

A real-time test of food hazard awareness

MILLMAN, Caroline <<http://orcid.org/0000-0003-4935-0477>>, RIGBY, D, JONES, D and EDWARDS-JONES, G

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1 ***A Real-Time Test of Food Hazard Awareness***

2

3 ***Abstract***

4 **Purpose**

5 Food poisoning attributable to the home generates a large disease burden, yet is an unregulated
6 and largely unobserved domain. Investigating food safety awareness and routine practices is fraught
7 with difficulties. We develop and apply a new survey tool to elicit awareness of food hazards. Data
8 generated by the approach are analysed to investigate the impact of observable heterogeneity on
9 food safety awareness.

10 **Design/methodology/approach**

11 We develop a novel Watch-&-Click survey tool to assess the level of awareness of a set of
12 hazardous food safety behaviours in the domestic kitchen. Participants respond to video footage
13 stimulus, in which food hazards occur, via mouse clicks/screen taps. This real-time response data is
14 analysed via estimation of count and logit models to investigate how hazard identification patterns
15 vary over observable characteristics.

16 **Findings**

17 User feedback regarding the Watch-&-Click tool approach is extremely positive. Substantive
18 results include significantly higher hazard awareness among the under 60s. People who thought they
19 knew more than the average person did indeed score higher but people with food safety
20 training/experience did not. Vegetarians were less likely to identify 4 of the 5 cross contamination
21 hazards they observed.

22 **Originality/value**

23 A new and engaging survey tool to elicit hazard awareness with real-time scores and feedback is
24 developed, with high levels of user engagement and stakeholder interest. The approach may be

- 25 applied to elicit hazard awareness in a wide range of contexts including education, training and
- 26 research.
- 27 Keywords: food safety; hazard awareness; Situation Awareness; Poisson; logit

28 **1. Introduction**

29 The incidence of foodborne infectious intestinal disease continues to be a burden to the UK with
30 11 million working days lost annually at a cost of £2 billion (FSA, 2010/2011, 2011). Risk management
31 programmes have been developed in the UK for the two pathogens responsible for the greatest
32 burden and mortality rates – *Listeria* and *Campylobacter*. *Campylobacter* causes most bacterial cases
33 of foodborne illness in the UK and Europe. Whilst the number of *Campylobacter* outbreaks is
34 increasing, incidence remains associated with sporadic cases of unknown origin often associated
35 with the home (EFSA, 2012; HPA, 2012). In the UK 11% of outbreak data are associated with the
36 home, with over a third of attributed outbreaks in Europe associated with the home (EFSA, 2012).
37 The UK Food Standards Agency (FSA) has targeted improved domestic food practices to reduce
38 foodborne disease (FSA, 2010/2011).

39 The continuing importance of the public's storing, handling and cooking of raw chicken has been
40 emphasised by the UK poultry industry missing the 2013 contamination targets which were agreed
41 with the FSA in 2010, and looking likely to miss the 2105 targets also – with 70% of raw chicken on
42 sale in the UK testing positive for *Campylobacter*. Given that there seems to be no imminent decline
43 in poultry contamination rates, then correct handling of chicken in the home is likely to be central to
44 any reduction in the disease burden associated with Campylobacteriosis.

45 Food safety is one of many contexts where an assessment of hazard awareness is valuable. This
46 may be as part of a test of knowledge (such as an examination after a training course) or for research
47 purposes. In this paper we outline the development of a hazard awareness testing tool and report
48 substantive results from its first application in the realm of domestic food hazard awareness.
49 Specifically, we use the tool to investigate which domestic food hazards are more/less likely to be
50 identified and how individual characteristics influence the (i) probability of specific hazards being
51 identified, and (ii) the aggregate number of hazards people identify.

52 **1.1. Eliciting Hazard Awareness**

53 Many methods are used to assess knowledge and awareness including self-completion
54 questionnaires, interviews, focus groups and observational studies. Each has strengths and
55 limitations when seeking to understand awareness and routine behaviours. For example, whilst self-
56 reported awareness may be the most simple and convenient way to conduct such assessments there
57 is often a discord between stated and actual behaviour (Abbot, Byrd-Bredbenner, Schaffner, Bruhn,
58 & Blalock, 2007; Beattie, 2010; Kendall, et al., 2004; Medeiros, Hillers, Kendall, & Mason, 2001;
59 Redmond & Griffith, 2003a, 2003b; van Asselt, Fischer, de Jong, Nauta, & de Jonge, 2009).

60 Biases are known to cause a divergence between both reported and actual behaviours and the
61 attitudes people articulate and their behaviours. The discords are likely to be greater when
62 individuals are asked questions which they interpret to have a normative element, and hence for
63 which they perceive there to be more socially acceptable responses. This social desirability bias may
64 arise with questions concerning attitudes, opinions or behaviours.

65 Optimistic bias (OB) may also widen the gulf between attitudes and behaviours (Fischer, Frewer,
66 & Nauta, 2006; Miles, Braxton, & Frewer, 1999; Miles & Scaife, 2003; Parry, Miles, Tridente, Palmer,
67 & Group, 2004; Sharot, 2011; Sparks & Shepherd, 1994; Weinstein, 1987). Optimistic bias causes
68 people to systematically “underestimate the risks associated with many potentially risky behaviours
69 or events” (Fischer & Frewer, 2009:577) meaning, in the context of food safety, individuals believe
70 that they are less vulnerable to food safety hazards than the average person.

71 One response to the potential gulf between stated and actual attitudes/behaviours is to
72 complement, or substitute, survey methods with additional approaches such as microbiological
73 assessment or behavioural observation (Abbot, et al., 2007; Anderson, Shuster, Hansen, Levy, & Volk,
74 2004; Fischer, et al., 2007; Parry, et al., 2004; Redmond, Griffith, & Peters, 2000). Observation may
75 involve the observer being present with the participants (Curtis, et al., 2003; Evans, 2011) or the use
76 of video surveillance (Anderson, et al., 2004; Kendall, et al., 2004; van Asselt, et al., 2009). A recurring
77 issue for observational studies is minimising the effect of observation (Clayton & Griffith, 2001;

78 Evans, 2011) since people tend to behave differently if watched (Gill & Johnson, 1997; Redmond &
79 Griffith, 2003a). Well-designed self-reporting studies are still capable of yielding valuable
80 information; Milton and Mullan (2012) find positive correlations between self-reported and observed
81 food safety behaviours.

82 Survey techniques typically employed to elicit people's behaviours or attitudes prompt the
83 participant to be slow and thoughtful in their responses. There is however increasing interest in the
84 notion that people use differing cognitive processes when they navigate their everyday experiences
85 as opposed to more unusual, challenging situations. This conjecture of System 1 (fast, intuitive) and
86 System 2 (slow, deliberate) thinking (Kahneman, 2003) poses some interesting challenges for
87 researchers who prompt people to use System 2 thinking when taking part in research concerning
88 behaviours that typically involve System 1 thinking.

89 The Situation Awareness (SA) (M.R. Endsley, 1995) approach to assessing hazard awareness
90 seeks to test an individual's ability to identify inappropriate behaviours, or dangerous conditions or
91 events, taking into account the surrounding environment and the processes taking place within it. SA
92 is defined as the 'perception of the elements in the environment within a volume of time and space,
93 the comprehension of their meaning, and the projection of their status in the near future' (pg 36:
94 M.R. Endsley, 1995).

95 Situation Awareness testing typically involves the use of video footage or a simulator to create a
96 realistic scenario within which hazard awareness or specific skills are tested. The process or
97 simulation is viewed by the participant and they respond to hazards as they become apparent during
98 the process. Thus Situation Awareness (SA), which brings together a range of cognitive processes, is
99 the active processing of situational information as new information is combined with existing
100 knowledge and a composite picture of the situation is developed.

101 Much of the situation awareness research has been conducted in test settings, for example an
102 early driving test (Pelz & Krupat, 1974) used a driver's-view video footage with respondents pulling a
103 lever as they saw hazards develop. Situation Awareness has been used to elicit hazard perception in
104 many settings, often associated with highly skilled operator tasks such as driving and air traffic
105 control (Mica R. Endsley & Rodgers, 1994; Horswill & McKenna, 2004; McGowan & Banbury, 2004;
106 Wetton, et al., 2010) as well as the fields of sport, healthcare and chess (Durso, et al., 1995; Gaba,
107 Howard, & Small, 1995; James & Patrick, 2004; Rowe & McKenna, 2001; Wright, Taekman, & Endsley,
108 2004).

109 SA approaches have been subject to validation tests. The most widely known example is the
110 driving hazard perception test which has been successfully validated against real behaviour in a
111 number of ways (Horswill and McKenna (2004). Real driving behaviour has been compared to test
112 behaviour (Watts & Quimby, 1979) and the comparison between SA test scores and actual behaviour
113 has been undertaken with a very specific and germane form of behaviour: motoring accidents (Pelz &
114 Krupat, 1974). More recently differences in SA tests were compared between novice and
115 experienced practitioners (Wetton, et al., 2010).

116 The Watch-&-Click Hazard Awareness testing tool reported in this paper is rooted in this approach,
117 eliciting hazard awareness using a video stimulus that prompts non-verbal responses under time
118 pressure.

119 ***2. The Watch-&-Click Hazard Testing Tool***

120 We now set out the development of the Watch-&-Click tool for eliciting hazard awareness and its
121 first application, the investigation of food hazard awareness in the domestic kitchen.

122 The tool allows assessment of the level of awareness of potentially hazardous food behaviours
123 by asking respondents to view and respond, via mouse click or screen tap, to hazards embedded in
124 video footage of food preparation. This is done online, in real-time. Following on-screen explanatory

125 details and instructions, participants take the Watch-&-Click test which is embedded within a
126 broader survey including questions on demographic, behavioural and attitudinal characteristics.

127 The system's components are video footage containing the practices of interest in which hazards
128 occur. This is embedded within an interface which allows respondents to view the footage and
129 register their perception of a hazard (via mouse clicks/screen taps) with the response data (temporal
130 and spatial coordinates) recorded. The third element is a database in which the response data are
131 stored, and routines combine the predefined hazard definitions with respondents' click data to
132 define whether each hazard is hit or missed. Individualised scores and appropriate feedback can then
133 be generated and displayed to the respondent.

134 We now explain these elements with reference to the food safety application before reporting
135 substantive results.

136 ***2.1. Hazard selection, definition and filming***

137 Given that raw chicken presents a significant risk if mishandled, particularly with respect to the
138 pathogens *Campylobacter* and *Salmonella* (Neimann, Engberg, Molbak, & Wegener, 2003; Parry,
139 Palmer, Slader, Humphrey, & Grp, 2002) the video footage featured the preparation of a chicken
140 salad. In the film, hazardous behaviours associated with raw chicken were present along with other,
141 more general, food safety hazards. The hazards included behaviours which could contaminate either
142 the food prepared, the 'cook' or surfaces/items in the kitchen. Table 1 details the hazards featured
143 in the video footage stimuli.

144

145 *Table 1. Hazards used in the survey*

146

147 The hazards included were intended to vary in terms of likelihood of identification by
148 respondents, to ensure a mix of hazard difficulty. The obvious hazard of undercooked chicken was
149 not included since the extent of chicken cooking is difficult to convey unobtrusively in film and so text
150 annotation was added to the film to indicate the chicken was fully cooked.

151 ***2.1.1. Storyboarding, staging, filming and editing***

152 The film was structured so as to include the hazards in a naturalistic sequence in which an
153 individual prepared a warm chicken salad for two. During filming and editing, enactment of the
154 hazards was managed to ensure that hazards were temporally spaced, appropriately visible (without
155 obvious signposting) and that inadvertent hazards were not introduced. Care was also taken to
156 ensure that there was a sufficient gap between hazards, to minimise the risk of misattribution (a late
157 click for one hazard being interpreted as a click for a subsequent hazard). Two films were made,
158 comprising different combinations of the hazards listed in Table 1.

159 ***2.2. Development of the Watch-&-Click interface***

160 The films were converted to Adobe Flash format for web delivery and embedded within a
161 bespoke online survey system. Participants were only shown one film, to which they were allocated
162 at random. Software was developed to enable the time and location of the hazard identification
163 clicks/taps to be recorded in real-time. Figure 1 shows a screenshot of the video challenge in
164 progress. The clicks are recorded in the database and the respondent is able to see their clicks being
165 registered via a click counter.

166

167 *Fig. 1. The web interface showing the click counter*

168

169 ***2.3. Survey Questions***

170 Attitudinal questions were asked prior to the Watch-&-Click test. These were designed to
171 measure respondents' perceptions of their own levels of risk, control and knowledge regarding food
172 poisoning in the home, and those of the average person. These allowed optimistic bias to be
173 identified at the individual level (Parry, et al., 2004). The three pairs of risk, control and knowledge
174 questions were of the form "how much [risk] do you think there is to you personally [to the average
175 person] from food poisoning in the home?"

176 The survey's final stage comprised questions on demographics and food-specific questions
177 concerning experience of food illness, diet and any training or qualifications in food safety.

178 **3. Research and Modelling approach**

179 The Watch-&-Click approach is applied to domestic food hazard awareness in the domestic
180 kitchen. A number of research questions can be addressed using the data generated:

- 181 1. Which food hazards are more/less likely to be identified?
- 182 2. How do individual characteristics influence the probability of identification of specific
183 hazards?
- 184 3. How many hazards in aggregated do people identify?
- 185 4. How do individual characteristics influence these aggregate hazard identification scores?

186 While research questions 1 and 3 are investigated by simple tabulations of the data, models are
187 estimated on the click-response data to interrogate questions 2 and 4 concerning the impact of
188 individual characteristics on (i) the probability of specific hazards being identified, and (ii) aggregate
189 hazard identification scores.

190 A logit model was estimated in which the probability of a hazard being identified ($Y=1$ for hazard
191 hit; $Y=0$ for a miss) is a function of characteristics X :

$$192 \quad P(Y = 1) = \frac{\exp(\alpha + \sum \beta_K X_K)}{1 + \exp(\alpha + \sum \beta_K X_K)} \quad (1)$$

193 with the effects of those characteristics on the probability of hazard identification captured by the
 194 estimated β coefficients.

195 To investigate the impact of characteristics on individuals' total hazard identification scores a
 196 right censored Poisson count model is estimated (Hilbe & Judson, 1999). The count modelled is the
 197 number of hazards identified by the individual. We assume a Poisson distribution for the dependent
 198 variable (number of hazard hits) and a censored model is estimated since the number of hazards is
 199 capped (8 for Film1; 6 for Film2).

200 A random variable Y is said to have a Poisson distribution with parameter u if it takes values $y =$
 201 $0, 1, 2, \dots$ with a probability

$$202 \quad P(Y = y) = \frac{e^{-u}u^y}{y!} \quad (2)$$

203 The likelihood function for the censored Poisson model (Hilbe & Judson, 1999) is:

$$204 \quad L(u, X) = \prod_{i=1}^N f(x_i, u)^{I(p_i=1)} \left(\sum_{j=0}^{x_i} f(j, u) \right)^{I(p_i=0)} \left(1 - \sum_{j=0}^{x_i} f(j, u) \right)^{I(p_i=-1)} \quad (3)$$

205 where

- 206 - N is the number of cases
- 207 - $p_i = 1$ if the i th observation is not censored, 0 if left censored, -1 if right censored
- 208 - $I(p_i)$ is the indicator function, taking the value one when the statement in parentheses is
 209 true, otherwise taking the value 0
- 210 - f is the probability density function of a Poisson random variable with parameter u
- 211 - $u = \exp(X\beta)$
- 212 - $1 - \sum_{j=0}^{x_i} f(j, u)$ is the probability of observing x_i or more events when $E(Y) = u$
- 213 - $\sum_{j=0}^{x_i} f(j, u)$ is the probability of observing x_i or fewer events when $E(Y) = u$
- 214 - x_i are characteristics

215 Many characteristics to be included in these models were readily available from the survey, but
216 some had to be derived from raw data. Perceptions are measured from the attitudinal questions
217 regarding risk, control and knowledge extending the work of Parry et al. (2004). From these data
218 optimistic bias is tested for using a difference score between a respondent's answers to the
219 questions about themselves and those about the average person. Typically, OB has been tested using
220 a one-sample t-test (Parry, et al., 2004; Sargeant, Majowicz, Sheth, & Edge, 2010; Weinstein, 1987).
221 However, as the difference scores are ordinal not interval we use the non-parametric Wilcoxon
222 Mann-Whitney test to test the hypothesis that the sample median is equal to zero and therefore
223 shows no bias. Whilst optimistic bias is a group effect (Parry, et al., 2004; Rothman, Klein, &
224 Weinstein, 1996), we create a bias rating (0=no bias, 1=bias) for individuals.

225 **4. Results**

226 **4.1. Recruitment and demographics**

227 Recruitment occurred via snowball sampling. Thirty three seed emails were sent to individuals in
228 the UK, one to Australia and one to the US. Subsequent recruitment was rapid with over 300 people
229 completing the survey within three weeks - in total 576 responses were gathered. The characteristics
230 of the sample are set out in Table 2 indicating that 404 (70%) of the participants were female with
231 14% from outside the UK (from the Netherlands, France, Ireland, the USA and Australia). The sample
232 was ethnically diverse with 31% of the sample from a non-white British background. 11% of
233 participants were vegetarian or vegan. One hundred and forty seven (26%) reported having had food
234 poisoning in the last 5 years, but only 29 had visited the doctor of whom 16 had had laboratory
235 confirmation of their food poisoning. Some knowledge, experience or qualification in food safety was
236 claimed by 266 (46%) respondents.

237

238 *Table 2. Summary of characteristics used in the analysis*

239

240 ***4.2. User Experience***

241 The rapid recruitment process provided some evidence that people found the Watch-&-Click
242 survey engaging and accessible. This was further borne out by the comments left at the survey's end
243 (no adverse comments were left) of which this selection are indicative:

- 244 - "I think the video is a very nice method to see if people are aware of where the risks are.
245 I think it is much more efficient than a questionnaire for example"
- 246 - "Very innovative and realistic video"
- 247 - "Interesting to have a video clip instead of the usual boring old tick box questionnaire"
- 248 - "Great Learning experience"

249 As the Watch-&-Click Hazard Awareness tool runs in real-time a debrief question was asked to
250 assess if the speed of the film (and the participant's ability to keep pace) was problematic.
251 Participants responded favourably, with 367 (63.72%) of individuals stating that the speed was
252 "fine", and 129 (22.4%) "a little fast but I managed". Only 11 respondents indicated that the film was
253 "too fast".

254 We now turn to some substantive results yielded by the approach, combining the data described
255 and the models set out in Section 3.

256 ***4.3. Identification of hazards***

257 Individuals' click behaviour was analysed to calculate the number of hazards identified (hazard
258 hits). Whilst temporal and spatial click coordinates were stored in a server side database sitting
259 'behind' the web interface experienced by respondents, only temporal click coordinates were
260 analysed in this study. Figure 2 shows the distribution of hazard identification scores for each of the
261 2 films in which the maximum number of hazards was 8 (film 1) and 6 (film 2).

262

263 *Fig. 2. Hazard identification scores (by film)*

264

265 7% of the film1 sample (10 %, film2) identified none of the hazards, and 15% (17%, film2)
266 identified 2 or less of the hazards they saw. 12% and 23% of participants identified all of the hazards
267 they saw in films 1 and 2 respectively. Figure 3 shows the hazard identification rates for each of the
268 hazards. The most commonly identified hazards were cross contamination from hands which had
269 handled raw chicken (cc-bowl, 84%), storage of raw chicken in the fridge's top shelf (cc-store, 81%)
270 and wiping (rather than washing/replacing) a chopping board and knife which had been used with
271 raw chicken before cutting salad ingredients (cc-board, 79%).

272

273 *Fig. 3. Hazard identification rate*

274

275 The least commonly identified hazards were the use of utensils covered in raw marinade to serve
276 cooked chicken (cc-utensils, 53%) and the inappropriately high fridge temperature (8.9°C) evident
277 from the digital fridge thermometer (temp, 57%, in film 1). Identification rates for this fridge
278 temperature hazard is worthy of a little more discussion. While the hazardous behaviours embedded
279 in the film were designed to be as naturalistic as possible, it was difficult to display the fridge
280 temperature without it being a little conspicuous. Consequently, two films were created, with
281 different temperatures displayed in each. In film 1 a hazardous temperature of 8.9°C was visible,
282 while in film 2 a safe temperature of 4.7°C was visible. While 57% identified 8.9°C as a hazard, 48% of
283 film 2 viewers identified 4.7°C as a hazard. This suggests the proportion of the sample knowing
284 safe/hazardous fridge temperatures is far below the 57% shown in Figure 3.

285 ***4.4. Optimistic Bias***

286 The presence of OB was tested by calculating the difference between individuals' rating of their
287 own, and the average person's, levels of risk, control and knowledge. For all 3 dimensions the scores
288 are significantly different from zero indicating OB was present within the group. The participants
289 indicated that the average person is at a significantly greater risk of getting food poisoning ($p < 0.001$),
290 has less knowledge ($p < 0.001$) and less control ($p < 0.001$) compared to themselves. An individual level
291 characteristic was generated to indicate whether the person exhibited each form of OB. Descriptive
292 statistics for these 3 dummies are displayed in Table 2, with 63% of participants exhibiting OB in
293 relation to risk, 37% in relation to control and 75% regarding knowledge.

294 Having summarised the hazard identification patterns and levels of optimistic bias descriptively,
295 we now report results of modelling work to identify the role of observable characteristics on hazard
296 identification scores, and the probability of identifying specific food safety hazards.

297 ***4.5. Explaining variation in hazard awareness***

298 Estimation of the Poisson count model outlined in Section 3 allowed investigation of the effect
299 of independent variables (characteristics) on individuals' Hazards Identification Score (HIS). These
300 characteristics included gender, age group, children in the household, food safety qualifications, food
301 poisoning within 5 years and whether they were a vegetarian. Respondents' perceptions, biases and
302 experience of the survey process were also included: personal perceptions of risk, control and
303 knowledge, dummies for OB (risk) OB (control) and OB (knowledge) and perception of the film's
304 speed (fine/a little fast but ok/ too fast). A summary of these variables and their descriptive statistics
305 are in Table 2.

306 Table 3 shows results of full (model 1) and parsimonious (model 2) Poisson models with
307 explanatory variables removed using a stepwise approach until all remaining variables were
308 significant at $p \leq 0.05$. For ease of interpretation the effects are displayed as incidence rate ratios
309 calculated by exponentiation of raw coefficients. Young adults (aged 18-29) and Adults (aged 30-59)

310 were significantly more likely to score higher than those aged over 60, with an increased HIS of 29%
311 and 21% respectively. There was a positive effect of claimed levels of knowledge with each additional
312 point on the 6 point knowledge scale corresponding to a 10% increase in the HIS. In contrast there
313 was no significant difference in the HIS for those professing to have food safety qualifications or
314 training. This was also the case for those reporting they found the film too fast, indeed those
315 reporting it “a little fast” scored significantly higher than those who reported the speed as “fine”.

316

317 *Table 3. Poisson regression results: impact of characteristics on Hazard Identification Score (HIS)*

318

319 The effect of characteristics on the probability of specific hazards being identified was
320 investigated using multivariate logistic regression. The independent variables listed above were again
321 removed using a stepwise approach to produce a final model for each hazard, each of which is set
322 out in Table 4.

323

324 *Table 4. Binary Logit Regression: Impact of characteristics on probability of identifying specific*
325 *hazards*

326

327 The age effects identified in the aggregate count model results are present again, but only for
328 some of the hazards. Young adults and adults were more likely to identify the cross contamination
329 hazard of utensils coated in raw marinade being used to serve up food (cc-utensils), the raw
330 marinade being poured over the salad as a dressing (cc-marinade) and dirty hands being used to
331 touch the radio (cc-radio). There were no age effects for other hazards. Women were more likely to

332 identify two of the cross contamination hazards (dirty hands being used to touch the radio (cc-radio)
333 and marinade bottle (cc-bottle)). The presence of children in the model had no effect for 6 of the 8
334 hazards, but there were effects, of opposite sign for 2 hazards: people with children were more likely
335 to spot the raw marinade being used as a dressing (cc-marinade) but less likely to spot a hygiene
336 hazard (hyg-nose). Vegetarians were less likely to identify 3 of the hazards, and more likely to spot
337 none of the others. The washing of chicken (cc-chicken) was less likely to be spotted by them as were
338 2 cross contamination hazards (cc-radio, cc-bottle).

339 Having had food poisoning in the last 5 years affected the probability of identifying only one of
340 the hazards, with such formerly ill people less likely to notice the same utensils being used with raw
341 and later cooked chicken (cc-utensils). People claiming to have food safety qualifications/knowledge
342 (qual) and those believing they had more knowledge (obknow), and at lower risk (obrisk), than the
343 average person were found to be more likely to identify a series of hazards.

344 People with food safety qualifications/knowledge (qual) were more likely to spot the excessively
345 warm fridge (temp) as well as the utensil cross contamination problem (cc-utensil). Respondents'
346 belief that they had more food safety knowledge than the average person (obknow) affected the
347 probability of spotting more hazards than any other characteristic. This trait affected the chances of
348 spotting 5 hazards, positively in all cases. It was the only characteristic that increased the likelihood
349 of identifying poor hand washing practices. It was one of only two characteristics (the other being
350 obrisk) that increased the probability of people identifying the washing of raw chicken as a hazard
351 (cc-chicken). People exhibiting OB (obknow, obrisk) were also more likely to identify the marinade as
352 dressing hazard (cc-marinade). While the effects of OB regarding risk and knowledge were positive in
353 all cases, people exhibiting OB (control) were found not to be more or less likely than the sample
354 average to spot any of the hazards.

355 These effects of individual-level characteristics can be summarised for the individual hazards.
356 Hence identifying the washing of chicken (cc-chicken) as a hazard was less likely among vegetarians

357 (veggie), but more likely for those believing they had more knowledge or lower risk than the average
358 person (obknow, obrisk). Similarly, the use of raw marinade as a salad dressing (cc-marinade) was
359 more likely to be identified by those under 60 (young, adult), those with children in the household
360 (child) and those believing they had more knowledge or were at lower risk than the average person
361 (obknow, obrisk).

362

363 **5. Discussion**

364 This study was initiated to assess the awareness of hazardous food behaviours in the domestic
365 kitchen. In the process of doing so a novel method of eliciting hazard awareness was conceptualised,
366 developed and applied. The method developed was rooted in Situation Awareness.

367 The aim was to design a simple, intuitive and engaging testing tool. Whilst we do not have user
368 experience ratings to compare with an equivalent, standard format survey, the speed with which the
369 survey spread from initial seed emails and the number of completions amassed suggests a positive
370 user experience. More direct evidence is available from the comments respondents left which were
371 unanimously positive and which in many cases made unprompted, positive, comparisons with more
372 typical standard formats. These responses suggest the method exhibits good face validity.

373 Some findings resonate with other research. For example washing raw chicken was not identified
374 as a hazard by 38% of the sample, a rate similar to the 41% who report always washing poultry in the
375 FSA's 'Food and You' (F&Y) survey (FSA, 2014). The fridge temperature of 8.9°C was identified as a
376 hazard by 57% of the film1 sample, a rate which corresponds to the 53% of respondents in waves 2
377 and 3 of the F&Y survey which correctly identified the correct temperature range (0 - 5 °C). However
378 the inferences that can be drawn from these results are questioned by the finding that 48% of the
379 film2 sample identified the safe temperature of 4.7°C as a hazard. This highlights the need to
380 understand the impact upon respondent behaviour of the means by which knowledge is elicited,

381 whether it be visual (this study) or the use of interval response options (F&Y survey). Just as a fridge
382 temperature being displayed was probably taken as a 'clue' by some respondents, the correct
383 temperature range presented in the F&Y survey adjacent to the categories of below 0°C, and 5-8°C
384 may well have prompted an overestimate of knowledge of correct temperatures.

385 Individuals claiming to have food safety qualifications or knowledge (qual) were found to be
386 more likely to identify 3 of the 8 hazards. The characteristic that was positively correlated with
387 identification of the highest number of hazards was the belief that one had more knowledge of food
388 safety at home than the average person (obknow). People believing this to be the case were more
389 likely to spot 5 of the 8 hazards. These 2 effects were, together, significant across all 8 of the hazards,
390 but never together; suggesting that the personal assessment of knowledge was a more powerful
391 predictor than a person having been through training *per se*. The results do pose a question as to
392 whether the assessment of people believing they know more than the average person really is a bias
393 – the results in this study suggest that, on average, these people do indeed know more about food
394 safety at home (premised on the belief that the scores generated by the survey are a robust measure
395 of food safety knowledge). Believing one had more control over the food poisoning risk at home was
396 not positively correlated with spotting any of the hazards.

397 Those exhibiting OB in knowledge were also found to score higher in aggregate within the test
398 (by 11%). This effect was however far less strong than that associated with age: being aged 18-29 or
399 30-59 meant increases in the HIS of approximately 20% and 30% respectively. While older age groups
400 have been found previously to be more likely to deviate from recommended food safety practices in
401 the home (for example in F&Y reports), younger age groups have been found to have the same
402 tendency. The results from the Poisson and logit models here are contrary to this: the 18-29 group
403 effects were positive and typically stronger than the 30-59 effects.

404 Respondents' self-reported levels of knowledge and whether they have specialist training or
405 experience being positively correlated with higher probabilities of identifying many of the hazards,

406 suggest the approach exhibits convergent validity. Further support for the validity of the approach
407 can be drawn from past validity investigations of Situation Analysis methods (see Section 1) most
408 commonly involving driver behaviour. The reliability of the Watch-&-Click Hazard Testing Tool is
409 further investigated by testing the internal consistency for each film - Film 1 (Cronbach's alpha = .82),
410 film 2 (Cronbach's alpha = .74). These levels compare well with reported consistencies in hazard
411 perception tests for example 0.83 and 0.84 (Bruce, Unsworth, Tay, & Dillon, 2015) and 0.72
412 (McGowan & Banbury, 2004). Horswill and McKenna (2004) highlights that the psychometric
413 reliability of hazard perception test is variable with the number of hazards and the definition of
414 hazard limiting internal consistency – the lower number of hazards may explain the lower reported
415 alpha for film 2.

416 **6. Conclusions**

417 Food behaviours in the home are difficult to observe and unlike the commercial food sector
418 there is no training required or inspection programme in operation. Poor practices in storing and
419 preparing food in the home cause significant health and economic damages. Whilst interventions
420 along the food chain can reduce public exposure to food pathogens, behaviour in the home can still
421 be a major factor in generating cases of foodborne illness. In the case of *Campylobacter* which is
422 strongly associated with the consumption of chicken, FSA targets for the poultry sector set in 2010
423 were missed in 2013 and are likely to be missed again in 2015. Since *Campylobacter* contamination of
424 birds is declining little if at all, then there is still a considerable public health burden falling upon the
425 consumer. Understanding, and potentially improving, people's food safety knowledge in the home
426 offers potential to reduce the disease burden.

427 The Watch-&-Click Hazard Testing Tool developed and applied here, rooted in Situation
428 Awareness, attempts to provide participants with an environment that is not too different to that of
429 a normal domestic kitchen. Participants complete the study online and anonymously, potentially
430 reducing observer bias. The use of real-time responses creates a time pressure thereby discouraging

431 users to over-deliberate instead utilising fast, automatic, associative processes. By limiting the
432 amount of time that an individual has to consider the hazards, it is hoped that this in turn allows less
433 time for the respondent to consider what they should 'do' and increases the likelihood they will
434 respond in accordance with their own routine behaviours.

435 Further work could be undertaken to make formal comparisons of how the click response data
436 correlate with more traditionally elicited survey responses. A more challenging task will be to test
437 the hazard awareness scores against real practices in the home. The approach has potential to be
438 applied in other contexts, indeed some respondents contacted the authors to enquire whether the
439 approach could be applied to non-food settings in which they worked or trained. Further work is
440 underway to refine the statistical analysis of participants' click response data to account for variation
441 in the number of times they click. This seeks to capture the possibly differing levels of information
442 contained within a click from a heavy clicker as opposed to a sparse one.

443 The Watch-&-Click Hazard Testing Tool has since late 2014 been trialled with pupils in UK
444 secondary schools. The positive user experience identified in this paper has been replicated, with
445 both teachers and pupils extolling its virtues in terms of accessibility and engagement. This resonates
446 with the rapid recruitment rates and positive feedback from participants and food industry and food
447 safety stakeholders in this study. This suggests that the Watch-&-Click tool can be a positive addition
448 to the range of existing methods for eliciting and improving food safety awareness.

449 ***References***

450 Abbot, J. M., Byrd-Bredbenner, C., Schaffner, D., Bruhn, C. M., & Blalock, L. (2007). Comparison of
451 food safety cognitions and self-reported food-handling behaviors with observed food safety
452 behaviors of young adults. *European Journal Clinical Nutrition*, 63, 572-579.

453 Anderson, J. B., Shuster, T. A., Hansen, K. E., Levy, A. S., & Volk, A. (2004). A Camera's view of
454 consumer food-handling behaviors. *Journal of the American Dietetic Association, 104*(2), 186-
455 191.

456 Beattie, G. (2010). *Why aren't we saving the planet?: a psychologist's perspective*. London:
457 Routledge.

458 Bruce, C., Unsworth, C. A., Tay, R., & Dillon, M. P. (2015). Development and validation of the
459 Occupational Therapy Risk Propensity Test (OT-RiPT) for drivers with disability. *Scandinavian*
460 *Journal of Occupational Therapy, 22*(2), 147-152.

461 Clayton, D., & Griffith, C. (2001). Observation of food safety practices in catering using notational
462 analysis. *British Food Journal, 106*(3), 211-227.

463 Curtis, V., Biran, A., Deverell, K., Hughes, C., Bellamy, K., & Drasar, B. (2003). Hygiene in the home:
464 relating bugs and behaviour. *Social Science & Medicine, 57*(4), 657-672.

465 Durso, F. T., Truitt, T. R., Hackworth, C. A., Crutchfield, J. M., Ohrt, D. D., Nikolic, D., Moertl, P. M., &
466 Manning, C. A. (1995). Expertise and chess: A pilot study comparing situation awareness
467 methodologies. In D. J. Garland, Endsley, M. R. (Ed.), *Experimental Analysis and*
468 *Measurement of Situation Awareness* (pp. 295-303). Daytona Beach, FL: Embry-Riddle
469 Aeronautical Press.

470 EFSA. (2012). The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic
471 Agents and Food-borne Outbreaks in 2010. *EFSA Journal, 10*(3).

472 Endsley, M. R. (1995). Towards a theory of situation awareness. *Human Factors, 37*(1), 32-64.

473 Endsley, M. R., & Rodgers, M. D. (1994). Situation Awareness Information Requirements Analysis for
474 En Route Air Traffic Control. *Proceedings of the Human Factors and Ergonomics Society*
475 *Annual Meeting, 38(1)*, 71-75.

476 Evans, D. (2011). Beyond the throwaway society: Ordinary domestic practice and a sociological
477 approach to household food waste. *Sociology*.

478 Fischer, A. R. H., De Jong, A. E. I., Van Asselt, E. D., De Jonge, R., Frewer, L. J., & Nauta, M. J. (2007).
479 Food safety in the domestic environment: An interdisciplinary investigation of microbial
480 hazards during food preparation. *Risk Analysis, 27(4)*, 1065-1082.

481 Fischer, A. R. H., & Frewer, L. J. (2009). Consumer familiarity with foods and the perception of risks
482 and benefits. *Food Quality and Preference, 20(8)*, 576-585.

483 Fischer, A. R. H., Frewer, L. J., & Nauta, M. J. (2006). Toward improving food safety in the domestic
484 environment: A multi-item rasch scale for the measurement of the safety efficacy of
485 domestic food-handling practices. *Risk Analysis, 26(5)*, 1323-1338.

486 FSA. (2010/2011). Annual Report of the Chief Scientist. In (Vol. 2012).

487 FSA. (2011). The Second Study of Infectious Intestinal Disease in the Community (IID2). In London,
488 UK.

489 FSA. (2014). Food and You 2014. In.

490 Gaba, D. M., Howard, S. K., & Small, S. D. (1995). Situation awareness in anesthesiology. *Human*
491 *Factors, 37(1)*, 20-31.

492 Gill, J., & Johnson, P. (1997). *Research methods for managers* (2nd Edition ed.): Paul Chapman
493 Publishing.

494 Hilbe, J. M., & Judson, D. H. (1999). Right, left, and uncensored Poisson regression. *Stata Technical*
495 *Bulletin*, 8(46).

496 Horswill, M. S., & McKenna, F. P. (2004). Drivers' hazard perception ability: Situation awareness on
497 the road. In S. Banbury & S. Tremblay (Eds.), *A cognitive approach to situation awareness :
498 theory and application* (pp. 155-175). Aldershot, Hampshire, England; Burlington, VT:
499 Ashgate Pub.

500 HPA. (2012). Analysis of general foodborne outbreaks shows campylobacter as the leading cause in
501 England and Wales in 2011. *Health Protection Report*, 6(18).

502 James, N., & Patrick, J. (2004). The role of situation awareness in sport. In S. Banbury & S. Tremblay
503 (Eds.), *A cognitive approach to situation awareness : theory and application* (pp. 297-316).
504 Aldershot, Hampshire, England; Burlington, VT: Ashgate Pub.

505 Kahneman, D. (2003). A perspective on judgment and choice: Mapping bounded rationality.
506 *American Psychologist*, 58(9), 697-720.

507 Kendall, P. A., Elsbernd, A., Sinclair, K., Schroeder, M., Chen, G., Bergmann, V., Hillers, V. N., &
508 Medeiros, L. C. (2004). Observation versus self-report: Validation of a consumer food
509 behavior questionnaire. *Journal of Food Protection*, 67(11), 2578-2586.

510 McGowan, A. M., & Banbury, S. P. (2004). Evaluating interruption-based techniques using embedded
511 measures of driver anticipation. In S. Banbury & S. Tremblay (Eds.), *A cognitive approach to*

512 *situation awareness : theory and application* (pp. 176-192). Aldershot, Hampshire, England;
513 Burlington, VT: Ashgate Pub.

514 Medeiros, L. C., Hillers, V. N., Kendall, P. A., & Mason, A. (2001). Food Safety Education: What Should
515 We Be Teaching To Consumers? *Journal of Nutrition Education*, 33(2), 108-113.

516 Miles, S., Braxton, D. S., & Frewer, L. J. (1999). Public perceptions about microbiological hazards in
517 food. *British Food Journal*, 101(10), 744-762.

518 Miles, S., & Scaife, V. (2003). Optimistic bias and food. *Nutrition Research Reviews*, 16, 3-19.

519 Milton, A. C., & Mullan, B. A. (2012). An application of the theory of planned behavior - A randomized
520 controlled food safety pilot intervention for young adults. *Health Psychology*, 31(2), 250-259.

521 Neimann, J., Engberg, J., Molbak, K., & Wegener, H. C. (2003). A case-control study of risk factors for
522 sporadic *Campylobacter* infections in Denmark. *Epidemiology and Infection*, 130(3), 353-366.

523 Parry, S. M., Miles, S., Tridente, A., Palmer, S. R., & Group, S. a. E. W. I. D. (2004). Differences in
524 perception of risk between people who have and have not experienced *Salmonella* food
525 poisoning. *Risk Analysis*, 24(1), 289-299.

526 Parry, S. M., Palmer, S. R., Slader, J., Humphrey, T., & Grp, S. E. W. I. D. L. (2002). Risk factors for
527 *Salmonella* food poisoning in the domestic kitchen - a case control study. *Epidemiology and*
528 *Infection*, 129(2), 277-285.

529 Pelz, D. C., & Krupat, E. (1974). Caution profile and driving record of undergraduate males. *Accident*
530 *Analysis & Prevention*, 6, 45-58.

531 Redmond, E. C., & Griffith, C. J. (2003a). A comparison and evaluation of research methods used in
532 consumer food safety studies. *International Journal of Consumer Studies*, 27(1), 17-33.

533 Redmond, E. C., & Griffith, C. J. (2003b). Consumer food handling in the home: a review of food
534 safety studies. *Journal of Food Protection*, 66, 130-161.

535 Redmond, E. C., Griffith, C. J., & Peters, A. C. (2000). Risk based observational assessment of
536 consumer food safety behavior and implications for food safety education. *Proceedings of*
537 *the Second Nsf International Conference on Food Safety*, 113-119.

538 Rothman, A. J., Klein, W. M., & Weinstein, N. D. (1996). Absolute and Relative Biases in Estimations of
539 Personal Risk. *Journal of Applied Social Psychology*, 26(14), 1213-1236.

540 Rowe, R. M., & McKenna, F. P. (2001). Skilled anticipation in real-world tasks: Measurement of
541 attentional demands in the domain of tennis. *Journal of Experimental Psychology: Applied*,
542 7(1), 60-67.

543 Sargeant, J. M., Majowicz, S. E., Sheth, U., & Edge, V. L. (2010). Perceptions of Risk and Optimistic
544 Bias for Acute Gastrointestinal Illness: A Population Survey. *Zoonoses and Public Health*,
545 57(7-8), e177-e183.

546 Sharot, T. (2011). *The optimism bias : a tour of the irrationally positive brain*. New York: Pantheon
547 Books.

548 Sparks, P., & Shepherd, R. (1994). Public perceptions of food-related hazards: Individual and social
549 dimensions. *Food Quality and Preference*, 5(3), 185-194.

550 van Asselt, E., Fischer, A., de Jong, A. E. I., Nauta, M. J., & de Jonge, R. (2009). Cooking Practices in the
551 Kitchen-Observed Versus Predicted Behavior. *Risk Analysis*, 29(4), 533-540.

- 552 Watts, G. R., & Quimby, A. R. (1979). Design and Validation of a Driving Simulator. In.
- 553 Weinstein, N. D. (1987). Unrealistic optimism about susceptibility to health problems: Conclusions
554 from a community-wide sample. *Journal of Behavioral Medicine*, 10(5), 481-500.
- 555 Wetton, M. A., Horswill, M. S., Hatherly, C., Wood, J. M., Pachana, N. A., & Anstey, K. J. (2010). The
556 development and validation of two complementary measures of drivers' hazard perception
557 ability. *Accident Analysis & Prevention*, 42(4), 1232-1239.
- 558 Wright, M. C., Taekman, J. M., & Endsley, M. R. (2004). Objective measures of situation awareness in
559 a simulated medical environment. *Quality and Safety in Health Care*, 13, Suppl 1:i65-71.
- 560
- 561