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Assessing Smart Glasses-Based Foodservice Training: An Embodied Learning Theory Approach

Évaluation d'une formation en service alimentaire basée sur des lunettes intelligentes : une approche de théorie de l'apprentissage incarné

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Abstract

The present study evaluated active, hands on foodservice training delivered through smart glasses compared to passive, strictly video-based training. Handwashing performance variables were measured, including frequency and efficacy. Participants in the strictly video-based group (N = 24) were four times more likely to wash hands than the smart glasses group (N = 25), (95% CI: 1.129 - 14.175). The results highlight how smart glasses training where participants physically practice handwashing can result in poorer learning outcomes compared to traditional training methods. This may be due to: (a) the nature of the instructional content which involved prospective memory, compared to previous studies with embodied learning and smart glasses that assessed retrospective memory and motor functions, or (b) the psychological effects of hand cleansing on memory experienced by the smart glasses group during training. Future research could explore the effect of simulation training with smart glasses on other foodservice tasks.

Résumé

La présente étude a évalué une formation en service alimentaire active et appliquée, livrée par l'entremise de lunettes intelligentes, comparativement à une formation passive strictement basée sur la vidéo. Des variables de rendement relatives au lavage des mains ont été mesurées, y compris la fréquence et l'efficacité. Les participants du groupe dont la formation était strictement basée sur la vidéo (N = 24) étaient quatre fois plus susceptibles de se laver les mains que les participants du groupe aux lunettes intelligentes (N = 25), (95 % IC : 1,129 – 14,175). Les résultats soulignent que la formation par lunettes intelligentes dans laquelle les participants s'exercent à se laver les mains peut entraîner de moins bons résultats d'apprentissage que les méthodes de formation traditionnelles. Cela peut être dû à : a) la nature du contenu pédagogique, dans lequel la mémoire prospective intervient, comparativement à des études préalables avec l'apprentissage incarné et les lunettes intelligentes, qui ont évalué la mémoire rétrospective et les fonctions motrices, ou b) aux effets psychologiques sur la mémoire dont le groupe aux lunettes intelligentes aurait fait l'expérience durant la formation. Des études futures pourraient explorer l'effet de la formation par simulation à l'aide de lunettes intelligentes sur d'autres tâches de service alimentaire.

Introduction

Global demand for food consumed outside the home is on the rise, as all four major geographic regions of the world are forecasted to experience significant growth over the next ten years (Cushman & Wakefield, 2017). Americans alone are eating out more than ever before, spending larger portions of their food dollars on food consumed outside the home compared to thirty years ago (ERS, 2017). With these trends in mind, foodservice entities have a legal and moral responsibility to equip and train food workers to prevent cross contamination, cook food to the proper temperature, store food properly, and maintain good personal hygiene (FDA, 2011; FDA, 2010). Adhering to these well-established food safety practices is instrumental in decreasing the risk of foodborne illness transmission (FDA, 2010). Foodborne illness is problematic in the U.S. and worldwide; the World Health Organization estimates that globally over 600 million people are sickened every year, leading to an estimated 420,000 deaths (World Health Organization, 2015).

To adapt to the changing spending habits of consumers, foodservice entities may also consider exploring other ways to conduct workplace training. The restaurant industry, under the umbrella of the hospitality industry, has the highest employee turnover rate of private sector industries (Grindy, 2017), which necessitates effective training. History reflects that the type of instructional media has little impact on instructional outcomes (Reiser, 2001). Prior studies on foodservice training have shown no differences in learning outcomes between using lectures or computers (Behnke & Ghiselli, 2004; Costello, Gaddis, Tamplin, & Morris, 1997). Therefore, the advantages, disadvantages, and unique properties of training methods should be carefully evaluated.

Passive training, involving lectures and videos, is commonly used in the foodservice industry, as it allows for a cost effective means to transmit large amounts of information (Egan et al., 2007; Medeiros, Cavalli, Salay, & Proença, 2011). New instructional methods involving wearable computers, such as smart glasses, allow users to navigate through training by a scrolling touch pad located on the temple or by voice commands. Workers then physically complete tasks as they appear on the head-mounted, optical display. Smart glasses thus can entail simulated, hands free training where participants physically interact with the training content compared to passively receiving the information in a lecture. This property of smart glasses training differs from traditional lectures and may have a positive effect on learning outcomes, given research on embodied learning (Johnson-Glenberg, Megowan-Romanowicz, Birchfield, & Savio-Ramos, 2016; Kontra, Lyons, Fischer, & Beilock, 2015).

Smart glasses have been used as alternative training modalities in manufacturing and healthcare (Li et al., 2017). Positive results from these industries demonstrate the potential benefits of smart glasses application in the food industry. However, much of what is known about the impact of smart glasses training is limited to a few studies in the medical field that teach different skills than those utilized in the food industry (Dougherty & Badawy, 2017).

Additionally, prior studies in healthcare on smart glasses training have typically involved small sample sizes (Dougherty & Badawy, 2017). Given the significant investment of training with smart glasses, more research could provide new knowledge that would help foodservice stakeholders make informed decisions on which training medium to use for instructing employees. While informal pilot studies have been conducted in the food industry (della Cavo, 2014), smart glasses have not been compared with traditional training modalities that involve passive learning. To date, little is known how smart glasses impact training transfer in foodservice.

The present study evaluated how smart glasses-based training affects learning outcomes of handwashing behaviors. The goals of this study were to: (a) develop a smart glasses-based training module incorporating modern theories of cognition and adult learning and (b) compare handwashing performance outcomes between smart glasses-based and strictly video-based foodservice training modules.

Background

Modern theories of cognition, most notably embodied cognition, sometimes called grounded cognition, explain that much of the brain's function is rooted in sensorimotor outputs and inputs (Barsalou, 2008; Wilson, 2002). In this regard, knowledge is not stored simply as symbols in the brain, but instead is represented by sensory-motor experiences (Barsalou, 2008). Simulation is a central feature of embodied cognition, which occurs when the brain processes interactions with the learning environment, then recreates those experiences. Multi-modal interactions that involve perception, motor activity, and introspection are used by the brain to create new knowledge structures that enable the learner to better recall the training in the future.

Simulations are rooted in the principle of identical elements: greater training transfer occurs when the training module is similar to the environment in which the training material is later implemented (Thorndike & Woodworth, 1901). This is evident by the seminal study on context dependent memory which found recall of words was 50% better when the learning and recall environment were identical (Godden & Baddeley, 1975). The principle of identical elements implies that the more training mimics the work environment of an employee, the greater the likelihood the employee will execute the learned behaviors. The present study focuses on one aspect of embodied learning based on the overarching tenet of embodied cognition, that physical interaction with the training content may have a positive effect on learning outcomes (Wilson, 2002).

Recent evidence for embodied learning suggests physical experiences affected learning outcomes in a college physics course (Kontra et al., 2015). Students were divided into an action group and an observation group. Students in the action group, who participated in learning interaction by physically tilting a set of wheels, performed better on a quiz compared to the observation group who only watched the action group. Brain images obtained through functional magnetic resonance imaging confirmed that greater activation of sensorimotor systems in the brain occurred with students in the action group. Additional research suggests incorporating principles of embodied learning leads to improved knowledge retention over time (Johnson-Glenberg et al., 2016).

There is a need to develop food safety curricula for workers that incorporates modern theories of cognition and adult learning theory principles (Fraser & Simmons, 2017), yet a review of 23 food safety training interventions found sparse reliance on education theory (Viator, Blitstein, Brophy, & Fraser, 2015). Food safety training modules have relied heavily on traditional pedagogical approaches that involve a teacher in a classroom providing information to students with the belief that this will translate to behavior change (Fraser & Simmons, 2017; Medeiros et al., 2011). Under these circumstances, the student is expected to passively assimilate abstract food safety principles and procedures, while rarely engaging with the environment these principles are applied to. These methods require little participant involvement and engagement, while delaying practical application of the learning material. A review of 46 studies on food hygiene training found limited evidence for the effectiveness of passive, classroom-based training (Egan et al., 2007). This passive approach to learning is largely analogous to traditional theories of cognition that describe the mind as processing information apart from perceptual and motor systems, in stark contrast to the tenets of embodied learning (Wilson, 2002).

Principles of embodied learning, while not stated explicitly, have been featured in several food safety training interventions (Medeiros et al., 2011). Our understanding of how these methods affect training outcomes, however, is limited to knowledge assessments and employee preferences. Food handlers who received participatory handwashing training in addition to traditional lecture/video training had higher knowledge scores than food handlers who received only lecture/video training (Lillquist, McCabe, & Church, 2005). Hands-on activities are generally more engaging to employees (Dipietro, 2006; Lillquist et al., 2005) and allow employees to learn at their own pace (Dipietro, 2006).

Smart glasses are an alternative training modality for use in the foodservice industry and allow incorporation of embodied learning principles through physical execution of the training content. In this regard, smart glasses-based training incorporates modern theories of adult learning and cognition, notably embodied and self-directed learning. Research from the healthcare industry highlights how smart glasses may be applied in the food industry to train food handlers and facilitate learning of food safety practices. This research has encompassed patient interactions, treatment skills, and anatomy (Benninger, 2015; Iversen, Kiami, Singh, Masiello, & von Heideken, 2016; Son et al., 2017). For example, in a simulated operative setting designed to assess learned motor skills, surgery residents achieved lower error scores with needle placement after training with smart glasses compared to receiving directions only from an instructor (15 ± 4 vs. $18 = 5$, $p < 0.05$) (Brewer, Fann, Ogden, Burdon, & Sheikh, 2016).

One study assessed vestibular examination skills which require high level psychomotor functions (Iversen et al., 2016). The researchers used a prospective, randomized controlled trial and found a combination of smart glasses and verbal instruction resulted in slightly better clinical skills scores compared to only verbal instruction (Median = 19 vs Median = 18, $p < .05$). In another study, smart glasses were used as a form of technology-aided intervention to guide social interactions for children with autism (Kinsella, Chow, & Kushki, 2017). All participants were able to complete the intervention and reported positive experiences from the training. No comparisons were made to traditional intervention methods.

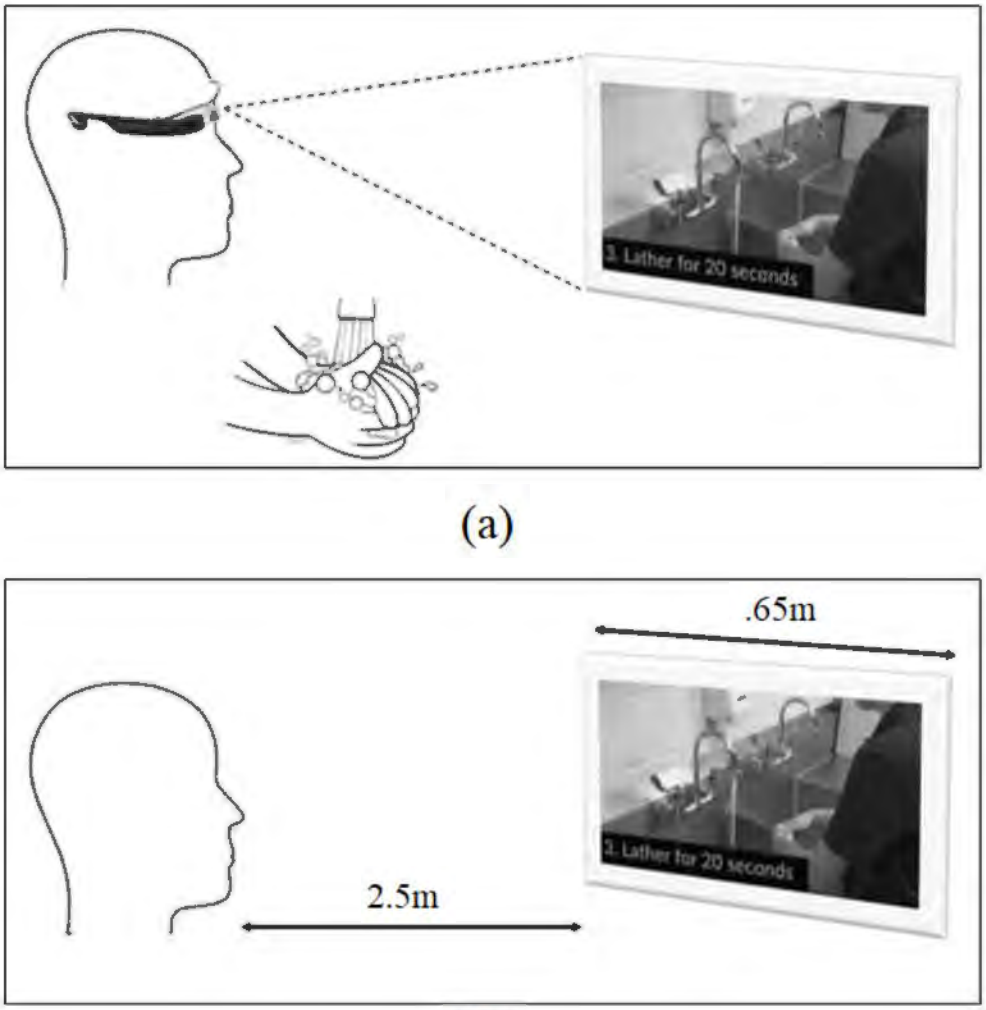
To the best of our knowledge, no prior studies have determined the impact of embodied learning with smart glasses compared to more hands-off training on food safety behaviours.

Furthermore, evidence for embodied learning is limited to retrospective memory exercises characteristic of in class quizzes or exams where students are responsible for recalling information learned in the past. This differs from prospective memory exercises that require executing an action at a specific moment in the future (McDaniel & Einstein, 2007). Prospective memory typifies what foodservice employees utilize to implement learned food safety practices at appropriate times during food preparation (Pellegrino, Crandall, & Seo, 2015). The present study aims to shed additional light on the effects of embodied learning on prospective memory outcomes.

Method

Procedures

Video training. Participants assigned to the strictly video-based training group completed one session on sandwich making and when and how to wash hands. Participants viewed the training from 2.5m away and the video was displayed as .65m in length, analogous to the smart glasses display which is equivalent to viewing a .65m T.V. from 2.5m away (Figure 1) (Google, 2018b). Participants watched, but did not physically practice, the six handwashing steps that were to be completed that included: (a) before handling the sandwich and (b) after handling cooked deli meat and before handling vegetables that went on the sandwich. The lack of physical interaction with the training content thus involved passive, as opposed to active learning.



(a)

(b)

Figure 1. Smart glasses-based foodservice simulation training (a) and strictly video-based foodservice training (b).

Smart Glasses Training. Participants assigned to the smart glasses group completed two separate training sessions. The first session familiarized participants with the technology (Medrano, Nyhus, Smolen, Curran, & Ross, 2017). Video use is more ubiquitous than smart glasses use to date, and a lack of familiarity with smart glasses could serve as a confounding variable. Participants were given an instruction sheet made by the training software developer on how to use and navigate through training content with smart glasses. Participants were allowed the option of progressing through the training verbally by voice activation, manually by swiping and touching the scroll pad located on the side, or a combination of the two. Participants then learned how to clean and disassemble a deli slicer. This deli slicer training was a series of skills and text that involved no handwashing. The deli slicer blade had been previously removed and metal protrusions covered with Styrofoam to help ensure participant safety. Participants returned for a second session an average of 8.8 days later (SD = 3.5) to complete the sandwich and handwashing training. The sandwich making was a series of pictures with text, while the handwashing training consisted of the same video footage used in the strictly video-based training group. Participants manually or verbally progressed through the six handwashing video clips corresponding with the six steps on how to wash hands. This was done before handling the sandwich and after touching the cooked deli meat but before handling the vegetables that were placed on the sandwich, as instructed by the training. Handwashing was physically practiced at a sink with soap and paper towels, functioning as a simulation involving active and embodied learning.

Prospective Memory Overview. A prospective memory (PM) design was employed to test the effectiveness of the smart glasses and strictly video-based training modules at promoting handwashing (Figure 2). Prospective memory relies on planning an action to execute in the future, rather than the recollection of learned material characteristic of retrospective memory (McDaniel & Einstein, 2007). In this experiment, an ongoing task (or cover task) was used in conjunction with target events, similar to prior experiments with PM (Guynn, McDaniel, & Einstein, 1998; Pellegrino, Crandall, & Seo, 2015). The four target PM events were presented to participants during training and included: (a) before handling food, (b) after cleaning, (c) after touching cooked deli meat and before touching vegetables, and (d) after touching money.

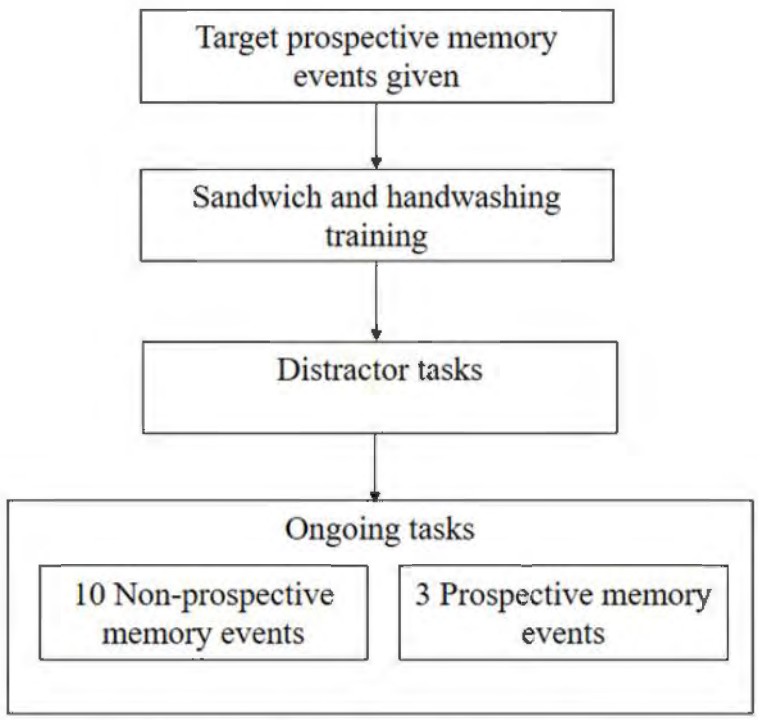


Figure 2. Experimental procedure for testing the target prospective memory events of when to wash hands.

Prospective Memory Experiment. Participants in both groups completed training that informed them that they were going to learn how to make a specific sandwich and that handwashing was important when working with food. Sandwich making was deemed an appropriate procedure to learn with handwashing. Before making the sandwich, the four target PM events on when to wash hands were presented in a text format, which included: (a) before handling food, (b) after cleaning, (c) after touching cooked deli meat and before touching vegetables, and (d) after touching money. Participants were also instructed on the six steps on how to wash hands, according to the Centers for Disease Control and Prevention (CDC), consisting of wetting the hands, applying soap, lathering for 20 seconds, rinsing, drying, and turning off the faucet with the paper towel (CDC, 2015). The sandwich making involved placing ten food items in a specific order and included handling cooked deli meat directly followed by touching carrots. Before handling carrots, participants were again trained on the six handwashing steps to reinforce the training content. Following the sandwich making, participants completed two distractor tasks, which served as buffers between the PM instructions and ongoing tasks. Participants were given one minute to memorize a picture showing a bin with a random assortment of items, then given the same bin with the items jumbled and told to arrange them based on the recollection of the picture. This distractor task functioned as a control for potential discrepancies in hand cleanliness desirability between the two training groups, as the smart glasses group had practiced handwashing. This task was chosen based on prior research that has shown how bodily states can impact psychological states associated with perceived contamination (Koerner, 2015). Participants were then shown a short video on basic, cooking-related volume conversions, then completed a quiz on the video to assess conversion knowledge.

Participants were then ushered into a separate room with a second researcher to complete the ongoing tasks. The first researcher who administered the training and distractor tasks made no contact with the second researcher who gave the ongoing tasks. The second researcher was blind to which training participants received. Five open, numbered bins were set up side by side on a counter each with different materials inside. Handwashing facilities were located adjacent to the bins and consisted of a sink, soap, and paper towels. Inside each bin were two paper plates. The plate on the left held either stopper holders, wooden popsicle sticks, pieces of cooked deli meat, tomatoes, or marbles. The cooked deli meat was of the same substance as that portrayed in the training modules but in a different shape. The plate on the right in each bin was empty.

The second researcher verbally administered 13 volume conversion problems that corresponded with a specific bin number. A pilot study (n = 10) confirmed the appropriate difficulty of the ongoing tasks. Participants were told they would be responsible for portioning the appropriate number of items that corresponded with the bin and measurement called out by the second researcher before beginning. They were given an example problem of, "Bin 1: 6 teaspoons equal how many tablespoons?" In this case, the plate on the left in bin 1 contained stopper holders, with each stopper holder representing one tablespoon in this case. Participants were told the correct course of action, which was to go to bin 1 and transfer two stopper holders from the plate on the left to the plate on the right, since there are three teaspoons per tablespoon. Participants were informed they may be required to use the same bin for multiple problems, in which case they should continue to transfer items from the left plate to the right plate.

There was a total of three conversion problems that corresponded with two of the target PM events, including handling the tomatoes (before handling food), handling the cooked deli meat (before handling food), and handling the tomatoes right after handling the cooked deli meat (after touching cooked deli meat and before touching vegetables). Because of the specificity of the two target PM events, the 13 conversion problems were not randomized for each participant. Handwashing frequency, lather duration, and compliance with the CDC six steps were observed and documented by the trained second researcher during the ongoing tasks. Handwashing steps were coded as 1 or 0 for compliant or not compliant, respectively. Lathering for 20 or more seconds was considered compliant.

Demographic information was obtained on type of foodservice experience (if applicable) and whether participants had completed food safety training prior to the study (yes or no). The experiment lasted approximately 30 minutes.

Participants

This study was approved by the university's Institutional Review Board for human subjects research prior to data collection. Participants were recruited on a rolling basis through university-wide emails. All participants were pre-screened using the Maudsley Obsessive Compulsive Inventory Subscale (MOCI) (Foa et al., 2002), used in a previous study that measured handwashing behavior (Pellegrino, Crandall, & Seo, 2015). Pre-screening excluded individuals who scored a seven or higher on the MOCI, indicative of unusual sensitivities to handwashing in relation to an obsessive-compulsive disorder. Participants with food allergies or intolerances were excluded from the study. Participants who completed the smart glasses training (two, 30-minute sessions) and video training (one 30-minute session) received $40 and $20 in gift cards as compensation, respectively. Participants were informed that the study was on food handler training outcomes, but no other details were given. Participants were balanced between the two training groups based on their age, gender, foodservice experience (yes or no), MOCI score, and technology use. The technology use survey, based on a prior study (Agbatogun, 2013), contained a list of common interactive technologies, such as computers, the internet, mobile phones, tablets, and smart watches. Participants rated their use of each technology on a three-point scale ranging from frequently to never. Technology use for each participant was calculated as the sum of scores.

Materials

For both training groups, professional videographers shot all training content and a student from the university theatre department served as the acting food handler. Filming took place in a commercial kitchen. Glass, Enterprise Edition (Google, 2018a) was the brand of smart glasses used. Handwashing was chosen as the behavior of emphasis due to low compliance issues in the food industry (Todd, Greig, et al., 2010), the association between poor hand hygiene and foodborne illness outbreaks (Todd, Michaels, et al., 2010), and the risk of foodborne illness transmission attributed to poor personal hygiene (FDA, 2010). The handwashing footage used for each training event was identical.

Analytical Procedure

A total of 49 participants were recruited for this study. The average age for the smart glasses group was 27.48 years (SD = 12.47, range: 18-57) and for the video group was 26.75 years (SD = 10.67, range: 18-64) (Table 1). There were no significant differences between the two training groups based on demographic variables including age ($t[47] = 0.22$, $p = .827$), MOCI score ($t[47] = 0.48$, $p = .64$), technology use ($t[47] = .-.22$, $p = .82$), gender ratio (smart glasses group: 5 men, 20 women; video group: 5 men, 19 women), foodservice experience ($\chi^2[1] = .18$, $p = .67$), and prior food safety training ($\chi^2[1] = 3.36$, $p = .07$).

Table 1

Demographic Characteristics of the Smart Glasses and Strictly Video-Based Training Groups

		Smart glasses group (N = 25)	Video group (N = 24)
Gender	Male	25%	21%
	Female	75%	79%
Age (average, years)		27.5	26.8
Foodservice experience (years)	None	28%	52%
	<1	16%	13%
	1-3	44%	22%
	4-7	8%	9%
	8+	4%	4%
Foodservice establishment type (% with experience)	Restaurant	44%	73%
	School cafeteria	6%	9%
	Catering	22%	0%
	Other	22%	9%
	Multiple	6%	9%
Prior food safety training	Yes	52%	26%
	No	48%	74%

Statistical Package for the Social Sciences version 24 was used to analyze the data set. The handwashing frequency data violated assumptions of normality for both training groups, as evident by a Shapiro Wilk's test ($p < .001$ for both training sessions). Additionally, the Levene's test showed a lack of homogeneity of variance ($p = .001$). Given violations in these assumptions, a non-parametric Chi-square test was used to determine differences in handwashing frequencies between the smart glasses and strictly video-based training groups (Mchugh, 2013). The Chi-square test relies on the assumption that in the contingency table of the dependent and independent variables, at least 80% of the cells have values of five or greater. In the 4x2 contingency table of the present study that consisted of handwashing frequency (never, once, twice, thrice) and training type, four of the eight cells had expected counts less than five. Therefore, handwashing frequency was collapsed into two categories of "never washed hands" and "washed hands at least once."

To determine an odds ratio of handwashing likelihood, binomial logistic regression was performed with training group as the independent variable and handwashing frequency (two possible outcomes of washed hands at least once and never washed hands) as the dependent variable.

Results

Handwashing Performance

Five (20%) and 12 (50%) participants in the smart glasses and video training groups, respectively, remembered to wash hands at least once (Table 2). There was a statistically significant difference in handwashing frequency between the two training groups ($\chi^2[1] = 4.86$, $p = .027$). Based on the logistic regression model, participants in the video group were four times more likely to wash hands compared to the smart glasses group (95% CI: 1.129 - 14.175). Lathering for at least 20 seconds was the handwashing step most out of compliance between the two groups, which occurred in 73% of all handwashing attempts. The next step most out of compliance was turning off the faucet with a paper towel, which occurred in 18% of handwashing attempts.

Table 2

Demographic Characteristics of the Smart Glasses and Strictly Video-Based Training Groups

	Smart glasses group	Video group
Handwashing frequency:		
Never	80%	50%
Once	20%	33%
Twice	-	13%
Thrice	-	4%
Handwashing event:		
Before handling food	-	18%
After touching meat	80%	70%
Other	20%	12%
Number of handwashing steps in compliance:		
4	40%	12%
5	40%	59%
6	20%	29%
Median lather time (seconds)	14	16.33

High attention allocation to PM events and cognitive load are associated with decreased performance in ongoing tasks (Walter & Meier, 2014). To determine if this explained differences in handwashing attempts between the two groups, the number of bins with the correct number of items on the plate on the right was calculated for each participant and compared across the two groups. Based on the results of a post-hoc, Man Whitney U test, there were no significant differences between the smart glasses and video training groups in the number of bins with a correct number of items, $U = 239.5$, $p = .586$.

Discussion

The purpose of the study was to assess smart glasses-based foodservice training in comparison to strictly video-based foodservice training. Participants in the strictly video-based training group were much more likely to remember to wash their hands.

The present research study incorporated principles of embodied learning into foodservice training modules that focused on translating knowledge (when to wash hands) into transferred action (applying the knowledge by handwashing at the appropriate times in the actual foodservice environment). As such, the experiment tested PM, or remembering to complete an action in the future, in contrast to prior studies on embodied learning that assessed learning through retrospective memory, or recollection of past actions or knowledge (Johnson-Glenberg et al., 2016; Kontra et al., 2015). Additionally, while research in the medical field with smart glasses has seen more positive results with hands on training, participants were instructed predominantly on use of motor skills and high-level psychomotor functions (Brewer et al., 2016; Iversen et al., 2016). This fundamental difference in experimental design - the type of learning assessed - may provide one explanation for why physically interacting with the training material was less effective at promoting handwashing frequency, especially considering theories on embodied cleansing.

Embodied cleansing is a subset of embodied cognition and refers to how hygiene practices influence psychological outcomes (Koerner, 2015). Exposure to objects perceived as dirty can result in mental contamination, associated with feelings of uncleanliness and urges to remove the contamination. This process can occur without coming into physical contact with disgusting items (Fairbrother, Newth, & Rachman, 2005; Rachman, 1994). In light of the present study, participants in both groups may have experienced some degree of mental contamination. Participants in the smart glasses group would have been able to immediately address these feelings through physically washing their hands twice during the training. However, for participants sitting in the strictly video-based training group, the problem of hygiene remained unsolved, potentially resulting in increased agitation and thus attentional resources to handwashing and improved PM performance. It was proposed that active participation in handwashing training would increase its relative importance for the smart glasses group, driving PM. However, this degree of importance may have been influenced by learners washing hands during the training. A PM event influenced by embodied cleansing may explain the poor embodied learning outcomes observed compared to a prior study that assessed retrospective memory events, such as quizzes (Kontra et al., 2015).

Another explanation for the results relates to the attentional demands associated with smart glasses use. In a study on visual attention, it was found that information presented on smart glasses can be highly disruptive to concurrent tasks (Lewis & Neider, 2016). Several other studies encompassing driver attention (Sawyer, Finomore, Calvo, & Hancock, 2014) and high angle climbing (associated with search and rescue teams or firefighting) (Woodham, 2015) have confirmed the distractive nature of wearing smart glasses. The attention of learners in the smart glasses training was diverted to manually progress through the training, either verbally by voice activation or tapping the side scroll pad. This additional cognitive load, while potentially less taxing on the attention system compared to prior studies with smart glasses, may have resulted in fewer attentional resources remaining available for the target PM events compared to the video group. Questions remain as to how increased practice using smart glasses may impact attention and distraction levels over time. The study results are of interest considering that participants in the smart glasses group came in for an additional session to familiarize themselves with the technology around nine days before the performance task.

Limitations

This study had several limitations. The smart glasses group came in for an additional session, and it is unknown whether this could have impacted handwashing performance after the training. Future work should consider an experimental design that entails equal time commitments between training groups, as well as controlling for differences in how participants proceed with the training. While attempts were made to control for discrepancies in hand cleanliness through the item arrangement task, this may have led to increased desirability for hand hygiene in the video group, thus having a greater effect on remembering to wash hands. Knowing when to and how to wash hands is sometimes learned at an early age (Whitby et al., 2007). Efforts were made to control for prior knowledge by instructing participants to wash hands for events not normally associated with handwashing. Future work should have participants complete knowledge assessments of how to wash hands as another control for the experiment.

The handwashing frequencies may have been affected by participant comfort level in interrupting the researcher to wash hands in between calling out bin instructions. In this regard, increases in handwashing frequencies may be observed for both training groups when participants are allowed more autonomy between conversion tasks. Total handwashing duration and lathering times were determined by an observer, which may have introduced a margin of error. While the observer was trained, future work may consider filming handwashing performance that would allow for potentially more accurate determination of handwashing duration.

The perceived and actual cognitive load of training with smart glasses was not measured and future research would benefit by accounting for this variable. Additionally, this study was cross sectional in design and was not able to measure the impact of training modality over time. Furthermore, this experiment was conducted in a laboratory setting to control for potentially moderating variables such as workload and time constraints. Future studies should consider comparing training modalities among currently employed food handlers in real world foodservice environments to examine the external validity of the present study's results.

Conclusion

This study contributes to the growing body of knowledge of wearable computers in the workplace. Participants in the video group were significantly more likely to remember to wash hands compared to the smart glasses group. The results highlight how embodied learning may be contingent upon the nature of the training material; the present study examined prospective memory in contrast to prior research on embodied learning and smart glasses that has tested retrospective memory and motor functions. Differences observed in the treatment groups may also be attributable to discrepancies in mental contamination levels. While embodied learning through simulation is a novel, theoretically sound approach that has been shown to improve learning outcomes in previous studies, this research shows how it may be dependent on the type of learning assessed. New forms of computer-meditated training involving smart glasses have potential to impact the food industry, but more research is needed on other food safety and food handling practices to translate this potential into reality.

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