

Modelling Individual Hand Hygiene Habits, Through the Introduction of a Smart Digital Dispensing System, in a Healthcare Institution

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Abstract: In general, properly performed hand disinfection, by healthcare workers, plays a crucial role in reducing the number of nosocomial infections. My research project focuses on a ward of a health care institution, where a digital dispensing system has been installed. This system detects which dispensers have been used for hand disinfection and it also detects instances when hand disinfection should have been carried out, but was not. Additionally, by dividing the entire staff into no more than 4 main groups (physicians, nurses, technical personnel and other employees) information can be gathered on the hand hygiene practices of each group. In my case study, I used 25 semi-structured interviews, to demonstrate which of the learning processes facilitate proper hand hygiene practice, which are the factors that help and impede the proper execution of hand disinfection. The third part of my exploratory research, aimed to present the impact of the introduction of a digital dispensing system on hand disinfection habits. My research project applies a new approach, by using the theoretical background of viewing hand disinfection, from the perspective of habits and analyzing my main lines of inquiry against this background. Informal learning, i.e., learning from practices, as opposed to formal learning, plays a prominent role in learning processes. This means that the workplace has a key role in the transfer of the correct knowledge to healthcare workers, in order to increase the effectiveness of hand disinfection. The acquisition of hand hygiene knowledge is facilitated by presentation materials incorporating abundant visuals and small group practical lessons using fluorescent demonstrations to teach proper rub-in technique. The availability of point-of-care dispensers promotes good practice, which is further supported by the introduction of a digital dispensing system. By presenting the hand hygiene results achieved by the teams, the use of digital dispensers creates a competitive environment, thus, providing an organizational framework for the effective implementation of the individual learning process, in this case, the practice of proper hand disinfection.

Keywords: hand disinfection; hand hygiene training; habits; learning modelling; digital infection control

1 Theoretical Background

1.1 Conceptual Evolution of Habits

Aristotle called “habit”, an acquired disposition which is necessary for the performance of certain types of actions. According to Aristotle, habits show our truest self, because a habit is an action that is done without thinking [1].

The associationism school of psychology views habit as the atomistic element of human behavior [17], where habit is created as the result of associations of the response evoked by the stimulus. This view has long dominated much of the research on habits. These – often forced – divisions seldom lead to a full understanding and this is also true in the case of habits, and a different view, the organicism school of thought, breaks with the divisions and sees habits as dynamically configured, stable patterns that become reinforced and linked to the individual. Followers of this school of thought tend to focus their research on the balance between the organism and its environment, in which the individual and its environment are in constant interaction [1].

Today, it is clear that the ecological systems approach is gaining ground in science, including the science of psychology, whereby multi-level, complex interactions are studied and psychological processes and human behavior are interpreted within this system of interactions [27]. If our actions are subjected to increased cognitive control during the interaction, then habit can be construed as a learning process [4].

Since the turn of the millennium, a strengthening second generation school of thought in psychology has been asserting that human thinking cannot be independent of bodily existence, i.e., the functioning of mind and body are inseparable from each other. The “concept of cognition has also been transformed – it no longer means information processing separate from emotions, perception, and movement, but integrated processes supporting meaningful action in the world” [27] in the organicism tradition, cognition is being explored along what we would today call more ecological, self-organizing lines. According to the organicism concept of habit, it is a trained motor behavior that involves the whole body and the surrounding environment [15].

Psychology and neuroscience define habit as a type of decision-making process in which the same behavior is always performed in the same context, regardless of the outcome [5].

The results of basic neuroscience research on habits suggest that habits are multifaceted, rather than simple stimulus-response behaviors [26]. Today the

clarification of the concept of habits is becoming increasingly prominent in academic discourse.

1.2 The Definition of Habit

In describing the conceptual development of habit, I have presented the main directions of research, and in this section I present habit as a mandatory stimulus-response (S-R) approach, since most research aims to describe habitual behaviors and life habits by means of this association. The best explanation is that human behavior is unlikely to be the result of a single S-R response, but is driven by complex processes, including both simpler decision-related actions and actions at a more abstract level [32]. In the case of lifestyle habits, our actions at the more abstract level become habits, and in the case of “slip-of-action” habits, the lower-level actions become habits.

When there are intermediate computations between stimulus and response, there is an opportunity for the final behavior to become habitual in a different way [32]. In such a case, the stimulus – instead of triggering a direct response – results in the selection of a certain goal, and the action necessary to achieve this goal is carried out. Thus, the process is broken down into stimulus-goal and goal-response actions, and either of these can become a habit. See Figure 1, abbreviations: R = response, S = stimulus.

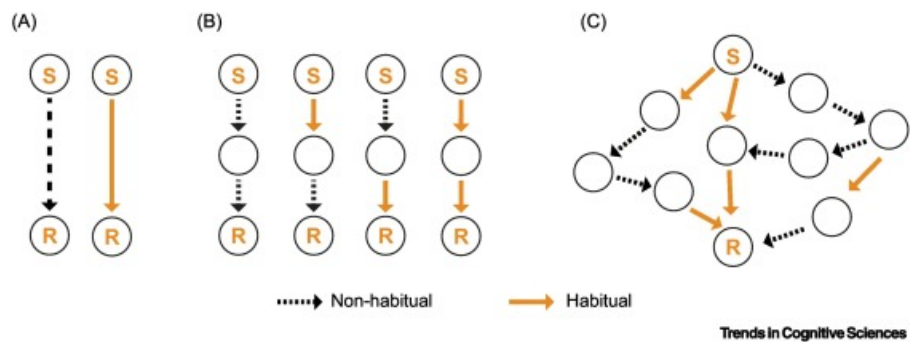


Figure 1
Stimulus-response reactions [32]

Generally speaking, habits are the results of complex processes and associated computations, where a stimulus is connected to a final response. The final response rarely follows directly from the stimulus and often it is reached through multiple intermediate detours. These are the intermediate computations.

1.3 The Relationship between Habits and Habitual Behavior

The lay definitions are mainly descriptive, characterizing habits as behaviors that often or permanently form part of our behavior. Scientific definitions, on the other hand, are explanatory as well as descriptive, while seeking to identify causality in the formation of behavior. These reasons can relate to past experiences and the underlying mental processes of the repetition of habits. Based on this, one of the fundamental ideas about the concept of habits is that these are formed by the activation of S-R (Stimulation-Response) associations [8].

Repeated past behavior is a key element in the formation of the habit and, once established, it promotes the formation of future behavior [14]. Based on the theories of habit research, habit and implicit beliefs can evolve side by side and reinforce each other over time [12].

In economics, the most commonly used model for studying the habits of individuals is to predict their future habits based on their recent behaviors. In the health care sector, due to the limited sampling opportunities, these ideas have not yielded a large number of research studies. With the introduction and use of digital tools capable of generating large volumes of data, it has become possible to investigate which of the multiple contextual variables are associated with the development of an individual's habit, and to infer how quickly habits develop. More than 40 million hand washing habits were observed in 2 hospitals over a 2-month period [5]. The outcome of the study supported the previous hypothesis that individuals' recent habits are highly likely to predict their future habits. The results suggest that the form of the hand-washing habit takes weeks and it is more likely to involve chains of sensorimotor actions that can be automated [5] and thus more quickly formed into a habit.

1.4 The Relationship between Automatism, Skill and Habit

Practice helps build automatism, which in turn helps accelerate response, while reducing cognitive load and promoting the habituation of behavior. Therefore, the primary function of practice here is to enable the individual to gain sufficient experience to establish this predictable process, which we call routine, where skill, habit, and cognitive load are all closely related [13].

In practice, the role of the testing of motor learning is to increase the speed at which an individual can perform multi-part tasks through practice, so that reaction times decrease exponentially during sequence learning.

Motivation has a role in moving habits from fully automatic processes to more controlled behavior based on outcome representations [21] [22]. Motivation improves performance and pushes the individuals beyond their normal limits.

Motivation allows more aggressive correction of errors as well as improves cognitive and motor accuracies [20].

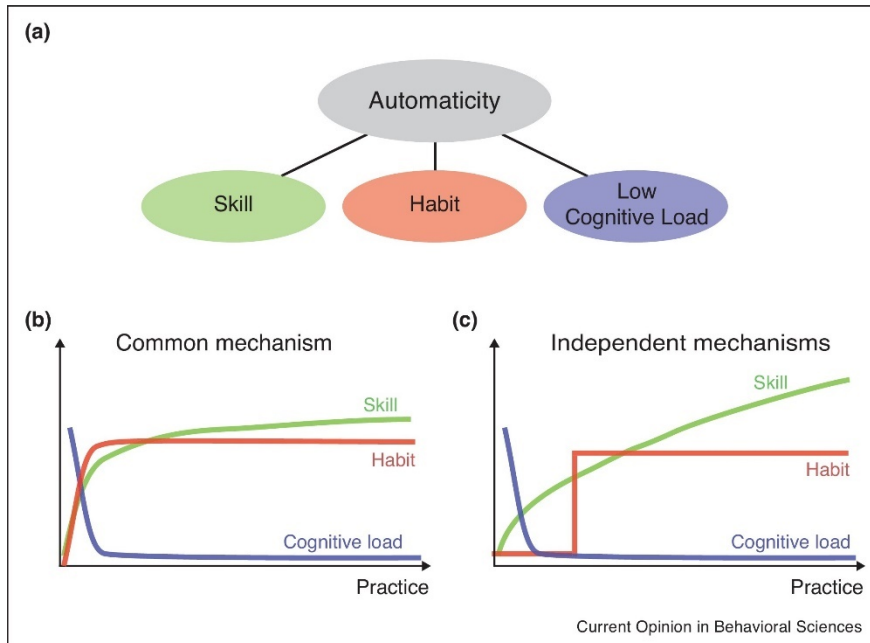


Figure 2

Components and time course of automatism; adapted from Haith 2018 [13]

2 Methodology

Following research objectives proposed by Maxwell [23], I chose a qualitative research method for my study. My aim was to achieve a fundamental understanding of the meaning of events and situations from the point of view of the participants, to understand the specific context in which they acted and the impact of that context on their actions.

My research aimed to discern what causes the activity to happen or not to happen, to search for the causal links involved in the correct performance of a specific activity, in this case hand disinfection, and to gain an understanding that facilitates the correct performance of hand disinfection in the long term.

Accordingly, I have chosen a qualitative methodology for the research, and I have collected data by conducting face-to-face and online interviews.

The purpose of this work is to better understand:

- 1) What learning processes did the interviewees experience and which of those promotes the correct hand disinfection procedure.
- 2) What factors help and impede the proper implementation of hand disinfection.
- 3) The broader context of the impact of a digital dispensing system's introduction on hand disinfection habits.

2.1 Sample Selection

In my research, I used targeted sampling. Since my lines of inquiry sought answers to “how” and “why” type questions and I was looking for answers to contextual circumstances, I have carried out a case study [31]. I had the opportunity to perform direct data collection through meetings with healthcare workers in a healthcare institution that was the first in Hungary to utilize a digital dispensing system. My interviews were conducted with 25 employees, at pre-arranged times, in a semi-structured interview framework. The main characteristics of the sample used in my research are presented in Table 1.

Table 1
Distribution of data collection by job title and gender

Job title	Male	Female	Total
Manager	1	1	2
Physician	1	8	9
Nurse	0	14	14

The semi-structured interview explored the everyday issues related to hand disinfection activities of healthcare staff from the perspective of the interview subjects' world. The semi-structured interview technique is similar to a normal conversation, with the difference that it is a special form of interviewing that aims to obtain sufficient information about the phenomenon to be characterized [19].

In order for the research to meet the above criteria, I used a questionnaire, covering the topics relevant to the research. I asked each of these questions, and based on the individual responses to each, I asked further clarifying questions where necessary, in order to obtain the information for the original question. The questionnaire includes questions concerning on the following topics:

- ✓ When, where and how did you acquire hand hygiene knowledge?
- ✓ When and where did you last attend hand hygiene training?
- ✓ What did you learn and do you use this knowledge in practice or not?
- ✓ Where do you remember that you need to disinfect your hands?
- ✓ What factors make you prefer and not prefer to disinfect your hands?

- the availability of the dispenser
 - the quality of the product
- ✓ How does it facilitate appropriate hand hygiene?

The total number of staff at the research site is 5 healthcare workers. All possible interview time-table were published on the intranet, employees volunteered to be interviewed at their own choice, signing a consent form to have their interview recorded and processed. Thus, we can say that 50% of the total number of employees participated in the research.

During the data collection phase, I conducted semi-structured interviews of 0.5 to 1 hour length with the employees who volunteered for this activity. I conducted one-on-one interviews with 10 subjects via the online MS Teams application and with 15 subjects in the selected healthcare facility, recorded the interviews with their consent and transcribed the recordings. Next, I subjected the transcript to holistic coding [7]. Accordingly, I have divided the whole text according to which part of the text was essential for my research, and separated it from the other parts. Then I worked with the extracted texts by coding them according to the keywords selected based on my lines of inquiry and grouping them according to the coding. After re-reading the interviews, I formed further subgroups and looked for patterns. I also treated my notes on the conversations during and after the interviews as data and processed them according to the coding.

After the coding phase, I conducted a deductive thematic data analysis, grouping the interviews according to their knowledge of the relevant literature and re-analyzing them.

3 Results

3.1 What Training and Learning Processes Were Identified by the Interviews and Which One of Those Promotes Good Hand Disinfection Practice

3.1.1 Formal and Informal Training Practices

In terms of formal training, participation in trainings, tailored to healthcare specialties were crucial and the practices were prepared in collaboration with the head of department by drawing up an annual training plan. The training focused on developing “hard” skills.

Hard skills development training is aimed at updating the skills needed to fulfil particular job requirements, and is freely chosen by the employees according to their interests. For physicians, this mainly means attending international conferences, while for nurses, due to the lack of language skills, it mainly involves attending conferences held in Hungary.

Training aimed at developing “soft” skills (team building, cooperation, and communication) mainly includes training to facilitate cooperation between co-workers and training to improve communication with each other and with their patients. The latter type of trainings have become a priority, in the last year and are in great demand, but the number of training sessions was limited by their own departmental budget.

Informal training provides a framework for training new employees, with examples of the classic scenario of working alongside a senior colleague. The new employee is assigned to a selected, highly experienced colleague for a 3-month period to learn the processes. If the new employee then has any difficulty in a certain topic, he also may know who has the most knowledge in the subject and whom to seek to learn from.

When asked where they first heard about and where they learned good hand disinfection practice, most of the interviewees mentioned their educational institution; some interviewees were less sure, and while they mentioned the institution, they could not remember what the curriculum was. The practice of hand disinfection was learned after commencing their job, in practical training taught and demonstrated by the person who led the training exercise. They made a clear distinction by sharing their views that their current workplace, where they provide intensive care, has the highest level of hand hygiene practice they have encountered in their careers. The interviewees highlighted the recent formal training using visualization and the usefulness of the Semmelweis scanner to visually demonstrate the rub-in technique.

Among the interviewees, the group of nurses who are responsible for training parents in hand hygiene practices showed a higher proportion of formal knowledge of hand hygiene than the physician group.

The following table shows the competency matrix of the staff in the department examined in this study and the examples of practices that were found to develop staff competencies.

Table 2

Competency matrix of the staff of the department examined in the study based on Csillag, 2020

1. Professional/technical	2. Soft/social	
Cognitive competences related to the operation of healthcare equipment and	2.1 Cognitive and emotional self-regulation	<ul style="list-style-type: none"> - Motivation to help - Precision - Problem solving

medical devices/systems and the interpretation of the logical relationships behind them		- Ability and willingness to learn
	2.2 Interpersonal relationship management	- Communication - Conflict management - Empathy
	2.3 Managing organizational relationships	- Cooperation - Adaptation - Knowledge transfer - Feedback - Initiative - Taking responsibility

Table 3

Forms of competence development for staff in the department examined in the study based on Csillag, 2020

Types of competence	Forms of development
1. Professional/technical competence	- Hard skills training - University education - Working alongside a senior colleague - Learning by doing
2. Soft/social competence	- Staff meetings - Soft skills training - Working alongside a senior staff member

3.1.2 Learning Environment, Organizational and Social Elements of the Learning Environment

Each workplace creates its own characteristic learning environment, through the development of its own workplace culture, policies and processes, and leadership. The employee who enters this workplace learning environment also has an impact, as an individual, on this workplace learning environment. As a result of the environmental impact, it is up to the individual to independently decide whether to apply feedback or not. This dynamic interaction can be examined based on whether this environment is conducive or restrictive for the individual [10]. On a learning diagram each organization corresponds to a point located on the line, with one endpoint being the learning-enhancing environment and the other endpoint being the learning-limiting environment. In the department examined in this study, openness to learning is both emphasized and expected from the staff based on the requirements and the example of its leadership. By organizing community-building programs, the department head contributes to the flow of knowledge within the organization. The department head expects from the staff to practice good hand hygiene and requires their individual inputs. In order to develop the necessary

knowledge, several interviewees mentioned the training using the Semmelweis scanner to teach the correct rub-in technique, since visualization was memorable for them and thus mentioned it as an example of supportive learning. Likewise, the role of the external hand hygiene mentor was seen as a supportive learning means, and several interviewees mentioned a co-worker who was seen as an expert in hand hygiene.

3.2 What Factors Help and Impede the Proper Implementation of Hand Disinfection

Stimulating theoretical education, with plenty of interesting visual elements, was cited as a factor facilitating hand hygiene activities. Many of the interviewees mentioned small-group workshops where, in addition to learning the rub-in technique, they could analyze the correct hand disinfection procedure at informal discussions. The introduction of the digital dispensing system was also mentioned as a supporting element, emphasizing that from then on “everyone had to do better and better”. Another factor supporting hand disinfection the staff mentioned was the fact that since the disinfectant dispenser was available everywhere, they used it more often. It was also stated that there was a strong managerial expectation to implement high standards of hand hygiene practice, and the use of digital dispensers allowed to see “where we are and how much we are doing”.

I identified two patterns in the set of hand hygiene barriers. One of them was the quality of the product available, meaning that they did not always get a high-quality product that did not dry out their skin. Unfortunately, some of those products “cause skin irritation for multiple employees, but they use them anyway due to the need to be disinfected”. The other pattern was in the area of process engineering, describing it as “if you have to gather supplies for an intervention and you forget something you either don’t have time for it or you have to start all over again”.

3.3 I Wished to Learn about the Broader Context of the Impact of a Digital Dispensing System’s Introduction on Hand Disinfection Habits

The dispensing system was cited by the staff as a supportive factor for learning. Another pattern among the answers suggested that there was a competition to see who did hand disinfection better, physicians or nurses. They expected the parent group would have the worst indicators. The interviewees were motivated to take responsibility and to carry out the hand disinfection activity, which was observed in most of the opinions. Finally, the last pattern showed that they saw the data as feedback, a mirror, and this motivated them to compete to show who was better.

performing the activity without the need to concentrate on the individual elements of the hand disinfection activity.

The grouping of keywords shows that the information and knowledge associated with the keywords in box “A” can be acquired primarily through formal learning. The majority of interviewees could not remember this period of time clearly and could not put into concrete terms what they had learned about hand disinfection. The knowledge associated with the keywords in box “B” can be learned primarily through informal learning, which is learning through practice. The majority of interviewees stated that they had acquired their knowledge of hand disinfection through practice, with most of them citing the location of my case study as the place contributing the greatest to their individual knowledge of hand disinfection. Learning through practice is important, because this is the stage leading to the next level of knowledge where the essential element is to practice hand hygiene in the right way at the right time.

Thus, the goal in box “B” is to convert these into a habit. The key concepts in box “B” necessary to form the habit are listed as independent decision points, and the sum of these decisions determines the final outcome, i.e., the completion of a correct hand disinfection. These intermediate decision points can become independent habits and any one of them can become a habit in conjunction with another (Figure 1). The decision points listed in box “B” are intermediate points where decisions are made before the correct hand disinfection activity is run. However, these intermediate points are essential points supported by literature and they are key to the overall hand disinfection activity. These include dispenser availability, dispenser reliability in terms of dispensing accuracy [3], and product quality [29]. The majority of interviewees emphasized that product quality is a key factor in their willingness to carry out hand disinfection activities, since they can feel the difference in product quality on their hands and that their reason to consciously carry out the activity is due to their strong motivation to help (Table 2), as mentioned earlier. However, this can also contribute to the mental fatigue of workers in the long term. And looking through the elements depicted in box “B”, we are still only at the decision points upstream of the muscle stimulus for the hand disinfection activity. At this point hand disinfection has not yet taken place. Data from the scientific literature also support the notion that moving through these upstream points is a critical decision point for the completion of the hand disinfection process. The hand disinfection process was the first process to be standardized in ISO, confirming that moving through the decision points requires local decisions and practical implementation (ISO 23447:2023). Afterwards, once muscle stimulation has been evoked, another essential decision point for the whole process is the correct technique and using the right amount of disinfectant to carry out rubbing [2] [29] [30].

The vast majority of the interviewees emphasized that the training on the fluorescent marker rub-in technique [2] was visually informative and memorable for them, and they recall the feedback and visualization when they perform hand disinfection.

The full habit-process described above requires moving through intermediate decision points by introducing intermediate habits; however, converting the full habit process into a habit by practicing it is key to reducing and preventing nosocomial infections [28].

The digital dispenser was also included in the decision points in box “B”. When asked about its role, the vast majority of interviewees said that it gives them immediate feedback on whether or not a disinfection procedure has been carried out, and if necessary, they can disinfect their hands immediately. This suggests that the presence of the digital dispenser shortens the path between the decision points and the muscle stimulus (Figure 3). The immediate feedback reaffirms the high level of commitment to infection prevention that was already present, which in my case study was clearly linked by interviewees to the fact that infections can be reduced by carrying out proper hand disinfection activities.

Successful hand hygiene activity remains the key to reducing nosocomial infections. There are references in the literature to monitor the entire hand disinfection process in practice [24] [28]. The digital dispensing system deployed is the result of the decision of the department’s head included in the case study, and thus it also facilitates the implementation of process monitoring supported by the literature. Institutions shall pay attention to the latest guidelines and recommendations, including the most recent ISO 23447:2023 hand hygiene standard, and adjacent quality requirements towards dispensers [34].

Summary

Habits have a prominent place in psychological and neuroscientific research today, since a significant portion of human behavior is made up of habits. When the goal is the transformation of a key activity, such as hand disinfection in healthcare, into a habitual behavior, it is important to understand how habits are learned and formed. In my research, I aimed to demonstrate that if a habit is not a simple S-R activity, but involves multiple complex interdependent decisions, with intermediate computations in the S-R response, the final behavior can become a habit via different pathways depending on which small direct S-R process became a habit. Good hand disinfection practice is an expected behavior of healthcare workers, and many joint decision-making processes are involved in transforming it into a habit. Identifying intermediate decision points and consciously developing the practice of habits are necessary for achieving good hand hygiene compliance.

This research is the first step of a longitudinal study. in which we will ask users again about their perceptions of digital dispensers, within 3 months of the introduction of the digital dispensers, to examine infection-free periods and the levels of dispenser use in patient areas, to infer changes in individual hand hygiene habits.

Generalizability

The selection of the case studies can be considered random, in the sense that it took place in a selected ward of an institution that was the first to use a digital dispensing system in Hungary. The setting for the case study is a neonatal intensive care unit (NICU), which is of particular importance in that the role of hand transmissions, in nursing and medical workflows, in this unit, can be more directly monitored, than in other levels of the healthcare system.

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Conflicts of Interest

The author declares no conflict of interest. Aliz Benkó is employed by HARTMANN-RICO Hungária Kft.

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