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Mental models: a basic concept for human factors design in infection prevention

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SUMMARY

Much of the effort devoted to promoting better hand hygiene is based on the belief that poor hand hygiene reflects poor motivation. We argue, however, that automatic unconscious behaviour driven by 'mental models' is an important contributor to what actually happens. Mental models are concepts of reality – imaginary, often blurred, and sometimes unstable. Human beings use them to reduce mental load and free up capacity in the conscious mind to focus on deliberate activities. They are pragmatic solutions to the complexity of life. Knowledge of such mental processes helps healthcare designers and clinicians overcome barriers to behavioural change. This article reviews the concept of mental models and considers how it can be used to improve hand hygiene and patient safety.

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Once upon a time ...

... a senior infection control physician set out on a covert mission to observe hand hygiene in an intensive care unit. He selected a room with three patient bays, the outer two of which were occupied by intubated, sedated patients. It was around 3 o'clock on a late summer afternoon and a gentle sunlight was filtering through the blinds of the large windows. There was none of the usual hectic activity in the room, only the soothing sound of the two ventilators going in and out of sync. A young nurse who was sitting at the computer terminal by one patient seemed also to be responsible for a second patient, whose bed was beneath the window. The curtains between patient bays were half open so she could see both

patients from where she was sitting. The physician introduced himself as an infection control physician interested in the physical environment of the intensive care unit. He asked the nurse about the process of cleaning the bays between patient admissions, how cleaners knew what to do and if there was always enough time for the required procedure. The nurse replied with her views and the conversation turned to her very recent participation in simulation-based hand hygiene training a few days earlier. She reviewed the training enthusiastically, saying that she found the 'My five moments of hand hygiene' concept plausible and helpful.¹ During this exchange, an alarm on the second patient's monitor went off. The nurse went over, silenced the alarm on the monitor while establishing what was wrong, adjusted the ventilator tube, and checked the infusion pumps and the infusion hubs. This happened three times during the twenty-minute conversation. To the astonishment of the observing physician, she completely ignored all the hand

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hygiene indications both before and after touching the patient or his surroundings, resulting in a compliance rate of 0% for six hand hygiene opportunities. After a while, a technician arrived to attend to the continuous haemofiltration machine of the second patient, equally ignoring most of the hand hygiene opportunities while wearing the same pair of gloves for the whole care procedure (overall compliance, 25%). The physician ended the conversation with the nurse and, in line with his covert observation protocol, left the intensive care unit without mentioning her hand hygiene lapses. This is a true story of events some years ago at a major tertiary care hospital in Switzerland. It suggests that we need to change our thinking about hand hygiene performance and infection prevention strategies.

When assessing the verbalized attitudes and beliefs of this nurse against the theory of planned behaviour, she would certainly score high on intention to act.² She expressed positive beliefs about the outcome of the activity, and she would probably also have responded positively if questioned about social norms.³ Moreover, the behaviour in question was not obstructed by any of the frequently cited barriers to hand hygiene – since time pressure did not appear to be an issue, and hand-rub dispensers were abundant and conveniently located around each bed.⁴ Why, then, did she fail to act as she intended?

The conscious mind's bias of being in control

The mismatch between the expressed intentions and the actual behaviour of the young nurse is just one pointer to the now widely accepted belief that certain processes that determine behaviour are unconscious. The attempt to better understand these processes has led to an operational definition of unconsciousness as 'a lack of awareness regarding the influences or effects of a triggering stimulus.'^{5,6} The psychologist and Nobel Prize winner in economics, Daniel Kahneman, has shown elegantly how our unconscious minds control our judgement and behaviour – and that we are 'hardwired' to ignore this fact. An evolutionary explanation for our brains working this way is easy to accept if one considers the advantages, for survival in a hostile environment, of quick and intuitive actions. Furthermore, deliberate thinking requires effort and draws on limited mental resources. Relying on intuition to make sense of complex situations quickly and so remain in action may therefore be seen as an 'economic' necessity.

The theory of mental models

It is postulated that human beings understand the world by unconsciously forming working 'mental models' of the things they observe.^{7,8} Such models are internal images, gathered through experience and observations to collectively form an internal representation of the individual's understanding of the world around her. These 'small-scale models' of external reality are then unconsciously projected on to subsequent experiences, serving as a guide to interpret new observations and make predictions.⁹ It is worth noting that whereas mental models form the basis of how we understand and communicate with the world, they are by no means complete, nor necessarily accurate, representations of reality.⁸ They are pragmatic

solutions for dealing with complexity. A popular example is the London Underground map, an iconic representation of the real network of tunnels and stations. The map is useful to get from station A to station B, but not at all geographically accurate. Adding information to a model does not necessarily make the model more useful. Indeed, the simplistic nature of mental models may be the key to their utility, enabling faster intuitive decisions. Similarly, it is the simplicity of the London Underground map (in not portraying real distances in scale) that makes it so is easily readable.

We are largely unaware of our constant recourse to mental models. Cues in the external environment serve as triggers, unconsciously activating relevant mental models. Predictions are then generated based on these mental models, which provide a shortcut, allowing consequent actions to be executed quickly, without conscious deliberation each time a similar set of inputs is encountered. This feature of mental models is what makes them simultaneously economically efficient and yet highly susceptible to error.

Since they rely heavily on past experiences, mental models may be activated in response to environmental stimuli that appear similar, yet are fundamentally different from previously experienced situations – resulting in false predictions and suboptimal behaviour. For example, in a study of home thermostat use, Kempton revealed two commonly held mental models among Michigan residents about how thermostats function.¹⁰ One particular mental model predicts that setting the thermostat to a higher temperature increases the rate with which heat is released. This mode of operation is learned through previous experience with gas burners and water valves, where increasing the setting increases the rate of flow. It is, however, an inaccurate mental model when applied to thermostats, which actually monitor current temperature and adapt flow of heat in order to maintain the desired setting. This inaccurate mental model causes many people to operate thermostats ineffectively, resulting in wasted energy and high costs.

Moreover, two people faced with the same situation may hold different mental models. If left unresolved, this variation may present challenges for team coordination, as different individuals respond differently to the same cues. Contradictory mental models may even exist within the same individual. One can easily imagine how such a system can lead to misguided reasoning and behaviour. That is why the concept of mental models is useful to those interested in dealing with human error.

There are two opportunities for avoiding erroneous perception and behaviour based on mental models: human factors design and individual 'mindfulness'. Here we elaborate only on the former.

Mental models at the core of human factors design in healthcare

Human factors design is the scientific discipline that seeks to optimize the interactions among humans and other system elements, particularly in work environments, for the benefit of both well-being and overall system performance (International Ergonomics Society, 2000; <http://www.iea.cc/whats/>). Over the past decade, human factors design has been increasingly recognized as a tool for optimizing healthcare, particularly in the field of patient safety and infection prevention.^{11–18} The

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