible consequences are based on objective verifiable information, while in SEUT, individuals subjectively evaluate probabilities of consequences a priori with their personal knowledge and beliefs.

## 2.4.2 DESCRIPTIVE THEORIES

Descriptive theories describe how individuals make decisions in real life situations. They state that human decision making can systematically deviate from rationality, under the influence of subtle subconscious factors.

Simon first argued that rationality is an unrealistic assumption for human decision making. Thus, he proposed the concept of "bounded rationality", which considers that individual rationality is limited by the available information, the tractability of the decision problem, the cognitive limitations of their minds, and the time available to make the decision [63, 64]. The "satisficing" principle was developed to describe decision making with bounded rationality, proposing that individuals attempt to obtain a satisfactory solution rather than an optimal one [65, 66].

Kahneman and Tversky also noted that humans do not process information in the perfectly rational way assumed by normative theories. They developed the Prospect Theory, with the underlying idea that individuals use heuristics to process information, and they make decisions based on perceived gains and losses rather than the final

outcomes [67-69]. The theory posits that individuals put more emphasis on gains rather than losses, making the choice most likely to achieve gains [67-69]. In other words, if an individual is faced with two choices that are equivalent in end results but presented differently (one presented in terms of gains and the other presented in terms of losses), the individual is likely to choose the one suggesting gains. The Prospect Theory suggests that an individual's preferences are influenced by framing of the information, such as the use of language, numbers, and diagrammatic representations, and that their perception of risks is affected by the reference points or anchors used to describe those risks [67-69]. According to this theory it is important to keep a balanced presentation of information to avoid biased framing effects, and to provide both absolute (population level) and relative (comparator level) risk information to ensure accurate risk perceptions. An alternative to the Prospect Theory is the Regret Theory [70]. It adds the variable of potential regret to the regular values of gains and losses and suggests that individuals avoid decisions that could lead to regret.

The Conflict Model of Decision Making is another widely recognized descriptive theory.[71]. This model suggests that decision making involves conflict by which stress is engendered, and such stress in turn influences how people behave and process information related to decision making. It outlines five patterns that individuals tend to follow when coping with stressful decisions: (1) unconflicted adherence, in which the individual just ignores the decision, (2) unconflicted change, in which the individual chooses whatever is recommended without questioning the decision, (3) defensive avoidance, in which the individual attempts to avoid and postpone the decision to

relieve the stress, (4) hypervigilance, in which the individual makes an impulsive choice without considering the consequences of the choice, and (5) vigilance, in which the individual searches systemically for relevant information, carefully evaluates the viable alternatives, and makes a non-impulsive decision. According to the theory, vigilance is the only pattern that is adaptive and can lead to high-quality decisions.

### 2.4.3 PRESCRIPTIVE THEORIES

Prescriptive theories bridge the identified gap between normative theories and descriptive theories, recognizing that, in spite of imperfect reasoning and computational abilities, humans can be assisted to conform with the desired normative principles and make rational decisions.

Multi Criteria Decision Analysis (MCDA) is a well-known prescriptive approach to supporting complex decision making [72]. It is most applicable to decision problems that are characterized as a choice among alternatives with multiple, often conflicting, criteria. There are a variety of MCDA methods, of which the value-based methods are the most frequently applied in the healthcare context [73, 74]. The value-based methods seek to associate a quantitative number ("value") with each alternative to indicate how well the alternative meets the decision criteria, so that all alternatives can be compared and ranked to generate the best choice [72]. Calculating the "value" of an alternative requires two essential steps: (1) *weighing*, which captures the relative importance of a criterion with respect to achieving the overall objective of decision making, and (2) *scoring*, which captures an alternative's performance within a criterion [72]. The overall

"value" of an alternative is represented by an aggregated form of the obtained weights and scores [72].

### 2.4.3.1 SMARTER

The underlying theories of value-based methods can be different. Some methods are based on Multi-Attribute Utility Theory (MAUT) [75]. The MAUT methods use criteria priorities as weights and option utilities as scores. The most theoretically correct MAUT method is difficult to implement in practice so simpler methods have been developed that approximate the results of the original method very closely. SMARTER is one of the approximation methods. It uses swing weights to determine the criteria priorities. Specifically, the decision maker is asked to pretend to have an option that has the lowest possible score on all the criteria, and then asked to indicate which criterion they would choose if they could improve the option's performance from worst to best on just one criterion. The chosen criterion is then given the highest priority. The process is repeated using the remaining criteria until all the criteria are ranked. With regards to the option utilities, they are determined directly from the data available for the alternatives but transformed from the criterion-specific measurement scales to a standardized utility scale running from 0-100. The "value" of an option is generated by combining the weights (option utilities in this case), and the scores (the criteria priorities in this case) using the additive weighting method:

$$\text{Option Value} = \sum_{n=1}^N w_n s_n \quad (1)$$

where  $N$  are the indexes of the criteria,  $W_n$  are the weights, one for each criterion (summing to 1), and  $S_n$  are the scores, one for each criterion.

To illustrate the SMARTER method, I will show how we can use it to make a decision for colon cancer screening. Let us assume three tests are available for colon cancer screening, which are Fecal Immunochemical Test (FIT), Stool DNA Test, and Colonoscopy, and we evaluate them on three different criteria, namely effectiveness, risk, and cost (as shown in Table 2-3).

**Table 2-3: Option Data for Colon Cancer Screening**

| <b>Option/Criteria</b> | <b>Effectiveness</b> | <b>Risk</b>  | <b>Cost</b>     |
|------------------------|----------------------|--|-----------------|
| <b>FIT</b>             | 75% detection rate   | no risk of complication  | \$8 per test    |
| <b>Stool DNA</b>       | 92% detection rate   | no risk of complication  | \$650 per test  |
| <b>Colonoscopy</b>     | 95% detection rate   | 4 in 1000 experience complications such as perforation, bleeding, infections, and etc. | \$2000 per test |

To determine the criteria priorities, one is asked to pretend to have an option that has the worst possible detection rate, the highest possible risk, and the highest possible cost, and asked which criterion they would like to improve from its worst performance to its best performance. Let us say we choose detection rate as the highest priority, and

then risk of complications, and then cost as the lowest priority. This rank ordering is then used to assign rank order centroid weights.

**Table 2-4: Criteria Priorities and Weights**

| <b>Criterion</b>  | <b>Effectiveness</b> | <b>Risk</b> | <b>Cost</b> |
|-------------------|----------------------|-------------|-------------|
| <b>Priorities</b> | #1                   | #2          | #3          |
| <b>Weights</b>    | 0.50                 | 0.33        | 0.17        |

To determine the option utilities, we will take the raw data describing how well the options meet each of the criteria and transform them into utility functions using the following equation:

$$u = V * \left(\frac{100}{\Delta}\right) - min * \left(\frac{100}{\Delta}\right) \quad (2)$$

where  $u$  is the transformed value,  $V$  is the raw data value,  $\Delta$  is the difference between the maximum acceptable value and the minimum acceptable value on each criterion, and  $min$  is the minimum acceptable value. For example, if the lower and upper bounds chosen for the evaluative criteria are 50%-100% for detection rate, 0%-0.5% for risk of complications, and \$0-2500 for cost, we get the following option utilities as shown in Table 2-5.

**Table 2-5: Option Utilities and Total Scores**

| <b>Criteria</b> | <b>Effectiveness</b> | <b>Risk</b> | <b>Cost</b> |  |
|-----------------|----------------------|-------------|-------------|--|
| <b>Priority</b> | #1                   | #2          | #3          |  |

| <b>Weights</b>     | 0.50     |               | 0.33     |               | 0.17     |               |             |
|--------------------|----------|---------------|----------|---------------|----------|---------------|-------------|
|                    | Raw Data | Utility Score | Raw Data | Utility Score | Raw Data | Utility Score | Total Score |
| <b>FIT</b>         | 75%      | 50            | 0        | 100           | 8        | 99.68         | 74.95       |
| <b>Stool DNA</b>   | 92%      | 84            | 0        | 100           | 650      | 74            | 87.58       |
| <b>Colonoscopy</b> | 95%      | 90            | 0.4%     | 20            | 2000     | 20            | 55.00       |

The total score is calculated by multiply each option’s rank order centroid by the utility score for each criterion, summing over all criteria, and then normalized the results. For example, FIT’s total score =  $(0.5*50) + (0.33*100) + (0.17*99.68)$ .

### 2.4.3.2 Analytic Hierarchy Process

There are also methods based on Analytic Hierarchy Process (AHP) [76-78]. Unlike the MAUT-based methods, AHP methods arrange decision criteria in a hierarchy and require the decision maker to make a series of pairwise comparisons of the alternatives with respect to all criteria to determine weights and scores.

To illustrate the AHP method, let us use the same example to explain how to use it to make a decision for colon cancer screening. According to AHP, the weights are determined by sequentially comparing all possible pairs of criteria in terms of their priorities to the decision goal using a scale of 1-9 as shown below.

**Table 2-6: The Scale for Pairwise Comparisons**

| Intensity of Importance | Definition       | Explanation  |
|-------------------------|------------------|--|
| 1                       | Equal importance | Two elements contribute equally to the decision goal |

|   |                        |  |
|---|------------------------|--|
| 3   | Moderate importance    | One element is favored moderately over another         |
| 5   | Strong importance      | One element is favored strongly over another           |
| 7   | Very strong importance | One element is favored very strongly over another      |
| 9   | Extreme importance     | One element is favored extremely strongly over another |
| Intensities of 2, 4, 6, and 8 can be used to express intermediate values. |                        |  |

For example, we ask the decision maker to compare all evaluative criteria in pair in terms of their priorities to choose the best screening test and get the assignments as shown in Table 2-7.

**Table 2-7: Criteria Priorities**

| Criteria      | Effectiveness | Risk | Cost | 3 <sup>rd</sup> Root Product | Priority Vector |
|---------------|---------------|------|------|------------------------------|-----------------|
| Effectiveness | 1             | 5    | 7    | 3.27                         | 0.73            |
| Risk          | 1/5           | 1    | 3    | 0.84                         | 0.19            |
| Cost          | 1/7           | 1/3  | 1    | 0.36                         | 0.08            |
|               |               |      |      | 4.47                         | 1.00            |

The next step according to AHP is to get the 3<sup>rd</sup> root product values, which are calculated as follows:

- Effectiveness:  $1 * 5 * 7 = 35$   $(1/3) = 3.27$
- Risk:  $(1/5) * 1 * 3 = (3/5)$   $(1/3) = 0.84$
- Cost:  $(1/7) * (1/3) * 1 = (1/21)$   $(1/3) = 0.36$

Then the 3<sup>rd</sup> root of product values can be normalized to get the appropriate weights for each criterion. The weights for each criterion are calculated as follows:

- Effectiveness:  $3.27 / 4.47 = 0.73$
- Risk:  $0.84 / 4.47 = 0.19$
- Cost:  $0.36 / 4.47 = 0.08$

The same pairwise comparison method is used in determining the scores of the options with regard to each evaluative criterion. For example, we ask the decision maker to compare all options in pair first with regard to detection rate and get the assignments as shown in Table 2-7.

**Table 2-8: Option Priorities with Respect to Detection Rate**

| Detection Rate | FIT | Stool DNA | Colonoscopy | 3 <sup>rd</sup> Root Product | Priority Vector |
|----------------|-----|-----------|-------------|------------------------------|-----------------|
| FIT            | 1   | 1/5       | 1/7         | 0.31                         | 0.08            |
| Stool DNA      | 5   | 1         | 1/2         | 1.36                         | 0.33            |
| Colonoscopy    | 7   | 2         | 1           | 2.41                         | 0.59            |
|                |     |           |             | 4.08                         | 1.00            |

Then we used the same calculation as used for criteria priorities to calculate the option priorities with respect to detection rate (shown in Table 2-7). The same comparisons and calculations are repeated until we get option priorities with respect to all evaluative criteria. Finally, we use the additive weighting methods to generate the summary scores indicating how well each option meets the decision goal. For example,

FIT's total score =  $0.73 * 0.08 + 0.19 * (\text{FIT option priority with respect to Risk}) + 0.08 * (\text{FIT option priority with respect to Cost})$ .

## 2.4.4 SUMMARY OF DECISION THEORIES

Normative theories assume that humans are rational decision makers who are capable of analyzing information accurately and making a choice that maximizes their benefits.

However, descriptive theories argued that humans do not always make rational decisions and their decision making can be influenced by factors such as how the information is presented and processed. Prescriptive theories acknowledge that humans are not rational decision makers, but they can be assisted to conform with the desired normative principles and make rational decisions. The system proposed in this dissertation is built upon the prescriptive theories in general and the value-based MCDA in particular. In the dissertation, I compare the different methods as reviewed in 2.4.3 in a perfectly controlled setting by using an ECA, exploring their usability as well as effects on decision quality and decision-making experience.

## 2.5 CONSTRUCTS AND MEASURES FOR SDM

The goal of SDM is to ensure high-quality decisions, which have been defined as the extent to which patients are informed, involved in the decision making, and receive care that meets their personal goals and needs [79-81]. According to the International Patient Decision Aids Standards (IPDAS) group, it is important to measure patient involvement

in the decision-making process as well as decision quality to evaluate the effects of SDM interventions. In a recent review, Sepucha and Scholl presented a list of constructs that can be measured to understand the effects of SDM interventions and the quality of decisions [82]. These constructs can be broadly divided into 3 categories: decision antecedents, decision making process, and decision outcomes.

## 2.5.1 DECISION ANTECEDENTS

Decision antecedents focus on features of individuals or organizations influencing the decision-making process, including patient preferences for participation in decision making, levels of health literacy and numeracy, and the availability of decision support in a healthcare system.

The Control Preference Scale [83] is a widely used instrument for decision antecedents, assessing an individual's preferred role in medical decision making. It is designed as a set of cards, each portraying a different role in medical decision making using a cartoon and a statement. These roles range from the individual making the decision (an active role), the individual making the decision jointly with a physician (a shared role), to the physician making the decision (a passive role). A respondent is asked to choose one card that describes the ideal role they prefer to play in decision making.

The Rapid Estimate of Adult Literacy in Medicine (REALM) [43] is another widely used instrument in this category, assessing an individual's level of health literacy defined as "the degree to which individuals have the capacity to obtain, process,

and understand basic health information and services needed to make appropriate health decisions" [58]. Originally designed as an oral reading and recognition test, REALM asks respondents to pronounce 66 common medical words and lay terms for body parts and illness to determine their level of health literacy. Possible scores range from 0 to 66, with higher scores indicating higher levels of health literacy.

Numeracy is defined as the ability to understand and process quantitative information [84], and can be assessed using a validated instrument [85]. Originally designed as a statistical test, this instrument consists of 10 statistical questions to evaluate an individual's understanding of risk concepts and their ability to solve basic probability problems. Possible scores range from 0-10, with higher scores indicating higher levels of numeracy.

## 2.5.2 DECISION MAKING PROCESS

The category of decision-making process has a focus on features or behaviors in the process, including the level of patient involvement in decision making, and experience of patients with the decision-making process.

The Shared Decision-Making Questionnaire (SDM-Q-9) [86] is a commonly used instrument for assessing the decision-making process. It is a 9-item scale used to measure an individual's perceived level of involvement in decision making for their own tests, treatments, or care. Possible scores range from 1 to 6, with higher scores indicating higher level of involvement in the decision-making process. This scale has

demonstrated appropriate psychometric properties (Cronbach's alpha of 0.938) [86] and has been shown to be useful for assessing SDM in multiple medical contexts [86, 87].

The Decisional Conflict Scale (DCS) [88] is another important instrument for measuring the decisional process, specifically measuring an individual's uncertainty in making a decision. It is a 16-item scale with 5 subscales: uncertainty, informed, values clarify, support, and effective decision. Possible scores range from 0 to 100, with higher scores indicating higher level of decisional conflict. DCS has been used in many studies evaluating patient decision aids [89] and has presented strong psychometric properties (score of 25 or below associated with follow-through with decisions) in various treatment contexts and patient samples [90].

### 2.5.3 DECISION OUTCOMES

Decision outcomes focus on the quality of decisions, such as knowledge, decision satisfaction, and decision regret.

A knowledge test can be used for measuring an individual's knowledge and understanding in the key concepts related to the decision problem. It is often designed for the specific decision problem being discussed.

The Satisfaction with Decision Scale [91] is a commonly used instrument for measuring the quality of decision. It is a 6-item scale used to assess an individual's satisfaction with the decision. Possible scores range from 1 to 5, with 1 indicating not satisfied at all and 5 indicating very satisfied.

A final outcome instrument is the Decision Regret Scale (DRC). It is a 5-item scale for measuring the level distress or remorse after making the decision. The possible scores of DRC range from 0 to 100, with higher scores indicating higher level of decision regret. This scale has undergone a psychometric testing study, showing strong internal consistency and correlation with decisional conflict, satisfaction with decision, and quality of life [92].

## 2.6 DECISION SUPPORT TECHNIQUES

### 2.6.1 PATIENT DECISION AIDS

Patient Decision Aids (PtDAs) are tools designed to support patient participation in SDM, by presenting standardized information about medical choices and providing structured methods to help patients consider these choices [28, 93]. PtDAs come in various formats, including paper-based pamphlets, videos, and computer-based programs. They can be used independently by patients or as an adjunct to the clinical consultation.

Since 2003, five Cochrane reviews have been published regarding PtDAs for people facing health treatment and screening decisions [28-32]. These PtDAs were developed for more than 50 different decisions, the most common of which included screening decisions such as prostate cancer, breast cancer, and prenatal screening, surgical decisions such as mastectomy, hysterectomy and prostatectomy, and decisions for genetic testing and medication treatments. The majority of the PtDAs were used by

people in preparation for clinical visits; a smaller number were used during the visit with the clinician.

The latest review, which included a total of 105 randomized controlled trials, has shown consistent evidence about the positive effects of using PtDAs for patient decision making [32]. Compared to usual care, PtDAs increased patient knowledge of relevant options (mean difference 13.27/100; 95% confidence interval 11.32 to 15.23; n=52 studies), accuracy of perceived risk (risk ratios 2.10; 95% confidence interval 1.66 to 2.66; n=17 studies), and value-choice congruence (risk ratios 2.06; 95% confidence interval 1.46 to 2.91; n=10 studies). Additionally, PtDAs decreased patient decisional conflict related to feeling uninformed (mean difference -9.28/100; 95% confidence interval -12.20 to -6.36, n= 27 studies), indecisiveness about their values (mean difference -8.81/100; 95% confidence interval -11.99 to -5.63; n=23 studies), and the proportion of passive patients in decision making (risk ratios 0.68; 95% confidence interval 0.55 to 0.83; n=16 studies). The effects of PtDAs on anxiety, general health outcomes and condition-specific health outcomes remain yet to be determined. Importantly, the clinical trials did not report adverse events associated with the use of PtDAs on these dimensions.

While research studies have demonstrated the benefits of PtDAs on the decision quality and the decision-making process, it has been argued that PtDAs are not enough to ensure SDM, as a full SDM interaction requires more than just standardized information delivery [34, 94]. In addition, the majority of the currently available PtDAs have been developed independently of the theoretical frameworks reviewed in Section

2.2. A review of 55 trials of PtDAs revealed that few of these interventions explicitly referred to a theory or model of decision making, and of those that did, many did not explain how the theory had informed the design of the decision aid [95]. Similar findings were also reported in a review of decision aids specially for cancer screening.

## 2.6.2 DECISION COACHING

Decision coaching is a process in which a trained human coach provides individualized, nondirective guidance to patients to help them understand the medical evidence, consider their values and priorities, develop skills in deliberation, and become more involved in SDM in order to make an informed decision [35, 36]. Coaching is often provided face-to-face, over the phone, in emails, or via the internet. It can be used alone or in combination with a decision aid.

Several studies have explored the use of decision coaching to promote patient participation and improve their decision making. In a study for women considering hormone replacement therapy (HRT) during and after menopause, a coaching consultation was described, in which a pharmacist walked patients through the benefits and risks of HRT, answered their questions, and helped them develop a provisional plan regarding HRT [96]. A clinical trial comparing this pharmacist consultation to the use of a decision aid showed decreased decisional conflict and high satisfaction with the education and the decision made in both groups. However, more post-menopausal participants exposed to the pharmacist consultation reached a yes or no decision compared to those in the decision aid group [96].

Myers developed a coaching program that involved a nurse educator providing decision counseling to patients facing health-related decisions. The nurse discussed the decision options, asked patients about their decision factors, and guided them through several exercises to determine their preferences [97]. To evaluate this coaching program, three cohort studies were conducted on the decision to undergo prostate cancer screening, the decision to be tested for prostate cancer risks, and the decision to participate in a trial of colorectal cancer prevention. Study results demonstrated the effectiveness of decision coaching for helping patients identify factors influencing their decision, clarifying their preferences for the options, and making a choice that best reflected their preferences [97].

Hunter et al. also looked at the use of decision coaching, specifically comparing the effects of group coaching, individual coaching, and the use of a decision aid [98]. In a clinical trial for prenatal diagnosis counseling for advanced maternal age patients, they found all three approaches to be effective in increasing patient knowledge and decreasing decisional conflict. Group coaching led to greater knowledge increase than individual counseling, and individual counseling led to higher satisfaction compared to the other approaches [98].

All these studies chose trained, high-quality health professionals to deliver the coaching session, which may not reflect actual clinical practices where the coaching quality varies depending on the communication skills of the health professional.

Other studies investigated the effects of decision coaching combined with a PtDA. Kennedy et al. described an intervention that used decision coaching along with

a PtDA to help women make a treatment decision about benign abnormal uterine bleeding [99]. In the intervention, participants received a PtDA with information about treatment options, followed by nurse coaching to clarify their values related to the options and prepare them to share their values with the surgeon [99]. Results of a clinical trial showed that women in the intervention group were more satisfied with their treatment results and their decision making process compared to women who received the usual care [99]. Belkora et al. developed a similar intervention, which involved patients reviewing a decision aid and then participating in a counseling session with a human coach. The coach discussed questions or concerns about the diagnosis, available options for treatment, patient goals, other people who might be involved in the decision, and the kind of information patients needed to support their decision making. The coach also took notes of patient questions, concerns, and their expressed values and shared them with the clinician. In addition, the coach accompanied patients to their clinic visits and helped take notes of the visit details. Several studies evaluating this process showed positive results [100-102]. To be specific, patients exposed to the intervention were more satisfied with their clinic visits and achieved higher decision quality. They also reported a greater match with their clinicians on the perception of the quality of decision making.

More recently, Stacey et al. conducted a systematic review of decision coaching in trials of PtDAs. They concluded that decision coaching has a similar impact to PtDAs on improving patient knowledge and reducing decisional conflict, whereas decision coaching tends to have additional benefits of clarifying patient values and improving

their decision-making experience [33]. Despite these benefits, decision coaching has not been widely used in practice settings. General barriers include lack of organizational support, lack of patient awareness of such services, and lack of reimbursement for these types of services [51, 103]. There have also been significant barriers related to implementing decision coaching by healthcare professionals, including lack of time, lack of knowledge and skills, and inadequate training in decision coaching [22, 51, 104].

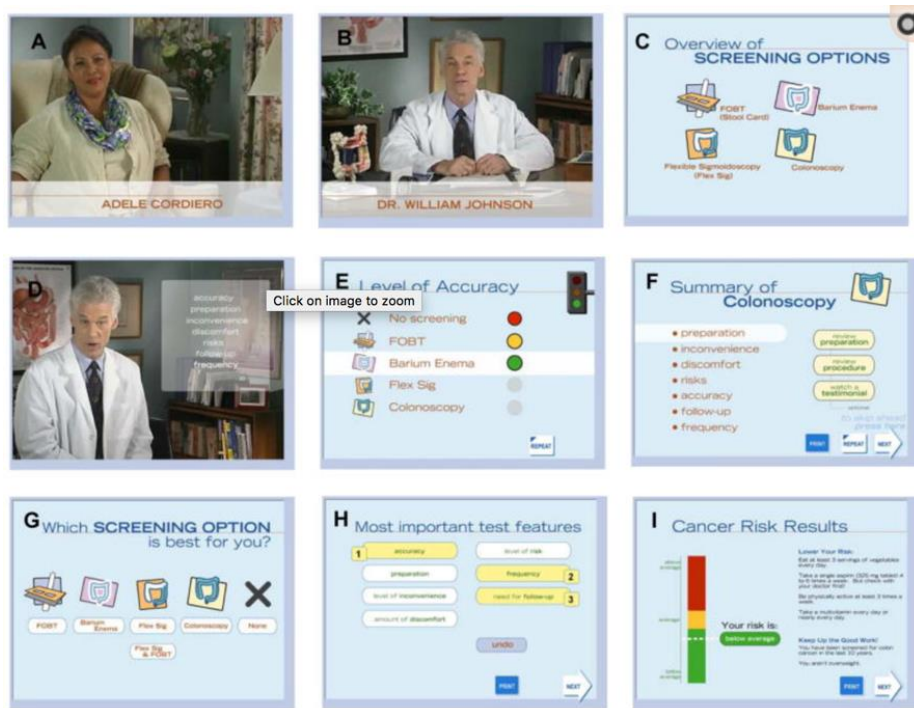
## 2.7 COMPUTERIZED TOOLS FOR SDM

As computer technology becomes ubiquitous in daily life and healthcare settings, a number of computerized tools have been developed to make decision support more engaging and more accessible to patients.

Hochlehnert et al. described a computer-based information tool to support SDM among Fibromyalgia patients [105]. Through an interactive interface, users can navigate information about Fibromyalgia and its typical symptoms, the causes and diagnosis of Fibromyalgia, and existing options for treatment. The tool combines text information with diagrams and also uses short video sequences for additional illustration. In a pilot evaluation study, participants reported the system to be easy to use and informative. Participants also appreciated the use of the computerized information tool and expressed the desire for such a tool in general practitioners' offices.

Schroy et al. developed a web-based decision aid for SDM regarding colorectal cancer (CRC) screening [106]. The decision aid discusses the colorectal cancer, the

screening options and the relevant test features such as accuracy and discomfort. It provides comparisons of each option with respect to individual test features. It also includes a decision-making module in which the user is asked to identify a preferred option and rank order the test features that influenced their selection. A randomized control trial comparing it to usual care found that the decision aid led to higher knowledge about CRC, greater intention for screening, and higher satisfaction with the decision-making process.

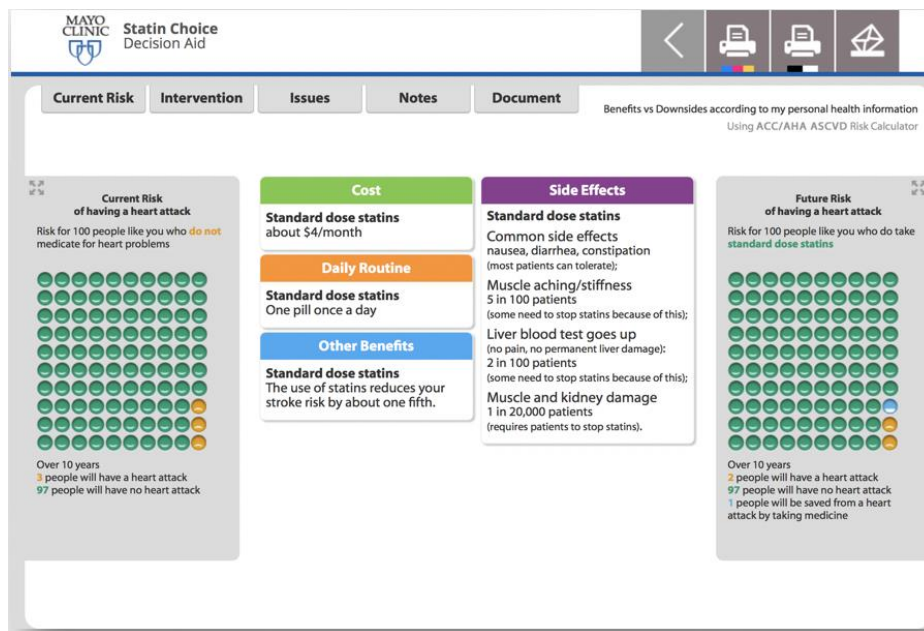


**Figure 2-3: Web Tool for Colorectal Cancer Screening**

Mathieu et al. developed an online decision aid to help women make choice about mammography screening [107]. The decision aid explains the benefits and potential harms related to mammography screening. It includes a worksheet to help users determine their preferences by asking them to rate their attitudes on a list of facts

related to mammography screening. A randomized controlled trial indicated the effectiveness of this decision aid, with results showing that participants who interacted with the aid were more knowledgeable and more likely to choose mammography screening than those who did not.

Another example of computerized SDM tools is the Statin Choice, which is a web-based decision aid developed by the Mayo Clinic for heart disease prevention. It is designed to be used by a health professional during the clinical visit. It starts by looking at the patient's current risk based on their medical record or patient information entered via an interactive panel. It then allows the patient to choose a specific prevention option and look at the benefits and issues associated with that choice. If the patient decides to proceed with a particular option, the system will generate a summary of that option including any notes entered during the consultation. The summary document can be printed as a PDF or emailed to the patient.



## Figure 2-4: Statin Choice

Elwyn et al. developed the Option Grid, which is a brief and easy to read online tool designed for use in clinical encounters to help patients and health professionals compare options [108]. It provides a standardized way of presenting options using summary tables in which all relevant options are listed side by side against questions that patients frequently ask, facilitating rapid comparison. Evaluated across different decision contexts, the Option Grid has proven to be effective in increasing patient knowledge and facilitating SDM in clinical encounters with minimal impact on the length of clinical encounters [109-112].

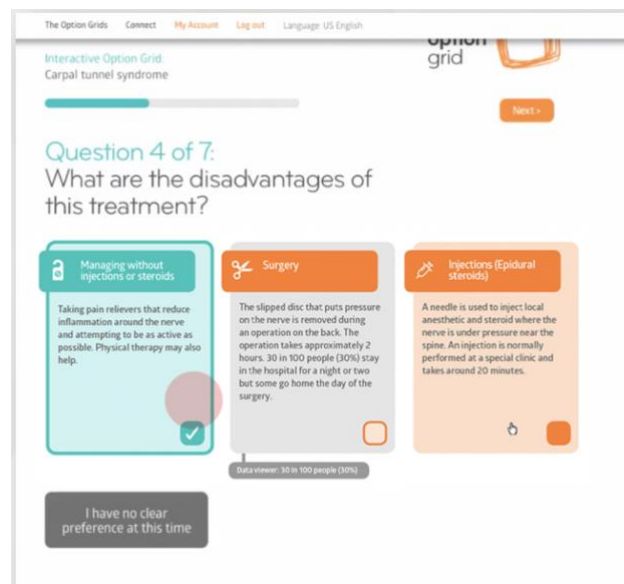


Figure 2-5: Option Grid

Other similar tools include a computerized decision aid for women considering post-menopausal HRT [113], a computerized decision aid for breast cancer prevention [114], a multimedia web tool on decisions related to prenatal testing [115], an automated tool to generate advance directives for end-of-life decisions [116], the

"Colorectal Web" for colorectal cancer screening [117], and a computer system installed in public workplaces for prostate cancer screening [118].

To summarize, a number of computerized tools have been developed to support SDM, many of which have been evaluated in formal studies and shown to be effective. However, these tools focus heavily on information provision without explicitly eliciting patient values and preferences. They also lack the empathy and alliance-building that a human healthcare provider would offer in clinical consultations. In addition, most currently available tools have not assisted patients in integrating their personal values and preferences with information about benefits and risks of relevant options to arrive at a best choice. In most cases, patients have had to perform this integration themselves, which can be cognitively difficult and emotionally burdened.

## 2.8 EMBODIED CONVERSATIONAL AGENTS FOR HEALTH COUNSELING

Embodied Conversational Agents (ECAs) are computer animated characters designed to simulate face-to-face conversation through the use of verbal and nonverbal behaviors present in human conversation [37]. The verbal behavior is primarily produced by synthesized or prerecorded speech and synchronized with various nonverbal behaviors including mouth movements, eye movements, head nods, hand gestures, facial displays, and body postures to convey supplementary semantic information in addition to speech and build relationship with users.

The use of ECAs has been explored in a wide range of applications, including virtual tutors in education [119-122], virtual coaches for job interviews [123-125], co-presenters in scientific presentations [126], tour guides [127, 128], storytellers [129, 130], and daily assistants or social companions [131, 132].

Of particular relevance to the proposed work are the ECAs developed in healthcare for the provision of health education and counseling. Bickmore and his team conducted a series of studies exploring the use of ECAs to help explain medical documents. They found ECAs to be effective tools for communicating complex health information to patients, particularly to those with low health literacy [38-42]. Patients with low health literacy are particularly satisfied with ECAs and ask more questions compared to those with adequate health literacy [41, 42]. In a study evaluating the effectiveness of a virtual nurse in explaining discharge information, patients indicated that they preferred this modality compared to human nurses, because they could spend as much time as needed to review the information, and could ask questions without feeling embarrassed [38].

Bickmore's team also explored the use of ECAs in longitudinal interventions for health behavior change. For example, they developed a virtual exercise coach to promote walking behaviors among older adults, with results from a randomized controlled trial showing that participants in the coach group walked significantly more steps than people in the control group [133]. They also developed the "Gabby" system to provide preconception care to young African American women by screening for over 100 health risks and addressing these risks in a series of conversations with a virtual

counselor called "Gabby". A randomized controlled trial showed that participants who used the "Gabby" system successfully resolved risks 25% more often than those in the control group. More recently, Bickmore et al. developed a virtual coach that is used in conjunction with medical group visits to help individuals with chronic pain and depression manage their stress [134]. They found that this intervention led to significantly more positive behaviors in stress management compared to usual care.

Other researchers have also investigated the role of ECAs as virtual health coaches to engage users in health interventions. McDonald et al. developed a virtual coach to help older adults improve their skills in communicating osteoarthritis pain information [135]. In a pilot study comparing the virtual coach with a video coach or no coach, they found participants who practiced talking with the virtual coach described significantly more important pain information compared to participants in the other two groups [135]. Hudlika et al. developed a virtual coach that provides meditation training and coaching via pre-recorded audios, to help people establish a regular mindfulness practice [136]. In a pilot evaluation study, they found that participants in the coached group practiced more frequently and for a significant longer time than participants in the control group [136]. Also, Monkaresi et al. developed the "IDL coach" for individuals with diabetes to manage their prescribed exercise, nutrition, blood glucose monitoring, and medication adherence, although no evaluation study is reported [137].

Rizzo and colleagues developed the "SimCoach" system to address depression and post-traumatic stress disorders (PTSD) among military service members [138],

although a randomized controlled did not find any clinically significant benefits of using "SimCoach" [139]. The same research group also developed the "SimSensei" system, a virtual clinical interviewer who automatically assesses user distress based on verbal and nonverbal behaviors correlated with psychological distress [140]. Initial studies of a Wizard of Oz (WoZ) and a fully automated version of the "SimSensei" system showed that participants were willing to share, comfortable sharing, and did share intimate information with the virtual interviewer [140]. More recently, Rizzo's group conducted an evaluation study comparing "SimSensei" to a self-report questionnaire with a sample of military service members. They found that participants reported significantly more PTSD symptoms to the SimSensei virtual interviewer than they did on the self-report instrument [141].

These systems have demonstrated the efficacy of using ECAs in counseling patients on various health problems, highlighting the potential of ECAs to be successfully applied in other health contexts. To date, few ECAs have been developed in the context of SDM. The only published work is a study by Robertson et al. [142], which described a virtual decision coach to help patients make shared decisions about treatment for prostate cancer. However, this work was limited to preliminary visual design of the virtual character, with evaluation limited to a formative example walk-through of a low-fidelity prototype.

## 2.9 SUMMARY OF RELATED WORK

Shared decision making is an ideal model for involving patients in medical decision making and it is particularly useful for preference-sensitive situations in which no single best option is available to every patient, each option has positive and negative qualities that patients value differently, and the best choice depends heavily on the values and preferences of the patient. However, there have been barriers for patients to actively and confidently participate in SDM, including lack of guidance and support from healthcare professionals, reluctance to discuss options and ask questions, and lack of health literacy and skills to effectively communicate with their healthcare providers. There have been several decision support techniques developed to support patient participation in SDM, namely patient decision aids and decision coaching. However, they either fail to address all essential components of SDM or there are barriers to using them by human healthcare providers in practice. The previous work on ECAs has shown that they are capable of providing health counseling and coaching in an effective way and have a positive impact on patient satisfaction and health outcomes. Thus, ECAs represent a promising alternative to the provision of decision support for SDM.

# 3 A VIRTUAL DECISION COACH FOR MEDICAL SHARED DECISION MAKING

The literature review suggests that ECAs can provide SDM by taking the role of a decision coach and providing support to patients as they move through the SDM process. In this chapter, I describe the development of a domain independent approach to automating the provision of decision support for SDM using an ECA. Specifically, I develop an ECA that acts as a virtual decision coach to facilitate SDM by automatically providing guidance and coaching on the essential tasks of SDM. The primary goal of this endeavor is to empower patients to actively participate in SDM and help them make a decision that is informed by the best available evidence and consistent with their personal values and preferences.

## 3.1 PRIMARY SDM TASKS

The literature review suggests that SDM follows a standard process in which the virtual decision coach can guide and coach patients on a series of tasks as they move through the SDM process. From the process models of SDM reviewed in 2.2, I condensed the four specific tasks that the virtual decision coach can assist with, namely problem identification, choice education, value clarification and preference elicitation (VC/PE), and decision making.

- **Problem Identification** is to identify the problem that needs to be addressed. The problem is often a decision in which a range of options exist. The virtual coach can help patients become aware of an impending choice among options and the importance of exercising personal values and preferences in making a decision that is right for them. The virtual coach can also check patient emotional state as well as their preferred role in decision making before proceeding to the next task.
- **Choice Education** is to inform the patient about relevant options and describe their benefits and risks. This task deals with the "objective evidence", referring to the general information about options, the benefits and risks inherent in each option, and the uncertainty information if any [143].

Where multiple options exist, a balanced representation of the benefits and risks of all options are needed. As patients may lack a medical background or be unfamiliar with the information being conveyed, the virtual coach can assess patient

understanding, check for misconception periodically, and offer the opportunity for review and clarification.

- **Value Clarification and Preference Elicitation** is to encourage patients to consider the benefits and risks of each relevant option and clarify values that may influence their decision making. This task deals with the "subjective evidence", focusing on patient attitudes and desirability towards the relevant options [143].

Although VC and PE are carried out together, they focus on different concepts and have independent tasks. Value is the key concept of VC, which refers to "a person's informed attitudes about the relative desirability or undesirability of a health care option's unique characteristics, including that option's protocol, possible benefits, and potential harm" [144]. The task of VC, thus, involves obtaining and comparing the importance that the patient attributes to the positive and negative characteristics of options. PE focuses on the concept of preference, which refers to "a person's overall most-favored option, after taking into account his or her attitudes toward each option's detailed characteristics" [144]. Therefore, the task of PE requires integrating patient values with the "objective evidence" and identifying the patient's most favored option.

There are multiple methods that can be used for value clarification and preference elicitation, of which "explicit" methods have been shown to improve chosen options congruent with patient values [31]. The "explicit" methods engage patients in tasks involving explicitly comparing, ranking, and rating relevant options and their characteristics. Card Sorting is one of the widely used "explicit"

methods. It asks the patient to rank order a list of criteria according to their importance to decision making. And based on that, several cards with option information are provided to patients to organize and pick the best choice. Other "explicit" methods include SMARTER and AHP as described in 2.4.3.

- **Decision Making** is to help the patient choose a preferred option to implement and break down barriers if any to implementing the preferred choice.

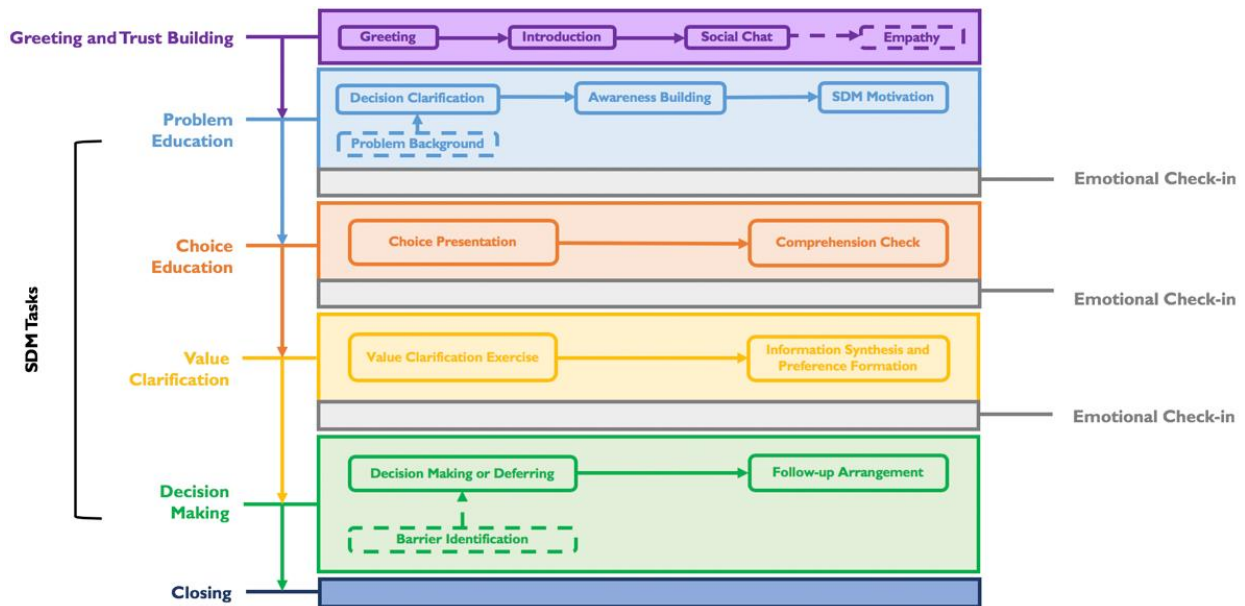
After VC/PE, the virtual coach and the patient can make a decision if the choice is clear to both parties. The coach can offer the opportunity for review, as the patient may want to reconsider and change their decision after searching for more information or after discussing the choice with their friends or family members. A decision can also be deferred for a later time if the patient has issues that remain unresolved, needs more time for deliberation, or wants to explore additional information.

## 3.2 CONVERSATIONAL STRUCTURE

The virtual decision coach addresses these SDM tasks through a decision coaching conversation. The structure of the conversation is shown in Figure 3-1. Specifically, the conversation consists of seven primary topics in the following order:

- **Greeting and Trust Building.** The conversation begins with a greeting and a self-introduction, and then moves quickly to a social chat portion in which the virtual coach asks how the user is generally feeling today and shows empathy as needed.

This portion of the conversation is designed for the virtual coach to build trust and rapport with its user and make sure the user is comfortable with the interaction.



**Figure 3-1: Conversation Structure of Decision Counseling**

- Problem Education.** The conversation then moves to address the first primary task of SDM. The virtual coach starts with a brief overview of what is going to be covered in the conversation, makes explicit the decision problem that needs to be addressed, and asks about the user’s level of familiarity with the decision problem in order to determine whether to provide additional background information. The virtual coach then discusses the preference-sensitive nature of the decision problem and highlights the importance of her collaboration with the user, in which the virtual coach contributes by providing scientific facts and the user contributes by sharing their personal values and preferences, in order to make a choice that uses the best available evidence while accounting for patient personal values and preferences.

- **Choice Education.** This next portion of the conversation addresses the second task of SDM. In this portion, the virtual decision coach seeks to explain all available options in a balanced way and with sufficient details in order to make sure the user is fully informed of the benefits and risks associated with each option before making a choice. The virtual coach first provides an overview of the available options with areas of contrast highlighted, and then presents the options with detailed explanation in a one-by-one manner, ending with a side-by-side summary table that allows the user to compare between different options. Icon arrays and images will be used to help explain risk concepts and provide additional information for complex medical procedures. At the end of each option explained, the virtual coach checks the user's understanding using a teach-back technique and provides clarification if misunderstanding is detected.
- **Value Clarification.** This portion of the conversation addresses the third primary task of SDM. The virtual decision coach seeks to help the user clarify their personal values and priorities related to the decision and identify the most preferred choice. In the conversation, the virtual coach guides the user through an explicit VC exercise to clarify their personal values and priorities about the different characteristics of the options, and then helps integrate these values with the best available clinical evidence presented in the choice education module, to suggest an optimal choice.
- **Decision Making.** The last task of SDM is addressed by this portion of the conversation. The virtual decision coach seeks to support the user to arrive at a decision and implement the preferred choice. In this portion, the virtual coach

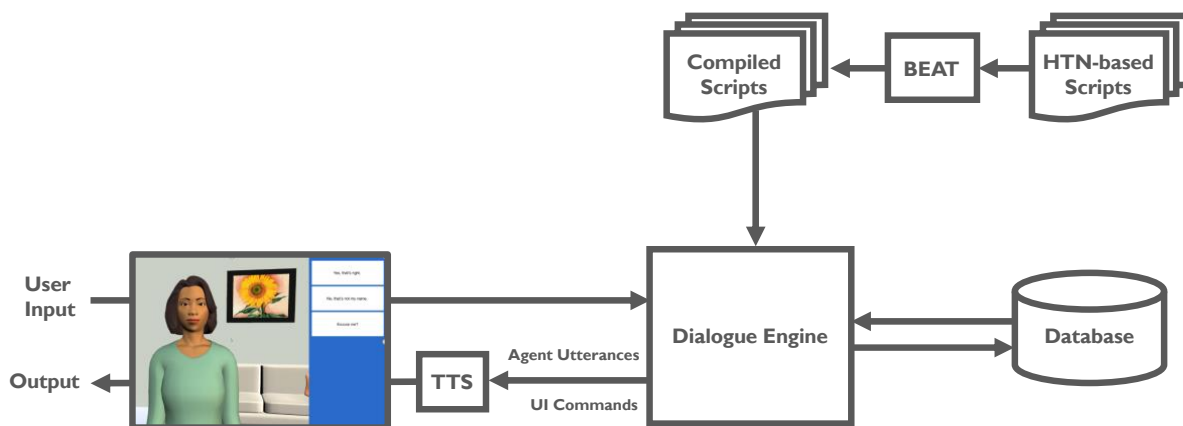
assesses the user's readiness to make a decision. If the user is ready to make a choice, the coach then helps the user develop a provisional plan to implement the preferred choice. If the user is unsure about the choice or prefers to defer the decision to a later time, the coach then identifies the barriers impeding the decision making and discuss possible solutions to resolve the barriers.

- **Emotion Checking.** This particular module is designed to check the emotional state of the user and determine if the user is ready to proceed to the next task of the SDM process. It is repeated three times, between the essential SDM tasks in the conversation. In this portion of the conversation, the virtual coach asks about the user's feeling about each primary task of SDM, offering the opportunity to resolve issues or concerns related to the present task.
- **Closing.** Finally, the virtual coach wraps up the conversation by summarizing what has been discussed in the conversation, as well as the choice made by the user and the implementation plan if any.

### 3.3 IMPLEMENTATION

The virtual decision coach is an ECA developed using a domain-independent computer framework as shown in Figure 4. The agent's conversational dialogues are scripted using a custom scripting language based on Hierarchical Transition Networks (HTN) and template-based text generation. HTN is not only used to model the hierarchical structure of the dialogues, but also to support common dialogue fragments to be reused

in several places of the conversation. The HTN-based scripts are then compiled into executable codes as part of the Dialogue Engine. This is a state-based dialogue manager that decides the next action (e.g., agent utterances and User Interface elements) of the agent system based on user inputs and variables defined before and during the conversation. User properties such as names are stored in a persistent database, allowing the agent to remember and refer back to information from prior dialogue turns, or prior conversations, if multiple conversations are required.



**Figure 3-2: Computer Agent Framework**

The agent itself is a 3D computer character animated and rendered in the Unity game engine using custom animation software. It talks using synthetic speech from a commercial Text to Speech (TTS) system and displays a range of nonverbal conversational behaviors, including hand gestures and eyebrow movement for emphasis, body posture shifts to mark topic boundaries, head nods for acknowledgement, gaze behaviors to signal turn taking, different facial expressions to communicate emotional state, and variable proximity such as wide to close-up camera shots. Most nonverbal conversational behavior is automatically generated for each

agent utterance and synchronized with agent speech using the BEAT text-to-embodied-speech system [145]. Users contribute to the conversation primarily by selecting items from a multiple-choice menu of utterance options, which are dynamically updated based on the conversational context at the end of each dialogue turn.

## 4 EVALUATING THE ACCEPTABILITY OF A VIRTUAL DECISION COACH

Based on the above framework, I developed a prototype system and conducted a pilot study to evaluate the feasibility of using an ECA as a decision coach, and the acceptability of the coach in supporting SDM on prenatal testing for Down Syndrome. In this chapter, I describe the prototype system, the pilot study conducted with the

prototype system, and the lessons learned from this study. This work has been published at the 18<sup>th</sup> ACM International Conference on Intelligent Virtual Agents, [146].

## 4.1 PROTOTYPE SYSTEM

Building upon the framework presented in Chapter 3, I developed a prototype system to help women make a shared decision regarding prenatal testing for Down syndrome. The prototype system was designed to cover 4 primary topics. Sample script of these topics are shown in Figure 4-1.

|  |
|--|
| <p><b><u>Greeting and Alliance Building</u></b></p> <p>AGENT: Good morning, I am Tanya. Great to meet you.<br/> USER: Hi, Tanya.<br/> AGENT: I know this can be strange. I hope you are comfortable.<br/> USER: I am fine, thanks.<br/> .....<br/> Agent: So, before we get started, let me give you an overview of what we are going to talk about today.<br/> .....</p>  |
| <p><b><u>Health Education</u></b></p> <p>AGENT: First, let us talk about down syndrome. So down syndrome is one of the most common chromosomal conditions in the world.<br/> USER: What is a chromosomal condition?<br/> .....<br/> AGENT: The goal of this conversation is to get you to know prenatal testing and <u>make a decision</u> about it. So it is important to know what options are available to you and to understand the benefits and risks of each option.<br/> USER: I see.<br/> AGENT: Ok, if you were pregnant, you would have three general choices. You could choose not to be tested, choose a screening test or a diagnostic test.<br/> USER: Tell me more about screening test.<br/> .....</p>   |
| <p><b><u>Value Clarification</u></b></p> <p>AGENT: All right, we have discussed all the available testing options for down syndrome. As I said before, making a choice for prenatal testing is a very personal decision. So it is very important to be clear about your personal values and preferences to make a decision that is right for you.<br/> USER: Right.<br/> AGENT: So, next, we will do a small exercise to clarify your values and preferences and identify a choice that is right for you.<br/> USER: Sure.<br/> AGENT: Great! I would like to start by asking you some questions, so I understand, what is important to you when it comes to <u>making a decision</u> about prenatal testing.<br/> USER: Go ahead.<br/> AGENT: Okay, would you tell me, out of all the aspects of a prenatal test, what is the most important thing to you?<br/> USER: The test can detect down syndrome if my baby really has it.<br/> .....<br/> AGENT: You are doing great. Here is your preference list. How do you feel about it?<br/> USER: It looks great.<br/> .....</p> |
| <p><b><u>Decision Making</u></b></p> <p>AGENT: I just did a quick analysis based on the information you provided. NIPT seems to be the best option for you, given that you would want your first child at 36. How do you feel about this option?<br/> USER: I think I like it.<br/> AGENT: I am glad to help you find an option that you like. I would highly recommend you discuss this option with your doctor after you find out you are pregnant.<br/> USER: I will.<br/> .....<br/> AGENT: That's all for today. I am glad you find an option you like. I hope all we have talked about today would be helpful to you and your future pregnancy.<br/> USER: It's helpful, thanks.<br/> AGENT: Great. Thanks for participating in our study and have a great day. Bye.<br/> USER: Bye.</p>   |

**Figure 4-1: Counseling Scripts for SDM regarding Prenatal Testing**

***Topic 1: Greeting and Alliance-Building***

The virtual coach begins the session by establishing rapport and therapeutic alliance [147] with the user through social chat and empathy.



**Figure 4-2: Virtual Coach Showing Empathy**

***Topic 2: Health Education***

The virtual coach continues by ensuring the user is fully informed of Down syndrome and prenatal testing, as well as the available options for prenatal testing, and to motivate the patient to participate in shared decision making. In the prototype, the virtual coach first talks about Down syndrome and the risk factors associated with Down syndrome, followed by a brief discussion about why shared decision making for prenatal testing is important in this context. The virtual coach then discusses prenatal testing in general and the testing options available for Down syndrome in particular.

The virtual coach uses text props to provide outlines of the topics under discussion and side-by-side table to allow users to compare between different testing options. The coach also uses stadium charts and images to help explain risk concepts and provide additional information for complex medical procedures. Deictic gestures are used to refer to these props during the coach's conversation with a user.



**Figure 4-3: Virtual Coach Using Various Visual Props**

***Topic 3: Value Clarification***

The virtual coach then helps users clarify their personal values and preferences related to prenatal testing by leading them through a value clarification exercise. In this exercise, the user is asked to rank order a list of attributes (e.g. detection rate, risk of miscarriage), by personal importance when it comes to making a decision regarding prenatal testing. The responses are then used to generate a preference list of testing options tailored to these personal priorities.

***Topic 4: Decision Making***

The virtual coach assists the user in making a final choice regarding prenatal testing. The virtual coach first makes a suggestion based on the values and preference information collected previously using SMARTER decision analysis algorithm as described in 2.4.3.1, and then asks the user how they feel about the option. Women can either accept the suggested option or choose a different one.

**4.2 PILOT STUDY**

To evaluate the acceptance and efficacy of the prototype system, I conducted a quasi-experimental study in which participants interacted with the virtual coach in a single counseling session, discussing Down syndrome and prenatal testing for this condition, with measures collected prior to and immediately after the session. The entire session took approximately 1 hour, and participants were compensated for their time.

### 4.2.1 PARTICIPANTS

To be eligible for the study, participants were required to be female, at least 21 years old, able to speak and read English, and have not had a child before but interested in having children in the future. Participants were recruited via fliers distributed around local campuses, stores, and community centers. The study was approved by the Northeastern University IRB (#17-12-01), and participants were compensated \$20 for their time.

### 4.2.2 PROCEDURE

The study was held in the Human-Computer Interaction (HCI) laboratory at Northeastern University. After being consented, participants completed baseline questionnaires, had their health literacy and numeracy assessed, and completed a knowledge test on prenatal testing. Participants were then asked to interact with the virtual decision coach for approximately 30 minutes. Immediately after the interaction, the same knowledge test was administered again, as well as questionnaires measuring how they felt about their decision, and their attitudes towards the decision-making

experience and the virtual coach. At the end of the study, a semi-structured interview was conducted to ask participants about their overall impression of the experience, which was audiotaped for subsequent analysis.

### 4.2.3 MEASURES

In addition to sociodemographic measures, I collected the following measures prior to (T0) and immediately after interacting with the virtual decision coach (T1).

- **Health Locus of Control** was assessed at T0 using the Multidimensional Health Locus of Control Scale [148], to evaluate the belief of an individual in who or what has control over their health. The scale has 18 statements of which 6 items indicating strong beliefs in internal control by oneself, 6 items indicating strong beliefs in external control by powerful others, and 6 items indicating strong beliefs in external control by chance.
- **Preferred Role in Decision Making** was assessed at T0 using the Control Preference Scale as described in 2.5.1.
- **Health Literacy (HL)** was assessed at T0 using the Rapid Estimate of Adult Literacy in Medicine (REALM) instrument as described in 2.5.1.
- **Numeracy** was assessed at T0 using the numeracy instrument as described in 2.5.1.
- **Knowledge about prenatal testing** was assessed at T0 and T1 using a knowledge scale that consisted of 12 true/false/don't know statements. The scale was based on a knowledge measure developed and validated to evaluate a web-based decision aid on decision making regarding prenatal testing [115]. The content of the original

measure was based on a generic list of domains considered to be essential to informed decision making in prenatal screening for Down syndrome [149, 150].

Cumulative knowledge scores (range 0-12) were derived by summing correct responses to the 12 individual knowledge questions.

- **Decisional Conflict** was assessed at T1 using the Decisional Conflict Scale as described in 2.5.2.
- **Decisional Regret** was assessed at T1 using the Decision Regret Scale as described in 2.5.3.
- **Decision Satisfaction** was assessed at T1 using the Satisfaction with Decision Scale as described in 2.5.3.
- **Attitudes towards the Decision-Making Experience** was assessed at T1 using 4 single-item questions on a 7-point scale.
- **Attitudes towards the Virtual Decision Coach** was assessed at T1 using 5 single-item questions on a 7-point scale.

## 4.2.4 RESULTS

I recruited a total of 13 participants, of whom 12 successfully completed the study and are included in the analysis. The demographics and personal characteristics of the participants are shown in Table 4-1.

**Table 4-1: Participant Sociodemographics**

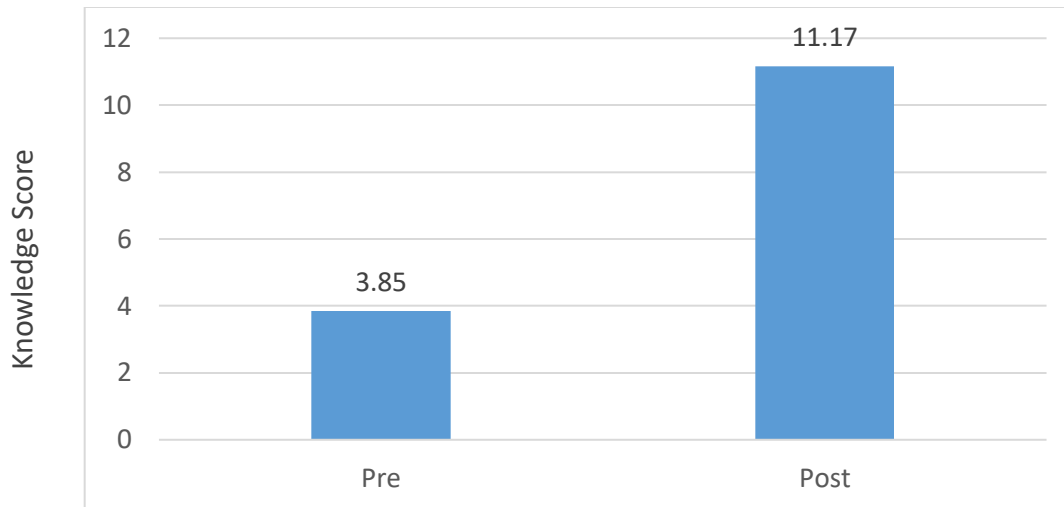
| <b>Participant Characteristics (N=12)</b> | <b>Descriptive Statistics</b> |
|---|-------------------------------|
| Age, mean (SD)                            | 24 (1.5)                      |

|                                |            |
|--------------------------------|------------|
| Ethnicity, n (%)               |            |
| Asian or Pacific Islander      | 9 (75)     |
| White                          | 3 (25)     |
| Marital Status, n (%)          |            |
| Single                         | 11 (92)    |
| Married                        | 1 (8)      |
| Education, n (%)               |            |
| Some College                   | 3 (25)     |
| College Graduate and Higher    | 9 (75)     |
| Health locus of control, n (%) |            |
| Internal control               | 11 (92)    |
| External control by chance     | 1 (8)      |
| Control preference, n (%)      |            |
| Active Role                    | 7 (58)     |
| Shared Role                    | 2 (17)     |
| Passive Role                   | 3 (25)     |
| Health literacy, n (%)         |            |
| Adequate                       | 9 (75)     |
| Inadequate                     | 3 (25)     |
| Numeracy (0-11), mean (SD)     | 10.3 (1.1) |

#### 4.2.4.1 Quantitative Results

Overall, participants were satisfied with their decision and the decision-making experience. Regarding their final choice for a future pregnancy: of the 12 participants, 1 preferred not to do prenatal testing, 6 preferred a screening test, and 5 preferred a diagnostic test. Eight participants liked the option recommended by the virtual coach and chose it as their final choice for prenatal testing.

**Knowledge of Prenatal Testing.** There was a significant increase in participant's knowledge score after using the agent-based decision aid ( $M=11.17$ ,  $SD=0.83$ ) compared to before ( $M= 3.58$ ,  $SD = 1.62$ ), paired  $t(11) = 13$ ,  $p<.01$ .



**Figure 4-4: Knowledge of Prenatal Testing Pre-Post**

**Decisional Conflict.** Participants reported low decisional conflict ( $M=19.79$ ,  $SD=8.89$ ) after talking to the agent, and their scores were significantly lower than the benchmark score of 25 in this scale, indicating participant tendency to make a decision instead of delaying or deferring a decision (One Sample t-test,  $p<.05$ ).

**Decision Regret.** Participants reported low decisional regret ( $M=20.83$ ,  $SD=10.41$ ) after the interaction, and their scores were significantly lower than a 'neutral' score of 50 (One-Sample Wilcoxon Signed Rank Test,  $p<.01$ ).

**Satisfaction with Decision.** Participants reported high satisfaction ( $M=4.19$ ,  $SD=0.45$ ) with the decision they made with the virtual coach, and their scores were significantly higher than a 'neutral' score of 3 (One-Sample Wilcoxon Signed Rank Test,  $p<.01$ ).

**Attitudes towards Decision Making Process.** Participants felt they received slightly more information than they wanted. However, they perceived low pressure about making the decision, with their scores significantly lower than a 'neutral score' of 3 (One-Sample Wilcoxon Signed Rank Test,  $p<.01$ ). They were highly satisfied with the

decision-making process and reported that they were very likely to adhere to their chosen prenatal testing option in the future, both significantly higher than a ‘neutral score’ of 3 (One-Sample Wilcoxon Signed Rank Test,  $p < .01$ ). (See Table 4-2.)

**Table 4-2: Attitudes towards Decision Making Experience**

| Questions  | Mean (SD)   | P-Value |
|--|-------------|---------|
| How much information did you get?<br>(1=Too little; 4=Just right; 7=Too much)  | 4.25 (0.75) | n.s. †  |
| How likely would you go with the option you prefer?<br>(1=Extremely unlikely; 7=Extremely likely)  | 5.67 (0.65) | <.01 ** |
| How much pressure did you feel?<br>(1=No pressure; 7=Extreme pressure)   | 2.75 (1.06) | <.01 ** |
| How satisfied were you with the decision-making process?<br>(1=Not satisfied; 7=Extremely satisfied)   | 5.58 (0.90) | <.01 ** |
| * Significant at the .05 probability level.<br>** Significant at the .01 probability level.<br>*** Significant at the .001 probability level.<br>† NS, nonsignificant. |             |         |

**Attitudes towards Virtual Decision Coach.** Participants were very satisfied with the virtual agent. They also liked the agent, trusted the agent, found the agent to be knowledgeable, and expressed a desire to make future decisions with the agent. One-sample Wilcoxon signed rank test demonstrated all ratings were significantly higher than a ‘neutral’ score of 3 ( $p < .01$ ). (See Table 4-3.)

**Table 4-3: Attitudes towards Virtual Decision Coach**

| Questions   | Mean (SD)   | P-Value |
|---|-------------|---------|
| How satisfied were you with the animated character? | 5.83 (0.83) | <.01 ** |

|  |             |         |
|--|-------------|---------|
| (1=Not at all; 7=Very satisfied)   |             |         |
| How much would you like to make future decisions with the animated character? (1=Not at all; 7=Very much)  | 5.58 (1.08) | <.01 ** |
| How much do you trust the animated character? (1=Not at all; 7=Very much)  | 5.75 (0.87) | <.01 ** |
| How much do you like the animated character? (1=Not at all; 7=Very much)   | 5.67 (0.98) | <.01 ** |
| How knowledgeable was the animated character? (1=Not at all; 7=Very knowledgeable)   | 6.17 (0.39) | <.01 ** |
| * Significant at the .05 probability level.<br>** Significant at the .01 probability level.<br>*** Significant at the .001 probability level.<br>† NS, nonsignificant. |             |         |

#### 4.2.4.2 Qualitative Results

Interview responses were transcribed and coded for common themes. In general, participants found the virtual decision coach helpful and easy to interact with, and they felt more informed after their conversation.

When asked about the most helpful topic in the decision aid, some participants referred to *“when she described all the procedures and what happens in each of them and you know how accurate these are and what are the risks and benefits”* because it helped *“understand what each of these procedures entail”* (P5). Some found *“the part where it asked you about what you value the most and you listed your priorities down to the bottom, and kind of analyzed those for what would match”* (P12) was most helpful because it *“helped you make a decision based on your information”* (P6). Some participants expressed appreciation for the side-by-side comparison table (Fig. 2) of the testing options. For example, *“after each*

*section, she had the two options side by side, so you can see the numbers side by side because you heard them and remembered them but visually seeing them side by side is probably most helpful” (P9).*

For participants who chose to accept the option suggested by the coach, they felt the agent’s suggestion provided a reassuring feeling. For example, *“I knew I would pick a screening test, but I was not sure about which one, and her suggestion was helpful, and I feel more sure about my choice” (P6).* Also, *“I feel it [agent’s suggestion] was probably reassuring because when I looked through it logically, the things that I took into account were also the things she took into account, so it came to the same result” (P12).*

Some participants chose an option other than the one the agent suggested simply because they had a preference for a particular option. For example, *“She suggested NIPT [...], but at the end of the day, I would really like to know whether my baby has Down syndrome or not [...], so I would prefer CVS” (P11).* There were also participants who preferred a different option for personal reasons. For example, *“I know I wouldn’t terminate my pregnancy, so I would prefer to have no test because I do not see the benefits of knowing this statistics or risks because it may probably cause more stress, so I would not want the number” (P10).*

When asked about ideas for future improvement, some participants suggested having the option to skip over information they were not interested in. Other participants expressed a desire for more detailed information, for example, *“I want to know more about the diagnostic test [...]. The risks are very similar. I want more details about what the small difference means” (P5).* And, *“Maybe it could be a little bit more elaborate on the*

*discomfort of the diagnostic test, like how long it is going to be and how severe, and is it going to be for everyone or just by chance” (P8). Also, “Maybe you can set up a section to talk about what if your baby is diagnosed with Down syndrome, and what are the options” (P7).*

## 4.3 CONCLUSION

This study demonstrated that ECAs can effectively perform in the role of decision coach to facilitate the SDM process, affirmatively answering RQ1. Participants demonstrated significant increases in knowledge, and high levels of satisfaction with their final decision and low levels of decisional conflict and regret after interacting with the virtual decision coach. They also liked the coach, trusted the coach, and were satisfied with the decision-making process guided by and the decision they made with the virtual decision coach.

# 5 COMPARATIVE EVALUATION OF VALUE CLARIFICATION PREFERENCE ELICITATION METHODS

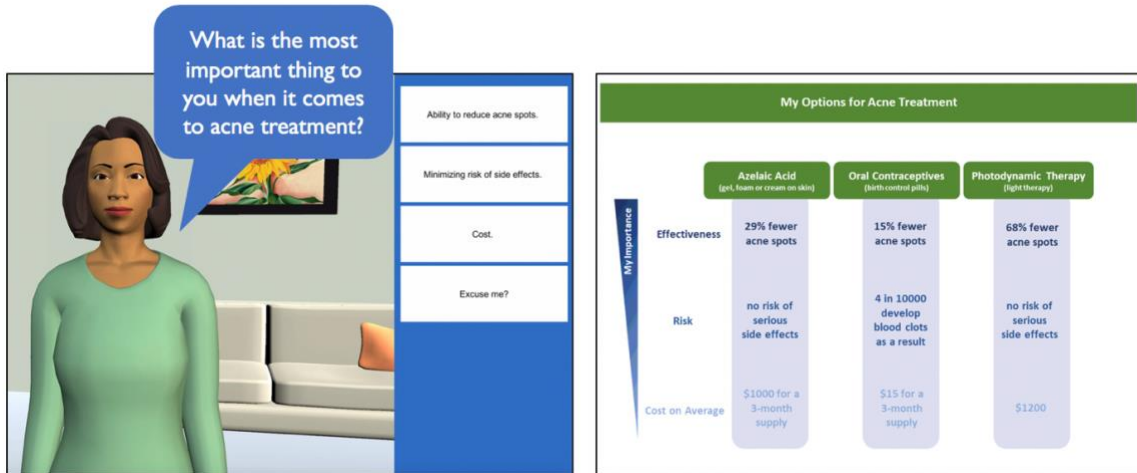
In the previous prototype system, I used the SMARTER approach for value clarification/preference elicitation (VC/PE). However, several other methods for VC/PE are available. There remains no established best practice, and the evidence about the effectiveness of any given method is limited. In addition, none of these methods have been evaluated in automated SDM systems with an ECA. Thus, I conducted an empirical study to compare three common VC/PE approaches delivered by an ECA in terms of their usability and effects on decision quality and decision-making experience. In this chapter, I describe the study as well as the lessons learned from this study.

## 5.1 STUDY CONDITIONS AND SYSTEMS

As suggested in the related work section, several VC/PE methods are available for clarifying patient values and integrating these values with scientific facts to identify patient preference. In this work, I sought to compare three specific VC/PE approaches, which are Card-Sorting, SMARTER, and Analytical Hierarchy Process (AHP). These three approaches were chosen for comparison because they can all be used for VC/PE on the individual level, but vary vastly in underlying decision-making frameworks, computational algorithms, and complexity in practical use.

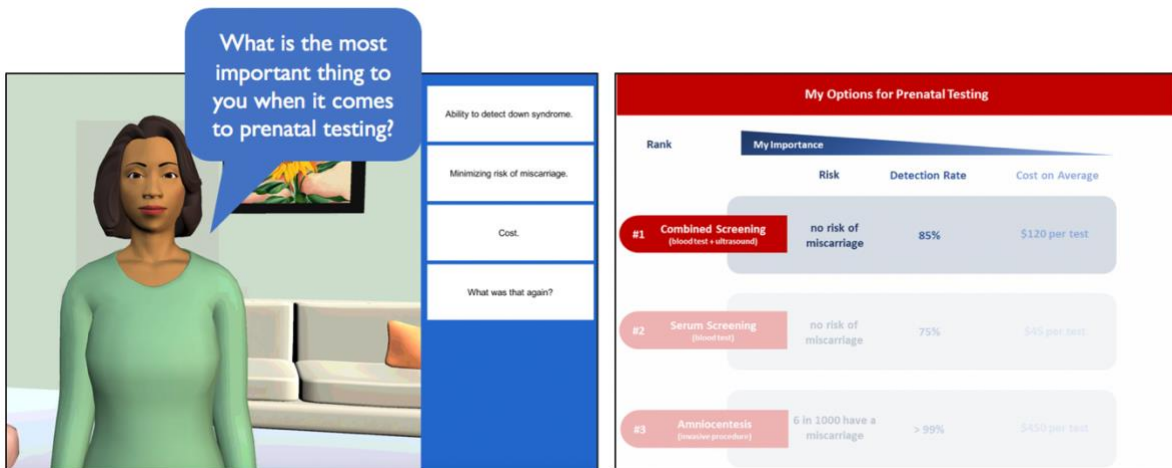
The study conditions are three VC/PE manipulations. I implemented these manipulations by developing different dialog scripts for each decision problem. Specifically, I created three versions of each dialog script, with Card Sorting, SMARTER, and AHP approaches to address the VC/PE task of SDM. The VC/PE manipulation was primarily within the value clarification module (Section 3.2) of the counseling conversation.

(1) **Card Sorting-based System:** after learning about the information of the decision problem as well as the key options and their attributes (e.g., effectiveness, risk, and cost), participants are asked to rank order the attributes based on their importance to decision making. The virtual coach then provides a summary table, in which the option attributes are ordered by the participant's rankings, and participants are asked to make a choice using this summary table.



**Figure 5-1: Ranking Exercise and Summary Table based on Card Sorting**

(2) **SMARTER-based System:** after learning about the information for the decision problem and key decision options and their attributes (e.g., effectiveness, risk, and cost), participants are asked to rank order the attributes based on their importance to decision making. The virtual coach then makes a recommendation based on the participant's rankings using the SMARTER algorithm as described in 2.4.3.1.



**Figure 5-2: Ranking Exercise and Recommendation using SMARTER**

(3) **AHP-based System:** after learning about the information of the decision problem as well as the key options and their attributes (e.g., effectiveness, risk, and cost), participants are asked to do a series of pairwise comparisons on both the attributes and the options with respect to each attribute. The virtual coach then makes a recommendation based on the participant's rankings using the AHP algorithm as described in 2.4.3.2.



**Figure 5-3: Pairwise Comparison and Recommendation using AHP**

To mitigate potential confounds of a particular decision problem on decision quality and decision-making experience, I chose to test the above approaches on three different decision problems. The three decision problems were selected to be as similar as possible with regards to the number of available options (all have 3 key options) and evaluative attributes (all can be evaluated using effectiveness, risk and cost), but different enough so that learning effects would be minimized. Specifically, the three decision problems were:

(a) **prenatal testing for down syndrome**, for which I selected Serum Screening, Combined Screening and Amniocentesis as three available options and effectiveness in detecting down syndrome (detection rate), risk of miscarriage and cost as evaluative attributes.

(b) **colon cancer screening**, for which I selected Stool DNA Test, Fecal Immunochemical Test and Colonoscopy as three available options and effectiveness in detecting colon cancer (detection rate), risk of complications and cost as evaluative attributes.

(c) **acne treatment**, for which I selected Azelaic Acid, Oral Contraceptives and Photodynamic Therapy as three available options and effectiveness in reducing acne spots, risk of side effects and cost as evaluative attributes.

## 5.2 COMPARATIVE EVALUATION STUDY

With the above systems, I conducted a three-arm, counterbalanced, within-subjects experiment in which participants interacted with a virtual decision coach to decide on a best choice for prenatal testing, colon cancer screening, and acne treatment using three different VC/PE approaches in three separate sessions on the same day.

The order of the study conditions as well as the decision problems used in each study condition were randomized (counterbalanced) for each participant to avoid confounds from these factors. As a result, each study participant engaged in three SDM sessions, delivered by the same virtual decision coach, with a random ordering of decision problems, and using a random ordering of VC/PE approaches.

## 5.2.1 PARTICIPANTS

To be eligible for the study, participants had to be female, at least 21 years old, able to speak and read English, and have not had a child before but interested in having children in the future. Participants were recruited via fliers distributed around local campuses, stores, and community centers. The Northeastern University IRB approved the study (IRB#17-12-01) and participants were compensated \$20 for their time.

## 5.2.2 PROCEDURE

The study was held in the Human-Computer Interaction (HCI) laboratory at Northeastern University and took approximately an hour to complete. Upon arrival, participants completed an informed consent process, filled out baseline measures and had their health literacy and numeracy assessed. Participants were then randomized to a treatment ordering and conducted three separate SDM sessions with different decision problems and VC/PE approaches. After each SDM session, participants completed a series of questionnaires measuring the system usability, how they felt about their decision, and their attitudes towards the decision-making experience and the virtual coach. At the end of the study, a semi-structured interview was conducted to ask participants about their overall impression of the experience, which was audiotaped for subsequent analysis.

## 5.2.3 MEASURES

In addition to sociodemographic measures, I collected the following self-report measures prior to (T0) and immediately after each decision-making session (T1).

- **Need for Cognition** was assessed at T0 using a validated measure [151]. The 18-item scale assesses individuals' likelihood to engage in and enjoy effortful cognitive activities.
- **Preferred Role in Decision Making** was assessed at T0 using the Control Preference Scale as described in 2.5.1.
- **Health Literacy (HL)** was assessed at T0 using the Rapid Estimate of Adult Literacy in Medicine (REALM) instrument as described in 2.5.1. I used the cut-point of 60 for high vs. low health literacy as done in previous studies.
- **Numeracy** was assessed at T0 using the numeracy scale as described in 2.5.1.
- **Choice-Value Congruence** was assessed at T1 for SMARTER and AHP conditions only, by the difference between the choice recommended by the virtual coach in the system and the choice made by the participant after the interaction.
- **System Usability** was assessed at T1 using 9 single-item statements on a 7-point scale.
- **Decisional Conflict** was assessed at T1 using the Decisional Conflict Scale as described in 2.5.2.
- **Decision Satisfaction** was assessed at T1 using the Satisfaction with Decision Scale as described in 2.5.3.
- **Attitudes towards the Decision-Making Experience** was assessed at T1 using 4 single-item questions on a 7-point scale.

- **Attitudes towards the Virtual Decision Coach** was assessed at T1 using 5 single-item questions on a 7-point scale.

## 5.2.4 RESULTS

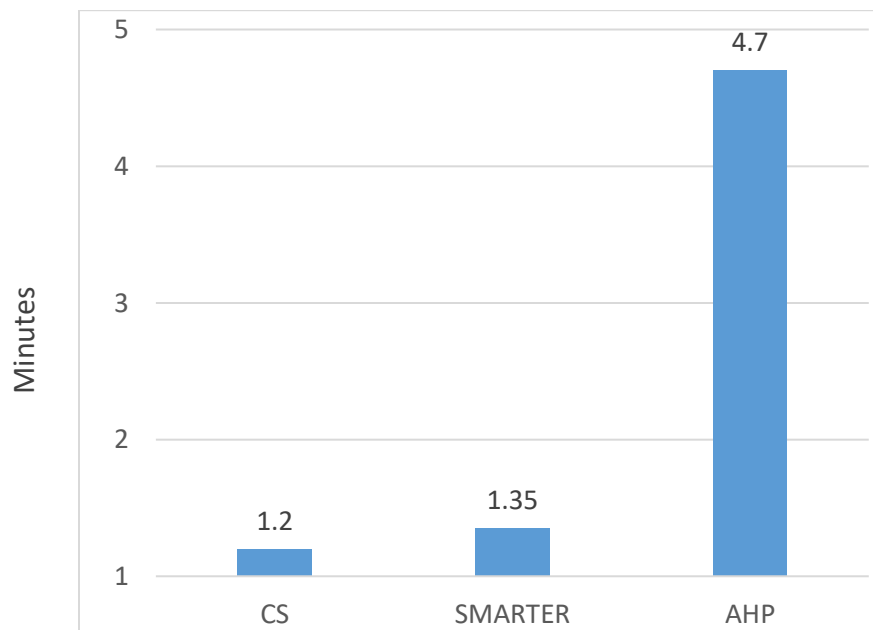
A total of 20 participants successfully completed the study and are included in the analysis. The demographic and personal characteristics of the participants are shown in Table 5-1.

**Table 5-1: Participant Sociodemographics**

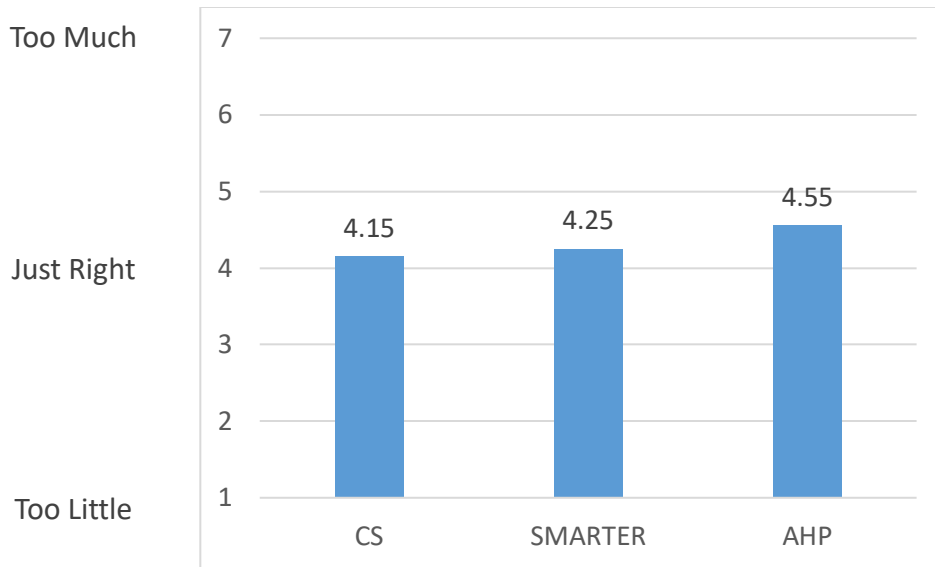
| <b>Participant Characteristics (N=20)</b> | <b>Descriptive Statistics</b> |
|---|-------------------------------|
| Age, mean (SD)                            | 23.5 (2.1)                    |
| Ethnicity, n (%)                          |                               |
| Asian or Pacific Islander                 | 10 (50)                       |
| White                                     | 9 (45)                        |
| Black, Not of Hispanic Origin             | 1 (5)                         |
| Marital Status, n (%)                     |                               |
| Single                                    | 20 (100)                      |
| Education, n (%)                          |                               |
| High School Graduate or GED               | 1 (5)                         |
| Some College                              | 8 (40)                        |
| College Graduate and Higher               | 8 (40)                        |
| Advanced Degree                           | 3 (15)                        |
| Control preference, n (%)                 |                               |
| Active Role                               | 8 (40)                        |
| Shared Role                               | 9 (45)                        |
| Passive Role                              | 3 (15)                        |
| Health literacy, n (%)                    |                               |
| Adequate                                  | 15 (75)                       |
| Inadequate                                | 5 (25)                        |
| Numeracy (0-10), mean (SD)                | 8.6 (1.9)                     |

### 5.2.4.1 Quantitative Results

**Time for Completion.** There was a main effect of study condition on the actual time spent on completing the VC/PE exercise ( $X^2(2) = 36.09, p < 0.01$ ). Participants deciding with AHP (M=4.7 mins, SD=0.64 mins) spent significantly longer time completing the VC/PE exercise than those deciding with SMARTER (M=1.35 mins, SD=0.48 mins) and Card Sorting (M=1.2 mins, SD=0.4 mins), as shown in Figure 5-4. However, when asked “How much time did you feel it took to go through the entire decision-making process”, participants felt they spent neither too little nor too much for all three conditions, as shown in Figure 5-5. No order effect or effect of health topics was observed on either of these measures.

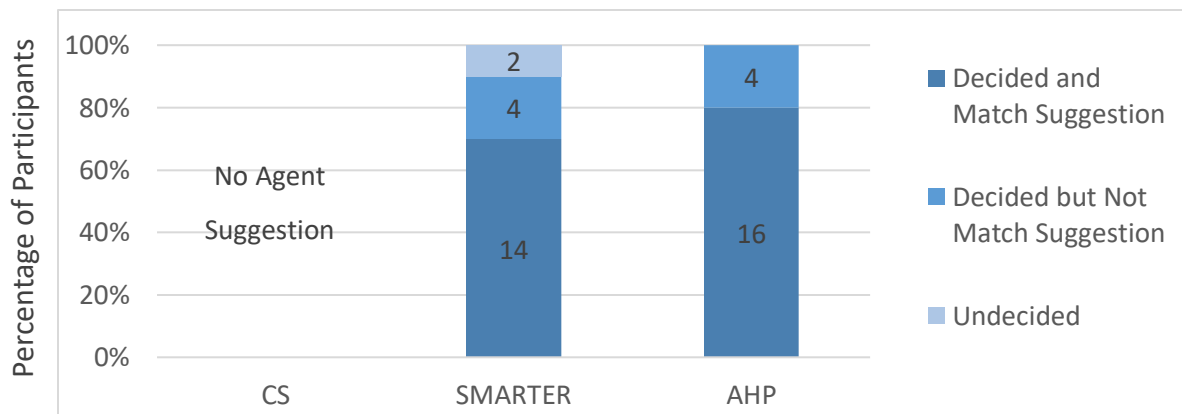


**Figure 5-4: Actual Time on VC/PE Exercise by Study Conditions**



**Figure 5-4: Perceived Time on Entire Process by Study Conditions**

**Value-Choice Congruence.** There was no significant difference between SMARTER and AHP on value-choice congruence (See Figure 5-5). All participants deciding with AHP (N=20) reached a decision, of which 16 made a choice that was the same as the virtual coach’s suggestion and 4 chose a different option. Among participants deciding with SMARTER, 14 made a choice that was the same as the virtual coach’s suggestion, 4 chose a different option, and 2 couldn’t reach a decision.



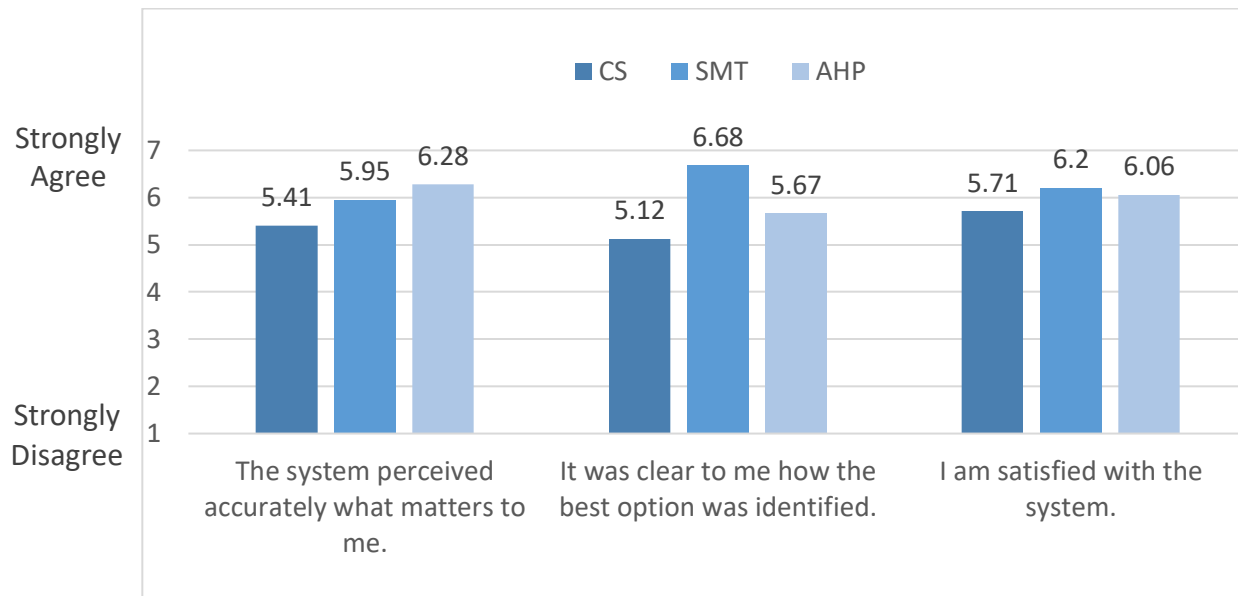
**Figure 5-5: Value-Choice Congruence by Study Conditions**

**System Usability.** Table 5-2 shows descriptive statistics of the usability measures.

Participants found the AHP system to be more accurate in understanding their values and preferences than the Card Sorting system ( $X_2(2) = 6.20, p < 0.05$ ). The SMARTER system was significantly better than the AHP and Card Sorting systems on result transparency ( $X_2(2) = 12.44, p < 0.01$ ) and was significantly better than the Card Sorting system on overall satisfaction with the system ( $X_2(2) = 6.68, p < 0.05$ ). See Figure 5-6. No order effect or effect of health topics was observed on any of these measures.

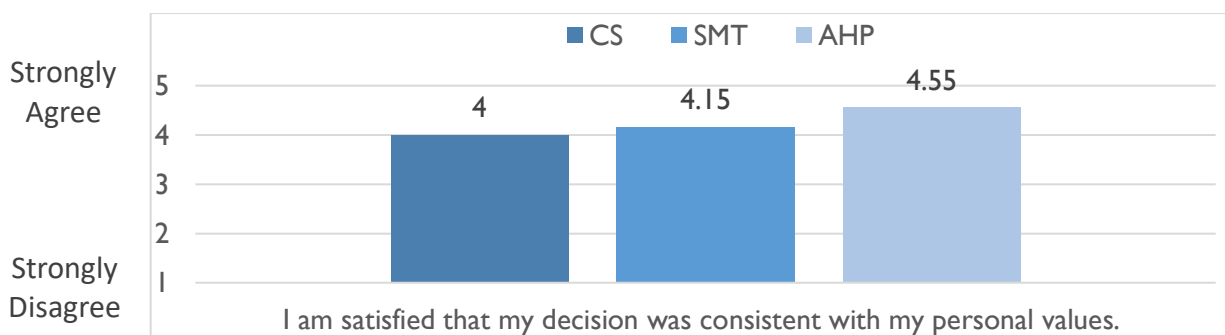
**Table 5-2: System Usability by Study Condition**

| <b>Statements<br/>(1-Strongly disagree, 7- Strongly agree)</b>   | <b>Card Sorting<br/>Mean (SD)</b> | <b>SMARTER<br/>Mean (SD)</b> | <b>AHP<br/>Mean (SD)</b> | <b>P</b> |
|--|-----------------------------------|------------------------------|--------------------------|----------|
| The system is easy to use.   | 6.82 (0.4)                        | 6.85 (0.36)                  | 6.67 (0.48)              | 0.07     |
| The system helped me think about what matters most to me.  | 6.06 (1.18)                       | 6.35 (0.91)                  | 6.50 (0.81)              | 0.15     |
| The system perceived accurately what matters most to me.   | 5.41 (1.16)                       | 5.95 (1.12)                  | 6.28 (0.84)              | 0.04 *   |
| The system helped me get ready to make a choice.   | 6.12 (0.85)                       | 5.90 (1.22)                  | 6.44 (0.86)              | 0.23     |
| The system is efficient.   | 5.82 (1.34)                       | 6.20 (1.17)                  | 5.78 (1.47)              | 0.25     |
| The system helped me identify which option is best for me.   | 5.41 (1.43)                       | 5.80 (1.29)                  | 6.17 (1.12)              | 0.10     |
| It is clear to me how the best option was identified.  | 5.12 (1.71)                       | 6.68 (0.55)                  | 5.67 (1.44)              | 0.002 ** |
| I am satisfied with this system.   | 5.71 (1.15)                       | 6.20 (0.93)                  | 6.06 (0.99)              | 0.03 *   |
| I would like to recommend this system to a friend.   | 5.12 (1.57)                       | 5.55 (1.53)                  | 5.56 (1.50)              | 0.22     |
| * Significant at the .05 probability level. ** Significant at the .01 probability level.<br>*** Significant at the .001 probability level. † NS, nonsignificant. |                                   |                              |                          |          |



**Figure 5-6: System Usability by Study Conditions**

**Decision Quality.** There were no significant differences on decisional conflict across study conditions. However, there was a main effect of study condition on decision satisfaction related to feeling the decision was consistent with their personal values ( $\chi^2(2) = 6.30, p < 0.05$ ). Specifically, participants were more satisfied that the decision was consistent with their personal values when deciding with AHP ( $M=4.55, SD=0.50$ ) than SMARTER ( $M=4.15, SD= 0.65$ ) and Card Sorting ( $M=4, SD=0.77$ ). No order effect or effect of health topics was observed on this measure.



### Figure 5-7: Decision Satisfaction by Study Conditions

**Decision Making Experience.** Table 5-3 shows the descriptive statistics for decision making experience. Participants perceived higher pressure about making the decision when deciding with AHP, compared to SMARTER and Card Sorting ( $\chi^2(2) = 9.19$ ,  $p < 0.05$ ). However, they reported they were more likely to adhere to their chose option in the future when deciding with AHP, compared to SMARTER and Card Sorting ( $\chi^2(2) = 6.49$ ,  $p < 0.05$ ). No order effect or effect of health topics was observed on any of these measures. There was no significant difference on other decision-making experience measures.

**Table 5-3: Decision Making Experience Ratings by Study Condition**

| Questions  | Card Sorting<br>Mean (SD) | SMARTER<br>Mean (SD) | AHP<br>Mean (SD) | P       |
|--|---------------------------|----------------------|------------------|---------|
| How much information did you get?<br>(1-too little, 7-too much)  | 3.75 (0.89)               | 3.80 (0.81)          | 3.75 (0.94)      | 0.85    |
| How likely would you go with the<br>option you prefer?<br>(1-extremely unlikely, 7-extremely<br>likely)              | 4.90 (1.70)               | 5.30 (1.45)          | 5.7 (1.49)       | 0.03 *  |
| How much pressure did you feel?<br>(1-no pressure at all, 7-extreme pressure)  | 1.65 (1.24)               | 1.70 (1.31)          | 2.45 (1.83)      | 0.01 ** |
| How satisfied were you with the<br>decision-making experience?<br>(1-not satisfied at all, 7-extremely<br>satisfied) | 5.33 (1.19)               | 5.70 (0.90)          | 5.65 (1.35)      | 0.61    |

\* Significant at the .05 probability level.

\*\* Significant at the .01 probability level.

\*\*\* Significant at the .001 probability level.

† NS, nonsignificant.

## 5.2.4.2 Qualitative Results

Interview responses were transcribed and coded for common themes. Overall, participants were satisfied with the decision-making experience and did notice the difference in the approaches used by the virtual decision coach for VC/PE.

*“I think the conversations were very informative. The information she provided was very helpful in making a particular decision because she talked about the cost and the risk. The information was communicated in a good way.” (P5)*

*“In the one about the colon cancer (Card Sorting) and the one about prenatal screening (SMARTER), I was asked to rank order which of the three factors matter the most to me, and the one about acne (AHP), I was asked to pick between two at a time and compare those... For the colon cancer one, she asked me about what I thought the best option for me was, and for the other two, she gave a suggestion and said do you agree this.” (P8)*

When asked about which system they liked the most, 10 participants preferred the SMARTER system, 8 preferred the AHP system, and 2 preferred the Card Sorting system. Participants who liked the SMARTER system the most felt the SMARTER system was very straightforward and efficient in getting a recommendation.

*“I feel like the colon cancer screening one (SMARTER) was most efficient. It was like what do you find most important, what is the next thing you find most important, and then here is your best option.” (P14)*

Participants who liked the AHP system the most appreciated the nuance comparisons of the options and the opportunities to evaluate the option attributes with personalized ratings, and they found the system helpful to support them consider the options in a detailed way that they would not have done by themselves.

*“I liked the last one (AHP) the most because it is the most comprehensive one, where like instead of just saying what is most important to me, I was also given the option to be like I feel that this is the same, and so factors like she feels that 200 dollars is a big difference but I think it not or something like that.” (P4)*

## 5.3 CONCLUSION

The study provided empirical evidence on the usability and efficacy of three different VC/PE approaches for SDM, addressing RQ2. Overall, participants preferred the SMARTER and AHP approaches over Card Sorting. Compared to AHP, SMARTER is superior in result transparency. Participants found it to be clearer as to how the best option was identified by the virtual coach when using SMARTER than AHP. However, participants felt their values to be perceived more accurately by the AHP system than the SMARTER system. They were also more satisfied with their decisions and more likely to adhere to their chosen option when deciding with AHP than SMARTER.

Therefore, AHP is a better approach to addressing the VC/PE task of SDM, given it has the benefit to accurately incorporate patient values and leads to higher decision satisfaction and likelihood to adhere to their chosen option. However, an improved

version is needed to address the issue on result transparency and decision-making pressure

The study also demonstrated that a virtual decision coach can be used to support SDM across different decision problems, addressing RQ3. Participants reported low levels of decisional conflict and high levels of satisfaction with their final decisions after the interaction with the virtual decision coach. They were also very satisfied with their decision-making experience regardless of study conditions.

# 6 EVALUATING A VIRTUAL SHARED DECISION-MAKING COACH FOR COLON CANCER SCREENING

The pilot study demonstrated the feasibility and acceptance of using a virtual decision coach to support SDM. The comparative study suggested AHP is a desirable approach for VC/PE. Based on these results, I developed a full AHP-based virtual SDM system to help older adults make a shared decision for colon cancer screening and evaluated it in a randomized controlled trial. In this chapter, I describe the system, the trial conducted with the system, and the results of the trial.

## 6.1 VIRTUAL SDM SYSTEM FOR CRC SCREENING

Colorectal cancer (CRC) is the second leading cause of cancer death among men and women in the United States. Screening has been shown to be an effective way to prevent and detect colorectal cancer, which can reduce CRC mortality and incidence [152]. As the vast majority of colorectal cancer occurs in people who are 50 or older, the United States Preventive Services Task Force (USPSTF) recommends that adults age 50-75 start regular screening for colorectal cancer [153]. However, according to a report from the Centers for Disease Control and Prevention (CDC), about 1 in 3 adults aged 50 to 75 years have not been screened for colorectal cancer as recommended by the USPSTF.

Shared decision making has been advocated as a potentially effective approach to increasing patient acceptance and adherence to CRC screening recommendations [153, 154]. Given that multiple screening tests are available for CRC screening, each with distinct advantages and disadvantages, and no consensus exists regarding the optimal test for all, CRC screening is an ideal case for shared decision making. Therefore, I developed a virtual SDM system to help older adults make a shared decision for colon cancer screening. The virtual SDM system was built upon the AHP prototype system described in Chapter 5, and it was significantly expanded to fully implement the framework discussed in Chapter 3. The full scripts of this system are shown in Appendix TBD. Specifically, the full system covers the following topics.

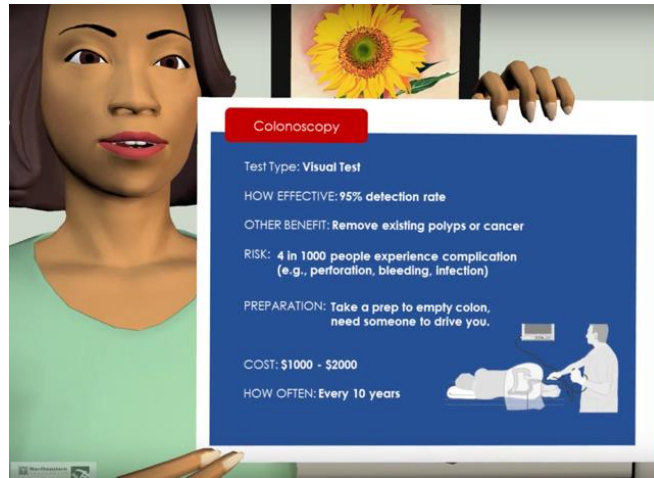
- (1) **Greeting:** the virtual coach begins the conversation with a brief self-introduction, greeting the user, and building trust through social chat and empathy.
- (2) **Agenda:** after greeting, the virtual coach moves to a section in which she provides a brief overview of the topics to be covered in the discussion.
- (3) **Colon Cancer Education:** the virtual coach then discusses what colon cancer is, its common symptoms, the risk of getting colon cancer for older adults, and why older adults should get colon cancer screening. Following this, the coach points out there is no best testing option for everyone and highlights the importance of practicing SDM in this context.



**Figure 6-1: Colon Cancer Education Section**

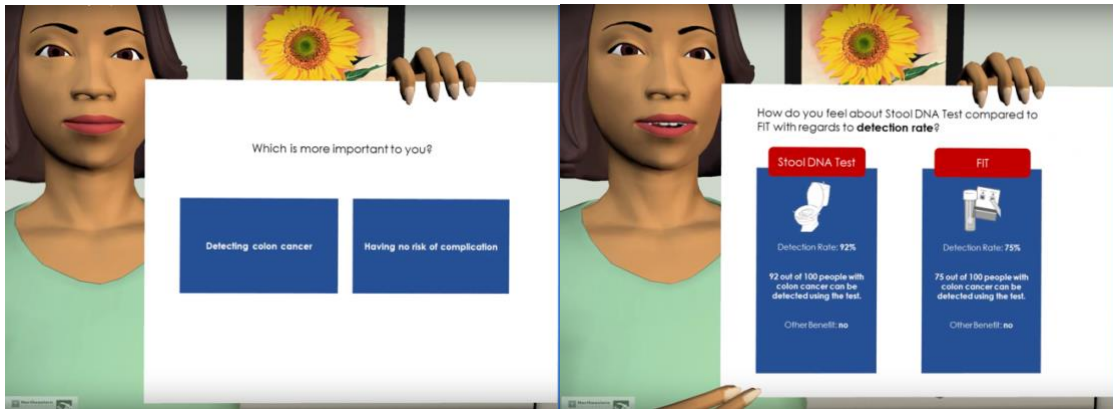
- (4) **Emotion Check 1:** the virtual coach then asks about how the user is feeling and if the user has any questions or needs a review of the previous section.
- (5) **CRC Screening Education:** the virtual coach then discusses the available options to screen for colon cancer and presents scientific facts about the pros and cons of each option. Three common screening options are discussed in the system: fecal immunochemical test (FIT), stool DNA test, and colonoscopy. For each of the

screening tests, the virtual coach explains what it is and how it is done, its detection rate, possible results, repeat frequency, risk if any, and the cost of the test. As shown in 6-2, a summary table with images and text props are used to highlight the important information.



**Figure 6-2: CRC Screening Education Section**

- (6) **Emotion Check 2:** the virtual coach asks about how the user is feeling and if the user has any questions or needs a review of the previous section.
- (7) **Value Exercise:** the conversation continues to a value exercise (Figure 6-3), which was designed based on AHP and covers a list of attributes that are commonly used in decision making for CRC screening, including detection rate, test preparation, frequency, risk, and cost [106]. Specifically, the user is asked to compare all the presented options and the evaluative attributes in pairs on a 9-point scale. The responses are then put into an AHP algorithm to calculate option priorities. Sample scripts are shown in Figure 6-4.



**Figure 6-3: AHP-based Value Exercise**

...

**AGENT:** So, when it comes to colon cancer screening, which would you say is more important, detecting colon cancer, or, having no risk of complications such as perforation or bleeding?

**USER:** Detecting colon cancer.

**AGENT:** Then how much more important is detecting colon cancer than having no risk of complications to you? Let us say 1 is they are equally important, and 9 is detecting colon cancer is extremely more important than having no risk of complications.

**USER:** Actually, they are equally important.

...

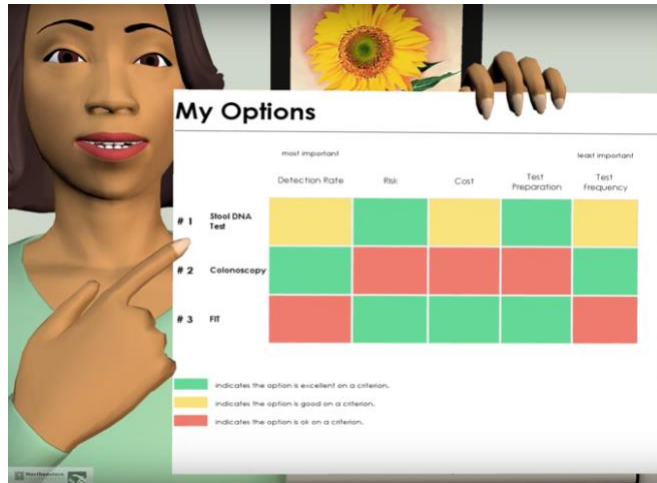
**AGENT:** So, how do you feel about stool DNA test compared to the FIT test with respect to detection rate? Let us say 1 is they are equally good on this aspect, and 9 is stool DNA test is a lot better than the FIT test.

**USER:** Stool DNA test is a lot better than FIT.

**Figure 6-4: Sample Dialogs for Value Exercise**

- (8) **Choice Recommendation:** as mentioned above, an underlying AHP algorithm is used to calculate the priorities of the presented options. The virtual coach then makes a suggestion based on the calculation results and explains to the user how the choice was derived from their responses in the value exercise and provides the user with options to accept or reject the recommendation. As shown in Figure 6-5, a

colour-themed chart is used to display the option priorities and help explain the trade-offs involved in each of the options.



**Figure 6-5: Choice Recommendation Chart**

(9) **Farewell:** the virtual agent wraps up the conversation and thanks the user for participating in the study.

## 6.2 EVALUATION STUDY

To evaluate the final system, I conducted a two-treatment between-subjects randomized controlled trial, in which participants were randomly assigned to either use the virtual system (intervention) or read a paper pamphlet (control) to learn about CRC screening and decide on the option they would prefer to use for CRC screening. The entire session took approximately 1 hour, was approved by the Northeastern University IRB, and participants were compensated for their time.

## 6.2.1 PARTICIPANTS

Participants were eligible if they were 50 to 75 years of age, able to speak and read English, and have not undergone any testing for colorectal cancer (CRC) screening. They were recruited via fliers posted online and distributed around local stores and community centers.

## 6.2.2 PROCEDURES

The study was held in the Human-Computer Interaction (HCI) laboratory at Northeastern University and took approximately one hour to complete. After obtaining informed consent, participants filled out the baseline measures, had their health literacy and numeracy assessed, and completed a knowledge test on CRC screening.

Participants were then randomized to either interact with a virtual decision coach (intervention) or read an educational pamphlet (control) to learn about CRC screening and make a decision about the kind of option they would want for CRC screening. The session for either condition took approximately 30 minutes. Immediately after the session, all participants were asked to complete the knowledge test again, as well as questionnaires measuring screening intentions, decision qualities, and their attitudes towards the decision-making experience. The intervention participants completed two additional questionnaires, with one measuring their involvement in SDM and the other measuring their attitudes towards the virtual decision coach. At the

end of the study, a semi-structured interview was conducted to learn about their overall impression of the experience, which was audiotaped for subsequent analysis.

### 6.2.3 MEASURES

In addition to sociodemographic measures, I collected the following self-report measures prior to (T0) and immediately after the SDM session (T1).

- **Need for Cognition** was assessed at T0 using a validated measure [151]. The 18-item scale assesses individuals' likelihood to engage in and enjoy effortful cognitive activities. Using a 7-point scale, the highest possible score on the Need for Cognition Scale is 54 and the lowest possible score is -54.
- **Preferred Role in Decision Making** was assessed at T0 using the Control Preference Scale as described in 2.5.1.
- **Health Literacy (HL)** was assessed at T0 using the Rapid Estimate of Adult Literacy in Medicine (REALM) instrument as described in 2.5.1. I used the cut-point of 60 for high vs. low health literacy as done in previous studies.
- **Numeracy** was assessed at T0 using the numeracy scale as described in 2.5.1. I used the median to dichotomize participants into high vs. low numeracy groups for analysis.
- **Knowledge about colon cancer screening** was assessed at T0 and T1 based on responses to a 12-item questionnaire (true/false/don't know) that was used in a previous study evaluating a computer decision aid for CRC screening [106].

Cumulative knowledge scores, ranging from 0-12, were derived by summing correct responses to the 12 individual knowledge questions.

- **Screening intentions** were also assessed as part of the post test. Participants were asked how sure they were to schedule an appointment to get screened for colon cancer and how sure they were to complete the screening test they scheduled, on an ordered 5-point scale ranging from "not sure at all" to "completely sure".
- **Decisional Conflict** was assessed at T1 using the Decisional Conflict Scale as described in 2.5.2.
- **Decision Satisfaction** was assessed at T1 using the Satisfaction with Decision Scale as described in 2.5.3.
- **Preparation for Decision Making** was assessed at T1 using the Preparation for Decision Making Scale [155] to evaluate individual's perceived usefulness of a decision support tool to prepare them for decision making. Possible scores range from 1 to 5, with 1 indicating not useful at all and 5 indicating very useful.
- **Attitudes towards the Decision-Making Experience** was assessed at T1 using 4 single-item questions on a 7-point scale.

For intervention participants, I collected two additional measures at T1.

- **Involvement in Shared Decision Making** was assessed using the 9-item Shared Decision-Making Questionnaire (SDM-Q-9) as described in 2.5.2.
- **Attitudes towards the Virtual Decision Coach** was assessed using 5 single-item questions on a 7-point scale.

## 6.2.4 RESULTS

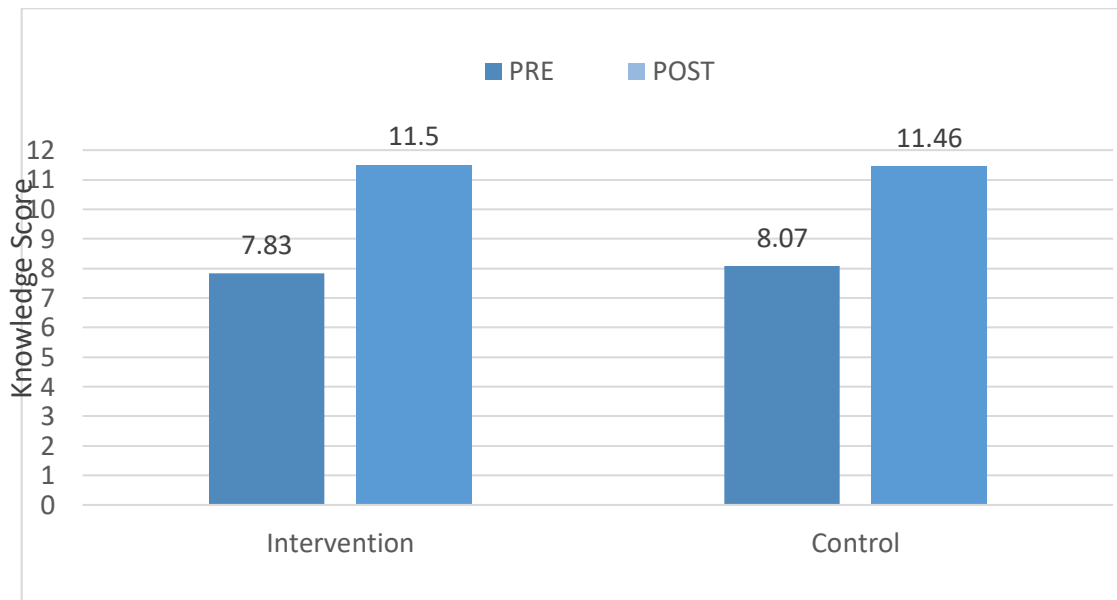
I recruited a total of 26 participants, of whom 1 did not successfully completed the study and was removed from the final analysis, 12 participants were randomized to the intervention condition, and 13 were randomized to the control condition. The demographics and personal characteristics of the participants are shown in Table 6-1.

**Table 6-1: Participant Sociodemographics**

| <b>Participant Characteristics (N=25)</b> | <b>Descriptive Statistics</b> |
|---|-------------------------------|
| Age, mean (SD)                            | 59 (5.8)                      |
| Ethnicity, n (%)                          |                               |
| White                                     | 17 (68)                       |
| Black, Not of Hispanic Origin             | 7 (28)                        |
| Asian or Pacific Islander                 | 1 (4)                         |
| Marital Status, n (%)                     |                               |
| Single                                    | 20 (80)                       |
| Divorced/Widowed                          | 4 (16)                        |
| Married                                   | 1 (4)                         |
| Education, n (%)                          |                               |
| High School Graduate or GED               | 2 (8)                         |
| Some College                              | 6 (24)                        |
| College Graduate                          | 14 (56)                       |
| Advanced Degree                           | 3 (12)                        |
| Need for Cognition, mean (SD)             | 19.7 (17.4)                   |
| Control preference, n (%)                 |                               |
| Active Role                               | 9 (36)                        |
| Shared Role                               | 11 (44)                       |
| Passive Role                              | 5 (20)                        |
| Health literacy, n (%)                    |                               |
| Adequate                                  | 25 (100)                      |
| Numeracy (split at median), n (%)         |                               |
| Adequate                                  | 13 (52)                       |
| Inadequate                                | 12 (48)                       |

### 6.2.4.1 Quantitative Results

**Knowledge of CRC Screening.** There was a significant increase in knowledge scores after the session compared to before, regardless of study conditions. For the intervention group, the knowledge scores increased to M=11.50 (SD=0.79) after the session, compared to M=7.83 (SD=1.75) before, paired t (11) =7.15, p<.01. For the control group, the knowledge scores were 11.46 (SD=0.88) after the session, compared to M=8.07 (SD=1.93) before, paired t (12) =7.14, p<.01. No significant difference in pre-test or post-test scores or change in scores was observed between study conditions.



**Figure 6-6: Knowledge of CRC Screening Pre-Post by Study Condition**

**CRC Screening Choice.** The final choices made by participants in each study condition are shown in Table 6-2. All intervention participants reached a decision after the session, while 2 control participants felt unsure about which option to choose. Of all participants in the intervention group, 8 chose the option suggested by the virtual decision coach as their final choice for CRC screening.

**Table 6-2: CRC Screening Choice by Study Condition**

| CRC Screening Test        | Intervention (N=12), n (%) | Control (N=13), n (%) |
|---------------------------|----------------------------|-----------------------|
| Fecal Immunochemical Test | 5 (41.7)                   | 4 (30.8)              |
| Stool DNA Test            | 4 (33.3)                   | 3 (23.1)              |
| Colonoscopy               | 3 (25)                     | 4 (30.8)              |
| Undecided                 | 0 (0)                      | 2 (15.3)              |

**Screening Intention.** Participants in the intervention group reported significantly greater intentions to schedule and complete a CRC screening test, compared to those in the control group (Friedman Test,  $p < .01$ , Table 6-3).

**Table 6-3: CRC Screening Intention by Study Condition**

| Questions<br>(1-extremely unsure, 7-extremely sure)  | Intervention<br>Mean (SD) | Control<br>Mean (SD) | p-value        |
|--|---------------------------|----------------------|----------------|
| How sure are you that you will schedule a colorectal cancer screening test?  | 5.92 (1.16)               | 4.08 (1.44)          | $p = 0.003$ ** |
| How sure are you that you will complete colorectal cancer screening test?  | 6.08 (0.99)               | 4.31 (1.60)          | $p = 0.004$ ** |
| * Significant at the .05 probability level.<br>** Significant at the .01 probability level.<br>*** Significant at the .001 probability level.<br>† NS, nonsignificant. |                           |                      |                |

**Decisional Conflict.** As shown in Table 6-3, the decision conflict scores were significantly lower for the intervention group ( $M = 4.95$ ,  $SD = 9.92$ ) compared to the

control group (M=13.34, SD=12.91), W=117, p<.05 (Mann-Whitney Test). With regards to its subscales, participants in the intervention group reported significantly lower decisional conflict related to feeling uninformed and indecisiveness about their personal values, compared to those in the control group.

**Table 6-3: Decisional Conflict by Study Condition**

| <b>Decisional Conflict Score (0-100)</b>   | <b>Intervention<br/>Mean (SD)</b> | <b>Control<br/>Mean (SD)</b> | <b>p-value</b> |
|--|-----------------------------------|------------------------------|----------------|
| Total Score  | 4.95 (9.92)                       | 13.34 (12.91)                | 0.033 *        |
| Informed Subscale Score  | 2.08 (7.22)                       | 12.18 (17.55)                | 0.025 *        |
| Value Clarity Subscale Score   | 4.17 (10.36)                      | 16.03 (16.83)                | 0.049 *        |
| Support Subscale Score   | 6.25 (15.54)                      | 12.82 (17.55)                | 0.113          |
| Uncertainty Subscale Score   | 4.86 (10.33)                      | 12.82 (16.53)                | 0.194          |
| Effective Decision Subscale Score  | 6.77 (9.78)                       | 12.98 (16.43)                | 0.487          |
| * Significant at the .05 probability level.<br>** Significant at the .01 probability level.<br>*** Significant at the .001 probability level.<br>† NS, nonsignificant. |                                   |                              |                |

**Satisfaction with Decision.** Participants in the intervention group reported a slightly higher level of satisfaction with their decisions (M=4.60, SD=0.63), compared to those in the control group (M=4.49, SD=0.56). However, the difference did not achieve statistical significance.

**Preparation for Decision Making.** The scores on the Preparation for Decision Making scale were significantly higher for the intervention group (M=4.73,

SD=0.65) than the control group (M=4.03, SD=0.99),  $W=35.5$ ,  $p<.05$  (Mann-Whitney Test), indicating the virtual shared decision making system was more useful than the educational pamphlet in preparing the participants for making a health decision.

**Decision Making Experience.** As shown in Table 6-4, participants in the intervention group felt they received slightly more information compared to those in the control group. However, the difference was not statistically significant. The likelihood to adhere to their chosen CRC screening option was significantly higher for the intervention group (M=6.33, SD=1.07) compared to the control group (M=4.3, SD=0.93),  $W=24.5$ ,  $p<.05$  (Mann-Whitney Test). Both groups perceived a low level of pressure about making the decision. The ratings on satisfaction with the decision-making experience were higher for the intervention group than the control group. Yet, no statistical significance was achieved.

**Table 6-4: Decision Making Experience Ratings by Study Condition**

| Questions  | Intervention<br>Mean (SD) | Control<br>Mean (SD) | p-value |
|--|---------------------------|----------------------|---------|
| How much information did you get?<br>(1-too little, 7-too much)                                      | 5.00 (1.04)               | 4.23 (0.93)          | 0.134   |
| How likely would you go with the<br>option you prefer?<br>(1-extremely unlikely, 7-extremely likely) | 6.33 (1.07)               | 5.15 (1.21)          | 0.014 * |
| How much pressure did you feel?<br>(1-no pressure at all, 7-extreme pressure)                        | 1.42 (0.90)               | 1.38 (0.96)          | 0.668   |

|  |             |             |       |
|--|-------------|-------------|-------|
| How satisfied were you with the decision-making experience?<br>(1-not satisfied at all, 7-extremely satisfied)   | 6.25 (1.22) | 5.84 (0.99) | 0.162 |
| * Significant at the .05 probability level.<br>** Significant at the .01 probability level.<br>*** Significant at the .001 probability level.<br>† NS, nonsignificant. |             |             |       |

**Involvement in Decision Making.** The intervention participants reported a high score of SDM-Q-9 (M=5.35, SD=0.62), indicating they were highly involved in the process of making a shared decision with the virtual decision coach for CRC screening.

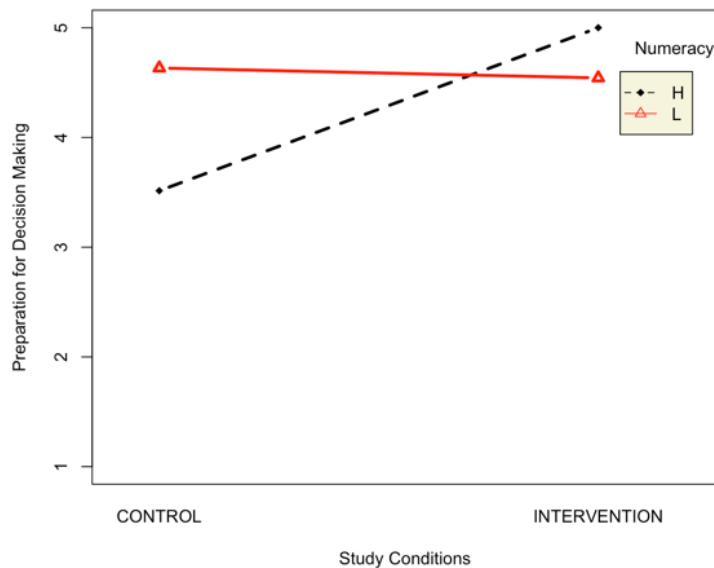
**Virtual Decision Coach Ratings.** As shown in Table 6-5, the intervention participants were very satisfied with the virtual decision coach. They also liked the coach, trusted the coach, found the coach to be knowledgeable, and expressed a desire to make future decisions with the coach.

**Table 6-5: Virtual Decision Coach Ratings**

| Questions   | Intervention Mean (SD) |
|---|------------------------|
| How satisfied are you with Tanya?<br>(1-not at all, 7-very much)                            | 6.08 (1.08)            |
| How much would you like to make future decisions with Tanya?<br>(1-not at all, 7-very much) | 5.83 (1.27)            |
| How much do you trust Tanya?<br>(1-not at all, 7-very much)                                 | 6.00 (1.04)            |
| How much do you like Tanya?   | 5.75 (1.36)            |

|   |             |
|---|-------------|
| (1-not at all, 7-very much)                                 |             |
| How knowledgeable was Tanya?<br>(1-not at all, 7-very much) | 6.41 (0.79) |

**Interaction Effect.** I found a significant interaction effect of study condition and numeracy on preparation for decision making,  $F(1,21) = 10.31, p < .01$  (Align Ranked Transform Tool-ARTool, Figure 6-7). Participants with high level of numeracy perceived the virtual SDM system guided by the decision coach to be significantly more useful in preparing them for making the decision compared to the educational pamphlet. No such difference was observed between study conditions for participants with low level of numeracy.



**Figure 6-7: Interaction Effect of Study Condition and Numeracy on Preparation for Decision Making**

### 6.2.4.2 Qualitative Results

**Intervention Condition:** participants were generally satisfied with the virtual SDM system. The majority of participants found the system to be very informative.

*“It was very informative, I learned quite a lot. It sort of made you to think about what kind of decisions you are going to make and what the options are. Everything was very clear. I am happy and I learned a lot.” (P6)*

*“It was very informative. I mean I learned something that I was not aware of. I knew colonoscopy but I was not aware of these other tests.” (P21).*

They also liked the amount of information and the level of detail being provided.

*“There was a good amount of information. It was not overdone, just right.” (P20)*

*“It was pretty straightforward. I did not have to go into any kind of detail about my family history, pretty cut and dried, I liked that.” (P8)*

Some participants expressed appreciation for the information being presented in a balanced, unbiased way.

*“She presented the facts on both sides, equally, in such a way that was balanced...It was objective, there was no promo for a particular product so there was no bias, just facts, and that is very important.” (P2)*

*“It was very specific, very concrete, took consideration my preferences, and it was not subjective. It was objective and I liked that.” (P8).*

Some participants mentioned the system helped them *“weigh all of the factors”* (P24). There were comments particularly related to the value exercise portion of the conversation. Some felt *“it (the exercise) made you think about it (attribute) and*

*made you think about your opinion on it too.” (P20) and “it (the exercise) helped you better understand the process of making a decision... I liked the type of questions because normally people don’t ask that type of things and you do not ask yourself either, it is always a good thing when somebody asked you the questions because they forced you to think and that is a good thing”(P6). One participant really liked the pairwise comparison and felt “it was a good way to narrow down by variables, to compare each individual variable with another one, I liked that because I can choose between two variables at a time as opposed to ranking multiple ones from 1 to 5, which is often a hard thing to do.”(P8).*

When asked whether they would make a choice using the virtual SDM system, several participants provided positive responses.

*“I liked that she gave you all the options, she gave you the costs and everything...It was very intelligent so people can make a decision on that.” (P20)*

*“You know at the end of the thing, she had all of the information, she kind of according to your responses, gave you the answer. That was very good, I liked it.” (P26)*

When asked about how they felt about the recommendation made by the virtual decision coach, most participants appreciated the recommendation regardless of whether it matched what they ultimately decided to do or not. They also liked the format in which the recommendation was presented and the flexibility to accept or reject the recommendation. P8 mentioned *“I liked in the end, it presented it in a good format, in different colors, it was summarized, then I liked I could look at it*

*closely and I might want to go back and change something, but it was not very important because I still had choices, I can still re-consider, I am not locked in to a particular choice.*" Only 1 participant expressed that he did not like the recommendation and found it "overly aggressive" to have an animated character make a suggestion because he believed *"only doctors know what is best"*.

I also received comments on the virtual decision coach. The majority of the participants felt the virtual coach was very *"knowledgeable"*. Some participants felt it was *"interesting"* because *"it feels like talking to a screen"* (P7). One participant felt *"she was very encouraging because she kept saying that you are doing great (in the value exercise portion), and that was nice."* (P14).

Participants also provided useful suggestions for future improvements. Some suggested having a print-out option for the final recommendation table so they could bring it to their doctor's appointment and use it to start the conversation with their doctors. Some suggested making the interaction completely voice-based so they could interact with the virtual coach using speech instead of using the touch screen. Some suggested improving the graphics of the virtual coach, adding more animations for body movements and facial expressions.

**Control Condition:** participants had mixed feelings about the pamphlet.

Participants who liked the pamphlet felt *"it was very clear, and it was very easy to read"* (P9) and they believed *"too much information would overload people"* (P9) and *"short is good"* (P12). Some also mentioned *"it is good because some patients may not*

*feel comfortable discussing it with doctors so maybe reading about it first so that when you have a doctor's appointment and when you go to doctors, it is like you know something about it as opposed to just the doctor telling you"*(P11). Some participants particularly liked the colorful diagrams or images that were used to clarify the point being discussed or explain a concept because *"they catch your attention"* (P11) and *"they were very illustrative"* (P12).

Some participants were not satisfied with the pamphlet. They felt *"the information was too general"* (P10) and *"it was not very helpful...It did not prepare you to think about what was important to you, what should be incorporated with your values, it gave very little information about the options"* (P5). One of the most common complaints was related to the limited information that was given.

*"There could be more information like what the results mean because there could be different results for different people...and what to do if the result comes back positive and what to do if it is negative and other stuff that needs to be taken"* (P10)

*"I feel like I would need more information about the different options...I mean it was pretty brief, and outlines of the different treatments, I think I would have to go online and talk to my doctors, or talk to people who had the different tests to learn more about the different options"* (P13).

Participants also complained about having little definition or support to understand the medical terms that was used to explain a medical concept.

*“It used some terms to help explain things, but nobody knows what those mean”*  
(P5)

*“It used a couple of words that I’ve never seen or heard before. One was with P and the other one was with S...I would like to have a little definition of each word.”*(P15)

When asked about if they would make a choice using the pamphlet, many participants were hesitant and expressed a desire of talking to a doctor to discuss further.

*“I definitely wouldn’t make a decision just based on the pamphlet; I would want to talk to the doctors. I saw the different options, which to me were fairly clear, but I just would like the doctor to give a little more detail, information about each test, and which one would be more applicable to me.”* (P15).

*“I do not know if I would use it to make a specific choice. I would use it as a beginning tool to help understand what my choices are... Making a decision about which test, I think that is a little more complicated...I think if the doctor gives it to me and I would read it and have a consultation with the doctor, and the doctor could explain all the differences, then I think that would be helpful, but that alone, wouldn’t help me.”* (P22)

## 6.3 CONCLUSION

I developed a virtual SDM intervention to help older adults decide on the best choice for CRC screening and evaluated it in a randomized controlled trial,

comparing the intervention to a standard educational pamphlet. Results of the trial found that participants from both conditions had significant improvement in knowledge about colon cancer screening. However, participants in the intervention group showed significantly higher intentions to schedule and complete a screening test compared to those in the control condition.

With regards to the effects on decision qualities, there was a significant difference between study conditions on decisional conflict: participants interacting with the virtual decision coach reported significantly lower decisional conflict compared to those receiving the pamphlet. Participants in the intervention condition also reported a slightly higher satisfaction with their decisions compared to those in the control condition, although no statistical significance was achieved. I also found an interaction effect of study condition and participant numeracy levels on their preparation for decision making. Specifically, participants with high level of numeracy perceived the virtual decision coach to be more useful in preparing them for making a health decision than the educational pamphlet, while no difference was observed for participants with low level of numeracy. Although the measure of preparation for decision making was not included in the comparative evaluation study in which different VC/PE methods were compared, no interaction effect of study condition and participant numeracy levels (dichotomized using median) was observed on any of the outcome measures in that study. However, the interaction effect in the present study indicates a need to tailor the VC/PE methods used by the virtual

decision coach to people with low level of numeracy in order to help them better prepare for decision making.

With regards to the effects on decision making experience, there was a significant difference between study conditions on the likelihood to adhere to their decisions, with participants in the intervention group being significantly more likely to go with their preferred choice compared to those in the control. While participants from both groups received slightly more information than they wanted, they perceived low pressure on making the decision and were generally satisfied with their decision-making experience.

For the intervention participants, I also assessed their levels of involvement in the decision-making process and their attitudes towards the virtual decision coach who guided them through the SDM process. Overall, participants felt they were highly involved in the process of decision making, and they were very satisfied with the virtual decision coach. They also liked the coach, trusted the coach, and found the coach knowledgeable, and expressed a desire to make future decisions with the coach.

# 7 CONCLUSIONS

In this dissertation, I provide a theoretical framework to automate the provision of decision support using an ECA to help patients participate in SDM. I also compare different VC/PE approaches in a perfectly controlled setting by using an ECA and examine the usability as well as the effectiveness of each given VC/PE approach. In addition, I demonstrate that the ECA can perform the role of decision coach to facilitate SDM for various decision problems and have positive effects on decision quality and decision-making experience. Specifically, I answered four research questions as follows:

*RQ1. Will people accept an ECA in the role of decision coach to guide them through the SDM process?*

In a quasi-experimental study with 13 participants exploring the use of a virtual decision coach to support decision making for prenatal testing, I demonstrated that ECAs can effectively perform in the role of decision coach to facilitate the SDM process. Results of this study showed that there was a significant increase

in knowledge after interacting with the virtual coach, compared to before. Participants reported high levels of satisfaction with their decisions and low levels of decisional conflict and regret after interacting with the virtual coach. They also liked the coach, trusted the coach, and were satisfied with the decision-making process guided by and the decision they made with the virtual decision coach.

*RQ2. What is the best decision-making framework for a virtual decision coach to use to support SDM?*

*RQ3. Can a virtual decision coach be generalized to support SDM across different decision problems?*

To explore the usability as well as efficacy of different VC/PE approaches for SDM, I conducted a within-subject study with 20 participants comparing three available approaches (Card Sorting vs. SMARTER vs. AHP) used by a virtual decision coach for VC/PE in the process of SDM. Results of this study showed that participants preferred SMARTER and AHP over Card Sorting. While SMARTER led to better result transparency, AHP exhibited superiority over SMARTER as to how well participants felt the virtual coach accurately perceived their values. In addition, AHP led to higher levels of decision satisfaction and adherence to the chosen choice, compared to SMARTER.

As this study was conducted in three different task domains, which were prenatal testing, colon cancer screening and acne treatment respectively, it demonstrated that a virtual decision coach can be used to support different SDM

problems. Results of the study showed that all participants reported low levels of decisional conflict and high levels of satisfaction with their final decisions after interacting with the virtual coach. They were also very satisfied with their decision-making experience regardless of study conditions.

*RQ4. Is a virtual decision coach more effective than standard patient education materials for improving the decision-making process and decision quality?*

Based on the results of previous studies, I developed a full virtual SDM system to help older adults make shared decisions on colon cancer screening. This full system expanded the existing prototype to include a comprehensive education about colon cancer screening and different screening tests. It also used an improved AHP approach to address the VC/PE task of SDM, which covered a full list of evaluation criteria that are commonly used in decision making for colon cancer screening. It also included a section in which the virtual decision coach provided interpretation of the suggested choice and explain the trade-offs that were involved to get the best choice.

To fully evaluate the effectiveness of this virtual SDM system, I conducted a randomized controlled trial comparing this final system with a standard control condition. In a single counseling session, 26 older adults were randomly assigned to either interact with the virtual decision coach or read an educational pamphlet to learn about colon cancer screening and make a choice about which screening test they would prefer to use in the future. Results of the study showed that intervention participants had significantly greater intention to get screened

for colon cancer, compared to control participants. They also demonstrated lower levels of decisional conflict and higher levels of likelihood to adhere to their chosen options, compared to those in the control group. In addition, I observed a significant interaction effect of study condition and numeracy on preparation for decision making, with participants with high numeracy skills perceiving the virtual SDM system to be more useful in preparing them for decision making compared to the pamphlet.

### *Discussion*

Our approach to use a virtual decision coach to facilitate SDM is demonstrated to be well accepted and have positive impacts on decision qualities and the decision-making experience. The most significant result from the studies is that participants perceived the virtual decision coach as more effective than a standard educational pamphlet in terms of increasing participant screening intentions, decreasing decisional conflict, and leading to higher likelihood to adhere to the choice they made with the virtual coach. In addition, participants were highly involved in the decision-making process and highly satisfied working with the virtual coach.

These findings are consistent with the existing literature in SDM and ECAs and additionally they provide empirical evidence for the usability and efficacy of different existing VC/PE approaches, which has not been much explored in practical settings. I implemented alternative VC/PE approaches in the embodied conversational agent platform, which was perfectly controlled.

While human coaches may follow a protocol to deliver a specified approach, the ECA can do so with perfect fidelity. By using an ECA, I was also able to deliver each of the VC/PE approaches randomly to isolate the influence of VC/PE approaches from the characteristics of the agent. This would be exceedingly difficult to do with human coaches.

Furthermore, I provided a simulation of human decision coaching using an ECA with demonstrated evidence about the efficacy of an ECA-based decision coach across different decision problems. This extends the existing forms of decision support, which includes PtDAs and human decision coaching. In addition to providing standardized information as most currently available PtDAs do, the automated decision coach incorporated theory-based exercise and tools to clarify personal values and integrate these values with medical information to arrive at a best choice. It also includes components to build alliance with its users and address their emotional states throughout the decision-making process.

#### *Future Work*

While the use of the AHP approach to support VC/PE provided a certain degree of personalization by allowing the user to specify the subtle difference in importance they assigned to each evaluative criterion, the current VC/PE exercise did not support changes in the evaluative criteria to be included in the exercise and the subsequent analysis. The existing exercise was designed based on a fixed list of criteria that were commonly used in decision making for colon

cancer screening. However, some of these criteria might not be as important to certain users as to the others. Also, there might be other factors that the user wants to take into account under certain circumstances. So, the system could be improved in the future by allowing the user to choose from the existing list the criteria they want to include in the exercise or add new criteria that are important to their decision making.

The results of the final evaluation study indicate that the use of virtual decision coach with AHP-based VC/PE method is more effective than the standard pamphlet among people with high level of numeracy to prepare them for decision making. However, it remains unclear what works best for people with inadequate numeracy skills, especially in terms of clarifying their values and eliciting their preferences. Future research can be conducted to explore the particular needs of people with limited health numeracy on the aspect of VC/PE and find out what adjustments are needed for the virtual decision coach to better address these needs in order to facilitate their decision making.

Adapting the virtual decision coach to assist patients with longitudinal sequential decision-making – in which they need to make a sequence of decisions over time [156] – represents another important direction of future research. Ultimately, a randomized clinical trial with longitudinal measures of long-term decision satisfaction, decisional regret and decisional conflict are needed to more thoroughly evaluate the approach.

Furthermore, the studies presented in this dissertation demonstrated the effectiveness of the virtual decision coach to facilitate SDM compared to a standard educational pamphlet. However, it remains unknown how effective this approach is compared to other existing forms of decision support. Future research should be conducted to compare the virtual decision coach with a computerized patient decision aid as well as a human decision coach to further examine its comparative effectiveness.

## REFERENCE

1. Emanuel, E.J. and L.L. Emanuel, *Four models of the physician-patient relationship*. *Jama*, 1992. **267**(16): p. 2221-2226.
2. Collins, E.D., et al., *Can women with early-stage breast cancer make an informed decision for mastectomy*. *J Clin Oncol*, 2009. **27**(4): p. 519-525.
3. Berman, A., *Living life in my own way – and dying that way as well*. *Health Affairs*, 2012. **31**(4): p. 871-874.
4. Steinberg, E., et al., *Clinical practice guidelines we can trust*. 2011: National Academies Press.
5. Hawker, G.A., et al., *Determining the need for hip and knee arthroplasty: the role of clinical severity and patients' preferences*. *Medical care*, 2001: p. 206-216.
6. Baker, A., *Crossing the quality chasm: a new health system for the 21st century*. *BMJ: British Medical Journal*, 2001. **323**(7322): p. 1192.
7. Chewning, B., et al., *Patient preferences for shared decisions: a systematic review*. *Patient education and counseling*, 2012. **86**(1): p. 9-18.
8. Clancy, C.M., *How patient-centered healthcare can improve quality*. *Patient Safety & Quality Healthcare*, 2008. **5**(2): p. 6-7.
9. Tattersall, R., *The expert patient: a new approach to chronic disease management for the twenty-first century*. *Clinical Medicine*, 2002. **2**(3): p. 227-229.
10. Hibbard, J.H. and J. Greene, *What the evidence shows about patient activation: better health outcomes and care experiences; fewer data on costs*. *Health affairs*, 2013. **32**(2): p. 207-214.
11. Lantz, P.M., et al., *Satisfaction with surgery outcomes and the decision process in a population-based sample of women with breast cancer*. *Health services research*, 2005. **40**(3): p. 745-768.

12. Rockville, M., et al., *Guide to Patient and Family Engagement: Environmental Scan Report*. 2012, Rockville, MD, Agency for Healthcare Research and Quality.
13. Elwyn, G., et al., *Implementing shared decision making in the NHS*. 2010.
14. Elwyn, G., et al., *Shared decision making: a model for clinical practice*. *Journal of general internal medicine*, 2012. **27**(10): p. 1361-1367.
15. Schneider, C., *The practice of autonomy: patients, doctors, and medical decisions*. 1998: Oxford University Press on Demand.
16. Stiggelbout, A.M., et al., *Shared decision making: really putting patients at the centre of healthcare*. *British Medical Journal (BMJ)*, 2012. **344**: p. e256.
17. Wennberg, J.E., E.S. Fisher, and J.S. Skinner, *Geography and the debate over medicare reform*. *Health Affairs*, 2003: p. W96.
18. Charles, C., A. Gafni, and T. Whelan, *Shared decision-making in the medical encounter: what does it mean?(or it takes at least two to tango)*. *Social science & medicine*, 1997. **44**(5): p. 681-692.
19. Makoul, G. and M.L. Clayman, *An integrative model of shared decision making in medical encounters*. *Patient education and counseling*, 2006. **60**(3): p. 301-312.
20. Barry, M.J. and S. Edgman-Levitan, *Shared decision making – the pinnacle of patient-centered care*. *New England Journal of Medicine*, 2012. **366**(9): p. 780-781.
21. *NHS Patient Surveys 2017*.
22. Légaré, F., et al., *Barriers and facilitators to implementing shared decision-making in clinical practice: update of a systematic review of health professionals' perceptions*. *Patient education and counseling*, 2008. **73**(3): p. 526-535.
23. Frosch, D.L., et al., *Authoritarian physicians and patients' fear of being labeled 'difficult' among key obstacles to shared decision making*. *Health Affairs*, 2012. **31**(5): p. 1030-1038.

24. Adams, J.R., et al., *Communicating with physicians about medical decisions: a reluctance to disagree*. Archives of internal medicine, 2012. **172**(15): p. 1184-1186.
25. Landi, S. and L. Hernandez, *Promoting health literacy to encourage prevention and wellness: Workshop summary*. 2011: National Academies Press.
26. Peters, E., et al., *Numeracy skill and the communication, comprehension, and use of risk-benefit information*. Health Affairs, 2007. **26**(3): p. 741-748.
27. Berkman, N.D., et al., *Health literacy interventions and outcomes: an updated systematic review*. Evid Rep Technol Assess (Full Rep), 2011. **199**(1): p. 941.
28. O'Connor, A., et al., *Decision aids for people facing health treatment or screening decisions (Cochrane Review)*. The Cochrane Library, 2003. **2**.
29. O'Connor, A.M., et al., *Decision aids for people facing health treatment or screening decisions*. Cochrane database of systematic reviews, 2009(3).
30. Stacey, D., et al., *Decision aids for people facing health treatment or screening decisions*. Cochrane Database Syst Rev, 2011. **10**(10).
31. Stacey, D., et al., *Decision aids for people facing health treatment or screening decisions*. The Cochrane Library, 2014.
32. Stacey, D., et al., *Decision aids for people facing health treatment or screening decisions*. Cochrane database of systematic reviews, 2017(4).
33. Stacey, D., et al., *Decision coaching to prepare patients for making health decisions: a systematic review of decision coaching in trials of patient decision AIDS*. Medical Decision Making, 2012. **32**(3): p. E22-E33.
34. Kopecky, K.E., D. Urbach, and M.L. Schwarze, *Risk Calculators and Decision Aids Are Not Enough for Shared Decision Making*. JAMA Surgery.
35. Stacey, D., et al., *Decision coaching to support shared decision making: a framework, evidence, and implications for nursing practice, education, and policy*. Worldviews on Evidence-Based Nursing, 2008. **5**(1): p. 25-35.

36. O'Connor, A.M., D. Stacey, and F. Légaré, *Coaching to support patients in making decisions*. 2008, British Medical Journal Publishing Group.
37. Cassell, J., et al., *Embodied conversational agents*. 2000: MIT press.
38. Bickmore, T.W., L.M. Pfeifer, and B.W. Jack. *Taking the time to care: empowering low health literacy hospital patients with virtual nurse agents*. in *Proceedings of the SIGCHI conference on human factors in computing systems*. 2009. ACM.
39. Bickmore, T.W., L.M. Pfeifer, and M.K. Paasche-Orlow. *Health document explanation by virtual agents*. in *International Workshop on Intelligent Virtual Agents*. 2007. Springer.
40. Bickmore, T., L. Pfeifer, and L. Yin, *The role of gesture in document explanation by embodied conversational agents*. *International Journal of Semantic Computing*, 2008. **2**(01): p. 47-70.
41. Bickmore, T.W., et al., *Usability of conversational agents by patients with inadequate health literacy: evidence from two clinical trials*. *Journal of health communication*, 2010. **15**(S2): p. 197-210.
42. Bickmore, T.W., L.M. Pfeifer, and M.K. Paasche-Orlow, *Using computer agents to explain medical documents to patients with low health literacy*. *Patient education and counseling*, 2009. **75**(3): p. 315-320.
43. Davis, T.C., et al., *Rapid estimate of adult literacy in medicine: a shortened screening instrument*. *Family medicine*, 1993. **25**(6): p. 391-395.
44. Charles, C., A. Gafni, and T. Whelan, *Decision-making in the physician-patient encounter: revisiting the shared treatment decision-making model*. *Social science & medicine*, 1999. **49**(5): p. 651-661.
45. Evidence, C. *How much do we know?* 2013 [cited 2018 July 21]; Available from: [clinicalevidence.bmj.com/x/set/static/cms/efficacy-categorisations.html](http://clinicalevidence.bmj.com/x/set/static/cms/efficacy-categorisations.html).
46. Fisher, B., et al., *Twenty-year follow-up of a randomized trial comparing total mastectomy, lumpectomy, and lumpectomy plus irradiation for the treatment of invasive breast cancer*. *New England Journal of Medicine*, 2002. **347**(16): p. 1233-1241.

47. Busari, J.O., *The discourse of generational segmentation and the implications for postgraduate medical education*. Perspectives on medical education, 2013. **2**(5-6): p. 340-348.
48. Godolphin, W., A. Towle, and R. McKendry, *Challenges in family practice related to informed and shared decision-making: a survey of preceptors of medical students*. Canadian Medical Association Journal, 2001. **165**(4): p. 434-435.
49. Guimond, P., et al., *Validation of a tool to assess health practitioners' decision support and communication skills*. Patient education and counseling, 2003. **50**(3): p. 235-245.
50. Murray, M.A., V. Fiset, and B. O'connor, *Learning needs of nurses at a residential hospice*. Journal of Hospice & Palliative Nursing, 2004. **6**(2): p. 108-116.
51. Stacey, D., et al., *Barriers and facilitators influencing call center nurses' decision support for callers facing values-sensitive decisions: a mixed methods study*. Worldviews on Evidence-Based Nursing, 2005. **2**(4): p. 184-195.
52. Légaré, F., et al., *Primary health care professionals' views on barriers and facilitators to the implementation of the Ottawa Decision Support Framework in practice*. Patient education and counseling, 2006. **63**(3): p. 380-390.
53. Bruera, E., et al., *Patient preferences versus physician perceptions of treatment decisions in cancer care*. Journal of clinical oncology, 2001. **19**(11): p. 2883-2885.
54. Say, R., M. Murtagh, and R. Thomson, *Patients' preference for involvement in medical decision making: a narrative review*. Patient education and counseling, 2006. **60**(2): p. 102-114.
55. Coulter, A., *Patient information and shared decision-making in cancer care*. 2003, Nature Publishing Group.
56. Coulter, A., *When should you involve patients in treatment decisions?* 2007, British Journal of General Practice.
57. Olthuis, G., C. Leget, and M. Grypdonck, *Why shared decision making is not good enough: lessons from patients*. Journal of medical ethics, 2014. **40**(7): p. 493-495.

58. Kindig, D.A., A.M. Panzer, and L. Nielsen-Bohlman, *Health literacy: a prescription to end confusion*. 2004: National Academies Press.
59. Epstein, R. and R.L. Street, *Patient-centered communication in cancer care: promoting healing and reducing suffering*. 2007: National Cancer Institute, US Department of Health and Human Services, National Institutes of Health Bethesda, MD.
60. Bekker, H., et al., *Informed decision making: an annotated bibliography and systematic review*. Health Technol Assess, 1999. **3**(1): p. 1-156.
61. Neumann, J. and O. Morgenstern, *Theory of games and economic behaviour*. 1944, Princeton University Press Princeton.
62. Karni, E., *Savage's subjective expected utility model*, in *The New Palgrave Dictionary of Economics*. 2008, Springer. p. 1-5.
63. Simon, H.A., *Theories of bounded rationality*. Decision and organization, 1972. **1**(1): p. 161-176.
64. Simon, H.A., *Bounded rationality and organizational learning*. Organization science, 1991. **2**(1): p. 125-134.
65. Simon, H.A., *Rational choice and the structure of the environment*. Psychological review, 1956. **63**(2): p. 129.
66. Barnard, C. and H.A. Simon, *Administrative behavior. A study of decision-making processes in administrative organization*. New York: Free Press, 1947.
67. Kahneman, D. and A. Tversky, *Prospect theory: An analysis of decision under risk*, in *Handbook of the fundamentals of financial decision making: Part I*. 2013, World Scientific. p. 99-127.
68. Tversky, A. and D. Kahneman, *The framing of decisions and the psychology of choice*. science, 1981. **211**(4481): p. 453-458.
69. Kahneman, D., *A perspective on judgment and choice: mapping bounded rationality*. American psychologist, 2003. **58**(9): p. 697.

70. Loomes, G. and R. Sugden, *Regret theory: An alternative theory of rational choice under uncertainty*. The economic journal, 1982. **92**(368): p. 805-824.
71. Janis, I.L. and L. Mann, *Decision making: A psychological analysis of conflict, choice, and commitment*. 1977: free press.
72. Belton, V. and T. Stewart, *Multiple criteria decision analysis: an integrated approach*. 2002: Springer Science & Business Media.
73. Marsh, K., et al., *Assessing the value of healthcare interventions using multi-criteria decision analysis: a review of the literature*. Pharmacoeconomics, 2014. **32**(4): p. 345-365.
74. Dolan, J.G., *Multi-Criteria clinical decision support*. The Patient: Patient-Centered Outcomes Research, 2010. **3**(4): p. 229-248.
75. Keeney, R.L. and H. Raiffa, *Decisions with multiple objectives: preferences and value trade-offs*. 1993: Cambridge university press.
76. Saaty, T.L., *The analytic hierarchy process: planning, priority setting, resource allocation*. 1980: McGraw-Hill International Book Company.
77. Saaty, T.L., *How to make a decision: the analytic hierarchy process*. European journal of operational research, 1990. **48**(1): p. 9-26.
78. Saaty, T.L., *Decision making with the analytic hierarchy process*. International journal of services sciences, 2008. **1**(1): p. 83-98.
79. Sepucha, K.R., F. Fowler, and A. Mulley, *Policy support for patient-centered care: the need for measurable improvements in decision quality*. HEALTH AFFAIRS-MILLWOOD VA THEN BETHESDA MA-, 2004. **23**: p. VAR-54.
80. Barry, M.J., *Involving patients in medical decisions: how can physicians do better?* Jama, 1999. **282**(24): p. 2356-2357.
81. Sepucha, K.R., et al., *Establishing the effectiveness of patient decision aids: key constructs and measurement instruments*. BMC medical informatics and decision making, 2013. **13**(2): p. S12.

82. Sepucha, K.R. and I. Scholl, *Measuring shared decision making: a review of constructs, measures, and opportunities for cardiovascular care*. *Circulation: Cardiovascular Quality and Outcomes*, 2014. **7**(4): p. 620-626.
83. Degner, L.F., J.A. Sloan, and P. Venkatesh, *The control preferences scale*. *Canadian Journal of Nursing Research Archive*, 1997. **29**(3).
84. Peters, E., *Beyond comprehension: The role of numeracy in judgments and decisions*. *Current Directions in Psychological Science*, 2012. **21**(1): p. 31-35.
85. Lipkus, I.M., G. Samsa, and B.K. Rimer, *General performance on a numeracy scale among highly educated samples*. *Medical decision making*, 2001. **21**(1): p. 37-44.
86. Kriston, L., et al., *The 9-item Shared Decision Making Questionnaire (SDM-Q-9). Development and psychometric properties in a primary care sample*. *Patient education and counseling*, 2010. **80**(1): p. 94-99.
87. Ballesteros, J., et al., *Psychometric properties of the SDM-Q-9 questionnaire for shared decision-making in multiple sclerosis: item response theory modelling and confirmatory factor analysis*. *Health and quality of life outcomes*, 2017. **15**(1): p. 79.
88. O'Connor, A.M., *Validation of a decisional conflict scale*. *Medical decision making*, 1995. **15**(1): p. 25-30.
89. Sepucha, K., et al., *2012 UPDATED CHAPTER L: ESTABLISHING THE EFFECTIVENESS*.
90. Kryworuchko, J., et al., *Appraisal of primary outcome measures used in trials of patient decision support*. *Patient education and counseling*, 2008. **73**(3): p. 497-503.
91. Holmes-Rovner, M., et al., *Patient satisfaction with health care decisions: the satisfaction with decision scale*. *Medical Decision Making*, 1996. **16**(1): p. 58-64.
92. O'Connor, A., *User Manual – Decision Regret Scale*. *Ottawa Hospital Research Institute Patient Decision Aids Website*. 2013.

93. O Connor, A.M., H.A. Llewellyn-Thomas, and A.B. Flood, *Modifying unwarranted variations in health care: shared decision making using patient decision aids*. HEALTH AFFAIRS-MILLWOOD VA THEN BETHESDA MA-, 2004. **23**: p. VAR-63.
94. Hargraves, I., et al., *Shared decision making: the need for patient-clinician conversation, not just information*. Health affairs, 2016. **35**(4): p. 627-629.
95. Durand, M.-A., et al., *Where is the theory? Evaluating the theoretical frameworks described in decision support technologies*. Patient education and counseling, 2008. **71**(1): p. 125-135.
96. Deschamps, M.A., et al., *Impact of pharmacist consultation versus a decision aid on decision making regarding hormone replacement therapy*. International Journal of Pharmacy Practice, 2004. **12**(1): p. 21-28.
97. Myers, R.E., *Decision counseling in cancer prevention and control*. Health Psychology, 2005. **24**(4S): p. S71.
98. Hunter, A., et al., *A randomized trial comparing alternative approaches to prenatal diagnosis counseling in advanced maternal age patients*. Clinical genetics, 2005. **67**(4): p. 303-313.
99. Kennedy, A.D., et al., *Effects of decision aids for menorrhagia on treatment choices, health outcomes, and costs: a randomized controlled trial*. Jama, 2002. **288**(21): p. 2701-2708.
100. Sepucha, K.R., et al., *Building bridges between physicians and patients: results of a pilot study examining new tools for collaborative decision making in breast cancer*. Journal of Clinical Oncology, 2000. **18**(6): p. 1230-1238.
101. Belkora, J., et al., *Evaluation of a visit preparation intervention implemented in two rural, underserved counties of Northern California*. Patient education and counseling, 2006. **64**(1-3): p. 350-359.
102. Belkora, J., et al., *Training community resource center and clinic personnel to prompt patients in listing questions for doctors: follow-up interviews about barriers and facilitators to the implementation of consultation planning*. Implementation Science, 2008. **3**(1): p. 6.

103. Woolf, S.H., et al., *Promoting informed choice: transforming health care to dispense knowledge for decision making*. *Annals of internal medicine*, 2005. **143**(4): p. 293-300.
104. Gravel, K., F. Légaré, and I.D. Graham, *Barriers and facilitators to implementing shared decision-making in clinical practice: a systematic review of health professionals' perceptions*. *Implementation Science*, 2006. **1**(1): p. 16.
105. Hochlehnert, A., et al., *A computer-based information-tool for chronic pain patients: Computerized information to support the process of shared decision-making*. *Patient education and counseling*, 2006. **61**(1): p. 92-98.
106. Schroy III, P.C., et al., *The impact of a novel computer-based decision aid on shared decision making for colorectal cancer screening: a randomized trial*. *Medical Decision Making*, 2011. **31**(1): p. 93-107.
107. Mathieu, E., et al., *Helping women make choices about mammography screening: an online randomized trial of a decision aid for 40-year-old women*. *Patient education and counseling*, 2010. **81**(1): p. 63-72.
108. Elwyn, G., et al., *Option Grids: shared decision making made easier*. *Patient education and counseling*, 2013. **90**(2): p. 207-212.
109. Elwyn, G., et al., *Supporting shared decision making using an Option Grid for osteoarthritis of the knee in an interface musculoskeletal clinic: A stepped wedge trial*. *Patient education and counseling*, 2016. **99**(4): p. 571-577.
110. Fay, M., et al., *Using Option Grids: steps toward shared decision-making for neonatal circumcision*. *Patient education and counseling*, 2016. **99**(2): p. 236-242.
111. Marrin, K., et al., *Option Grids to facilitate shared decision making for patients with Osteoarthritis of the knee: protocol for a single site, efficacy trial*. *BMC health services research*, 2014. **14**(1): p. 160.
112. Tsulukidze, M., S.W. Grande, and M.R. Gionfriddo, *Assessing Option Grid® practicability and feasibility for facilitating shared decision making: An exploratory study*. *Patient education and counseling*, 2015. **98**(7): p. 871-877.

113. Rostom, A., et al., *A randomized trial of a computerized versus an audio-booklet decision aid for women considering post-menopausal hormone replacement therapy*. Patient Education and Counseling, 2002. **46**(1): p. 67-74.
114. Ozanne, E.M., et al., *Pilot trial of a computerized decision aid for breast cancer prevention*. The breast journal, 2007. **13**(2): p. 147-154.
115. Beulen, L., et al., *The effect of a decision aid on informed decision-making in the era of non-invasive prenatal testing: a randomised controlled trial*. European Journal of Human Genetics, 2016. **24**(10): p. 1409.
116. Levi, B.H., S.R. Heverley, and M.J. Green, *Accuracy of a decision aid for advance care planning: simulated end-of-life decision making*. The Journal of clinical ethics, 2011. **22**(3): p. 223.
117. Ruffin IV, M.T., M.D. Fetters, and M. Jimbo, *Preference-based electronic decision aid to promote colorectal cancer screening: results of a randomized controlled trial*. Preventive medicine, 2007. **45**(4): p. 267-273.
118. Allen, J.D., et al., *A randomized trial of a computer-tailored decision aid to improve prostate cancer screening decisions: results from the take the wheel trial*. Cancer Epidemiology and Prevention Biomarkers, 2010: p. 1055-9965. EPI-09-0410.
119. Ward, W., et al., *My science tutor: A conversational multimedia virtual tutor for elementary school science*. ACM Transactions on Speech and Language Processing (TSLP), 2011. **7**(4): p. 18.
120. Wang, F., et al., *Animated pedagogical agents as aids in multimedia learning: Effects on eye-fixations during learning and learning outcomes*. Journal of Educational Psychology, 2018. **110**(2): p. 250.
121. Johnson, W.L. and J.C. Lester, *Face-to-face interaction with pedagogical agents, twenty years later*. International Journal of Artificial Intelligence in Education, 2016. **26**(1): p. 25-36.
122. Villarica, R. and D. Richards. *Intelligent and empathic agent to support student learning in virtual worlds*. in *Proceedings of the 2014 Conference on Interactive Entertainment*. 2014. ACM.

123. Gebhard, P., et al. *Exploring interaction strategies for virtual characters to induce stress in simulated job interviews*. in *Proceedings of the 2014 international conference on Autonomous agents and multi-agent systems*. 2014. International Foundation for Autonomous Agents and Multiagent Systems.
124. Gebhard, P., et al., *Serious Games for Training Social Skills in Job Interviews*. *IEEE Transactions on Games*, 2018.
125. Anderson, K., et al., *The TARDIS framework: intelligent virtual agents for social coaching in job interviews*, in *Advances in computer entertainment*. 2013, Springer. p. 476-491.
126. Trinh, H., L. Ring, and T. Bickmore. *Dynamicduo: co-presenting with virtual agents*. in *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. 2015. ACM.
127. Bickmore, T.W., et al. *Public displays of affect: deploying relational agents in public spaces*. in *CHI'08 Extended Abstracts on Human Factors in Computing Systems*. 2008. ACM.
128. Kopp, S., et al. *A conversational agent as museum guide—design and evaluation of a real-world application*. in *Intelligent virtual agents*. 2005. Springer.
129. Fourati, N., et al. *Facial expressions of appraisals displayed by a virtual storyteller for children*. in *International Conference on Intelligent Virtual Agents*. 2016. Springer.
130. Bae, B.-C., et al. *Towards an empathizing and adaptive storyteller system*. in *Eighth Artificial Intelligence and Interactive Digital Entertainment Conference*. 2012.
131. Vardoulakis, L.P., et al. *Designing relational agents as long term social companions for older adults*. in *International Conference on Intelligent Virtual Agents*. 2012. Springer.
132. Yaghoubzadeh, R., et al. *Virtual agents as daily assistants for elderly or cognitively impaired people*. in *International Workshop on Intelligent Virtual Agents*. 2013. Springer.

133. Bickmore, T.W., et al., *A randomized controlled trial of an automated exercise coach for older adults*. *Journal of the American Geriatrics Society*, 2013. **61**(10): p. 1676-1683.
134. Shamekhi, A., et al. *Augmenting group medical visits with conversational agents for stress management behavior change*. in *International Conference on Persuasive Technology*. 2017. Springer.
135. McDonald, D.D., T. Gifford, and S. Walsh, *Effect of a virtual pain coach on older adults' pain communication: a pilot study*. *Pain Management Nursing*, 2011. **12**(1): p. 50-56.
136. Hudlicka, E., *Virtual training and coaching of health behavior: Example from mindfulness meditation training*. *Patient education and counseling*, 2013. **92**(2): p. 160-166.
137. Monkaresi, H., et al. *Intelligent diabetes lifestyle coach*. in *OzCHI workshops programme*. 2013.
138. Rizzo, A., et al., *SimCoach: an intelligent virtual human system for providing healthcare information and support*. *International Journal on Disability and Human Development*, 2011. **10**(4): p. 277-281.
139. Meeker, D., et al., *SimCoach evaluation: a virtual human intervention to encourage service-member help-seeking for posttraumatic stress disorder and depression*. *Rand health quarterly*, 2016. **5**(3).
140. DeVault, D., et al. *SimSensei Kiosk: A virtual human interviewer for healthcare decision support*. in *Proceedings of the 2014 international conference on Autonomous agents and multi-agent systems*. 2014. International Foundation for Autonomous Agents and Multiagent Systems.
141. Rizzo, A., et al., *Clinical interviewing by a virtual human agent with automatic behavior analysis*. *The 2016 Proceedings of the ICDVRAT*, 2016.
142. Robertson, S., et al., *The visual design and implementation of an embodied conversational agent in a shared decision-making context (eCoach)*, in *Learning and Collaboration Technologies*. 2015, Springer. p. 427-437.
143. Edwards, A. and G. Elwyn, *Shared decision-making in health care: Achieving evidence-based patient choice*. 2009: Oxford University Press.

144. Llewellyn-Thomas, H.A. and R.T. Crump, *Decision support for patients: values clarification and preference elicitation*. Medical care research and review, 2013. **70**(1\_suppl): p. 50S-79S.
145. Cassell, J., H.H. Vilhjálmsón, and T. Bickmore. *Beat: the behavior expression animation toolkit*. in *Proceedings of the 28th annual conference on Computer graphics and interactive techniques*. 2001. ACM.
146. Zhang, Z. and T. Bickmore. *Medical Shared Decision Making with a Virtual Agent*. in *Proceedings of the 18th International Conference on Intelligent Virtual Agents*. 2018. ACM.
147. Frieswyk, S.H., et al., *Therapeutic alliance: Its place as a process and outcome variable in dynamic psychotherapy research*. Journal of Consulting and Clinical Psychology, 1986. **54**(1): p. 32.
148. Wallston, K.A., B. Strudler Wallston, and R. DeVellis, *Development of the multidimensional health locus of control (MHLC) scales*. Health education monographs, 1978. **6**(1): p. 160-170.
149. Schoonen, H., et al., *Informed decision-making in prenatal screening for Down's syndrome: what knowledge is relevant?* Patient Education and Counseling, 2011. **84**(2): p. 265-270.
150. Schoonen, M., et al., *The provision of information and informed decision-making on prenatal screening for Down syndrome: a questionnaire-and register-based survey in a non-selected population*. Patient education and counseling, 2012. **87**(3): p. 351-359.
151. Cacioppo, J.T. and R.E. Petty, *The need for cognition*. Journal of personality and social psychology, 1982. **42**(1): p. 116.
152. Pignone, M., et al., *Cost-effectiveness analyses of colorectal cancer screening: a systematic review for the US Preventive Services Task Force*. Annals of internal medicine, 2002. **137**(2): p. 96-104.
153. Force, U.P.S.T., *Screening for colorectal cancer: US Preventive Services Task Force recommendation statement*. Annals of internal medicine, 2008. **149**(9): p. 627.

154. Levin, B., et al., *Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology*. *CA: a cancer journal for clinicians*, 2008. **58**(3): p. 130-160.
155. Bennett, C., et al., *Validation of a preparation for decision making scale*. *Patient education and counseling*, 2010. **78**(1): p. 130-133.
156. Scherrer, A., et al., *Breast cancer therapy planning—a novel support concept for a sequential decision making problem*. *Health care management science*, 2015. **18**(3): p. 389-405.

# APPENDIX A: BASELINE QUESTIONNAIRE (STUDY I, II, III)

Please take a moment and answer a few questions about yourself:

**Date of Birth:** \_\_\_\_\_

**Sex:** M / F

**Ethnic Background (check one):**

- American Indian or Alaskan Native \_\_\_\_\_
- Asian or Pacific Islander \_\_\_\_\_
- Black, Not of Hispanic Origin \_\_\_\_\_
- White, Not of Hispanic Origin \_\_\_\_\_
- Hispanic \_\_\_\_\_

**Marital Status (check one):**

- Single \_\_\_\_\_
- Married \_\_\_\_\_
- Divorced/Widowed \_\_\_\_\_

**Last grade of school completed (check one):**

- Less than high school (0-8) \_\_\_\_\_
- Some high school \_\_\_\_\_
- High school graduate or GED \_\_\_\_\_
- Technical school education \_\_\_\_\_
- Some college \_\_\_\_\_
- College graduate \_\_\_\_\_
- Advanced degree \_\_\_\_\_

**Occupation:** \_\_\_\_\_

**How much experience do you have with computers (check one)?**

- I've never used one. \_\_\_\_\_
- I've tried one a few times. \_\_\_\_\_
- I use one regularly. \_\_\_\_\_
- I'm an expert. \_\_\_\_\_

**How do you feel about using computers (check one)?**

- I don't like them. \_\_\_\_\_
- They're OK. \_\_\_\_\_
- They can be useful. \_\_\_\_\_
- I love playing with them. \_\_\_\_\_

**How comfortable are you using a computer mouse (check one)?**

- Not comfortable \_\_\_\_\_
- Somewhat comfortable \_\_\_\_\_
- Very comfortable \_\_\_\_\_

**What would you rather use to enter information into a computer (check one)?**

- A keyboard and mouse \_\_\_\_\_
- A touch screen \_\_\_\_\_

**How would you prefer written information be given to you by a computer (check one)?**

- As written text \_\_\_\_\_
- Spoken \_\_\_\_\_

## APPENDIX B: NEED FOR COGNITION SCALE (STUDY II, III)

For each of the statements below, please indicate to what extent the statement describes you by putting an X on the dot.

**I would prefer complex to simple problems.**

extremely uncharacteristic     •     •     •     •     •     •     •     extremely characteristic

**I like to have the responsibility of handling a situation that requires a lot of thinking.**

extremely uncharacteristic     •     •     •     •     •     •     •     extremely characteristic

**Thinking is not my idea of fun.**

extremely uncharacteristic     •     •     •     •     •     •     •     extremely characteristic

**I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.**

extremely uncharacteristic     •     •     •     •     •     •     •     extremely characteristic

**I try to anticipate and avoid situations where there is a likely chance I will have to think in depth about something.**

extremely uncharacteristic     •     •     •     •     •     •     •     extremely characteristic

**I find satisfaction in deliberating hard and for long hours.**

extremely     •     •     •     •     •     •     •     extremely

uncharacteristic

characteristic

**I only think as hard as I have to.**

extremely  
uncharacteristic

• • • • • • •

extremely  
characteristic

**I prefer to think about small, daily projects than long-term ones.**

extremely  
uncharacteristic

• • • • • • •

extremely  
characteristic

**I like tasks that require little thought once I've learned them.**

extremely  
uncharacteristic

• • • • • • •

extremely  
characteristic

**The idea of relying on thought to make my way to the top appeals to me.**

extremely  
uncharacteristic

• • • • • • •

extremely  
characteristic

**I really enjoy a task that involves coming up with new solutions to problems.**

extremely  
uncharacteristic

• • • • • • •

extremely  
characteristic

**Learning new ways to think doesn't excite me very much.**

extremely  
uncharacteristic

• • • • • • •

extremely  
characteristic

**I prefer my life to be filled with puzzles that I must solve.**

extremely  
uncharacteristic

• • • • • • •

extremely  
characteristic

**The notion of thinking abstractly is appealing to me.**

extremely uncharacteristic • • • • • • • extremely characteristic

**I would prefer a task that is intellectual, difficult and important to one that is somewhat important but doesn't require much thought.**

extremely uncharacteristic • • • • • • • extremely characteristic

**I feel relief rather than satisfaction after completing a task that required a lot of mental effort.**

extremely uncharacteristic • • • • • • • extremely characteristic

**It's enough for me that something gets the job done; I don't care how or why it works.**

extremely uncharacteristic • • • • • • • extremely characteristic

**I usually end up deliberating about issues even when they do not affect me personally.**

extremely uncharacteristic • • • • • • • extremely characteristic

## APPENDIX C: HEALTH LOCUS OF CONTROL SCALE (STUDY I)

For each of the statements below, please indicate to what extent you agree or disagree with the statement by circling one of the numbers. Please use the following scale:

1 = strongly disagree      4 = slightly agree  
2 = moderately disagree    5 = moderately agree  
3 = slightly disagree      6 = strongly agree

**1. If I get sick, it is my own behavior which determines how soon I get well again.**

1                                  2                                  3                                  4                                  5                                  6

**2. No matter what I do, if I am going to get sick, I will get sick.**

1                                  2                                  3                                  4                                  5                                  6

**3. Having regular contact with my physician is the best way for me to avoid illness.**

1                                  2                                  3                                  4                                  5                                  6

**4. Most things that affect my health happen to me by accident.**

1                                  2                                  3                                  4                                  5                                  6

**5. Whenever I don't feel well, I should consult a medically trained professional.**

1                                  2                                  3                                  4                                  5                                  6

**6. I am in control of my health.**

1                                  2                                  3                                  4                                  5                                  6

**7. My family has a lot to do with my becoming sick or staying healthy.**

1                      2                      3                      4                      5                      6

**8. When I get sick, I am to blame.**

1                      2                      3                      4                      5                      6

**9. Luck plays a big part in determining how soon I will recover from an illness.**

1                      2                      3                      4                      5                      6

**10. Health professionals control my health.**

1                      2                      3                      4                      5                      6

**11. My good health is largely a matter of good fortune.**

1                      2                      3                      4                      5                      6

**12. The main thing which affects my health is what I myself do.**

1                      2                      3                      4                      5                      6

**13. If I take care of myself, I can avoid illness.**

1                      2                      3                      4                      5                      6

**14. Whenever I recover from an illness, it's usually because other people (for example, doctors, nurses, family, friends) have been taking good care of me.**

1                      2                      3                      4                      5                      6

**15. No matter what I do, I 'm likely to get sick.**

1                      2                      3                      4                      5                      6

**16. If it's meant to be, I will stay healthy.**

1                      2                      3                      4                      5                      6

**17. If I take the right actions, I can stay healthy.**

1                      2                      3                      4                      5                      6

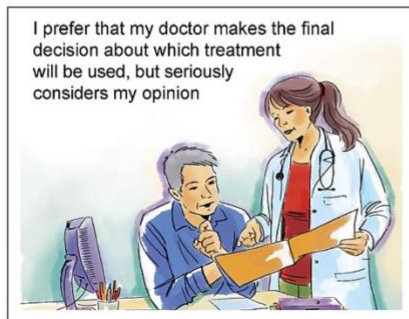
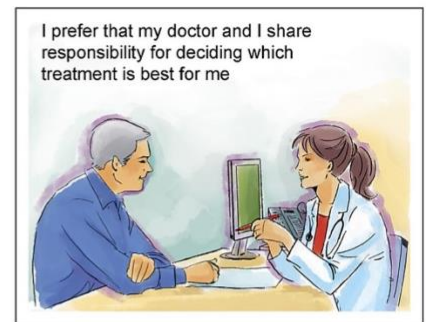
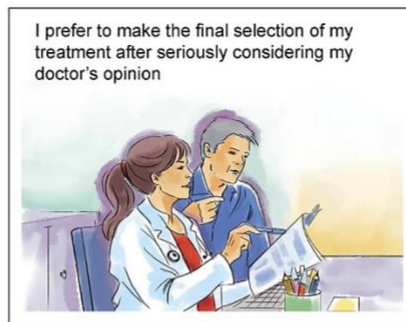
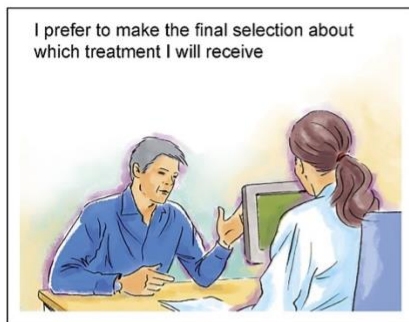
**18. Regarding my health, I can only do what my doctor tells me to do.**

1                      2                      3                      4                      5                      6

## APPENDIX D: CONTROL PREFERENCE SCALE (STUDY I, II, III)

The following charts describe five hypothetical scenarios of a consultation with your doctor where a decision about (any) treatment must be made.

Please pick the one you **like the MOST**.



## APPENDIX E: NUMERACY SCALE (STUDY I, II, III)

Please answer the following questions:

- 0. Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?**
  
- 1. Imagine that we rolled a fair, six-sided die 1,000 times. Out of 1,000 rolls, how many times do you think the die would come up even (2, 4, or 6)?**
  
- 2. In the BIG BUCKS LOTTERY, the chances of winning a \$10.00 prize is 1%. What is your best guess about how many people would win a \$10.00 prize if 1,000 people each buy a single tick to BIG BUCKS?**
  
- 3. In the ACME PUBLISHING SWEEPSTAKES, the chance of winning a car is 1 in 1,000. What percentage of tickets to ACME PUBLISHING SWEEPSTAKES win a car?**
  
- 4. Which of the following numbers represent the biggest risk of getting a disease?**  
  
\_\_\_1 in 100, \_\_\_1 in 1000
  
- 5. Which of the following numbers represents the biggest risk of getting a disease?**  
  
\_\_\_\_\_ 1%, \_\_\_\_\_ 10%, \_\_\_\_\_5%

- 6. If person A's risk of getting a disease is 1% in ten years, and person B's risk is double that of A's, what is B's risk?**
  
- 7. If person A's chance of getting a disease is 1 in 100 in ten years, and person B's risk is double that of A's, what is B's risk?**
  
- 8. If the chance of getting a disease is 10%, how many people would be expected to get the disease?**
  
- 9. If the chance of getting a disease is 20 out of 100, this would be the same as having a \_\_\_\_\_% chance of getting the disease.**
  
- 10. The chance of getting a viral infection is .0005. Out of 10,000 people, about how many of them are expected to get infected?**

## APPENDIX F: KNOWLEDGE TEST FOR PRENATAL TESTING (STUDY I)

Please answer the following questions about prenatal testing:

- 1. The risk that a child has Down Syndrome can be determined through prenatal testing during pregnancy.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 2. The probability that an unborn child has Down Syndrome is generally very low (fewer than 1 in every 100 births).**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 3. All children with Down Syndrome have developmental and intellectual delays.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 4. The Combined Test consists of an ultrasound screening of the baby's neck and a blood test on the mother.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 5. The NIPT only consists of a blood test on the mother.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 6. If the results of Combined Test or NIPT are abnormal, it means that baby has Down Syndrome.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 7. If the results of Combined Test or NIPT are normal, the child may still prove to have Down Syndrome when born.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**8. The Amniocentesis or Chorionic Villus Sampling may induce a miscarriage.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**9. Both Amniocentesis or Chorionic Villus Sampling can determine with certainty as to whether a child has Down Syndrome.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**10. Amniocentesis can be performed within the first trimester (first 3 months).**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**11. If Down Syndrome is diagnosed during the first half of pregnancy, it is an option for a pregnant woman to terminate the pregnancy.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**12. Prenatal screening for Down Syndrome is compulsory for every pregnant woman in the United States.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

## APPENDIX G: KNOWLEDGE TEST FOR CRC SCREENING (STUDY III)

Please answer the following questions about colorectal cancer screening.

- 1. Colorectal cancer is the number 1 cause of cancer death among non-smokers.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 2. Both men and women are at risk of getting colorectal cancer.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 3. People 50 years of age and older are more likely to get colorectal cancer than younger people.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 4. People of all racial and ethnic groups can get colorectal cancer.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 5. Most colorectal cancer develop from growths called polyps.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 6. Removing polyps can prevent colorectal cancer.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

- 7. You only have to worry about getting colorectal cancer if someone in your family has had it.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**8. You can have colorectal cancer and not have any symptoms.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**9. You can have colorectal polyps and not have any symptoms.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**10. The goals of screening are to find polyps and cancer before they cause symptoms.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**11. If found early, most colorectal cancers can be cured by surgery.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

**12. You should begin screening for colorectal cancer at age 50.**

True \_\_\_\_\_ False \_\_\_\_\_ I do not know \_\_\_\_\_

## APPENDIX H: SYSTEM USABILITY (STUDY II)

Below is a list of statements that describe the decision support system. For each statement, please indicate how much you agree or disagree.

**1. The system is easy to use.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

**2. The system helped me think about what matters most to me.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

**3. The system perceived accurately what matters most to me.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

**4. The system helped me get ready to make a choice.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

**5. The system is efficient.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

**6. The system helped me identify which option is best for me.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

**7. It is clear to me how the best option was identified.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

**8. I am satisfied with this system.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

**9. I would like to recommend this system to a friend.**

Strongly disagree    •    •    •    •    •    •    •    Strongly agree

# APPENDIX I: DECISIONAL CONFLICT SCALE (STUDY I, II, III)

Please show how you feel about these statements by circling a number from 1 to 5.

**1. I know which options are available to me.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**2. I know the benefits of each option.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**3. I know the risk and side effects of each option.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**4. I am clear about which benefits matter most to me.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**5. I am clear about which risks and side effects matter most.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**6. I am clear about which is more important to me (the benefits or the risks and side effects).**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**7. I have enough support from others to make a choice.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**8. I am choosing without pressure from others.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**9. I have enough advice to make a choice.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**10. I am clear about the best choice for me.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**11. I feel sure about what to choose.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**12. This decision is easy for me to make.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**13. I feel I have made an informed choice.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**14. My decision shows what is important to me.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**15. I expect to stick with my decision.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**16. I am satisfied with my decision.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

## APPENDIX J: DECISION REGRET SCALE (STUDY I)

Please think about the decision you made with the animated character and indicate to what extent you agree or disagree with the following statements by circling one of the numbers.

**1. It was the right decision.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**2. I regret the choice that was made.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**3. I would go for the same choice if I had to do it over again.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**4. The choice did me a lot of harm.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**5. The decision was a wise one.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

## APPENDIX K: SATISFACTION WITH DECISION SCALE (STUDY I, II, III)

Please answer the following questions about the decision you made with the animated character:

**1. I am satisfied that I am adequately informed about the issues important to my decision.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**2. The decision I made was the best decision possible for me personally.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**3. I am satisfied that my decision was consistent with my personal values.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**4. I expect to successfully carry out (or continue to carry out) the decision I made.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**5. I am satisfied that this was my decision to make.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

**6. I am satisfied with my decision.**

|                      |          |                              |       |                   |
|----------------------|----------|------------------------------|-------|-------------------|
| 1                    | 2        | 3                            | 4     | 5                 |
| Strongly<br>Disagree | Disagree | Neither Agree<br>or Disagree | Agree | Strongly<br>Agree |

## APPENDIX L: INTENTION FOR CRC SCREENING (STUDY III)

Please answer the following questions about colorectal cancer screening:

**How sure are you that you will schedule a colorectal cancer screening test?**

Extremely  
Unsure

Strongly  
Unsure

Somewhat  
Unsure

Neutral

Somewhat  
Sure

Strongly  
Sure

Extremely  
Unsure

**How sure are you that you will complete a colorectal cancer screening test?**

Extremely  
Unsure

Strongly  
Unsure

Somewhat  
Unsure

Neutral

Somewhat  
Sure

Strongly  
Sure

Extremely  
Unsure

## APPENDIX M: PREPARATION FOR DECISION MAKING SCALE (STUDY III)

Please show your opinion of the educational material by circling the number to show how much you agree with each statement.

### Did the educational material ...

#### 1. Help you recognize that a decision needs to be made?

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

#### 2. Prepare you to make a better decision?

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

#### 3. Help you think about the pros and cons of each option?

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

#### 4. Help you think about which pros and cons are most important?

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

#### 5. Help you know that the decision depends on what matters most to you?

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

#### 6. Help you organize your own thoughts about the decision?

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

#### 7. Help you think about how involved you want to be in this decision?

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

#### 8. Help you identify questions you want to ask your doctor?

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

**9. Prepare you to talk to your doctor about what matters most to you?**

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

**10. Prepare you for a follow-up visit with your doctor?**

|            |          |          |             |              |
|------------|----------|----------|-------------|--------------|
| 1          | 2        | 3        | 4           | 5            |
| Not at all | A little | Somewhat | Quite a bit | A great deal |

# APPENDIX N: DECISION MAKING EXPERIENCE (STUDY I, II, III)

Please answer the following questions about the decision-making experience:

*Write an 'X' on each line (on one of the dots):*

## 1. How much information did you get?

To little      •      •      •      •      •      •      •      Too much  
Just right

## 2. How much time did you feel it took to go through the entire process? (Study II Only)

To little      •      •      •      •      •      •      •      Too much  
Just right

## 3. How likely would you go with the option you prefer?

Extremely unlikely      •      •      •      •      •      •      •      Extremely likely

## 4. How much pressure did you feel?

No pressure      •      •      •      •      •      •      •      Extreme pressure

## 5. How satisfied were you with the decision-making process?

Not satisfied      •      •      •      •      •      •      •      Extremely satisfied

## APPENDIX O: ATTITUDES TOWARDS DECISION COACH (STUDY I, II, III)

Please answer the following questions about the animated character:

*Write an 'X' on each line (on one of the dots):*

How **satisfied** are you with Tanya?

not at all    •    •    •    •    •    •    •    very satisfied

How much would you like to **make future decisions** with Tanya?

not at all    •    •    •    •    •    •    •    very much

How much do you **trust** Tanya?

not at all    •    •    •    •    •    •    •    very much

How much do you **like** Tanya?

not at all    •    •    •    •    •    •    •    very much

How **knowledgeable** was Tanya?

not at all    •    •    •    •    •    •    •    very  
knowledgeable

## APPENDIX P: SDM-Q-9 (STUDY III)

Below are statements related to your decision-making experience with Tanya. For each statement, please indicate how much you agree or disagree.

**1. Tanya made clear that a decision needs to be made.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

**2. Tanya wanted to know exactly how I want to be involved in making the decision.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

**3. Tanya told me that there are different options for treating my medical condition.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

**4. Tanya precisely explained the advantages and disadvantages of the treatment options.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

**5. Tanya helped me understand all the information.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

**6. Tanya asked me which treatment option I prefer.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

**7. Tanya and I thoroughly weighed the different treatment options.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

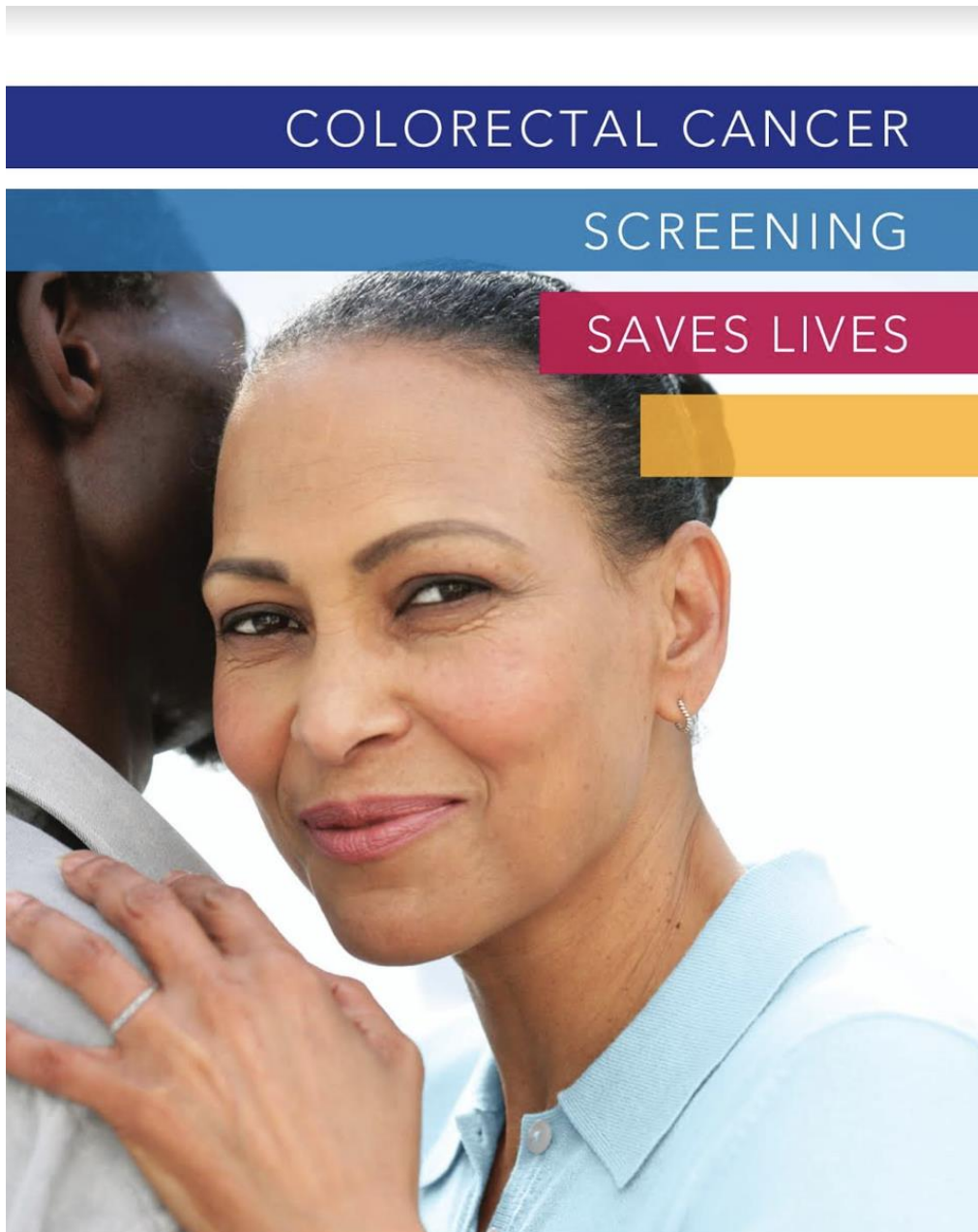
**8. Tanya and I selected a treatment option together.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

**9. Tanya and I reached an agreement on how to proceed.**

|                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Completely<br>Disagree   | Strongly<br>Disagree     | Somewhat<br>Disagree     | Somewhat<br>Agree        | Strongly<br>Agree        | Completely<br>Agree      |

## APPENDIX P: COLORECTAL CANCER BROCHURE (STUDY III)



Colorectal cancer is the second leading cancer killer—but it doesn't have to be.



Both men and women are at risk for colorectal cancer.

# SCREENING SAVES LIVES

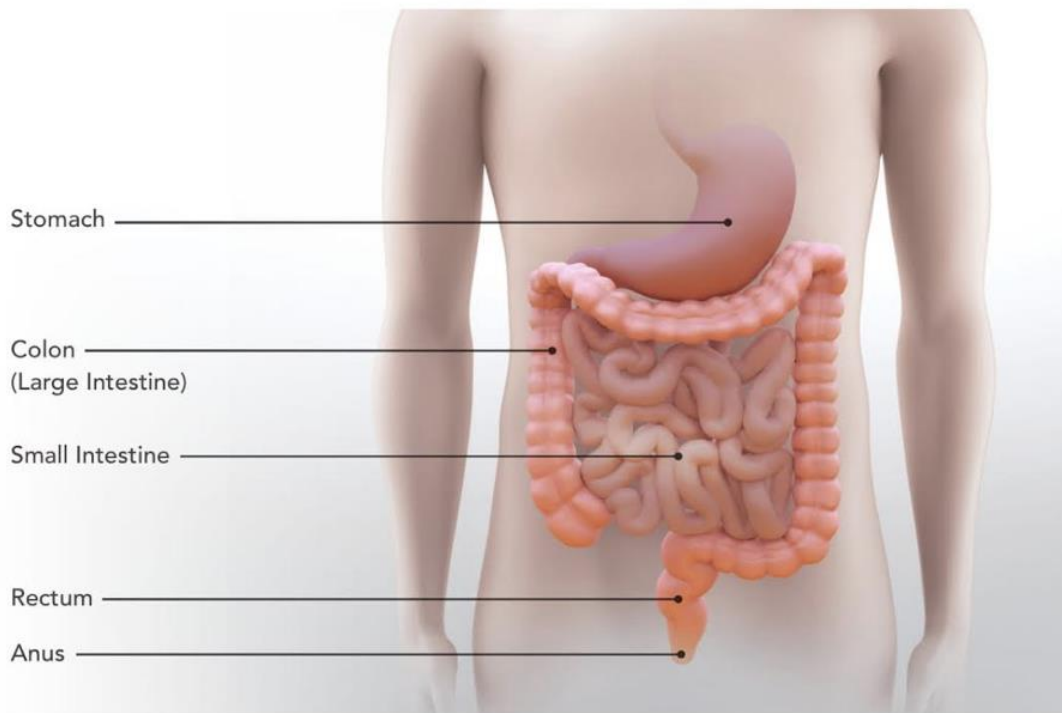
Among cancers that affect both men and women, colorectal cancer is the second leading cancer killer in the U.S. But it doesn't have to be.

There is strong scientific evidence that screening for colorectal cancer beginning at age 50 saves lives!

## WHAT IS COLORECTAL CANCER?

Cancer is a disease in which cells in the body grow out of control. Cancer is always named for the part of the body where it starts, even if it spreads to other parts of the body later.

Colorectal cancer is cancer that occurs in the colon or rectum. The colon is the large intestine or large bowel. The rectum is the passageway that connects the colon to the anus.

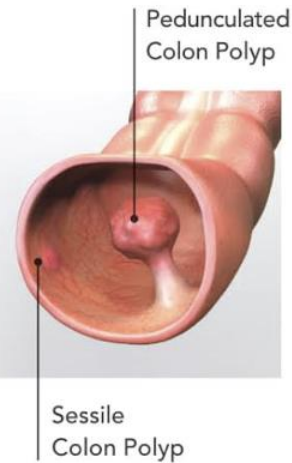


## SCREENING SAVES LIVES

If you're 50 or older, getting a colorectal cancer screening test could save your life.

### Here's How:

- Colorectal cancer usually starts from precancerous polyps in the colon or rectum. A polyp is a growth that shouldn't be there.
- Over time, some polyps can turn into cancer.
- Screening tests can find precancerous polyps, so they can be removed before they turn into cancer.
- Screening tests also find colorectal cancer early, when treatment works best.



## WHO GETS COLORECTAL CANCER?

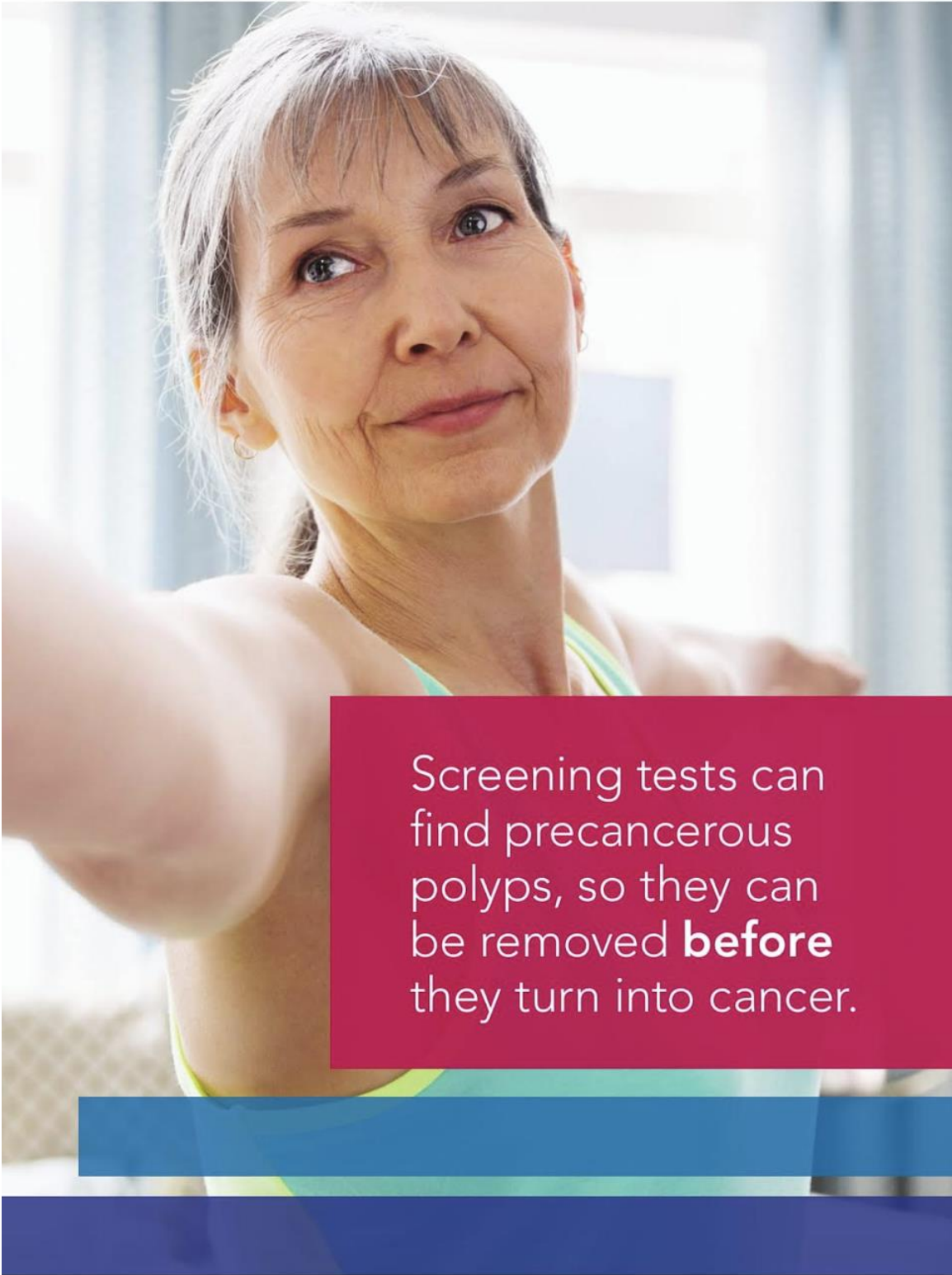
Colorectal cancer occurs most often in people aged 50 years or older. The risk increases with age. Both men and women can get colorectal cancer. If you are 50 or older, talk to your doctor about getting screened.

## AM I AT INCREASED RISK?

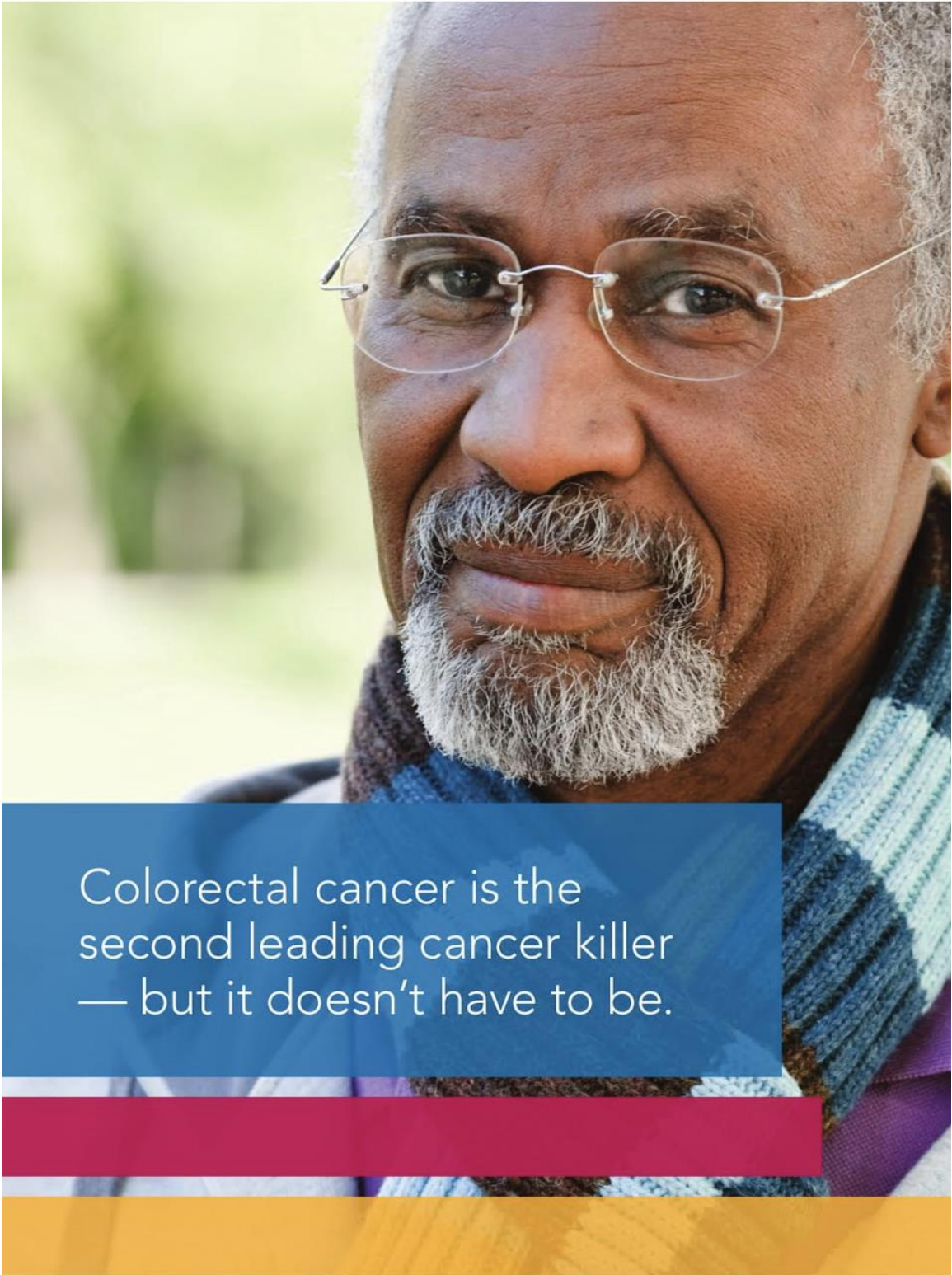
Your risk for colorectal cancer may be higher than average if:

- You or a close relative have had colorectal polyps or colorectal cancer.
- You have inflammatory bowel disease, Crohn's disease, or ulcerative colitis.
- You have a genetic syndrome such as familial adenomatous polyposis (FAP) or hereditary non-polyposis colorectal cancer.

If you think you may be at increased risk, speak with your doctor about when to begin screening, which test is right for you, and how often you should be tested.



Screening tests can find precancerous polyps, so they can be removed **before** they turn into cancer.



Colorectal cancer is the second leading cancer killer — but it doesn't have to be.

## WHAT ARE THE SYMPTOMS OF COLORECTAL CANCER?

People who have polyps or colorectal cancer don't always have symptoms, especially at first. Someone could have polyps or colorectal cancer and not know it. If there are symptoms, they may include:

- Blood in or on your stool (bowel movement).
- Pains, aches, or cramps in your stomach that don't go away.
- Losing weight and you don't know why.

If you have any of these symptoms, talk to your doctor. They may be caused by something other than cancer. However, the only way to know what is causing them is to see your doctor.

## FREE OR LOW-COST SCREENING

Where feasible, some states in CDC's Colorectal Cancer Control Program provide free or low-cost screenings to those who are eligible. To learn more, visit [www.cdc.gov/cancer/crccp/contact.htm](http://www.cdc.gov/cancer/crccp/contact.htm) or call **1-800-CDC-INFO** (1-800-232-4636).

Colorectal cancer screening tests may be covered by your health insurance policy without a deductible or co-pay. Check with your plan to find out which tests are covered for you.

## WHICH TEST IS RIGHT FOR YOU?

There is no single best test for any person. Each test has advantages and disadvantages. Talk to your doctor about which test or tests are right for you, and how often you should be screened.

### TYPES OF SCREENING TESTS

The U.S. Preventive Services Task Force recommends that adults aged 50–75 be screened for colorectal cancer. The decision to be screened after age 75 should be made on an individual basis. If you are aged 76–85, ask your doctor if you should be screened. Several different screening tests can be used to find polyps or colorectal cancer. They include:

---

#### Stool Tests

***Fecal Immunochemical Test (FIT):*** uses antibodies to detect blood in the stool. You receive a test kit from your health care provider. This test is done the same way as gFOBT.

**How often:** FIT once a year.

IF YOU'RE 50 OR OLDER,  
TALK WITH YOUR DOCTOR  
ABOUT GETTING SCREENED.

***FIT-DNA Test (or Stool DNA test):*** combines the FIT with a test to detect altered DNA in stool. You collect an entire bowel movement and send it to a lab to be checked for cancer cells.

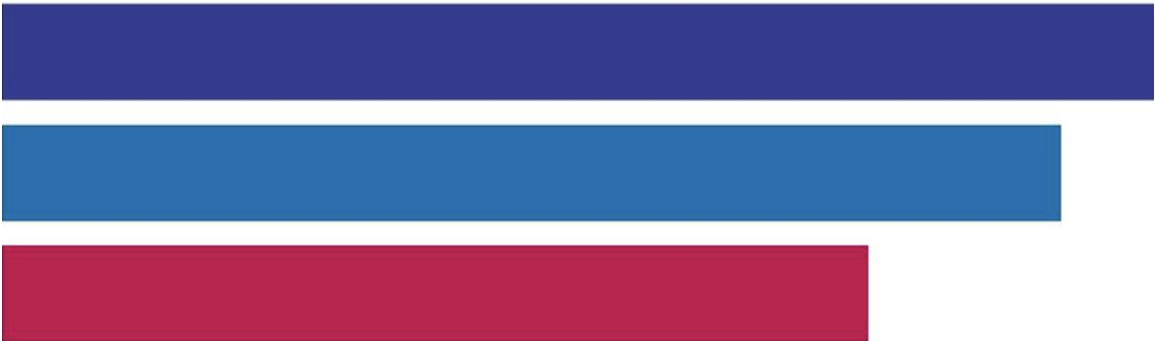
**How often:** FIT-DNA once every one or three years.

---

### **Colonoscopy**

Similar to flexible sigmoidoscopy, except the doctor uses a longer, thin, flexible, lighted tube to check for polyps or cancer inside the rectum and the entire colon. During the test, the doctor can find and remove most polyps and some cancers. Colonoscopy also is used as a follow-up test if anything unusual is found during one of the other screening tests.

**How often:** Every 10 years.



# APPENDIX Q: COLON CANCER SCREENING COUNSELING TRANSCRIPTS

## *Greeting Script*

STATE: GREET

AGENT: Good morning. My name is Tanya. Nice to meet you.

USERMENU: Hi, Tanya. => HOW\_ARE\_YOU

Nice to meet you. => HOW\_ARE\_YOU

STATE: HOW\_ARE\_YOU

AGENT: How are you doing today?

USERMENU: I'm doing great! => GREAT

I'm okay. => GOOD

I'm not feeling well. => NOT\_GOOD

STATE: GREAT

AGENT: I'm glad to hear it.

USERMENU: Thanks. => END

STATE: GOOD

AGENT: Great.

ACTION: END

STATE: NOT\_GOOD

AGENT: Oh, I am sorry to hear that. I hope you feel better soon.

USERMENU: Thanks. => END

## *Overview Script*

STATE: OVERVIEW

AGENT: Before we get started, let me give you an overview of what we are going to talk about today.

USERMENU: Okay.; Sure. => OVERVIEW\_1

STATE: OVERVIEW\_1

AGENT: We will talk about colorectal cancer and the tests you can order to screen for colorectal cancer.

ACTION: OVERVIEW\_2

STATE: OVERVIEW\_2

AGENT: We will also discuss how you feel about the different tests and help you decide which test is right for you.

Shall we get started?

USERMENU: Yes.; Go ahead. => END

*CRC Education Script*

STATE: CRC

AGENT: Let's talk about colorectal cancer first.

USERMENU: Ok, tell me all about it. => DEFINITION

Actually, I already know everything about it. => SCREENING

STATE: DEFINITION

AGENT: Colorectal cancer is the second leading cancer killer in the United States.

It is cancer that occurs in the colon or rectum.

USERMENU: Who can get colorectal cancer? => WHO

What is colon? => COLON

What is rectum? => RECTUM

STATE: COLON

AGENT: The colon is the large intestine, or large bowel.

USERMENU: Ok. => WHO

STATE: RECTUM

AGENT: The rectum is the passageway that connects the colon to the anus.

USERMENU: Ok. => WHO

STATE: ASTOUNDING

AGENT: Who can get colorectal cancer? => WHO

What is colon? => COLON

What is rectum? => RECTUM

STATE: WHO

AGENT: Men and women of all racial and ethnic groups can get colorectal cancer. People aged 50 years or older are more likely to get colorectal cancer than younger people.

ACTION: RISK

STATE: RISK

AGENT: And the risk for colorectal cancer may be even higher than average, if someone in your family has had colorectal polyps or colorectal cancer.

USERMENU: I see. => HOWEVER

STATE: HOWEVER

AGENT: However, colorectal cancer can be entirely preventable, and if found early, most of colorectal cancer can be cured by surgery.

USERMENU: How?; Tell me more. => POLYPS

STATE: POLYPS

AGENT: Most colon cancer starts as polyps in the colon or rectum. Over time, some polyps can turn into cancer.

USERMENU: Ok. => HARD\_KNOW  
What are polyps? => POLYPS\_DEF

STATE: POLYPS\_DEF  
AGENT: A polyp is a growth that should not be there.  
USERMENU: Ok. => HARD\_KNOW

STATE: HARD\_KNOW  
AGENT: People who have polyps or colorectal cancer do not always have symptoms, especially at first. Someone could have polyps or colorectal cancer and not know it.  
USERMENU: I see.; How can I know if I have colorectal polyps or cancer? => SCREENING

STATE: SCREENING  
AGENT: Screening tests can help save lives. These tests help find polyps, so they can be removed before turning into cancer. They can also find colorectal cancer early, when treatment works best.  
USERMENU: Ok.; Tell me more. => SCREENING1

STATE: SCREENING1  
AGENT: There are multiple tests available to screen for colorectal cancer.  
ACTION: SCREENING2

STATE: SCREENING2  
AGENT: Your healthcare provider may suggest you do the testing or even recommend a specific test to you. However, it is purely your decision whether or not to pursue the testing, and which test you would like to use.  
USERMENU: Ok.; Right. => SCREENING3

STATE: SCREENING3  
AGENT: I also want you to know that, there is no best option for every person. Each test has advantages and disadvantages. It is important to understand the pros and cons of each single test, to make a choice that is right for you.  
USERMENU: Ok. => END  
It's too much for me! => NOT\_ALONE

STATE: NOT\_ALONE  
AGENT: You are not doing this alone, I will be here for you. We will go through the testing options together, and then discuss your preferences to find out which test would be best for you.  
USERMENU: Ok.; This sounds better! => FEEL

STATE: FEEL  
AGENT: So =|GET("PARTICIPANT\_NAME")|=, how are you feeling right now?  
USERMENU: I'm OK, thanks. => ANY\_REVIEW  
I'm feeling pretty overwhelmed. => BREAK

STATE: ANY\_REVIEW

AGENT: Is there anything you'd like to review now before we talk more about screening options?

USERMENU: Yes. => Display a list of topics in this section  
No, I am good. => END

STATE: BREAK

AGENT: I totally understand. It is a lot of information. Would you like to take a break now?

USERMENU: Yes, that would be great. => Pause until participant is ok to proceed  
No, thanks. I am fine. => END

### *Screening Option Education Script*

STATE: OPTIONS

AGENT: So, next, let us talk about three testing options for colorectal cancer screening, and the pros and cons of each option.

USERMENU: Ok. => FIT

STATE: FIT

AGENT: The first option is called fecal immunochemical test or the FIT test.

USERMENU: Ok.; Tell me more. => FIT\_WHAT  
What is this test about? => FIT\_WHAT

STATE: FIT\_WHAT

AGENT: It is a stool test that you can do at home. You will receive a test kit from your health care provider. You need to use that to take a small amount of your stool and return the sample to your doctor for analysis.

USERMENU: I see. => FIT\_HOW  
What does the lab analysis do? => FIT\_HOW

STATE: FIT\_HOW

AGENT: The analysis checks for hidden blood in your stool, which can be an early sign of colorectal cancer.

USERMENU: Ok.; How effective is the test? => FIT\_EFFECT

STATE: FIT\_EFFECT

AGENT: The FIT test has a detection rate of 75 percent. Which means if 100 people with colorectal cancer take this test, 75 of them can be successfully detected, and the other 25 are missed.

USERMENU: I see.; What does the test result mean? => FIT\_RESULT

STATE: FIT\_RESULT

AGENT: You can receive either a negative or positive result.

ACTION: FIT\_NEGATIVE

STATE: FIT\_NEGATIVE

AGENT: A negative result means that no blood was found in your stool at the time of the test.  
And your doctor may recommend you repeat the test next year.  
ACTION: FIT\_POSITIVE

STATE: FIT\_POSITIVE

AGENT: A positive result indicates abnormal bleeding in your bowel, but it was not sure if the bleeding was caused by colon cancer or other things.

USERMENU: Ok.; I see.; What do I do then?; What happens then? => FIT\_CLNS

STATE: FIT\_CLNS

AGENT: Your doctor may recommend additional testing, which is typically a colonoscopy to look at the inside of the colon to see if cancer or polyps are there.

USERMENU: Go on.; Is the test risky? => FIT\_RISK

What is colonoscopy? => COLON\_FIT

STATE: COLON\_FIT

AGENT: Do not worry about this now. We will talk about this shortly.

USERMENU: Ok.; Sounds good. => FIT\_RISK

STATE: FIT\_RISK

AGENT: There is no risk associated with this test.

USERMENU: Ok.; How do I prepare for the test? => FIT\_PREPARATION

STATE: FIT\_PREPARATION

AGENT: No preparation is necessary for this test.

USERMENU: I see.; How much is this test? => FIT\_COST

STATE: FIT\_COST

AGENT: The FIT test costs around 8 to 20 dollars.

ACTION: FIT\_FREQUENCY

STATE: FIT\_FREQUENCY

AGENT: To maximize the benefit, it is recommended to do the FIT test once a year.

USERMENU: Ok. => DNA

STATE: DNA

AGENT: Another option you have is stool D-N-A test.

USERMENU: Ok.; Tell me more.; What is this test about? => DNA\_WHAT

STATE: DNA\_WHAT

AGENT: It is also a stool test, so you can do it at home. Different from the FIT test, you need to collect an entire bowel movement, and send it to a lab for analysis.

USERMENU: I see.; What does the lab analysis do? => DNA\_HOW

STATE: DNA\_HOW

AGENT: It checks for hidden blood, as well as any abnormal cells that may indicate colorectal cancer.

USERMENU: Ok.; How effective is the test? => DNA\_EFFECT

STATE: DNA\_EFFECT

AGENT: The stool D-N-A test has a detection rate of 92 percent. Which means if 100 people with colorectal cancer take this test, 92 of them can be successfully detected, and only 8 are missed.

USERMENU: I see.; What does the test result mean? => DNA\_RESULT

STATE: DNA\_RESULT

AGENT: You can receive either a negative or positive result.

ACTION: DNA\_NEGATIVE

STATE: DNA\_NEGATIVE

AGENT: A negative result means that there was no blood or cancer cells found in the stool at the time of the test. And your doctor may recommend you repeat the test in three years. </BEAT>\$

ACTION: DNA\_POSITIVE

STATE: DNA\_POSITIVE

AGENT: A positive result indicates some abnormal cells or blood were found in the stool sample.

USERMENU: Ok.; I see.; What do I do then?; What happens then? => DNA\_CLNS

STATE: DNA\_CLNS

AGENT: Your doctor may recommend additional testing, which is typically a colonoscopy to look at the inside of the colon to see if cancer or polyps are there.

USERMENU: Go on.; Is the test risky? => DNA\_RISK  
What is colonoscopy? => COLON\_DNA

STATE: COLON\_DNA

AGENT: We will cover this shortly.

USERMENU: Ok.; Sounds good. => DNA\_RISK

STATE: DNA\_RISK

AGENT: The stool D-N-A test is safe and poses no risk.

USERMENU: I see.; How do I prepare for the test? => DNA\_PREPARATION

STATE: DNA\_PREPARATION

AGENT: No preparation is necessary for this test.

USERMENU: Ok.; How much is this test? => DNA\_COST

STATE: DNA\_COST

AGENT: The stool D-N-A test costs around 400 to 800 dollars.

ACTION: DNA\_FREQUENCY

STATE: DNA\_FREQUENCY

AGENT: To maximize the benefit, it is recommended to do the stool D-N-A test every three years.

USERMENU: Ok. => COLONOSCOPY

STATE: COLONOSCOPY

AGENT: You can also use colonoscopy to screen for colorectal cancer.

USERMENU: Ok.; Tell me more.; What is this test about? => CLNS\_WHAT

STATE: CLNS\_WHAT

AGENT: It is a visual test that a doctor does to look inside your colon to see if cancer or polyps are there.

ACTION: CLNS\_HOW1

STATE: CLNS\_HOW1

AGENT: During a colonoscopy, the doctor inserts a long, flexible tube with a tiny video camera into the colon or rectum. The camera sends images to an external monitor, so the doctor can view the inside of your entire colon.

ACTION: CLNS\_HOW2

STATE: CLNS\_HOW2

AGENT: The doctor looks for abnormal tissues, such as polyps, and remove them for you if necessary.

USERMENU: Ok.; How effective is the test? => CLNS\_EFFECT1

STATE: CLNS\_EFFECT1

AGENT: Colonoscopy has a detection rate of 95 percent. Which means if 100 people with colorectal cancer take this test, 95 of them can be successfully detected, and only 5 are missed.

ACTION: CLNS\_EFFECT2

STATE: CLNS\_EFFECT2

AGENT: This is similar to the detection rate of stool D-N-A test. But a big benefit of colonoscopy is that, the doctor can help remove any polyps or abnormal tissues that are found during the test, so they do not have the chance to become cancer in the future.

USERMENU: I see.; What does the test result mean? => CLNS\_RESULT

STATE: CLNS\_RESULT

AGENT: You can receive either a negative or positive result.

ACTION: CLNS\_NEGATIVE

STATE: CLNS\_NEGATIVE

AGENT: A negative result means that there is polyps or abnormal tissue found in your colon. And your doctor may recommend you repeat the test in about 10 years.

ACTION: CLNS\_POSITIVE

STATE: CLNS\_POSITIVE

AGENT: A colonoscopy is considered positive if the doctor finds any polyps or abnormal tissue in the colon. Polyps or abnormal tissues that are removed during colonoscopy will be sent to a laboratory for analysis to determine if they are cancerous.

USERMENU: Go on.; Is the test risky? => CLNS\_RISK

STATE: CLNS\_RISK

AGENT: Because this is an invasive test, it involves certain risks. About 4 in every 1000 people experience complications with routine colonoscopy. Some of the complications include perforation, bleeding, and infection.

USERMENU: I see.; How do I prepare for the test? => CLNS\_PREPARATION

STATE: CLNS\_PREPARATION

AGENT: Before colonoscopy, it is important to clean the bowel properly. You need to take a prep, which can be tablets or something to drink, to empty your colon. It may cause diarrhea. In some cases, you may also need to use an enema kit to empty the colon.

ACTION: CLNS\_PREPARATION2

STATE: CLNS\_PREPARATION2

AGENT: You will be sedated, and you will need one or two days off work. You will also need someone to drive you.

USERMENU: Ok.; How much is this test? => CLNS\_COST

STATE: CLNS\_COST

AGENT: Colonoscopy can cost around 1000 to 2000 dollars.

ACTION: CLNS\_FREQUENCY

STATE: CLNS\_FREQUENCY

AGENT: To maximize the benefit, it is recommended to do colonoscopy every 10 years.

USERMENU: Ok. => FEEL

STATE: FEEL

AGENT: So, =|GET("PARTICIPANT\_NAME")|=, how are you feeling right now?

USERMENU: I'm OK, thanks. => ANY\_REVIEW

I'm feeling pretty overwhelmed. => BREAK

STATE: ANY\_REVIEW

AGENT: Is there anything you'd like to review now before we move forward?

USERMENU: Yes, I'd like to review the FIT test. => FIT topics again

Yes, I'd like to review the Stool DNA test. => Stool DNA topics again

Yes, I'd like to review colonoscopy. => Colonoscopy topics again.

No, I am good. => END

STATE: BREAK

AGENT: I totally understand. It is a lot of information. Would you like to take a break now?

USERMENU: Yes, that would be great. => Pause until participant is ok to proceed

No, thanks. I am fine. => END

*Value Clarification Exercise Script*

STATE: CRC\_EX\_AHP

AGENT: All right, now, We have talked about three screening tests that are available to you for detecting colon cancer. My goal is to help you identify the type of test you would want in the future.

ACTION: MOTIV

STATE: MOTIV

AGENT: Making a choice for colon cancer screening is a very personal decision. So, it is important to discuss your preferences and priorities to make a decision that is right for you.

ACTION: EXERCISE

STATE: EXERCISE

AGENT: Next, I would like to ask you several questions to figure out what might be best for you. Shall we get started?

USERMENU: Sure.; Go ahead. => CRITERIA

STATE: CRITERIA

AGENT: Here are the factors that people consider when making a decision for colon cancer screening.

ACTION: E0

STATE: E0

AGENT: Next, we will discuss how you feel about these factors. I will show you two factors at a time, and ask you to compare them, ok?

USERMENU: Ok.; Sure. => E1

STATE: E1

AGENT: So, when it comes to colon cancer screening, which would you say is more important, detecting colon cancer, or, having no risk of complications such as perforation or bleeding?

USERMENU: Detecting colon cancer. => \$SET("H\_PRIORITY", "DETECT");

SET("L\_PRIORITY", "RISK"); SET("MORE\_OPTION", "detecting colon cancer");

SET("LESS\_OPTION", "the risk of complications"); GO("E1\_CONT");\$

Having no risk of complications. => \$SET("H\_PRIORITY", "RISK"); SET("L\_PRIORITY", "DETECT"); SET("MORE\_OPTION", "the risk of complications"); SET("LESS\_OPTION", "detecting colon cancer"); GO("E1\_CONT");\$

STATE: E1\_CONT

AGENT: Then how much more important is =|GET("MORE\_OPTION")|=, than =|GET("LESS\_OPTION")|=? Let's say 1 is they are equally important to you, and 9 is =|GET("MORE\_OPTION")|= is extremely more important than =|GET("LESS\_OPTION")|=.

USERMENU: 1-equally important. =>

\$ SET(GET("H\_PRIORITY")+":"GET("L\_PRIORITY"), "1:1"); GO("E2"); \$

2=> \$ SET(GET("H\_PRIORITY")+":"GET("L\_PRIORITY"), "2:1"); GO("E2"); \$

3=> \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "3:1"); GO("E2"); \$  
4=> \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "4:1"); GO("E2"); \$  
5 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "5:1"); GO("E2"); \$  
6=> \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "6:1"); GO("E2"); \$  
7=> \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "7:1"); GO("E2"); \$  
8=> \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "8:1"); GO("E2"); \$  
9-extremely more important => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"),  
"9:1"); GO("E2"); \$

STATE: E2

AGENT: Ok. How about these. Which is more important for you?

USERMENU: Detecting colon cancer. => \$SET("H\_PRIORITY", "DETECT");  
SET("L\_PRIORITY", "COST"); SET("MORE\_OPTION", "detecting colon cancer");  
SET("LESS\_OPTION", "the cost"); GO("E2\_CONT");\$  
Cost. => \$SET("H\_PRIORITY", "COST"); SET("L\_PRIORITY", "DETECT");  
SET("MORE\_OPTION", "the cost"); SET("LESS\_OPTION", "detecting colon cancer");  
GO("E2\_CONT");\$

STATE: E2\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than  
=|GET("LESS\_OPTION")|=?

USERMENU: 1-equally important =>

\$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "1:1"); GO("E3"); \$  
2 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "2:1"); GO("E3"); \$  
3 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "3:1"); GO("E3"); \$  
4=> \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "4:1"); GO("E3"); \$  
5 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "5:1"); GO("E3"); \$  
6=> \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "6:1"); GO("E3"); \$  
7 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "7:1"); GO("E3"); \$  
8=> \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "8:1"); GO("E3"); \$  
9-extremely more important => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"),  
"9:1"); GO("E3"); \$

STATE: E3

AGENT: I see. How about these. Which would you say is more important for you?

USERMENU: Detecting colon cancer. => \$SET("H\_PRIORITY", "DETECT");  
SET("L\_PRIORITY", "PREP"); SET("MORE\_OPTION", "detecting colon cancer");  
SET("LESS\_OPTION", "the test preparation"); GO("E3\_CONT");\$  
Minimal test preparation. => \$SET("H\_PRIORITY", "PREP"); SET("L\_PRIORITY",  
"DETECT"); SET("MORE\_OPTION", "the test preparation"); SET("LESS\_OPTION",  
"detecting colon cancer"); GO("E3\_CONT");\$

STATE: E3\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than  
=|GET("LESS\_OPTION")|=?

USERMENU: 1-equally important =>

```
$ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "1:1"); GO("E4"); $
2 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "2:1"); GO("E4"); $
3 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "3:1"); GO("E4"); $
4=> $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "4:1"); GO("E4"); $
5 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "5:1"); GO("E4"); $
6=> $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "6:1"); GO("E4"); $
7 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "7:1"); GO("E4"); $
8=> $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "8:1"); GO("E4"); $
9-extremely more important => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"),
"9:1"); GO("E4"); $
```

STATE: E4

AGENT: Ok. How about these. Which is more important for you?

```
USERMENU: Detecting colon cancer. => $SET("H_PRIORITY", "DETECT");
SET("L_PRIORITY", "FREQ"); SET("MORE_OPTION", "detecting colon cancer");
SET("LESS_OPTION", "the test frequency"); GO("E4_CONT");$
Test frequency. => $SET("H_PRIORITY", "FREQ"); SET("L_PRIORITY", "DETECT");
SET("MORE_OPTION", "the test frequency"); SET("LESS_OPTION", "detecting colon
cancer"); GO("E4_CONT");$
```

STATE: E4\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than  
=|GET("LESS\_OPTION")|=?

USERMENU: 1-equally important =>

```
$ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "1:1"); GO("E5"); $
2 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "2:1"); GO("E5"); $
3 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "3:1"); GO("E5"); $
4=> $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "4:1"); GO("E5"); $
5 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "5:1"); GO("E5"); $
6=> $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "6:1"); GO("E5"); $
7 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "7:1"); GO("E5"); $
8=> $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "8:1"); GO("E5"); $
9-extremely more important => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"),
"9:1"); GO("E5"); $
```

STATE: E5

AGENT: Ok. How about these. Which would you say is more important for you?

```
USERMENU: Having no risk of complications. => $SET("H_PRIORITY", "RISK");
SET("L_PRIORITY", "COST"); SET("MORE_OPTION", "the risk of complications");
SET("LESS_OPTION", "the cost"); GO("E5_CONT");$
Cost. => $SET("H_PRIORITY", "COST"); SET("L_PRIORITY", "RISK");
SET("MORE_OPTION", "the cost"); SET("LESS_OPTION", "the risk of complications");
GO("E5_CONT");$
```

STATE: E5\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than =|GET("LESS\_OPTION")|=.

USERMENU: 1-equally important =>

```
$ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "1:1"); GO("E6"); $
2 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "2:1"); GO("E6"); $
3 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "3:1"); GO("E6"); $
4 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "4:1"); GO("E6"); $
5 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "5:1"); GO("E6"); $
6 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "6:1"); GO("E6"); $
7 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "7:1"); GO("E6"); $
8 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "8:1"); GO("E6"); $
9-extremely more important => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"),
"9:1"); GO("E6"); $
```

STATE: E6

AGENT: You are doing great. We just have a few more to go. How about these. Which is more important for you?

```
USERMENU: Having no risk of complications. => $SET("H_PRIORITY", "RISK");
SET("L_PRIORITY", "PREP"); SET("MORE_OPTION", "the risk of complications");
SET("LESS_OPTION", "the test preparation"); GO("E6_CONT");$
Minimal test preparation. => $SET("H_PRIORITY", "PREP"); SET("L_PRIORITY", "RISK");
SET("MORE_OPTION", "the test preparation"); SET("LESS_OPTION", "the risk of
complications"); GO("E6_CONT");$
```

STATE: E6\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than =|GET("LESS\_OPTION")|=.

USERMENU: 1-equally important =>

```
$ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "1:1"); GO("E7"); $
2 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "2:1"); GO("E7"); $
3 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "3:1"); GO("E7"); $
4 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "4:1"); GO("E7"); $
5 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "5:1"); GO("E7"); $
6 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "6:1"); GO("E7"); $
7 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "7:1"); GO("E7"); $
8 => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"), "8:1"); GO("E7"); $
9-extremely more important => $ SET(GET("H_PRIORITY")+":"+GET("L_PRIORITY"),
"9:1"); GO("E7"); $
```

STATE: E7

AGENT: Ok. How about these. Which would you say is more important for you?

```
USERMENU: Having no risk of complications. => $SET("H_PRIORITY", "RISK");
SET("L_PRIORITY", "FREQ"); SET("MORE_OPTION", "the risk of complications");
SET("LESS_OPTION", "the test frequency"); GO("E7_CONT");$
```

Test frequency. => \$SET("H\_PRIORITY", "FREQ"); SET("L\_PRIORITY", "RISK"); SET("MORE\_OPTION", "the test frequency"); SET("LESS\_OPTION", "the risk of complications"); GO("E7\_CONT");\$

STATE: E7\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than =|GET("LESS\_OPTION")|=.

USERMENU: 1-equally important =>

\$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "1:1"); GO("E8"); \$  
2 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "2:1"); GO("E8"); \$  
3 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "3:1"); GO("E8"); \$  
4 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "4:1"); GO("E8"); \$  
5 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "5:1"); GO("E8"); \$  
6 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "6:1"); GO("E8"); \$  
7 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "7:1"); GO("E8"); \$  
8 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "8:1"); GO("E8"); \$  
9-extremely more important => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "9:1"); GO("E8"); \$

STATE: E8

AGENT: I see. How about these. Which is more important for you?

USERMENU: Minimal test preparation. => \$SET("H\_PRIORITY", "PREP");

SET("L\_PRIORITY", "COST"); SET("MORE\_OPTION", "the test preparation");

SET("LESS\_OPTION", "the cost"); GO("E8\_CONT");\$

Cost. => \$SET("H\_PRIORITY", "COST"); SET("L\_PRIORITY", "PREP");

SET("MORE\_OPTION", "the cost"); SET("LESS\_OPTION", "the test preparation");

GO("E8\_CONT");\$

STATE: E8\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than =|GET("LESS\_OPTION")|=.

USERMENU: 1-equally important =>

\$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "1:1"); GO("E9"); \$  
2 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "2:1"); GO("E9"); \$  
3 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "3:1"); GO("E9"); \$  
4 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "4:1"); GO("E9"); \$  
5 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "5:1"); GO("E9"); \$  
6 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "6:1"); GO("E9"); \$  
7 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "7:1"); GO("E9"); \$  
8 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "8:1"); GO("E9"); \$  
9-extremely more important => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "9:1"); GO("E9"); \$

STATE: E9

AGENT: Ok. How about these. Which would you say is more important for you?

USERMENU: Minimal test preparation. => \$SET("H\_PRIORITY", "PREP");  
SET("L\_PRIORITY", "FREQ"); SET("MORE\_OPTION", "the test preparation");  
SET("LESS\_OPTION", "the test frequency"); GO("E9\_CONT");\$  
Test frequency. => \$SET("H\_PRIORITY", "FREQ"); SET("L\_PRIORITY", "PREP");  
SET("MORE\_OPTION", "the test frequency"); SET("LESS\_OPTION", "the test preparation");  
GO("E9\_CONT");\$

STATE: E9\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than  
=|GET("LESS\_OPTION")|=.

USERMENU: 1-equally important =>

\$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "1:1"); GO("E10"); \$  
2 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "2:1"); GO("E10"); \$  
3 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "3:1"); GO("E10"); \$  
4 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "4:1"); GO("E10"); \$  
5 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "5:1"); GO("E10"); \$  
6 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "6:1"); GO("E10"); \$  
7 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "7:1"); GO("E10"); \$  
8 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "8:1"); GO("E10"); \$  
9-extremely more important => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"),  
"9:1"); GO("E10"); \$

STATE: E10

AGENT: I see. How about these. Which is more important for you?

USERMENU: Test frequency. => \$SET("H\_PRIORITY", "FREQ"); SET("L\_PRIORITY",  
"COST"); SET("MORE\_OPTION", "the test frequency"); SET("LESS\_OPTION", "the cost");  
GO("E10\_CONT");\$

Cost. => \$SET("H\_PRIORITY", "COST"); SET("L\_PRIORITY", "FREQ");  
SET("MORE\_OPTION", "the cost"); SET("LESS\_OPTION", "the test frequency");  
GO("E10\_CONT");\$

STATE: E10\_CONT

AGENT: How much more important is =|GET("MORE\_OPTION")|=, than  
=|GET("LESS\_OPTION")|=.

USERMENU: 1-equally important =>

\$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "1:1"); GO("E11"); \$  
2 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "2:1"); GO("E11"); \$  
3 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "3:1"); GO("E11"); \$  
4 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "4:1"); GO("E11"); \$  
5 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "5:1"); GO("E11"); \$  
6 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "6:1"); GO("E11"); \$  
7 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "7:1"); GO("E11"); \$  
8 => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"), "8:1"); GO("E11"); \$  
9-extremely more important => \$ SET(GET("H\_PRIORITY")+":"+GET("L\_PRIORITY"),  
"9:1"); GO("E11"); \$

STATE: E11

AGENT: You are doing excellent! The next questions are about how you feel about the test performance on each of the factors.

USERMENU: Ok. => E12

STATE: E12

AGENT: So, how do you feel about stool D-N-A test compared to the FIT test with respect to detection rate? Let's say 1 is they are equally good on this aspect, and 9 is stool D-N-A test is extremely better than the FIT test.

USERMENU: 1-equally good => \$ SET("DETECT:STOOL:FIT", "1:1"); GO("E13"); \$  
2 => \$ SET("DETECT:STOOL:FIT", "2:1"); GO("E13"); \$  
3 => \$ SET("DETECT:STOOL:FIT", "3:1"); GO("E13"); \$  
4 => \$ SET("DETECT:STOOL:FIT", "4:1"); GO("E13"); \$  
5 => \$ SET("DETECT:STOOL:FIT", "5:1"); GO("E13"); \$  
6 => \$ SET("DETECT:STOOL:FIT", "6:1"); GO("E13"); \$  
7 => \$ SET("DETECT:STOOL:FIT", "7:1"); GO("E13"); \$  
8 => \$ SET("DETECT:STOOL:FIT", "8:1"); GO("E13"); \$  
9-extremely better. => \$ SET("DETECT:STOOL:FIT", "9:1"); GO("E13"); \$

STATE: E13

AGENT: Ok. How about colonoscopy compared to the FIT test with respect to detection rate?

USERMENU: 1-equally good => \$ SET("DETECT:CLNS:FIT", "1:1"); GO("E14"); \$  
2=> \$ SET("DETECT:CLNS:FIT", "2:1"); GO("E14"); \$  
3 => \$ SET("DETECT:CLNS:FIT", "3:1"); GO("E14"); \$  
4=> \$ SET("DETECT:CLNS:FIT", "4:1"); GO("E14"); \$  
5 => \$ SET("DETECT:CLNS:FIT", "5:1"); GO("E14"); \$  
6=> \$ SET("DETECT:CLNS:FIT", "6:1"); GO("E14"); \$  
7 => \$ SET("DETECT:CLNS:FIT", "7:1"); GO("E14"); \$  
8=> \$ SET("DETECT:CLNS:FIT", "8:1"); GO("E14"); \$  
9-extremely better => \$ SET("DETECT:CLNS:FIT", "9:1"); GO("E14"); \$

STATE: E14

AGENT: I see. How do you feel about colonoscopy compared to stool D-N-A test with respect to detection rate?

USERMENU: 1-equally good => \$ SET("DETECT:CLNS:STOOL", "1:1"); GO("E15"); \$  
2=> \$ SET("DETECT:CLNS:STOOL", "2:1"); GO("E15"); \$  
3 => \$ SET("DETECT:CLNS:STOOL", "3:1"); GO("E15"); \$  
4=> \$ SET("DETECT:CLNS:STOOL", "4:1"); GO("E15"); \$  
5 => \$ SET("DETECT:CLNS:STOOL", "5:1"); GO("E15"); \$  
6=> \$ SET("DETECT:CLNS:STOOL", "6:1"); GO("E15"); \$  
7 => \$ SET("DETECT:CLNS:STOOL", "7:1"); GO("E15"); \$  
8=> \$ SET("DETECT:CLNS:STOOL", "8:1"); GO("E15"); \$  
9-extremely better => \$ SET("DETECT:CLNS:STOOL", "9:1"); GO("E15"); \$

STATE: E15

AGENT: You are doing great. How do you feel about colonoscopy compared to the FIT test with respect to risk? Let's say 1 is they are equally risky, and 9 is colonoscopy is extremely riskier than the FIT test.

USERMENU: 1-equally riskier => \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:1"); GO("E16"); \$

2=> \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:2"); GO("E16"); \$

3 => \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:3"); GO("E16"); \$

4=> \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:4"); GO("E16"); \$

5=> \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:5"); GO("E16"); \$

6=> \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:6"); GO("E16"); \$

7 => \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:7"); GO("E16"); \$

8=> \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:8"); GO("E16"); \$

9-extremely riskier => \$ SET("RISK:STOOL:FIT", "1:1"); SET("RISK:CLNS:FIT", "1:9"); GO("E16"); \$

STATE: E16

AGENT: I see, how about colonoscopy compared to the stool D-N-A test with respect to risk?

USERMENU: 1-equally riskier. => \$ SET("RISK:CLNS:STOOL", "1:1"); GO("E17"); \$

2=> \$ SET("RISK:CLNS:STOOL", "1:2"); GO("E17"); \$

3 => \$ SET("RISK:CLNS:STOOL", "1:3"); GO("E17"); \$

4=> \$ SET("RISK:CLNS:STOOL", "1:4"); GO("E17"); \$

5 => \$ SET("RISK:CLNS:STOOL", "1:5"); GO("E17"); \$

6=> \$ SET("RISK:CLNS:STOOL", "1:6"); GO("E17"); \$

7 => \$ SET("RISK:CLNS:STOOL", "1:7"); GO("E17"); \$

8=> \$ SET("RISK:CLNS:STOOL", "1:8"); GO("E17"); \$

9-extremely riskier => \$ SET("RISK:CLNS:STOOL", "1:9"); GO("E17"); \$

STATE: E17

AGENT: You are doing great. How do you feel about stool D-N-A test compared to the FIT test with respect to cost? Let's say 1 is they are equally costly, and 9 is stool D-N-A test is extremely more costly than the FIT test.

USERMENU: 1-equally costly => \$ SET("COST:STOOL:FIT", "1:1"); GO("E18"); \$

2=> \$ SET("COST:STOOL:FIT", "1:2"); GO("E18"); \$

3 => \$ SET("COST:STOOL:FIT", "1:3"); GO("E18"); \$

4=> \$ SET("COST:STOOL:FIT", "1:4"); GO("E18"); \$

5 => \$ SET("COST:STOOL:FIT", "1:5"); GO("E18"); \$

6=> \$ SET("COST:STOOL:FIT", "1:6"); GO("E18"); \$

7 => \$ SET("COST:STOOL:FIT", "1:7"); GO("E18"); \$

8=> \$ SET("COST:STOOL:FIT", "1:8"); GO("E18"); \$

9-extremely more costly => \$ SET("COST:STOOL:FIT", "1:9"); GO("E18"); \$

STATE: E18

AGENT: I see. How about colonoscopy compared to the FIT test with respect to cost?

USERMENU: 1-equally costly. => \$ SET("COST:CLNS:FIT", "1:1"); GO("E19"); \$

2=> \$ SET("COST:CLNS:FIT", "1:2"); GO("E19"); \$

3 => \$ SET("COST:CLNS:FIT", "1:3"); GO("E19"); \$

4=> \$ SET("COST:CLNS:FIT", "1:4"); GO("E19"); \$  
5=> \$ SET("COST:CLNS:FIT", "1:5"); GO("E19"); \$  
6=> \$ SET("COST:CLNS:FIT", "1:6"); GO("E19"); \$  
7 => \$ SET("COST:CLNS:FIT", "1:7"); GO("E19"); \$  
8=> \$ SET("COST:CLNS:FIT", "1:8"); GO("E19"); \$  
9-extremely more costly => \$ SET("COST:CLNS:FIT", "1:9"); GO("E19"); \$

STATE: E19

AGENT: Ok. How do you feel about colonoscopy compared to stool D-N-A test with respect to cost?

USERMENU: 1-equally costly => \$ SET("COST:CLNS:STOOL", "1:1"); GO("E20"); \$  
2=> \$ SET("COST:CLNS:STOOL", "1:2"); GO("E20"); \$  
3 => \$ SET("COST:CLNS:STOOL", "1:3"); GO("E20"); \$  
4 => \$ SET("COST:CLNS:STOOL", "1:4"); GO("E20"); \$  
5 => \$ SET("COST:CLNS:STOOL", "1:5"); GO("E20"); \$  
6 => \$ SET("COST:CLNS:STOOL", "1:6"); GO("E20"); \$  
7 => \$ SET("COST:CLNS:STOOL", "1:7"); GO("E20"); \$  
8 => \$ SET("COST:CLNS:STOOL", "1:8"); GO("E20"); \$  
9-extremely more costly => \$ SET("COST:CLNS:STOOL", "1:9"); GO("E20"); \$

STATE: E20

AGENT: You are doing great. How do you feel about colonoscopy compared to the FIT test with respect to test preparation? Let's say 1 is they are equally complex, and 9 is colonoscopy is extremely more complex than the FIT test.

USERMENU: 1-equally complex => \$ SET("PREP:STOOL:FIT", "1:1");  
SET("PREP:CLNS:FIT", "1:1"); GO("E21"); \$  
2=> \$ SET("PREP:STOOL:FIT", "1:1"); SET("PREP:CLNS:FIT", "1:2"); GO("E21"); \$  
3 => \$ SET("PREP:STOOL:FIT", "1:1"); SET("PREP:CLNS:FIT", "1:3"); GO("E21"); \$  
4=> \$ SET("PREP:STOOL:FIT", "1:1"); SET("PREP:CLNS:FIT", "1:4"); GO("E21"); \$  
5=> \$ SET("PREP:STOOL:FIT", "1:1"); SET("PREP:CLNS:FIT", "1:5"); GO("E21"); \$  
6=> \$ SET("PREP:STOOL:FIT", "1:1"); SET("PREP:CLNS:FIT", "1:6"); GO("E21"); \$  
7 => \$ SET("PREP:STOOL:FIT", "1:1"); SET("PREP:CLNS:FIT", "1:7"); GO("E21"); \$  
8=> \$ SET("PREP:STOOL:FIT", "1:1"); SET("PREP:CLNS:FIT", "1:8"); GO("E21"); \$  
9-extremely more complex => \$ SET("PREP:STOOL:FIT", "1:1"); SET("PREP:CLNS:FIT", "1:9"); GO("E21"); \$

STATE: E21

AGENT: I see, how about colonoscopy compared to the stool D-N-A test with respect to test preparation?

USERMENU: 1-equally complex. => \$ SET("PREP:CLNS:STOOL", "1:1"); GO("E22"); \$  
2=> \$ SET("PREP:CLNS:STOOL", "1:2"); GO("E22"); \$  
3 => \$ SET("PREP:CLNS:STOOL", "1:3"); GO("E22"); \$  
4=> \$ SET("PREP:CLNS:STOOL", "1:4"); GO("E22"); \$  
5 => \$ SET("PREP:CLNS:STOOL", "1:5"); GO("E22"); \$  
6=> \$ SET("PREP:CLNS:STOOL", "1:6"); GO("E22"); \$  
7 => \$ SET("PREP:CLNS:STOOL", "1:7"); GO("E22"); \$

8=> \$ SET("PREP:CLNS:STOOL", "1:8"); GO("E22"); \$  
9-extremely more complex => \$ SET("PREP:CLNS:STOOL", "1:9"); GO("E22"); \$

STATE: E22

AGENT: You are doing great. How do you feel about the FIT test compared to the stool D-N-A test with respect to test frequency? Let's say 1 is they are both very frequent, and 9 is the FIT test is extremely more frequent than the stool D-N-A test.

USERMENU: 1-equally frequent => \$ SET("FREQ:STOOL:FIT", "1:1"); GO("E23"); \$  
2=> \$ SET("FREQ:STOOL:FIT", "2:1"); GO("E23"); \$  
3 => \$ SET("FREQ:STOOL:FIT", "3:1"); GO("E23"); \$  
4=> \$ SET("FREQ:STOOL:FIT", "4:1"); GO("E23"); \$  
5 => \$ SET("FREQ:STOOL:FIT", "5:1"); GO("E23"); \$  
6=> \$ SET("FREQ:STOOL:FIT", "6:1"); GO("E23"); \$  
7 => \$ SET("FREQ:STOOL:FIT", "7:1"); GO("E23"); \$  
8=> \$ SET("FREQ:STOOL:FIT", "8:1"); GO("E23"); \$  
9-extremely more frequent. => \$ SET("FREQ:STOOL:FIT", "9:1"); GO("E23"); \$

STATE: E23

AGENT: I see. How about the FIT test compared to colonoscopy with respect to test frequency?

USERMENU: 1-equally frequent. => \$ SET("FREQ:CLNS:FIT", "1:1"); GO("E24"); \$  
2=> \$ SET("FREQ:CLNS:FIT", "2:1"); GO("E24"); \$  
3 => \$ SET("FREQ:CLNS:FIT", "3:1"); GO("E24"); \$  
4=> \$ SET("FREQ:CLNS:FIT", "4:1"); GO("E24"); \$  
5=> \$ SET("FREQ:CLNS:FIT", "5:1"); GO("E24"); \$  
6=> \$ SET("FREQ:CLNS:FIT", "6:1"); GO("E24"); \$  
7 => \$ SET("FREQ:CLNS:FIT", "7:1"); GO("E24"); \$  
8=> \$ SET("FREQ:CLNS:FIT", "8:1"); GO("E24"); \$  
9-extremely more frequent. => \$ SET("FREQ:CLNS:FIT", "9:1"); GO("E24"); \$

STATE: E24

AGENT: Ok. How do you feel about the stool D-N-A test compared to colonoscopy with respect to test frequency?

USERMENU: 1-equally frequent. => \$ SET("FREQ:CLNS:STOOL", "1:1"); GO("E25"); \$  
2=> \$ SET("FREQ:CLNS:STOOL", "2:1"); GO("E25"); \$  
3 => \$ SET("FREQ:CLNS:STOOL", "3:1"); GO("E25"); \$  
4 => \$ SET("FREQ:CLNS:STOOL", "4:1"); GO("E25"); \$  
5 => \$ SET("FREQ:CLNS:STOOL", "5:1"); GO("E25"); \$  
6 => \$ SET("FREQ:CLNS:STOOL", "6:1"); GO("E25"); \$  
7 => \$ SET("FREQ:CLNS:STOOL", "7:1"); GO("E25"); \$  
8 => \$ SET("FREQ:CLNS:STOOL", "8:1"); GO("E25"); \$  
9-extremely more frequent. => \$ SET("FREQ:CLNS:STOOL", "9:1"); GO("E25"); \$

STATE: E25

AGENT: Thanks for ranking these items for me. It just helps me figure out which option might be good for you. => END

### *Agent Recommendation Script*

```
// computer analyzed user inputs of all options and generate the top choice
STATE: ANALYSIS
ACTION: $
    RANK_ORDER(_DSM_); // background calculation of the user input
    GO("RECOMMEND");
$

STATE: RECOMMEND
AGENT: So, I just did a quick analysis based on the information you provided.
It turned out that, =|GET("TOP_CHOICE")|= is the best option for you. </BEAT>$
USERMENU: Ok. => FEEL
    Show me more details. => RECOMMEND_DETAIL
    Why is it the best option for me? => EXPLAIN

// computer dynamically generate explanation
STATE: EXPLAIN
AGENT: =|GET("EXPLAIN1")|=
USERMENU: Ok.; Right.; Go on. => EXPLAIN2

STATE: EXPLAIN2
AGENT: =|GET("EXPLAIN2")|=
USERMENU: Ok.; Right.=> EXPLAIN3

STATE: EXPLAIN3
AGENT: =|GET("EXPLAIN3")|=
ACTION: EXPLAIN4

STATE: EXPLAIN4
AGENT: =|GET("EXPLAIN4")|=
USERMENU: Ok.; Right. =>EXPLAIN5

STATE: EXPLAIN5
AGENT: =|GET("EXPLAIN5")|=
USERMENU: Ok. => FEEL

STATE: RECOMMEND_DETAIL
AGENT: No problem. Here you are.
USERMENU: Ok.; I am done reading it. => FEEL
    Why is it the best option for me? => EXPLAIN_DETAIL

STATE: EXPLAIN_DETAIL
AGENT: =|GET("EXPLAIN1")|=
USERMENU: Ok.; Right.; Go on. => EXPLAIN_DETAIL2
```

STATE: EXPLAIN\_DETAIL2  
AGENT: =|GET("EXPLAIN2")|=.  
USERMENU: Ok.; Right.=> EXPLAIN\_DETAIL3

STATE: EXPLAIN\_DETAIL3  
AGENT: =|GET("EXPLAIN3")|=.  
ACTION: EXPLAIN\_DETAIL4

STATE: EXPLAIN\_DETAIL4  
AGENT: =|GET("EXPLAIN4")|=.  
USERMENU: Ok.; Right. =>EXPLAIN\_DETAIL5

STATE: EXPLAIN\_DETAIL5  
AGENT: =|GET("EXPLAIN5")|=.  
USERMENU: Ok. => FEEL

STATE: FEEL  
AGENT: How do you feel about this option?  
USERMENU: I like this option. => \$SET("USER\_OPTION",  
GetMixedCase(\_DSM\_, "TOP\_OPTION")); GO("LIKE\_SUGGESTED");\$  
I prefer a different test. => OPTION\_LIST  
I am not sure. => \$SET("USER\_OPTION", "Not Sure"); GO("NOT\_SURE");\$

STATE: NOT\_SURE  
AGENT: Is there another test you prefer to use?  
USERMENU: Yes. => OPTION\_LIST  
No. => NO\_PREF

STATE: NO\_PREF  
AGENT: That's okay. You do not have to decide now. Is there anything that prevents you from making a choice now? </BEAT>\$  
USERMENU: Yes, I need more information. => MORE\_INFO  
Yes, I want to discuss with my family or friends. => DISCUSS\_WITH\_FAMILY  
Not really. => END

STATE: MORE\_INFO  
AGENT: I understand. I recommend you make a list of questions that you want to get answers for and discuss them with your healthcare provider at your next medical appointment.  
USERMENU: Will do.; OK. => END

STATE: DISCUSS\_WITH\_FAMILY  
AGENT: Definitely, getting inputs from family members or friends are important when making a decision like this. I encourage you to have as many discussions as you need with your family or friends before making a choice that is right for you. => END

STATE: LIKE\_SUGGESTED

AGENT: I am glad to hear that. I would recommend you discuss this option with your doctor.  
USERMENU: Will do. => END

STATE: OPTION\_LIST

AGENT: Ok, which test do you prefer?

USERMENU: I prefer FIT. => \$SET("USER\_OPTION", "FIT"); GO("GLAD\_ANOTHER");\$

I prefer Stool DNA Test. => \$SET("USER\_OPTION", "DNA"); GO("GLAD\_ANOTHER");\$

I prefer Colonoscopy. => \$SET("USER\_OPTION", "Colonoscopy");

GO("GLAD\_ANOTHER");\$

I prefer not to be tested. => \$SET("USER\_OPTION", "Nothing"); GO("OK");\$

STATE: OK

AGENT: That's ok. You do not have to do any test if you do not want to.

ACTION: END

STATE: GLAD\_ANOTHER

AGENT: I am glad that you find a test you like. I would recommend you discuss this option with your doctor.

USERMENU: Will do. => END

*Farewell Script*

STATE: FAREWELL

AGENT: All right. That is all for today.

USERMENU: Ok. => THANKS

STATE: THANKS

AGENT: I want to thank you for participating in this study and I hope you have a nice day. Bye!

USERMENU: Bye-bye. => END