The Importance of Mental Models in Implementation Science

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Abstract

Background: Implementation science is concerned with the study of adoption, implementation and maintenance of evidence-based interventions and use of implementation strategies to facilitate translation into practice. Ways to conceptualize and overcome challenges to implementing evidence-based practice may enhance the field of implementation science. The concept of mental models may be one way to view such challenges and to guide selection, use and adaptation of implementation strategies.

Methods: A mental model is an interrelated set of beliefs that shape how a person forms expectations for the future and understands the way the world works. Mental models can shape how an individual thinks about or understands how something or someone does, can, or should function in the world. We review the concepts of mental models and illustrate how they pertain to implementation of an example intervention, shared decision making. A range of methods to elicit and analyze mental models are reviewed, including formal methods developed specifically for a given project.

Results: Mental models may be sparse or detailed, may be shared among actors in implementation or not, and may be substantially tacit, i.e., of limited accessibility to introspection. Actors' mental models can determine what information they are willing to accept and what changes they are willing to consider. We describe and illustrate multiple methods for eliciting and analyzing mental models including semi-structured interviews, cognitive task analyses and Delphi methods.

Conclusions: Understanding the mental models of actors in implementation can provide crucial information for understanding, anticipating, and overcoming implementation challenges. Successful implementation often requires changing actors' mental models or the way in which interventions or implementation strategies are presented or implemented. Accurate elicitation and understanding can guide strategies for doing so.

Background

People's views of the world, of themselves, of their own capabilities, and of the tasks that they are asked to perform, or topics they are asked to learn, depend heavily on the conceptualizations that they bring to the task.

-Donald A. Norman (in Mental Models, p.7)

Implementation science is concerned with adoption, implementation and maintenance of evidence-based interventions and use of implementation strategies to facilitate translation into practice.¹ The field has grown rapidly and has resulted in the development of frameworks, theories and approaches that assist in overcoming challenges to implementation difficulties.²⁻⁴ However, as in every field, there is still much room for understanding and insight.

One approach is to identify root causes of implementation challenges and then apply appropriate implementation strategies to overcoming these challenges.⁵ Another is to identify and study the mechanisms of action that explain how and why an implementation strategy works.⁶ Indeed, much recent work has involved the cataloging and selection of implementation strategies and identification of mechanisms or determinants of implementation outcomes.^{6,7} However, the field still struggles with ways to understand why interventions do and do not work – what is lacking when they don't get taken up and what was the in the “secret sauce” when they are successfully implemented and sustained?⁸ Certainly, frameworks such as the Consolidated Framework for Implementation Research (CFIR),⁵ integrated Promoting Action on Research Implementation in Health Services (iPARIHS),⁹ the Practical Robust Implementation and Sustainability Model (PRISM),¹⁰ and the Integrated Sustainability Framework⁸ can point to places to look for challenges. Perhaps there are other ways to consider the “big buckets” of implementation challenges by their root causes rather than the settings or actors or intervention characteristics.

We have found it useful to consider the concept of mental models as one of those big buckets. A mental model is an interrelated set of beliefs that shape how a person forms expectations for the future and understands the way the world works.¹¹⁻¹⁵ Mental models shape how an individual thinks about or understands how something or someone does, can, or should function in the world.¹¹ For example, a person's mental model of shared decision making (SDM) includes how they understand what shared decision-making is, how it functions, what it looks like in practice, and their role in it. One person's mental model of SDM may include use of decision aids to talk through a process; another person's mental model may focus on creating an environment of trust for the patient to make their own choice. Thus eliciting, understanding, and acting upon how different individuals and groups conceptualize mental models can be critical elements in health care improvement because they might reveal implementation challenges that seem unclear or intractable. Of course, another big bucket of challenges are ‘external’ and the practical ones – like having enough resources (money, time, people) to get an intervention to happen, or lack of knowledge or training. These challenges, though certainly important determinants,¹⁶ seem to have a different more on-the-surface quality to them, however, that make them qualitatively different from the kind that are perhaps more entrenched and more difficult to pinpoint, and perhaps also change, such as mental models.

In this paper, we propose that understanding mental models may separately and uniquely advance the field of implementation science (IS). We describe what mental models are, methods for eliciting and measuring them, and speculate about potential strategies to influence, adapt or at least understand them to enhance implementation efforts. Throughout, we use the example of shared decision-making¹⁷ as a multi-level

complex intervention to describe and explain the concepts presented.¹⁸ We conclude by discussing directions for clinical application and future research.

What is a Mental Model?

The concept of a mental model is used somewhat differently across disciplines, however, we adopt the view that a mental model is a person's mental representation of the way some aspect of the world works.¹⁴ More specifically, mental models are comprised of interrelated memories and conceptual knowledge that create an understanding of how something works in the real world and forms expectations about future events. For example, many, if not most, individuals in the US have a mental model about what happens, and in what order, when we have an appointment with our primary care physician: We check in, maybe pay a copay and fill out some forms, wait in the waiting room for our name to be called by a staff member who then measures weight and blood pressure, and assigns us to an examination room where we wait for the doctor/provider. This particular set of conceptual knowledge and expectations are formed primarily by our personal experiences and might also be formed by the transfer of cultural knowledge through media and social networks.

Mental models can be held with varying degrees of specificity and stability and are shaped by our knowledge and experiences. For example, a physician is likely to have a very different mental model of a primary care appointment than a person who has only been a patient. A person in a low or middle income country, or a person from a low-income background whose primary health care system contact has been with the emergency department, may have a different mental model of a primary care appointment, or may not have a mental model at all. As a result, they may have no expectations or different expectations for what will or should happen. To our knowledge, mental models have not been applied to patient physician communication. It is possible that errors in communication might often be rooted in a lack of a shared mental model, in addition to (or instead of) more obvious problems such as lack of a shared first language or other communication challenges.¹⁹

Mental models are always inaccurate to some extent, insofar as they are heuristics and involve stereotypes and expectations to make sense of the world. They cannot encapsulate all aspects of the world and tend to make imperfect predictions. When commonly shared mental models make inaccurate predictions, it can be a source of scientific insight and psychological fascination. For example, a common incorrect mental model about the physical world is that heavier objects fall faster than lighter ones. This mental model results in the expectation that a 20-pound ball will fall faster than a one-ounce ball, an expectation that was disproved compellingly by Galileo, but that is so intuitive that we must continue to dispel it in schoolchildren today.

The beliefs that comprise mental models can be explicit or tacit. *Explicit* beliefs are sometimes called the “know-what”²⁰ because people know what they believe to be true and can claim it. *Tacit* beliefs, on the other hand, are beliefs that are difficult to articulate. Drawing from our previous examples, beliefs about what happens at a doctor’s appointment are probably explicit in the sense that they are easy to articulate and we know roughly how these beliefs formed (i.e., from prior experiences going to the doctor). By contrast, beliefs about how fast different-weight objects fall is probably tacit in the sense that most people cannot explain why they believe that heavy objects fall faster than lighter objects, and the origin of this belief is similarly opaque.

The beliefs and expectations that are formed by our mental models sometimes become obvious (i.e. less tacit) when they are violated. For example, a wait of 10-20 minutes to see a doctor might be within scope of expectations, but a 45-minute wait would violate most people’s mental model about what is supposed to happen and trigger a complaint or visit back to the check-in desk. In this example, a violation of a mental model results in behavior to identify how or why that violation occurred.

Importantly, mental models have implications for how new information is accepted or rejected. When new information contradicts a mental model, we usually must make a choice: either change the mental model to incorporate the new information or change our view of the information to fit with the existing mental model, the latter of which could include rejecting, ignoring, or reinterpreting the new information.²¹ For example, research has shown that diagnostic labels can trigger patients to apply broad mental models which results in expectations for both treatment and disease progression.²² This creates a communication problem when the recommended course of action contradicts the mental model (e.g. a recommendation of active surveillance for “stage 0 breast cancer” violates most people’s mental model of what cancer is and how it progresses).²³ Patients must choose between either: a) changing their mental model versus b) rejecting the information. When new information contradicts a core belief of the mental model, it is usually far easier to reject the new information. Hence, mental models have important implications for learning, and for disbelief and resistance to and/or misunderstanding new information.

At this point, we have briefly touched upon the various characteristics of mental models. They can incorporate beliefs that are easy to articulate (i.e. explicit) or more tacit or “intuitive” in the sense that the beliefs themselves and the origin of those beliefs cannot be easily explained. Mental models can be more or less complex, a feature that usually depends on the depth of a person’s knowledge and experiences. They are comprised of beliefs that are “core” to the model versus beliefs that are more peripheral and inessential. Mental models can be more or less accurate, and more or less adaptive, in the sense of forming accurate predictions about future events. They can be shared between many people, cultures and

subgroups as a result of common experiences although it is important to keep in mind that mental models that are widely shared are not necessarily accurate (harkening back to Galileo's experiment).²⁴ Finally, mental models have implications for learning, interpretation and acceptance of new information, insofar as new information is more likely to be accepted if it can be easily incorporated into existing mental models.

How Mental Models Create a Barrier to Implementation: The Example of Shared Decision Making

Shared decision making is “a process of communication in which clinicians and patients work together to make informed healthcare decisions that align with what matters most to patients and their individual concerns, preferences, goals, and values.”²⁵ Recently, there have been policy efforts and even payer mandates for shared decision making. However, despite strong efficacy data on the effectiveness of decision aids and shared decision making, the implementation of shared decision making in real world settings has been minimal, and when successful, is rarely sustainable. There has been a host of efforts to describe “barriers” to shared decision making.^{17,26} Considering these barriers through the lens of mental models provides some clear examples of how the mental models of the parties involved in implementation could potentially be powerful drivers of implementation outcomes.

One example is the implantable cardioverter-defibrillator (ICD) for the prevention of sudden cardiac death for patients with heart failure. Recently, CMS mandated shared decision making with the use of a decision aid for this intervention.²⁷ However, there has been resistance to shared decision making for implanted defibrillators by clinicians and there are concerns that it is nothing more than a check box.²⁸ In our ongoing work on implementation, we have observed several mental models that seem to be influencing shared decision making in this space. For example, clinicians report things like (paraphrased from discussions to exemplify the underlying mental models), “I already do shared decision making”; “patients don't really have the capacity to understand the medical nuances”; or “I just don't have time for this.” Digging more deeply, there are often unsaid (and perhaps more powerful) mental models like, “my job is to help patients live as long as possible and I want them to get the ICD.”²⁹ At the patient level, mental models appear to also be influencing the implementation of shared decision making with comments like: “I trust my doctor and I'll do whatever they say”; or “This must be a good therapy because technologies are good.”^{30,31} The converse can also be true when someone has a mental model of distrust which could be one of the drivers of the observed disparities in ICD use.

Cancer screening is another active area of research in the shared decision-making space. In addition to the mental models discussed above, cancer itself seems to come with its own set of mental models around cancer itself like “cancer grows quickly and will kill you” and “why would it ever be bad to know about cancer.”³² These mental models are often formed through personal experiences and vast messaging

around cancer in society. Together, these mental models which exist with both patients and clinicians make it very difficult to explain complicated concepts like false positive test results and harms of screening and subsequent testing/treatment.³³ As such, cancer screening is often seen as a mandate rather than a preference sensitive decision and this has certainly influenced low uptake of shared decision-making. An infographic developed by Gilbert Welch and disseminated by the National Cancer Institute is an interesting illustration of an attempt to modify the common mental model that all cancers grow and kill; using an animal metaphor, it explains that some cancers are “turtles” (growing so slow that they will never cause problems), some are “birds” (growing so fast that they cannot be caught), others are “rabbits” (these are the ones that screening benefits).³⁴

At the same time, mental models can be powerful drivers of successful implementation. In the case of shared decision-making for left ventricular assist devices (LVAD), there are strong mental models that the therapy is highly invasive, can be both beneficial and harmful, that the clinicians have time to do shared decision making and want their patients to be informed, and that the existing industry materials are biased.³⁵⁻³⁹ The convergence of mental models in this space is serving as a powerful driver of adoption and implementation of shared decision making.⁴⁰ The failure of such convergence can, conversely, also result in failed implementation. We present Figure 1 to demonstrate a common cascade of events stemming from lack of attention to mental model issues during the planning and implementation phases of a new intervention.

These examples highlight the importance of understanding mental models when pursuing implementation work. Understanding these mental models will inform key aspects of many implementation strategies including targeted messaging and implementation support.

Methods

How to use Mental Models in Overcoming Implementation Challenges

If we accept that mental models can have a powerful influence over whether implementation happens or not, or happens well and is sustained, it would be helpful to know how to identify an individual or group’s mental model and assess if these mental models are creating a barrier to implementation.

First, where are the places that mental model issues might be lurking? As a starting point, if we utilize the framework of the Practical, Robust, Implementation and Sustainability Model (PRISM; Figure 2), it provides guidance that there are different contextual factors in different places that guide whether we get to the outcomes of reach, effectiveness, adoption, implementation and maintenance (RE-AIM outcomes, which are part of PRISM). There may be mental model issues with the intervention itself at either the organization

or recipient levels, or about the overall issue in question at the organization or recipient levels, with the implementation structure of the organization, or community, or the larger external environment. As seen in Figure 1, mental models of different ‘recipients’ in PRISM terms that do not align can create failure to implement. Or perceptions about the changing external environment (e.g. expectations about what may be coming concerning reimbursement for shared decision making) can increase or decrease use of shared decision making. Finally, mental models of different amounts and types of resources needed for the PRISM category of “Implementation and Sustainability Infrastructure” can lead to confusion or failure to provide sufficient support. For example, implementation of a decision aid to encourage shared decision making around a particular issue may be difficult in a practice where the majority of clinicians do not have a good mental model for how to use a decision aid, or if their mental model for shared decision making includes that it takes an exorbitant amount of time, or if their mental model of the decision causes them to believe that the decision should not be shared. Therefore, it may be wise for the implementation researcher or practitioner to identify “where” the mental model issue or issues may be residing. This provides valuable information about what might be a possible avenue forward for resolving the issue, if possible. Some mental models are entrenched into such immutable values that changing is unlikely or will take much effort over an extended time period.

Beyond “where” to look, how can you identify mental models? Essentially, the best way is to interact with the individual or group of interest to discover what is inside their thinking. We provide Table 1 as a list of ideas for methods of elicitation of mental models. Note that some are more helpful for initial ideas when you don’t know what the mental models might be (such as interviews) whereas other methods are more appropriate when some idea of the mental model might exist and then narrowing down to more explicit understanding is needed (such as card sort). A main point is that the individual seeking to elicit the mental model try to delve deep into understanding the “root causes” of the issue rather than remain on the surface; and to remain open to the more nuanced information the participant is providing. Also, some methods have been developed specifically for eliciting mental models, such as cognitive task analysis, whereas other more general methods, such as interviews, can sometimes lead researchers astray. It is much more likely in the latter case to get sincere and coherent narratives that just do not accurately capture important facets.

Once you have this information from the elicitation, then what do you do with it? How do you understand what you have identified? There are generally two steps left to complete your assessment: 1) analysis and 2) representation. Analysis can be undertaken in the way that most analysis is done, drawing upon quantitative and qualitative methods or usually best, a combination.⁴¹ For example, a quantitative approach might use a survey and compute descriptive statistics to describe the sample, or qualitative interviews might be analyzed using thematic analysis. These methods produce results about the mental model’s information you have been examining. The key is an in-depth enough exploration of key individuals’ mental models so that the implementation scientist can anticipate how these mental models

might create barriers to implementation through using an “implementation ladder” as provided in the example of Figure 1.

However, there are implementation strategies we might start with that have more immediate potential for mental model examination. We present Table 2 to encourage a conversation about these implementation strategies and their potential for mental model exploration. As a caution, we do not propose that identifying mental model issues and matching them with the “right” implementation strategy. Unfortunately, it will likely not be that simple. However, we offer a pathway to consider in which one might navigate, a process if you will. Please refer to Figure 3 for a suggested pathway to considering mental model challenges and how researchers and quality improvement leaders might navigate through the decision process. Researchers and implementers may also be helped by the conceptualization of how to select implementation strategies by considering both the form and the function as suggested by Mittman, et al.¹⁸ The function being the issue to be addressed and form to be the way it is delivered. We extend that mental models might be one type of issue to be addressed (a function) and the form to be determined by the stakeholders within the context. Additionally, an understanding of mental models is important when considering adaptations. For example, mental models can influence the type and purpose of adaptations made. Figure 3 does not completely address the issue of adaptation explicitly, however, we acknowledge that mental model issues often are part of adaptations as learning occurs through development.⁴⁶

Results

Considerations for use of Mental Models in Implementation Research – Some Questions and Possible Answers

What is useful out of this exercise and what might any of those reading this paper do with this information? First, the concept of mental models is perhaps most useful as a way of seeing the world, such that an explicit understanding of its existence and potential influence may shape the way implementation and research about implementation is approached. Therefore, we hope that one of the primary contributions of this paper is create a shared mental model about mental models for researchers or scientists. It enhances our world view of what is possible in research and what we can do in this field. Although this paper is grounded in implementation research, the closely developing area of improvement science that expands upon quality improvement work may also prove fruitful for those engaged in that work. There may be tools that could be developed for rapid elicitation of mental models for front-line clinicians and quality improvement specialists and their teams.

Do you need to be an expert to use the advice in this paper? The answer we hope is no, and that the research skills known already in the areas of quantitative and especially qualitative research will serve well in exploring mental models. The places where analysis is likely to get very complicated is the sorting out the pathways, the why, the influence of context and the various intersecting issues. For more complex

analyses, coding or applications, consultation and involvement of an expert in decision science may be recommended.

Last, the question must be asked – is it possible to change mental models? Yes, of course. This is the purpose of many of the implementation strategies available currently such as education and training, facilitation, reflection and audit and feedback. Each has an element of helping individuals and teams consider their beliefs and then have those beliefs questioned, such that each individual has the opportunity to form new belief systems. Interventions do have the ability to make changes and result in better care.⁴⁷ Do people actually change their mental models? Sometimes, no, they do not. Deeply held beliefs are often intractable. They do not change. Yet, knowing about these entrenched beliefs or ways of seeing the world will help us to know how perhaps we can provide information that will facilitate change even in the face of opposing mental models.

Discussion

While partially overlapping with some other concepts and work in the field of implementation science we propose that the consideration of mental models may be a unique lens through which to view implementation research. Mental models strongly influence how individual and groups think both explicitly and implicitly about tasks and priorities, shape how new initiatives get formed and take off (or not) and have implications for future work in the field.

This paper has focused predominantly on conceptualization of and potential for use of mental models in implementation science. We have illustrated their importance and provided examples of ways to assess mental models. At present it is speculative to describe exactly how mental models can be used to guide implementation and adaptations, but they seem very relevant to help diagnose and address key processes in the steps to successful/failed implementation. Limitations of this work include the need to further test and valid the concepts put forth in this paper. Although a large body of research exists illuminating the importance of mental models to other fields, it has only minimally been specifically applied to implementation science in the ways described here. Future research is needed to empirically test a) the predictive validity of mental models compared to other conceptual approaches; and b) the comparative effectiveness of interventions including versus not including mental models approaching to implementation.

Conclusions

Examination of implementation work with a mental models lens may create new opportunities for intervention and/or implementation strategies to be addressed in new ways or to identify pathways to failed implementation that can illuminate better understanding of how and why those interventions and/or implementation strategies are working (or not working). We are limited by our current tools, but future research could develop methods by which mental models may be reliably and pragmatically assessed and used to guide implementation strategies and adaptations.

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- JH: Provided the outline, conceptual guidance and implementation science specific content. Completed the final manuscript after approval by all authors.
- LS: Participated in conceptual development and writing of manuscript. Read and approved final manuscript.
- DM: Participated in conceptual development and writing of manuscript. Read and approved final manuscript.
- RG: Discussed and contributed to the outline and content; drafted sections of the manuscript; reviewed, edited and approved the final submission. His contributions were supported in part by grant P50 CA244688.
- LG: Participated in conceptual development and writing of manuscript. Read and approved final manuscript.
- All authors read and approved the final manuscript.

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Tables

Table 1: Overview of Common Mental Model Elicitation Methods		
Method	Description	Considerations
Survey	A series of questions with a closed ended response format (e.g., Likert scale from 1-5)	Efficient way to measure specific beliefs from a large group when one knows what the range of beliefs can be. Less suited for eliciting complex relationships in mental models. Models may have to be inferred.
Forced choice	A series of two-option choices presented to a participant, who is asked to choose one option over the other based on some criterion (e.g., preference, commonness, cost)	Suitable for eliciting rank and order among a narrower set of beliefs known beforehand. Less suited for eliciting complex relationships in mental models.
Card sort	A task in which the participant is given a set of cards with concepts to arrange in a way that is meaningful to them, either according to some set criterion (e.g., causal relationships) or not.	Suitable for eliciting grouping, sequencing, taxonomies, or processes. Cards can include images or be left blank for participants to fill-in.
Semi-structured interviews	An interview in which a set of questions is prepared beforehand but can be deviated from opportunistically to learn more about the target topic.	More accurate and complete representations of mental models. Can capture complex relationships, but is time-consuming, expensive, and requires skilled interviewers.
Cognitive task analysis ^{48,49}	A specific type of interview designed to elicit mental model and macrocognitive processes	Specifically designed to elicit and improve how teams function together in real world circumstances, but requires expert interviewers
Causal mapping ⁵⁰ and dynamic system diagraming ^{51,52}	Mapping out causal relationships, feedback loops, and causal conditions/ or rules.	More accurate and complete representations of causal relationships in mental models, but is time-consuming, expensive, and requires skilled interviewers.
Delphi process	Multi-phase process of eliciting beliefs from several individuals, synthesizing responses, and sending the synthesis back for feedback.	Useful for building a shared mental model among non-co-located individuals and identifying points of disagreement. The process is slow and can be expensive (may need to pay experts).
Observation	Watching the performance of an individual or groups of individuals by an objective observer.	Because only behavior is observed and cognitions are not elicited, beliefs need to be inferred, unless recorded and combined with retrospective think aloud (see below).
Think aloud	A process in which the participants explains aloud what she is thinking as she performs a task (concurrent) or watches a recording of herself performing a task (retrospective).	Concurrent think aloud requires some practice by both the interviewer and participant and can sometimes interfere with the task. Elicits rich information about mental models in context.
Synthesizing documents	Using existing documents, such as reports of adverse events and near misses, to infer beliefs and connections between beliefs.	Mental models are inferred and verification would require an additional method.

Table 2: A Few Implementation Strategies with Mental Model Illustrations and Examples with the Concept of Shared Decision Making		
Implementation Strategy	Mental Model Issue	Example with Shared Decision Making
Audit and feedback	Participants may have a misperception of how they perform relative to others	Providing audit and feedback may demonstrate the clinicians who believe they are completing SDM at a high level are actually below average
Training	Staff members may not be aware of the contextual factors or influencers involved or how to address them	Staff may not take the time to set up the visit for SDM because they don't understand the value of it for the patients
Collaboratives	Teams may be thinking differently about how to approach a quality improvement problem	Bringing teams together to discuss and utilize tools and approaches to determine common understanding around why SDM is important and how it can be organized

Abbreviations

- CFIR: Consolidated Framework for Implementation Research
- iPARIHS: integrated Promoting Action on Research Implementation in Health Services
- PRISM: Practical Robust Implementation and Sustainability Model
- SDM: Shared Decision Making
- RE-AIM: Reach, effectiveness, adoption, implementation, maintenance
- ICD: Implantable cardioverter-defibrillator
- LVAD: Left ventricular assist devices

Figures

Figure 1

Pathway of Failed Implementation

The Practical, Robust Implementation and Sustainability Model (PRISM)

Source: Feldstein AC, Glasgow RE. A practical, robust implementation and sustainability model (PRISM) for integrating research findings into practice. *Jt Comm J Qual Patient Saf* 2008; **34**(4): 228-43. Used with permission.

Figure 2

PRISM

Figure 3

Mental Model Consideration Pathway

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [AGREEReportingGuidelineChecklistforMentalModelspaper.docx](#)