

Recommendations for enhancing consumer safe food management behaviour with smartphone technology

Full Paper

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Abstract

Addressing consumer food safety risks through transdisciplinary research efforts highlight the importance of leveraging the affordances of smartphone technology. However, existing smartphone apps are limited by having safe food management (SFM) information in silos, gaps in context-based user experience research and insufficient evidence that portrays comprehensive evaluation. This paper reports on a research, which aimed to investigate how the affordances of smartphone technology can be leveraged to enhance the provision of information and facilitate knowledge retention to improve SFM behaviours. The findings produce key recommendations for improving information campaigns that aim to enhance SFM behaviour. It reveals that emerging software design approaches should be leveraged while incorporating context-based design principles in apps for SFM information campaigns. It further reveals that consumers should be prompted with multiple cues to revisit SFM apps for knowledge reinforcement. Finally, it highlights the importance of a consumer-centric approach to the development of SFM information campaigns.

Keywords Safe Food Management, Smartphone Applications (apps), Usability, Information Modalities, Knowledge Retention.

1 INTRODUCTION

Mitigating food safety risks is a major source of concern for various relevant stakeholders. Diverse process monitoring mechanisms have been implemented to address many of the risks (Varzakas and Arvanitoyannis 2008). However, most of these food safety mechanisms are limited to the 'paddock-to-purchase' (pre-purchase) phase of the product life. Thus, mitigating food safety risks after consumer purchase till the point of consumption (purchase-to-plate), is largely consumer responsibility (Bamgboje-Ayodele et al. 2016). Due to the alarming level of food poisoning outbreaks caused by unsafe domestic food handling practices, diverse education and awareness programs (Byrd-Bredbenner et al. 2013) have been implemented. Yet, many consumers remain inadequately informed and continue to engage in unsafe food handling practices (Bamgboje-Ayodele et al. 2016).

To support consumers in safe food management (SFM), transdisciplinary research efforts highlight the importance of leveraging the affordances of smartphone technology (Bamgboje-Ayodele et al. 2018) due to its widespread diffusion and its highly personalized nature, thus providing users with an array of capabilities and experiences that are tailored to their interests (Tossell et al. 2012). One way to demonstrate such level of personalization is the ability to allow users to download diverse mobile applications or 'apps' onto their smartphones (Jung 2014) which affords consumers the opportunity to inform themselves about specific areas of interests such as safe food management. However, evidence suggests that existing food safety apps, have three key limitations, which may be somewhat relevant to other app contexts. These limitations include providing SFM information in silos; not sufficiently incorporating context-based user experience research in their design and development; and mostly lacking comprehensive usability evaluation.

SFM information in silos: there is evidence that existing apps provide siloed information about the various aspects (safe shopping of perishable food items, safe transportation of perishable food items, safe storage of perishable food items, safe preparation of food items and appropriate kitchen hygiene practices) of domestic SFM for Australian consumers (Henley et al. 2012) thus resulting in a lack of continuity from one stage to the other. In addition, existing apps that are focused on food cooking tend not to emphasise the safety of the process; rather, the focus is usually on the recipe.

Gaps in context-based user experience research: there is insufficient evidence that existing apps have drawn upon the principle of modality effect (Mayer 2014), although some Information Systems studies argue for the impact of textual (Blanco et al. 2010), visual (Ha and Lennon 2010), verbal (Kim and Lennon 2008) or multiple modalities on consumer responses to such information. However, these information modality studies mostly focused on influencing consumer behaviour before product purchase which may not be applicable to the post-purchase context portrayed in this study. The principle of modality effect (Brunken et al. 2003), drawn from the cognitive theory of multimedia learning, argues that materials presented in a format that simultaneously uses the auditory and the visual sensory modality is better than by a format that uses only the visual modality when aiming to optimise consumer knowledge (Mayer and Chandler, 2001). Thus, providing a basis for the argument that there is tendency for a smartphone app which incorporates multiple information modalities to better deliver information to its user. However, the available evidence suggests the use of this principle only within pedagogical frameworks (Harskamp et al. 2007) which may not necessarily be applicable to domestic food handlers who tend to be adult consumers. Therefore, it is unclear if the principle of modality effect is applicable to adult consumers and whether it will improve user experience with SFM apps.

Lack of comprehensive evaluation: there is insufficient evidence to suggest that existing apps in SFM have been comprehensively evaluated (Oliveira et al. 2013) or that they were developed based on frameworks (including usability and health literacy) guiding m-health apps. The few evaluations conducted have been restricted usability assessments such that questions about the importance of contexts of use and the attributes and behaviours of end-users have been marginalised. This lack of evidence raises questions about whether best practice guidelines were adhered to, thus raising a key question: how can technology support SFM information delivery to consumers in a manner that facilitates consumer knowledge acquisition, knowledge retention and perceived behavioural change?

In this study, knowledge acquisition is described as knowledge inflow (Mom et al. 2007) where the recipient – the consumer – acquires SFM knowledge from the donor – government authorities, best practice guidelines, research studies. Knowledge retention is defined as the 'maintenance of knowledge' that exists in the minds of people and the 'maintenance of knowing' that is referred to as experiential action manifesting in behaviour (Caroline Martins and Meyer 2012). Knowledge application, involves selecting alternatives or prioritization before taking actions or decisions based on acquired knowledge (Verkasolo and Lappalainen 1998). Knowledge optimisation involves, ensuring that knowledge acquisition occurs, the knowledge has been retained and can be applied (Bamgboje-Ayodele et al. 2018).

This paper reports on the over-arching research, which aimed to investigate how smartphone technology affordances can be leveraged to enhance the provision of information and facilitate knowledge retention using a three-phase approach. More specifically, we present key recommendations for improving information campaigns that aim to enhance SFM behaviour with smartphone technology, emerging from findings from the over-arching research (all three phases). Following an extensive review of the literature on topics of relevance to this investigation in previous publications (Bamgboje-Ayodele et al. 2014; Bamgboje-Ayodele et al. 2015; Bamgboje-Ayodele et al. 2016; Bamgboje-Ayodele et al. 2018; Bamgboje-Ayodele et al. 2019a; Bamgboje-Ayodele et al. 2019b), this paper progresses by presenting a summary of the over-arching research, the method of research and a summary of findings across all three phases. It concludes by presenting recommendations for improving SFM information campaigns.

2 METHODS

This research adopted a pragmatic research philosophy and deployed a mixed-method design structured in three overlapping phases with ethical approvals with reference numbers H0014010, H0014658 and H0014965 gained from the Tasmanian Social Sciences Human Research Ethics Committee.

Phase 1 (Consumer Understanding) involved a nationwide survey (n=217) to identify Australian consumers' SFM knowledge gaps, and their information and communication preferences (both pre-and post-purchase) (Bamgboje-Ayodele et al. 2016). This survey was primarily focused on the consumption of red meat due to the enormous risks associated with its handling and management. This phase provided insight into the most problematic food handling practice for Australian consumers, to validate the existing literature on food poisoning (NSWFA 2014) and to scope the investigation to the most significant challenges. This led to the selection of three existing apps (text-based, graphics/picture-based and audio-visual) that most clearly addressed the knowledge gap which emerged from our findings as the biggest concern. At the end of this phase, it was imperative to design an app that integrates and addresses the SFM challenges in a single app rather than the existing multiple apps each addressing a challenge in a siloed manner. Phase 1 data was analysed using descriptive analysis on SPSS version 20 to produce a summary of the data in tables and graphs (Bamgboje-Ayodele et al. 2015).

Phase 2 (Design) involved the heuristic evaluation of the three multi-modal apps (text-based app, graphics/picture-based, and audio-visual app) based on Monkman and Kushniruk's (2013a) Health Literacy Online Heuristics (HLOH) framework and a consumer evaluation through focus group sessions (n=8) and card sort technique, using the three apps as high-fidelity prototypes. The criteria for selecting the existing SFM multi-modal apps and details about the apps have been published elsewhere (Bamgboje-Ayodele et al. 2015). This research activity aimed to identify the impact of the three information modalities on consumer understanding and to generate user requirements for the SFM app. The outcome of this phase provided rich insights into consumer requirements for a SFM app. Lessons learnt led to the design of the smartphone app for educating consumers on SFM practices (Bamgboje-Ayodele et al. 2019b). Phase 2 data was analysed using thematic analysis in line with the guideline provided by Braun and Clarke (2006) and the results are published in Bamgboje-Ayodele et al. (2019b).

Phase 3 (Implementation and Evaluation) - After the SFM app was developed ([App link](#)), it was evaluated through a field experiment (n=8), within a 4-week period. During this time, data was collected using open and closed questionnaires and was manually analysed. Six-weeks after the experiment, the participants were questioned to investigate their perceived knowledge retention and behavioural changes. This aimed to evaluate the impact of the design on SFM knowledge retention over time (Bamgboje-Ayodele et al. 2018). Phase 3 data was analysed both manually and descriptively as the small sample size prevented us from making further statistical analysis and conclusions (Bamgboje-Ayodele et al. 2018). This paper reports on the overall findings of the study and the recommendations for SFM information campaigns emerging from the over-arching findings.

3 RESULTS

3.1 Phase 1 – Consumer Understanding

The findings provided insights into the respondents biggest SFM knowledge gaps (see Bamgboje-Ayodele et al. (2015) for details). *The largest knowledge gap areas are safe cooking (97%), kitchen hygiene practices (64%) and safe storage (26%) respectively.* This reveals that consumers must learn basic SFM practices as smart devices (such as smart fridges, smart microwaves) handle different points in the purchase-to-plate process in silos and do not guarantee that the food on the plate is completely safe to eat. Consequently, the pervasiveness of ICT in the kitchen does not preclude unsafe food handling practices, which means domestic SFM knowledge is a necessity for consumers. One way to optimise

consumer knowledge is by leveraging the pervasiveness of smartphones for knowledge acquisition. Thus, the SFM smartphone app was designed to provide comprehensive information on all relevant SFM domains while prioritising each identified knowledge gap based on the findings, that is, safe cooking has a higher priority than kitchen hygiene practices, safe storage, reheating and transportation respectively. Therefore, the menu buttons were arranged in the order of priority.

3.2 Phase 2 - Design

To learn from existing SFM apps, three multimodal apps were evaluated based on heuristics evaluation (findings here (Bamgboje-Ayodele et al. 2015)) and consumer evaluation (findings here (Bamgboje-Ayodele et al. 2019b)). A summary of the consumer evaluation through focus groups revealed four themes: ACCESS, CONTENT, DESIGN and SEARCH.

ACCESS provides an overview of the factors that determine how easy consumers will be able to use and benefit from the app. This theme described the axial codes *Accessibility, No Cost to Users and Platform Compatibility*. It reveals the importance of the app size, download speed, level of compatibility with various phones and cost implication to users.

CONTENT emphasises the importance of how information is communicated and delivered to the users. This theme described the axial codes *Ethical Perception, Information content/Functionality, Information Tone and Value Add*. It reveals the importance of critically assessing the content and its completeness, the appropriateness and tone of the modality used whilst ensuring availability of additional beneficial information.

DESIGN describes the strategies and features that can influence the appearance of an app. This theme described the axial codes *Context of Picture Use, Context of Sound Use, Design and Aesthetics and Familiarity*. The theme reveals that attention must be paid to the app's choice of colours, layout, intuitiveness, pictures and its context, and the overall 'look and feel'. However, it was revealed that sound prompts may be regarded as a distraction in the kitchen.

SEARCH describes the factors affecting user experience when exploring and retrieving information. This theme described the axial codes *Layout of Information and Locating Information*. It reveals the importance of information structure as it impacts on users ease of navigation.

Having integrated the findings of the heuristic evaluation with the findings of the consumer evaluation lessons were learnt from the three existing apps and were incorporated into the design and development of the SFM app. Please see our previous papers for details, including screenshots of how user experience decisions for the SFM app were made based on these evaluations (Bamgboje-Ayodele et al. 2015; Bamgboje-Ayodele et al. 2019b).

3.3 Phase 3 – Implementation and Evaluation

After app design and development on both the iOS and Android platforms, a field experiment was conducted to evaluate participants' level of knowledge acquisition, knowledge retention and knowledge application. The participants in the experimental group were given access to the app only while the control group had access to the paper-based tool only. The learning tool was in the possession of each of the participants for four weeks. However, the learning materials were used differently by the two groups between one week and the other, as shown below;

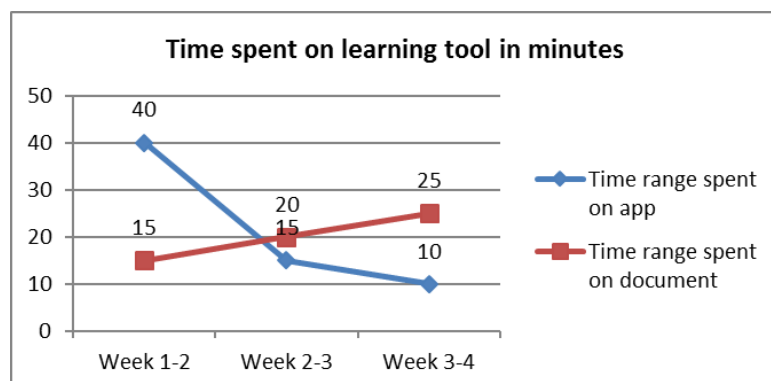


Figure 1: Phase 3 – Learning tool usage

As revealed by the results, the time range spent on the app by the experimental group declined between the initial and final week of the experiment while the time range spent on the paper-based tool increased within the same period. In addition, the findings reveal that the control group (paper-based tool users) could acquire the information more quickly than the experimental group (app users), but the experimental group could retain the acquired knowledge longer than the control group (Bamgboje-Ayodele et al. 2018). A summary of the findings is shown in Figure 2.

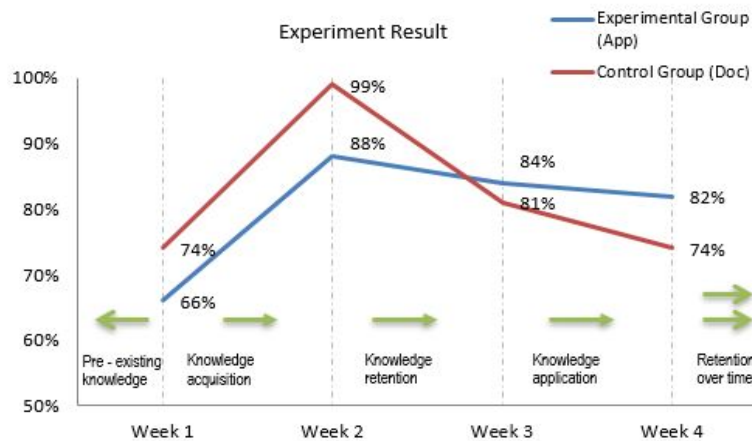


Figure 2: Phase 3 Results

Six-weeks post-experiment, participants were asked open ended questions and the findings reveal that all the participants in the experimental group adhered to the changes they intended to make to their day-to-day kitchen activities. However, for participants in the control group, only half of them could fulfil their initial intention of changing some day-to-day food handling practices.

4 DISCUSSION

The findings of the over-arching study result in the five key points below, which together answer the over-arching research question as stated in section 1: How can technology support SFM information delivery to consumers in a manner that facilitates consumer knowledge acquisition, knowledge retention and perceived behavioural change?

Key Point 1 - Multiple modalities are effective in delivering SFM information to influence knowledge retention when the information delivery tool is designed based on principles derived from an enhanced version of Monkman and Kushniruk's (2013b) HLOH framework.

Modality is applicable within the context of optimising consumers' knowledge on SFM based on how the information delivery tool is designed. According to Mayer and Chandler (2001), the principle of modality states that "knowledge acquisition is better facilitated by materials presented in a format that simultaneously uses the auditory and the visual sensory modality than by a format that uses only the visual modality". Drawn from the cognitive theory of multimedia learning, the modality effect refers to a cognitive load learning effect that occurs when partly visual and partly auditory information modes are presented which is more effective than when either of the modes is presented (Mayer 2014). This principle was explored in the context of this study by applying textual, visual and auditory information modalities in the app presented to the participants based on design principles derived from an enhanced version of Monkman and Kushniruk's (2013b) HLOH framework (Bamgboje-Ayodele et al. 2019b) listed as follows: ensuring the use of 'context appropriate images'; ensuring the use of 'pictures with a unilateral purpose'; and 'avoidance of the use of sound prompts'. These design principles emanated from the findings of Phase 2 of the study (Bamgboje-Ayodele et al. 2019b). The preliminary effectiveness of multiple modalities when presented in line with these principles, was demonstrated by the results of this study as the app facilitated longer knowledge retention when delivering SFM information to consumers.

Key Point 2 - The SFM app requires more time to be spent to achieve knowledge acquisition which resulted in retaining the knowledge for a longer time than the traditional information delivery techniques.

We draw on the cognitive load theory as the tasks and learning activities in this study required simultaneous integration of multiple and various sets of knowledge, skills and behaviours at a specific

time and place (Young et al. 2014). The app users demonstrated a higher level of knowledge retention over time when compared to the document users and this can be explained by the split-attention effect. This effect involves the physical integration, rather than physical separation, of verbal and pictorial information sources which enhances learning (Cierniak et al. 2009). As we integrated the different sources of information together into the app, we argue that this impacted the level of knowledge retention emanated by the participants.

In line with Herrlinger et al. (2016) and Leahy and Sweller (2011), who have argued that pictures and spoken text enhanced learning better than written text, we also found that the app users acquired the knowledge slowly but retained it longer in contrast to the document users. Similar to this finding is the study conducted by Wang et al. (2016) which revealed that when more attention was paid to the video and less attention paid to the text there was better retention of the learning outcomes. However, the findings in this study differ from those of Chandler and Sweller (1992) who found that students viewing integrated instruction spent less time processing the materials as the app users in this study spent more time acquiring the knowledge as a result of the extraneous cognitive load which occurred due to the additional learning that was required for the initial use of an app. Nonetheless, Chandler and Sweller (1992) also agreed that students viewing integrated instruction outperformed those with split attention condition. On the other hand, the findings are in line with the study conducted by Schmidt-Weigand et al. (2010) who revealed that participants showed a better learning performance the more time they spent looking at visualizations when text was spoken and integrated.

Therefore, in consonance with Schmidt-Weigand et al. (2010), it can be argued that the time devoted to process visualizations with spoken and integrated text such as videos may be an indicator of the quality of processing this information. The time a learner spends in using an app containing visualizations with spoken and integrated text, may be advantageous in facilitating knowledge retention for a longer time than traditional information delivery techniques.

Key Point 3 - *The use of a modified user centred design approach, using a heuristic framework with consumer evaluation outputs as a basis for app development, can support the development of an SFM app.*

Of the existing eHealth software design methodologies for app development, user-centred design (UCD) methods are commonly used in consumer-oriented products (Cafazzo et al. 2012). However, this research modified the conventional UCD approach by combining the outcome of a heuristic evaluation based on a health literacy online heuristics (HLOH) framework (Monkman and Kushniruk 2013a) and a consumer-based evaluation as a basis for the app development. Prior to the development of the SFM app, three existing apps (text-based, graphics/picture-based and integrated) that most clearly addressed safe food cooking, were selected for learning purposes, to facilitate design contributions across the apps from non-technical food consumers, and to provide a more valid evaluation using the three apps as fully functional prototypes. As it has been argued that user involvement leads to developing more usable designs (Abrams et al. 2004), we also argue that this method conforms with the basic principle of UCD through consumer involvement which led to the concept design (Bamgboje-Ayodele et al. 2015; Bamgboje-Ayodele et al. 2018; Bamgboje-Ayodele et al. 2019b). Therefore, in consonance with the approach utilised by Fleury et al. (2010), this non-conventional approach to UCD, also referred to as an inverted UCD approach, can successfully produce a useful knowledge acquisition tool for SFM information campaigns.

Key Point 4 - *Smartphone apps induce some level of cognitive load in adoption however; the affordance of its reuse for quick but infrequent re-visitations facilitates knowledge retention.*

This research reveals that the initial use of the smartphone app induces a higher level of extraneous cognitive load; reducing the rate at which knowledge is acquired during the first use. According to Brunken et al. (2003), extraneous cognitive load occurs due to how information is presented and the requirements of the activities on the working memory. Drawing on Moreno and Mayer (2005), we believe the principle of modality effect and the enhanced HLOH framework minimized the cognitive burden and resulted in a better demonstration of knowledge retention after quick app revisits. Thus, when participants spent less time on the app after the initial use, they demonstrated better knowledge retention unlike the document users.

This finding is in line with the temporal patterns that have been identified in the usage of smartphone applications which suggests short bursts of interactions (Jones et al. 2015). Ferreira et al. (2014) found that some apps are used in short bursts of less than 15 seconds which has become habitual for users. Whilst this habit encourages quick revisits to applications that contain fast changing content, Jones et al. (2015) argued that apps that relate to personal activities such as SFM follow a slow revisitation

pattern. Therefore, this explains the slow revisitation pattern and the little time spent on the SFM app which suggests that the affordance of re-use for quick but infrequent revisitations facilitates knowledge retention.

Thus, as this facilitated a better demonstration of knowledge retention on safe food management, it suggests that the affordance of re-use for quick but infrequent revisitations facilitates knowledge retention. Therefore, as it has been earlier argued that multiple information channels enhance food safety information dissemination (Kuttschreuter et al. 2014), it can be further argued that other information channels such as TV adverts, brochures, pamphlets and other media can be useful in drawing attention to the reuse or revisitation of such smartphone apps to reinforce and support the retention of consumer knowledge. This indicates that optimising consumers' safe food management knowledge cannot be a one-off activity as they require cues that prompt them into revising the app to maintain adequate knowledge level from time to time.

Key Point 5 - *Food related behaviour is intimately linked to the individual's attributes, habit, knowledge and context of use as the provision of SFM information does not necessarily result into its use, corresponding knowledge or expected behaviour.*

Although, it can be argued that the learner characteristics were not sufficiently built into the research design, this research has found that individual skills and attributes influence their response to knowledge optimisation. As consumers have diverse attributes such as age, gender, technology skills and food preparation skills, it is imperative to take these and other factors such as perceived personal relevance, individual differences moderating adult learning and closed-minded cognition into consideration.

Perceived personal relevance: The results suggest that the SFM practices of knowledgeable and experienced consumers are usually based on peripheral processing as they insist that information on SFM is not objectively personally relevant to them (Dijkstra and Ballast 2012). However, they realise that food safety risks can lead to food poisoning. Such consumers make low-to-medium involvement decisions based on their low level of perceived personal relevance, high skills and risk awareness. In consonance with van Trijp (2009), who argued that low involvement decisions are characterised by limited information processing due to low levels of perceived personal relevance and risk awareness, these findings reveal the impact of low-to-medium involvement decisions on SFM. Therefore, consumers with food safety knowledge, tend to relate with SFM information as a low-to-medium involvement task. Thus, that *the provision of SFM information does not necessarily result in the use of such information* most especially in cases where consumers believe that the available SFM information is not objectively personally relevant to them.

Individual differences moderating adult learning: The adult learning model differs from pedagogical models and is more applicable to the participants used in this research due to its focus on adult learners who are different from traditional students in the following ways (De Vito 2010): they are typically aged 24 years or older; they are not financially dependent on parents or guardians; their main responsibilities are outside schooling; and their principal identities have evolved beyond the role of full-time student.

Despite some participant demonstration of the six key principles of adult learning, they emanated individual differences that influenced the poor rate at which their knowledge was optimised (Bamgboje-Ayodele et al. 2018). This conforms with the argument provided by De Vito (2010) that individual differences is one of the factors that affect adult learning. One of the individual differences that could explain the finding of this study is cognitive aging. According to the processing speed theory of cognitive aging, it could be argued that poor processing speed and poor rate of knowledge optimisation was as a result of age changes in memory (Finkel et al. 2007). This is in consonance with the studies suggesting that older participants could demonstrate 'understanding' much more than 'remembrance' as the effect of age in recollection experience is determined by frontal lobe integrity and not by declining processing speed (McCabe et al. 2010). However, the findings of this study do not support such argument. In this study, some participants emanated individual differences, not relevant to age, which influenced the rate at which their knowledge on safe food management was optimised. Thus, it can be argued that *the use of information does not necessarily result in corresponding knowledge* as there are other individual factors that can influence the value derived from a knowledge optimisation process.

Closed Minded/Dogmatic Cognition: This research reveals that, despite all the precautions taken to ensure that the participants' knowledge are optimised (Bamgboje-Ayodele et al. 2015; Bamgboje-Ayodele et al. 2018; Bamgboje-Ayodele et al. 2019b), some participants appeared confident about the perception of their ability and they appeared ignorant about what they did not know which impeded

further learning. This behaviour is in line with the argument made by Fisher and C Keil (2015) that those who possess a high level of knowledge within a certain domain, have the tendency to exhibit a relatively high level of overconfidence. Perhaps, it is this level of overconfidence that made some participants closed-minded towards the learning process in this study. According to Ottati et al. (2015), closed-minded or dogmatic cognition, is the tendency to process information in a way that reinforces the person's prior opinion or expectation. Trafimow and Snizek (1994) has argued that those who believe they are experts tend to over-estimate the accuracy of their beliefs. Those who exhibit this behaviour are characterised as follows: they perceive themselves as experts due to their prior knowledge on the topic of discourse; they fail to learn further as they have become closed-minded towards new knowledge; and regardless of how often the information and/or knowledge acquisition tool is utilised, they fail to emanate tangible corresponding behavioural change due to the new knowledge they are expected to have acquired.

Thus, the findings in this research indicates that even *when safe food management information is used and it leads to corresponding knowledge, it does not necessarily mean that it would lead to expected behaviour* due to the cognitive orientation adopted by the individual. Therefore, this research aligns with the argument of Guerrero et al. (2009) that food related behaviour is intimately linked to the individual's attributes, habit, knowledge and context of use. Thus, *the provision of safe food management information does not necessarily result into its use, corresponding knowledge or expected behaviour*.

5 LIMITATIONS

Due to the difficulty in recruiting a sample that was representative of the Australian population, participants were limited to consumers in Hobart, Tasmania; thus, the outcome of the research may be skewed. Based on this small sample size, the findings of this study cannot be generalised to the Australian population and it may lead to a possibility of potential alternative explanations for the findings which favoured the use of the app rather than the document for knowledge retention. As such, further large-scale studies would need to be conducted based on a sample that is representative of the Australian population. In addition, more sophisticated app designs which include game-based concepts to facilitate better app-stickiness, crowd-sourced SFM knowledge from experts to frequently update the SFM app content and integrated social media interactions to encourage knowledge sharing may be more impactful when considering a full-fledged, nationwide SFM information campaign.

6 CONCLUSION AND RECOMMENDATIONS FOR SFM INFORMATION CAMPAIGNS

This paper has reported on research, which aimed to investigate how the affordances of smartphone technology can enhance the provision of information and facilitate knowledge retention. The findings reveal the following five key recommendations for improving SFM information campaigns.

App learning time is beneficial: The time a learner spends in using an app containing visualizations with spoken and integrated text during knowledge acquisition, may be advantageous in facilitating knowledge retention for a longer time than traditional information delivery techniques. Consequently, apps may be a useful tool for SFM information campaigns.

Emerging software design approaches can be leveraged: A non-conventional approach to UCD using a heuristic framework combined with consumer evaluation outputs, as a basis for app development, can successfully produce a smartphone app for facilitating SFM knowledge retention.

Use context-based design principles: Multiple modalities are effective in delivering SFM information to influence knowledge retention when used appropriately. In addition to generic mobile app design principles, other important SFM context-focused design principles when incorporating multiple modalities are (Bamgboje-Ayodele et al. 2019b): the use of context-appropriate messages; pictures must have a unilateral purpose; and avoidance of sound prompts.

Use multiple cues to reinforce knowledge: Although smartphone apps induce some level of cognitive load in adoption; the affordance of quick but infrequent revisitations over a short time facilitates knowledge retention. Therefore, SFM campaigns must use other channels such as TV adverts, pamphlets and other media as cues for app revisits to reinforce and support consumer knowledge retention. So, enhancing SFM knowledge cannot be a one-off activity.

Utilise a consumer-centric approach: In addition to attributes such as age, gender, technology skills and food preparation skills, perceived personal relevance, individual differences moderating adult

learning and cognitive orientation influences consumer SFM knowledge optimisation. Thus, food-related behaviour is intimately linked to consumer attributes, habit, knowledge and context of use. Consequently, the provision of SFM information does not necessarily result into its use, corresponding knowledge or expected behaviour. Therefore, it is imperative to conduct in-depth formative research to provide an understanding of individual attributes that could influence how SFM information is used.

7 REFERENCES

- Abras, C., Maloney-Krichmar, D., and Preece, J. 2004. "User-Centered Design," *Bainbridge, W. Encyclopedia of Human-Computer Interaction*. Thousand Oaks: Sage Publications (37:4), pp. 445-456.
- Bamgboje-Ayodele, A., Ellis, L., and Turner, P. 2014. "Empowering Consumers in Food Value Chains: Preliminary Insights from an Investigation into the Development of Tools for Food Safety," *The 25th Australasian Conference on Information Systems (ACIS 2014)*, Auckland, New Zealand.
- Bamgboje-Ayodele, A., Ellis, L., and Turner, P. 2015. "Supporting 'Good Habits' through User-Led Design of Food Safety Applications - Findings from a Survey of Red Meat Consumers," in: *Australasian Conference on Information Systems*. South Australia.
- Bamgboje-Ayodele, A., Ellis, L., and Turner, P. 2016. "A Food Recall Case Study in Australia – Towards the Development of Food Safety Applications for Consumers," *International Journal of Food Studies* (5:1).
- Bamgboje-Ayodele, A., Ellis, L., and Turner, P. 2018. "Safe Food Management and Smartphone Technology: Investigating the Impact of an App on Consumer Knowledge Retention," *Online journal of public health informatics* (10:3).
- Bamgboje-Ayodele, A., Ellis, L., and Turner, P. 2019a. "Developing a Framework for Understanding and Enhancing Consumers' Safe Food Management Behaviors – a Literature Review," *Journal of Agricultural & Food Information*, pp. 1-29.
- Bamgboje-Ayodele, A. E., Ellis, L., and Turner, P. 2019b. "Evaluating Consumer Food Safety Mobile Applications: Lessons Learned from Combining Assessment of Users, Usability & Context," *International Journal of Information Systems and Management* (2:1).
- Blanco, C. F., Sarasa, R. G., and Sanclemente, C. O. 2010. "Effects of Visual and Textual Information in Online Product Presentations: Looking for the Best Combination in Website Design," *European Journal of Information Systems* (19:6), pp. 668-686.
- Braun, V., and Clarke, V. 2006. "Using Thematic Analysis in Psychology," *Qualitative research in psychology* (3:2), pp. 77-101.
- Brunken, R., Plass, J. L., and Leutner, D. 2003. "Direct Measurement of Cognitive Load in Multimedia Learning," *Educational Psychologist* (38:1), pp. 53-61.
- Byrd-Bredbenner, C., Berning, J., Martin-Biggers, J., and Quick, V. 2013. "Food Safety in Home Kitchens: A Synthesis of the Literature," *International journal of environmental research and public health* (10:9), pp. 4060-4085.
- Cafazzo, J. A., Casselman, M., Hamming, N., Katzman, D. K., and Palmert, M. R. 2012. "Design of an Mhealth App for the Self-Management of Adolescent Type 1 Diabetes: A Pilot Study," *J Med Internet Res* (14:3), p. e70.
- Caroline Martins, E., and Meyer, H. W. 2012. "Organizational and Behavioral Factors That Influence Knowledge Retention," *Journal of Knowledge Management* (16:1), pp. 77-96.
- Chandler, P., and Sweller, J. 1992. "The Split-Attention Effect as a Factor in the Design of Instruction," *British Journal of Educational Psychology* (62:2), pp. 233-246.
- Cierniak, G., Scheiter, K., and Gerjets, P. 2009. "Explaining the Split-Attention Effect: Is the Reduction of Extraneous Cognitive Load Accompanied by an Increase in Germane Cognitive Load?," *Computers in Human Behavior* (25:2), pp. 315-324.
- De Vito, K. M. 2010. "Implementing Adult Learning Principles to Overcome Barriers of Learning in Continuing Higher Education Programs," *Online Journal for Workforce Education and Development* (3:4), p. 1.

- Dijkstra, A., and Ballast, K. 2012. "Personalization and Perceived Personal Relevance in Computer-Tailored Persuasion in Smoking Cessation," *British journal of health psychology* (17:1), pp. 60-73.
- Ferreira, D., Goncalves, J., Kostakos, V., Barkhuus, L., and Dey, A. K. 2014. "Contextual Experience Sampling of Mobile Application Micro-Usage," *Proceedings of the 16th international conference on Human-computer interaction with mobile devices & services*: ACM, pp. 91-100.
- Finkel, D., Reynolds, C. A., McArdle, J. J., and Pedersen, N. L. 2007. "Age Changes in Processing Speed as a Leading Indicator of Cognitive Aging," *Psychology and aging* (22:3), p. 558.
- Fisher, M., and C Keil, F. 2015. "The Curse of Expertise: When More Knowledge Leads to Miscalibrated Explanatory Insight," *Cognitive Science*).
- Fleury, A., Pedersen, J. S., and Larsen, L. B. 2010. "A Pragmatic Approach to Testing Issues in a Mobile Platform That Does Not yet Exist," *Adjunct Proceedings EuroITV 2010*, C. Peng, P. Vuorimaa, P. Näränen, C. Quico, G. Harboe and A. Lugmayr (eds.), Tampere University of Technology, Finland, pp. 262-263.
- Guerrero, L., Guàrdia, M. D., Xicola, J., Verbeke, W., Vanhonacker, F., Zakowska-Biemans, S., Sajdakowska, M., Sulmont-Rossé, C., Issanchou, S., and Contel, M. 2009. "Consumer-Driven Definition of Traditional Food Products and Innovation in Traditional Foods. A Qualitative Cross-Cultural Study," *Appetite* (52:2), pp. 345-354.
- Ha, Y., and Lennon, S. J. 2010. "Online Visual Merchandising (Vmd) Cues and Consumer Pleasure and Arousal: Purchasing Versus Browsing Situation," *Psychology & Marketing* (27:2), pp. 141-165.
- Harskamp, E. G., Mayer, R. E., and Suhre, C. 2007. "Does the Modality Principle for Multimedia Learning Apply to Science Classrooms?," *Learning and Instruction* (17:5), pp. 465-477.
- Henley, S. C., Stein, S. E., and Quinlan, J. J. 2012. "Identification of Unique Food Handling Practices That Could Represent Food Safety Risks for Minority Consumers," *Journal of Food Protection®* (75:11), pp. 2050-2054.
- Herrlinger, S., Höffler, T. N., Opfermann, M., and Leutner, D. 2016. "When Do Pictures Help Learning from Expository Text? Multimedia and Modality Effects in Primary Schools," *Research in Science Education*), pp. 1-20.
- Jones, S. L., Ferreira, D., Hosio, S., Goncalves, J., and Kostakos, V. 2015. "Revisitation Analysis of Smartphone App Use," in: *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*. Osaka, Japan: ACM, pp. 1197-1208.
- Jung, Y. 2014. "What a Smartphone Is to Me: Understanding User Values in Using Smartphones," *Information systems journal* (24:4), pp. 299-321.
- Kim, M., and Lennon, S. 2008. "The Effects of Visual and Verbal Information on Attitudes and Purchase Intentions in Internet Shopping," *Psychology & Marketing* (25:2), pp. 146-178.
- Kuttschreuter, M., Rutsaert, P., Hilverda, F., Regan, Á., Barnett, J., and Verbeke, W. 2014. "Seeking Information About Food-Related Risks: The Contribution of Social Media," *Food Quality and Preference* (37:0), pp. 10-18.
- Leahy, W., and Sweller, J. 2011. "Cognitive Load Theory, Modality of Presentation and the Transient Information Effect," *Applied Cognitive Psychology* (25:6), pp. 943-951.
- Mayer, R. E. 2014. "Cognitive Theory of Multimedia Learning," *The Cambridge handbook of multimedia learning* (43).
- Mayer, R. E., and Chandler, P. 2001. "When Learning Is Just a Click Away: Does Simple User Interaction Foster Deeper Understanding of Multimedia Messages?," *Journal of Educational Psychology* (93:2), p. 390.
- McCabe, D. P., Roediger III, H. L., McDaniel, M. A., Balota, D. A., and Hambrick, D. Z. 2010. "The Relationship between Working Memory Capacity and Executive Functioning: Evidence for a Common Executive Attention Construct," *Neuropsychology* (24:2), p. 222.
- Mom, T. J., Van Den Bosch, F. A., and Volberda, H. W. 2007. "Investigating Managers' Exploration and Exploitation Activities: The Influence of Top-Down, Bottom-up, and Horizontal Knowledge Inflows," *Journal of Management Studies* (44:6), pp. 910-931.

- Monkman, H., and Kushniruk, A. 2013a. "A Health Literacy and Usability Heuristic Evaluation of a Mobile Consumer Health Application," *MedInfo*, pp. 724-728.
- Monkman, H., and Kushniruk, A. 2013b. "A Health Literacy and Usability Heuristic Evaluation of a Mobile Consumer Health Application," *World Conference of Medical and Health Informatics*, Copenhagen, Denmark, pp. 724-728.
- Moreno, R., and Mayer, R. E. 2005. "Role of Guidance, Reflection, and Interactivity in an Agent-Based Multimedia Game," *Journal of Educational Psychology* (97:1), p. 117.
- NSWFA. 2014. "Food Poisoning." Australia: New South Wales Food Authority.
- Oliveira, L. C. R. d., Mitchell, V. A., and May, A. J. 2013. "Designing a Smart Phone App for Sustainable Cooking," in: *Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication*. Zurich, Switzerland: ACM, pp. 585-588.
- Ottati, V., Price, E. D., Wilson, C., and Sumaktoyo, N. 2015. "When Self-Perceptions of Expertise Increase Closed-Minded Cognition: The Earned Dogmatism Effect," *Journal of Experimental Social Psychology* (61), pp. 131-138.
- Schmidt-Weigand, F., Kohnert, A., and Glowalla, U. 2010. "Explaining the Modality and Contiguity Effects: New Insights from Investigating Students' Viewing Behaviour," *Applied Cognitive Psychology* (24:2), pp. 226-237.
- Tossell, C. C., Kortum, P., Shepard, C., Rahmati, A., and Zhong, L. 2012. "An Empirical Analysis of Smartphone Personalisation: Measurement and User Variability," *Behaviour & Information Technology* (31:10), pp. 995-1010.
- Trafimow, D., and Snizek, J. A. 1994. "Perceived Expertise and Its Effect on Confidence," *Organizational behavior and human decision processes* (57:2), pp. 290-302.
- van Trijp, H. C. 2009. "Consumer Understanding and Nutritional Communication: Key Issues in the Context of the New Eu Legislation," *European journal of nutrition* (48:1), pp. 41-48.
- Varzakas, T. H., and Arvanitoyannis, I. S. 2008. "Application of Iso22000 and Comparison to Haccp for Processing of Ready to Eat Vegetables: Part I," *International journal of food science & technology* (43:10), pp. 1729-1741.
- Verkasolo, M., and Lappalainen, P. 1998. "A Method of Measuring the Efficiency of the Knowledge Utilization Process," *IEEE Transactions on Engineering Management* (45:4), pp. 414-423.
- Wang, C.-Y., Tsai, M.-J., and Tsai, C.-C. 2016. "Multimedia Recipe Reading: Predicting Learning Outcomes and Diagnosing Cooking Interest Using Eye-Tracking Measures," *Computers in Human Behavior* (62), pp. 9-18.
- Young, J. Q., Van Merriënboer, J., Durning, S., and Ten Cate, O. 2014. "Cognitive Load Theory: Implications for Medical Education: Amee Guide No. 86," *Medical teacher* (36:5), pp. 371-384.

Weblink to the Safe Food Management (SFM) app

Android version - <https://play.google.com/store/apps/details?id=com.adeola.tams&hl=en>

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