SWISS FOODQUIZ: INDUCING NUTRITIONAL KNOWLEDGE VIA A VISUAL LEARNING BASED SERIOUS GAME

Prototype

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Abstract

Nutritional education programs have been proposed to counter the trend of excessive energy intake, identified as the main driver of overweight. Still, due to lack of resources, only a small part of society can be included in these personnel-intensive programs. Health information systems (HIS) in nutritional education have the potential to overcome these limitations, but still suffer under low end-user acceptance and interaction rates. Their current focus lies in abstract, too generic behavioural recommendations, which the end user cannot directly translate into health-beneficial real-world choices. In order to address these issues, we have built an automatic HIS prototype tailored to support the average consumer in gaining nutritional knowledge by applying paradigms from visual learning and serious gaming, established approaches in related fields to improves users' acceptance, motivation, intention and ultimately likelihood for health-beneficial behaviour changes. Preliminary results of a study with 350 users show high acceptance rates even for previously uninvolved users and measurable gains in nutritional knowledge over the usage phase. With the approach suggested in this paper, it can be shown that the extension of serious game principles to nutritional education can overcome contemporary HIS shortcomings of low acceptance and interaction rates among average, uninvolved and unhealthy users.

Keywords: Health information system, nutritional education, visual learning, serious gaming

1 Introduction

Due to the critically increasing numbers, obesity is becoming an alarming issue all over the world (Popkin, 2001; Sassi et al., 2009): In 2014 over 600 million adults and 42 million children were affected by obesity with growth rates of epidemic proportions (WHO 2015; Alexandratos & Bruinsma 2012). Because consequential diseases of obesity include chronicle conditions, such as diabetes and cardio-vascular diseases, which often require long-term, cost-intensive medical treatment, the increased occurrences cause a significant, expanding financial burden for health-care systems around the world (Omran, 1982; Popkin, 2001, 2002; Srinath et. al., 2004; Vorster, 2002; Puska, 2002).

In order to address these issues, nutritional education campaigns as part of multi-purpose programs have been proposed to counter the underlying excessive energy intake, identified as main driver of overweight (Dehghan et al. 2005; Swinburn et al. 2009). Since nutritional knowledge was found to play a pivotal role in behavioural change towards healthier diets (Spronk et al. 2014; Worsley 2002; Wardle et al. 2000; Young et al. 2011; Darnton 2008), experts recommend to foster nutritional knowledge among all children and adults (WHO, 2003; Popkin, 2002). However, due to limited financial resources, the majority of population cannot be included in current personnel-intense nutritional education programs, which additionally face the challenge of low acceptance rates (Kushner 1995).

Health information systems (HIS) have potential to spread nutritional knowledge towards broader audiences by providing personalized diet recommendations at significantly reduced costs over the internet (Brug et al. 2003; ChanLin et al. 2003). Still, also contemporary nutritional HIS experience low engagement rates, especially in demographic segments that are predestined for obesity, mainly due to low self-motivation and involvement (Williamson et al. 2006).

As serious games (Abt 1970) integrate education with the purpose of learning real-world relevant skills (Wattanasoontorn et al. 2014) into an entertaining environment (Landers et al. 2011), serious gaming offers a promising approach to mitigating low motivation and acceptance rates. The integration of serious gaming into HIS is already established in other health-related interventions, e.g. physical activity (Payne, Moxley, et al. 2015; Hamari & Koivisto 2013), but still relatively rarely seen in nutritional education (Lister et al. 2014; Majumdar et al. 2015).

The goal of this prototype is to exemplify that the extension of serious game principles to nutritional education can overcome contemporary nutritional HIS shortcomings of low acceptance and interaction rates, esp. among average, uninvolved and unhealthy users, and improve applicability of learnt educational content by visually representing locally available food items and healthier substitutes.

This paper adds to the body of existing research by providing insights into how serious gaming for nutritional HIS impacts high acceptance and interaction rates, esp. also among the nutritionally illiterate, unhealthy (adult) users that were previously unlikely to accept nutritional HIS (Williamson et al. 2006). Practitioners and dieticians can leverage upon similar, automatic nutritional HIS in their patient-consultations, as this paper proves that HIS usage correlates with measurable gains of directly applicable nutritional knowledge.

2 Related Work: Serious Gaming in Nutritional Education

Although the advantageous effect of nutritional HIS on health literacy and dietary behaviour has been confirmed (Tate et al. 2001; Turner-McGrievy & Tate 2011), their limited acceptance beyond the highly-interested, relatively healthy patients and low level of interaction rates are strongly criticized (Hebden et al. 2012; Block et al. 2015; Thomas et al. 2015; Casperson et al. 2015; Williamson et al. 2006). To overcome these issues of scaling HIS based interventions towards broader audiences and to increase interaction frequencies, serious games (Abt 1970; Deterding et al. 2011) as games with an educational or informative purpose were found to be effective (Hamari et al. 2014), e.g. at promoting physical activity (Hassan et al. 2012; Leahey & Rosen 2014; Thomas et al. 2015; Payne, Moxley, et al. 2015), digital medical interventions for (chronic) diseases (Kamel Boulos et al. 2015) and paediatric obesity prevention (Thompson 2014; Xu et al. 2014). Similar concepts remain to be rarely seen in nutritional education targeted towards adolescents and adults (Lister et al. 2014; Majumdar et al. 2015; Schneider et al. 2012).

Nutrition-related serious games teach nutritional knowledge or train food literacy (Wattanasoontorn et al. 2014; Lister et al. 2014) through a gamified, entertaining environment (Landers et al. 2011), e.g. by adding game design elements to an HIS (Hamari 2011; Deterding et al. 2011), such as badges, leaderboard, time constraint, goals, badges, levels, etc. (Deterding et al. 2011). As perceived benefits (Darnton 2008) lead to cognitive stimuli (Connolly et al. 2012), intrinsic motivation (Hamari et al. 2014), improved learning results (Connolly et al. 2012), greater interest (Cheong et al. 2013), positive attitude (Hamari & Koivisto 2013) and involvement in dietary health (van der Heijden 2004), the limitations of high entry-barriers for the nutritionally illiterate and uninvolved, as well as overall low acceptance and retention rates can be overcome (Payne, Lister, et al. 2015). Furthermore, besides improving acceptance, as serious games usually leverage upon proven health behaviour constructs, e.g.

goal-setting, self-monitoring and self-reward (Payne, Moxley, et al. 2015; Cugelman 2013), such games also improve users' motivation for (Connolly et al. 2012), attitude towards (Hamari & Koivisto 2013), intention to (Hamari & Koivisto 2013) and likelihood for (health-)beneficial behaviour change (Baranowski et al. 2008; Hamari et al. 2014).

The few available examples of serious games in adult nutritional education (Majumdar et al. 2015; Thompson et al. 2007) confirm the effectiveness of gamification (Deterding et al. 2011) enhanced HIS, but still lack real-world applicability of learnt knowledge as they only teach abstract, generic knowledge (Cornish & Moraes 2015; Andrews et al. 2000). Therefore, the integration of visual learning (Lu et al. 2011; ChanLin et al. 2003) of product packaging images promises superiority over contemporary education concepts, usually taught through reading and aural learning of abstract recommendations (Spronk et al. 2014), as the fast-paced product purchasing process hinders the required translation of abstract concepts towards a binary product-specific purchasing decision, esp. given the dependency on rarely used and difficult-to-interpret nutritional labels (Grunert et al. 2010; Spronk et al. 2014) and consumer confusion due to misleading product ad claims (Andrews et al. 2000; Cornish & Moraes 2015). Psychology research suggests that compared to learning based on reading or listening, image-based visual learning yields higher recognition and recall rates when facing visual examination tasks due to improved hypermnesia (Kroll & Potter 1984; Bergstein & Erdelyi 2008). As the visual examination of product packages plays a key role in the search-phase of purchasing decisions at the supermarket shelve (Breugelmans et al. 2006; Andrews et al. 2000; Clement 2007; Clement et al. 2013), packaging-image-based visual learning of nutritional attributes suggests better applicability of nutritional education. Besides integrations of serious gaming and visual learning, the prototype adheres to best-practices of traditional nutritional campaigns, including contemporary design (Rysdale 2008; Vignerová et al. 2011), regional-, cultural- and context-specific customization by including local product data (Lappalainen et al. 1998; Vignerová et al. 2011) and personalization towards the patient's food goals and knowledge, as users can choose to follow a predesigned learning route or select topics of interest (Worsley 2002). To the best of our knowledge, this prototype is the first serious game based HIS in nutritional education applying visual learning through packaging images from a national, cross-retailer, cross-brand product dataset.

3 Design Science Approach

The HIS prototype was developed in close collaboration with the Swiss association for nutrition (SGE-SSN 2015) and involved dietitians, IS researchers, computer scientists, medical experts as well as adolescent and adult end users. The research process followed the design science research paradigm (Hevner et al. 2004; Peffers et al. 2008; Gregor & Hevner 2013), using an iterative development cycle including multiple test phases with users, thereby optimizing application's properties towards the main constructs: Ease of use (Koivisto & Hamari 2014) was achieved through an introductorily tutorial, clear goals and clean user interface design utilizing large user buttons (Hamari et al. 2014). Social recognition (Hamari & Koivisto 2013) was realized through a publically visible leaderboard and rewards (Deterding et al. 2011), self-recognition (Okumus et al. 2015) through point scoring, visible round performance, post-round feedback and badges (Hamari et al. 2014), enjoyment (Cheong et al. 2013) was realized through colourful game design, themed statements between rounds and time constraints (Hamari et al. 2014). Perceived usefulness (Pereira et al. 2014) was attained through personalization of recommended dietary allowances, integration of educational content, visual representation of local products and the option to review and search all products of the database. The operationalization of main constructs orients itself towards relevant literature and similar applications (Hamari et al. 2014; Wattanasoontorn et al. 2014; Payne, Moxley, et al. 2015), as they tend to improve acceptance of (Okumus et al. 2015), satisfaction with (Zhang 2007) and prolong usage of HIS (van der Heijden 2004), which are the primary study goal. Besides improving acceptance and in order to support building health-beneficial attitudes, norms and perceived control as suggested by health behaviour theory (Glanz et al. 2008), "Swiss Foodquiz" also operationalizes goal setting (Payne, Moxley, et al. 2015) through the optional choice of selecting a nutrient (e.g. salt) or product category (e.g. salty snacks) and self-monitoring (Payne, Moxley, et al. 2015) through integration of historic user performance statistics. The iterative design process of an up-to-date serious gaming approach in regards to user experience, game design elements (Deterding et al. 2011) and aesthetics (Kapp 2012) is non-trivial and requires significant development efforts. Furthermore, designing the question-building logic that selects two substitutable products from within a certain category of the product database (GS1 2016), which contain at least a significant enough difference of a relevant nutrient as defined by the national association for nutrition, required iterative development cycles and input from dietitians as well as computer scientists (Fig. 5.b).

4 Design of Prototype

The serious game design of "Swiss Foodquiz" was inspired by the world's most played educational trivia game Quizup (QuizUp 2013), adapted to asking users to conduct a visual examination task requiring nutritional knowledge. The task simulates choosing products at the supermarket shelve, as the user has to choose the one out of two similar, visually presented food products with the higher content of a relevant given nutrient, e.g. identifying the cereal product with significantly higher amounts of sugar compared to its substitutable alternative (Fig. 1.c).

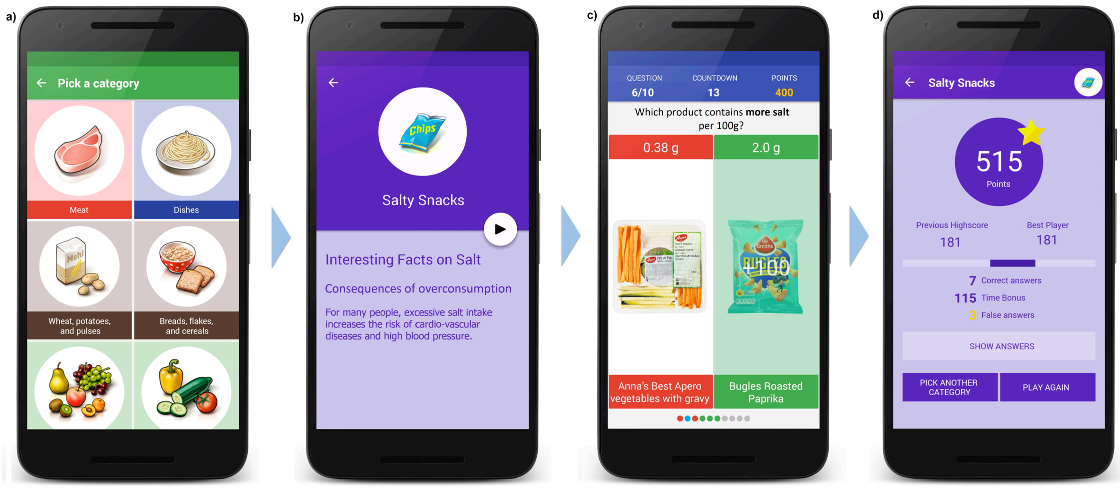

Figure 1. A round in the game consists of a) selecting a category, b) receiving relevant nutritional education about the upcoming category, c) answering ten visual examination tasks with instant feedback after each answer, d) receiving a score feedback

As the prototype design requires integration of a relevant product database, for which multiple alternatives were available, the national database featuring the highest data quality in regards to product package images and ingredient data was selected (GS1 2016). Alternative, although larger, but non-curated databases proved to be unusable due to inacceptable amount of flawed data entries. In this aspect, the EU Food Information Regulation (EU-1169/2011 2014) on the provision of food information online ratified in Dec. 2014 is paving the way for publicly accessible product databases covering multiple retailers and brands, enabling this and similar future HIS. In order to only include relevant comparisons of substitutable food items within the quiz, the currently 2996 products of the growing database were arranged into 19 main and 111 subcategories by the consumer-centric category design of the national association for nutrition. Further, for each subcategory, relevant nutrients and minimum nutritional differences between substitutable products were defined through a category-nutrient-mapping, hereby guaranteeing that the logic of the question-building algorithm only permits relevant questions about two substitutable, yet in regards to relevant nutritional content different food products (Fig. 5.b). Thus, the user not only receives relevant nutritional knowledge, but is also encouraged to apply gained knowledge in his purchasing routine through the visual discovery of healthier, substitutable products.

"Swiss Foodquiz" is implemented as a client-server application: The client side is a native Android application developed for Android smartphones and tablet-PCs, while the server side is realized as a RESTful, PHP-based API-framework, used to store user entries and performance, as well as to load the generated quiz rounds including nutritional and image data for each of the twenty products randomly selected for each round of ten questions by the question-building algorithm (Fig. 5.b).

When starting "Swiss Foodquiz" for the first time, users register through a mandatory, introductory survey asking for self-evaluations of their nutritional knowledge and involvement, as well as biomedical information, including body-mass-index and physical activity level, allowing the prototype to personalize nutritional recommendations towards the end-user, e.g. showing recommended dietary allowances. The questionnaire (Fig. 5.a) was completed by 74% of users, indicating high motivation to engage with the game. Before players can initiate the game, the game design mechanics are explained within an introductory tutorial enabling user self-efficacy (Kapp 2012). Depending on the game's setting, the user can then play the next round by following a predefined, randomized path or choose a specific nutritional category (e.g. salt, sugar, etc.) or product category (e.g. cereals, salty snacks, etc.), following the idea of goal-setting (Payne, Moxley, et al. 2015) (Fig. 1.a). Prior to each new round, the player receives educational statements about the upcoming category and nutrients, aiming to educate the user through tailored, personalized messages, e.g. based on recommended daily intake, thereby increasing perceived usefulness (Payne, Moxley, et al. 2015; Pereira et al. 2014) (Fig. 1.b). A round within the game is composed of ten questions, each asking the user to choose the one out of two similar, visually presented food products with the higher content of a relevant given nutrient (Fig. 1.c). While playing the game, the user is confronted with game design elements (Deterding et al. 2011), such as time constraining countdowns (Fig. 1.c), point-based incentivization of a score bonus for correct (malus for incorrect) answers crediting correct answers with 100 bonus points, while 100 malus points are deducted for false answers, thereby eliminating positive average scores for answer strategies based on random guessing instead of applying nutritional knowledge. In order to incentivize time management (Payne, Moxley, et al. 2015), a relative minor bonus of one point per left second is granted for correct, fast answers (countdown starts at 20 seconds, max. theoretical bonus per round: 200 points). After each round, the HIS evaluates the player's performance through a score-based performance feedback and potentially awards badge statuses, enabling self-recognition (Fig. 1.d) (Payne, Moxley, et al. 2015). Besides score feedback, the self-monitoring functionality (Payne, Moxley, et al. 2015) (Fig. 2.b) lets players review their performances across different category levels and explore areas of weaknesses they would need to address in order to gain scores. Social recognition as suggested by social cognitive theory (Bandura 1991) is applied by the leaderboard, which by default includes all peer players of the game, ranking them by performance (Fig. 2.c). In order to climb up the leaderboard, users have to perform well in all nutrients and product categories, since the sum of best respective level scores defines the position in the leaderboard, thereby incentivizing repeated iterations.

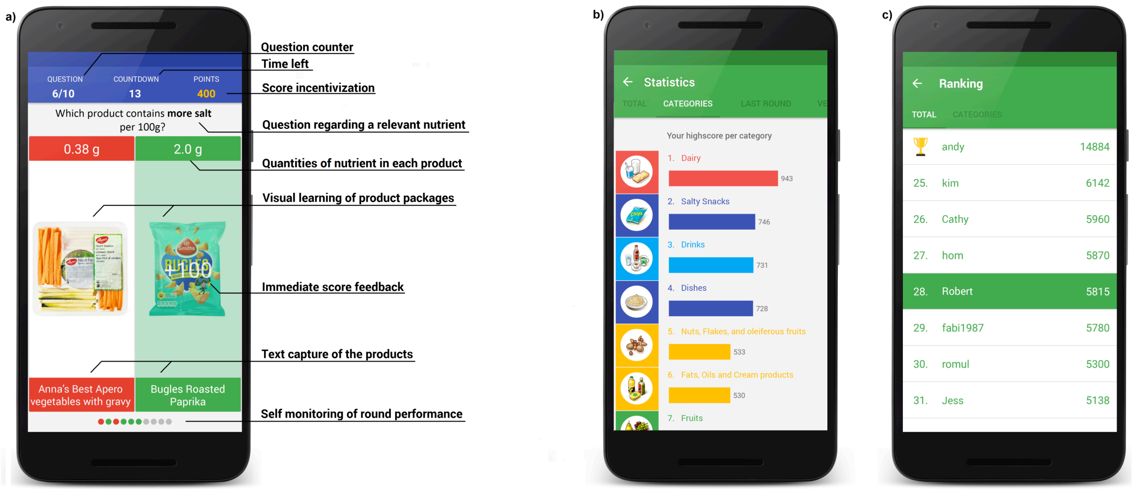

Figure 2. Gamification elements within the prototype are realized through a) game design elements, b) self-monitoring of task performance, c) leaderboard

All player inputs are logged on the server in order to assess user performances and HIS usage for further improvement of the application. Furthermore, future surveys in the post-signup usage phase will survey users regarding their satisfaction and potential suggestions for further development of the HIS, but also measure changes to the subjective self-evaluation of involvement and dietary behaviour.

5 Preliminary Results

The application was released under the name "Swiss Foodquiz" in the Swiss Google Android Play store, announced via social media and has recruited 475 downloads within a two-months preliminary testing period from Nov. 27th 2015 to Jan. 27th 2016. In total, 350 users (74%) completed the mandatory, introductory survey and were admitted for usage of the prototype. The dropout rate of users (26%) is very low, when considering that the introductory survey was compulsory.

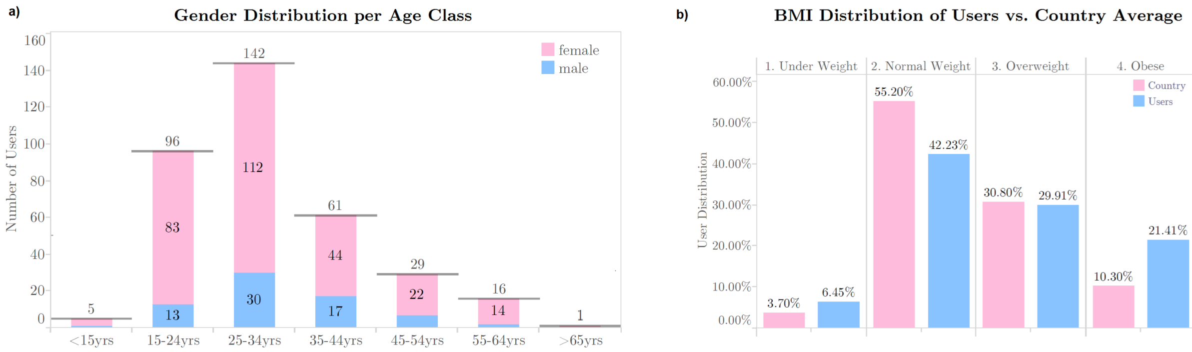

Figure 3. a) The prototype has high acceptance among adolescents and adults. The user base is an adequate sample of national population in terms of b) BMI distribution

The user distribution is composed of a majority of females (19.7% male, 80.3% female, Fig. 3.a), predominately adolescents and adults between 15 and 44 years of age (Fig. 3.a) and a realistic representation of the Swiss population's BMI distribution (Fig. 3.b). Especially worth mentioning is that the majority of user base can be considered uninvolved in (nutritional) health, as they are physically rather inactive in their leisure time (58%) and state that their self-evaluation towards nutritional knowledge is average or limited (56%) (Fig. 5.b). User participation was entirely motivated through intrinsic, voluntary motivation, as there was no incentivizing scheme or enforced enrolment obligation applied within the recruitment process. Treatment duration within the prototype reached an average of 167 answered questions (≈ 17 rounds) per user, which can be estimated to equal circa 50 minutes of nutritional education (Estimate: 15 sec. per question, add. 20% of time consuming educational content).

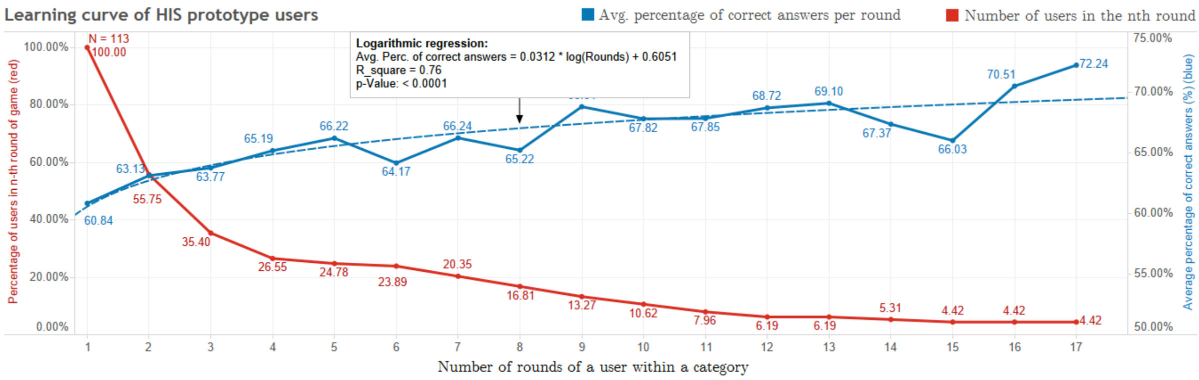

Figure 4. Performance of users increases over time, indicating a learning curve. In parallel, user retention wears off over time. A first, preliminary logarithmic regression yields significance regarding the improvement of task performance over time ($R^2 \approx 0.76$).

Our hypothesis is that by receiving nutritional information while engaging with the game, users eventually gain knowledge about products and nutrients, which is applied when answering future questions within the same category, thereby leading to higher task performances over time, measured by the percentage of correct questions per round. Learning curves show that player performance starts at below 61% and grows to above 72% throughout the game (Fig. 4), thereby doubling their performance when compared to pure guessing strategies (i.e. 50%). As learning curves follow logarithmic paths (Schilling et al. 2003), a logarithmic regression was applied on the subset of users who played multiple times within the same product category out of the 19 available main categories. Since the regression yields significance ($R^2 \approx 0.76$), the hypothesis of a positive learning effect is supported (Fig. 4). Additional analyses also proved that the positive learning effect holds true despite the dropouts of users, i.e. short- as well as long-term users of "Swiss Foodquiz" gained knowledge and increased performances.

Furthermore, voluntarily submitted user feedback explicitly mentioned experiencing learning effects especially on cereal products in regards to sugar impact, calories contained in processed food versus fresh food, salt intake via cheese consumption and an especially high interest in local foods and brands, thereby confirming the importance of context-sensitive customization of nutritional education towards locally present products and eating customs (Lappalainen et al. 1998; Vignerová et al. 2011).

6 Discussion

The preliminary results prove that the automatic HIS prototype can indeed address uninvolved as well as involved adolescent and adult users, thereby teaching quantifiable gains in nutritional education and achieving high acceptance and interaction rates. The user bias towards females is typical for nutritional HIS (Brug et al. 2003) and can be explained due to the announcement of the prototype in social media, where followers of the national association for nutrition are predominantly female. The overrepresentation of female users might be mitigatable through a more public presentation of the HIS in further outlets or adapting the serious game design towards men (Koivisto & Hamari 2014). Especially since the majority of users are relatively uninvolved in healthy nutrition or physically rather inactive (Fig. 5.a), and therefore unlikely to use other contemporary HIS (Williamson et al. 2006), the prototype's promising potential of enrolling the previously uninvolved and uninterested users (Hebden et al. 2012), and to eventually change their subjective attitude, involvement and behaviour in regards to nutritional education and healthy dietary intake, should be assessed in more detail in the future.

Limitations of the current state of the prototype are that the product database still contains errors (e.g. 100 errors reports were filed by users through crowdsourcing, i.e. 3.3%) and that therefore performance in the game is very unlikely to reach 100%. Adding to this circumstance, often purchased and well-known products are presented equally often as extremely rare and unknown products, for which users cannot estimate the nutritional content easily. Further, the question-building algorithm (Fig. 5.b) provides very hard questions, with the difference of two products sometimes being just 1%, making it tough even for dietitians and nutritional experts to score performances of above 95% in the game. The question, whether learning improvements occur, because users are learning nutritional facts of familiar products by heart instead of applying actual meta-knowledge, can be addressed by considering the combinatorics variety of possible product combinations provided by the question builder, currently offering multiple millions of possible questions, making it impossible to perform very well in the game without actually learning about fundamental nutritional concepts, provided by the educational elements (Fig. 1.b). Further, since little is yet known about excessive use of the prototype, a shut-off after one-hour usage per day is recommended in a productive scenario, for example by convincing the user to get physically active. Compared to currently available HIS applications, the results promise a more applicable gain of nutritional knowledge. Future work should therefore assess through detailed statistical analysis using t-tests or Bayesian methods, how much of the gained knowledge is stored in the short- and long-term memory and how users of the HIS prototype translate gained nutritional knowledge into changes of subjective intention and actual dietary behaviour (Darnton 2008). Together with the Swiss national association for nutrition, "Swiss Foodquiz" will be evaluated through further, longitudinal field studies and as part of existing obesity therapies and prevention programs, thereby measuring the education effect in the form of learning performance and its impact on dietary and purchasing behaviour, e.g. switching to healthier product alternatives discovered through the HIS prototype. In addition, future surveys will be conducted to evaluate improvements of subjectively perceived measures of attitude, intention and involvement (Darnton 2008). Future work on similar serious games in nutritional education should adhere to current best practice principles (Graafland et al. 2014).

7 Conclusion

This HIS prototype provides several contributions to theory and practice. First, it extends the current body of research (L. Hebden et al. 2012; Payne, Moxley, et al. 2015) on serious gaming in physical activity HIS towards nutritional HIS by exemplifying a new, scalable approach towards high acceptance and interaction rates within broader, adult audiences, esp. including the physically inactive and uninvolved users that were previously unlikely to accept (nutritional) HIS (Williamson et al. 2006). Second, the HIS offers high applicability of quantifiable knowledge gains due to integration of images representing locally available, real-world products. Third, it provides an instrument that is co-designed by dietitians, IS researchers, computer scientists, consumers and medical experts thus tailored to support the average consumers in gaining nutritional knowledge. Fourth, with the approach suggested in this paper, realizing a similar automatic and scalable HIS approach in nutritional education either as stand-alone or multi-purpose-HIS-integrated application becomes relatively straightforward and should encourage more data-owners to provide product ingredient data and product images publicly. As democratizing nutritional knowledge is a key element of promising obesity prevention strategies (WHO 2003; Finkelstein et al. 2012; Chopra et al. 2002), such automatic, scalable, serious gaming based HIS approaches aimed towards educating the adolescent as well as adult public can become a vital part of effective nutritional education and obesity prevention strategies.

8 Presentation of the Prototype

A fully functional, live demonstration of the prototype will be shown on an Android tablet-PC. The screen of the presentation device can be mirrored to larger projection screens. Attendees with an Android device may download the application from the Google Play Store.

9 Appendix

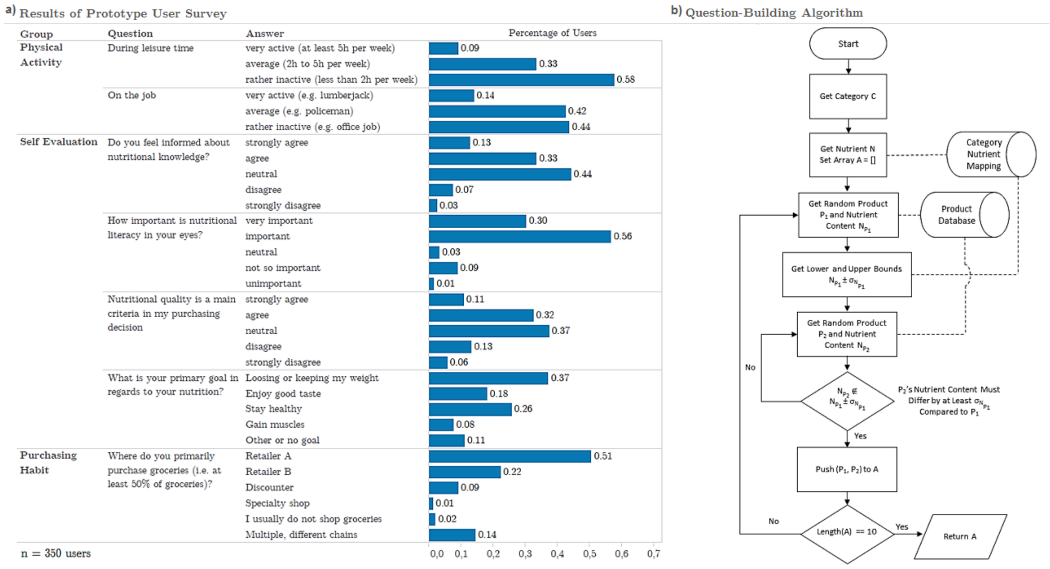

Figure 5. a) Results of introductory survey, b) Question-Building Algorithm

References

Abt, C.C., 1970. Serious Games. *Report: ED039447. 176pp. 1970*. Available at: http://csaweb105v.csa.com/ids70/view_record.php?id=4&recnum=23&log=from_res&SID=eo5p5u37ud9ovlov582u56qfg2.

Alexandratos, N. & Bruinsma, J., 2012. World agriculture towards 2030/2050: the 2012 revision. *ESA Working paper No. 12-03. Rome, Food and Agriculture Organization of the UN*, 20(4), p.375.

Andrews, J.C., Burton, S. & Netemeyer, R.G., 2000. Are Some Comparative Nutrition Claims Misleading? The Role of Nutrition Knowledge, Ad Claim Type and Disclosure Conditions. *Journal of Advertising*, 29(3), pp.29–42.

Bandura, A., 1991. Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, 50(2), pp.248–287. Available at: http://www.sciencedirect.com/science/article/pii/074959789190022L\nhttp://www.sciencedirect.com.laneproxy.stanford.edu/science/article/pii/074959789190022L\nhttp://www.sciencedirect.com.laneproxy.stanford.edu/science/article/pii/074959789190022L/pdf?md5=6.

Baranowski, T. et al., 2008. Playing for real: video games and stories for health-related behavior change. *American journal of preventive medicine*, 34(1), pp.74–82. Available at: http://www.sciencedirect.com/science/article/pii/S0749379707006472.

Bergstein, J. & Erdelyi, M., 2008. Recognition hypermnesia: how to get it. *Memory (Hove, England)*, 16(7), pp.689–702. Available at: http://www.ncbi.nlm.nih.gov/pubmed/18608979.

Block, G. et al., 2015. A Fully Automated Diabetes Prevention Program, Alive-PD: Program Design and Randomized Controlled Trial Protocol. *JMIR Research Protocols*, 4(1), pp.e3–e3. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=mnh&AN=25608692&site=ehost-live.

Breugelmans, E., Campo, K. & Gijsbrechts, E., 2006. The effects of shelf display on online grocery choices. *KUL Working Paper No. MO 0607*, pp.1–23. Available at: https://lirias.kuleuven.be/bitstream/123456789/121145/1/MO_0607.pdf.

Brug, J., Oenema, A. & Campbell, M., 2003. Past, present, and future of computer-tailored nutrition education. *The American journal of clinical nutrition*, 77(4 Suppl), p.1028S–1034S. Available at: http://ajcn.nutrition.org/content/77/4/1028S.abstract.

Casperson, S.L. et al., 2015. A Mobile Phone Food Record App to Digitally Capture Dietary Intake for Adolescents in a Free-Living Environment: Usability Study. *JMIR mHealth and uHealth*, 3(1), p.e30. Available at: http://mhealth.jmir.org/2015/1/e30/.

ChanLin, L.-J., Huang, R.-F.S. & Chan, J.-C., 2003. Web-based instruction in learning nutrition. *Journal of Instructional Psychology*, 30(1), pp.12–21. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2003-03343-003&lang=ja&site=ehost-live\nlins1005@mails.fju.edu.tw.

Cheong, C., Cheong, F. & Filippou, J., 2013. Quick Quiz: A Gamified Approach for Enhancing Learning. *PACIS 2013 Proceedings*, pp.1–14. Available at: http://aisel.aisnet.org/pacis2013/206.

Chopra, M., Galbraith, S. & Darnton-Hill, I., 2002. A global response to a global problem: The epidemic of overnutrition. *Bulletin of the World Health Organization*, 80(12), pp.952–958.

Clement, J., 2007. Visual influence on in-store buying decisions: an eye-track experiment on the visual influence of packaging design. *Journal of Marketing Management*, 23(9-10), pp.917–928.

Clement, J., Kristensen, T. & Grønhaug, K., 2013. Understanding consumers' in-store visual perception: The influence of package design features on visual attention. *Journal of Retailing and Consumer Services*, 20(2), pp.234–239. Available at: http://dx.doi.org/10.1016/j.jretconser.2013.01.003.

Connolly, T.M. et al., 2012. A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education*, 59(2), pp.661–686. Available at: http://dx.doi.org/10.1016/j.compedu.2012.03.004.

Cornish, L.S. & Moraes, C., 2015. The impact of consumer confusion on nutrition literacy and subsequent dietary behavior. *Psychology & Marketing*, 32(5), pp.558–574. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2015-17992-008&site=ehost-live\nl.cornish@coventry.ac.uk.

Cugelman, B., 2013. Gamification: What It Is and Why It Matters to Digital Health Behavior Change Developers. *JMIR Serious Games*, 15(12), p.e3. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4307817/\nhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4307817&tool=pmcentrez&rendertype=abstract.

Darnton, A., 2008. GSR Behaviour Change Knowledge Review - Reference Report: An Overview of behaviour change models and their uses. *Government Social Research*, (July), p.pgs. 10–15. Available at: http://resources.civilservice.gov.uk/wp-content/uploads/2011/09/Behaviour-change_practical_guide_tcm6-9696.pdf.

Dehghan, M., Akhtar-Danesh, N. & Merchant, A.T., 2005. Childhood obesity, prevalence and prevention. *Nutrition journal*, 4(Table 1), p.24.

Deterding, S. et al., 2011. From Game Design Elements to Gamefulness: Defining Gamification. In *Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments - MindTrek '11*. pp. 9–15. Available at: http://doi.acm.org/10.1145/2181037.2181040\nhttp://dl.acm.org/citation.cfm?doid=2181037.2181040.

EU-1169/2011, 2014. Regulation (EU) 1169/2011: Regulation on Food Information to Consumers. *Regulation (EU) 1169/2011*. Available at: http://ec.europa.eu/food/safety/labelling_nutrition/labelling_legislation/index_en.htm [Accessed January 23, 2016].

Finkelstein, E. a. et al., 2012. Obesity and severe obesity forecasts through 2030. *American Journal of Preventive Medicine*, 42(6), pp.563–570. Available at: http://dx.doi.org/10.1016/j.amepre.2011.10.026.

Glanz, K., Rimer, B.K. & Viswanath, K., 2008. *Health Behaviour and Health Education*, Available at: http://linkinghub.elsevier.com/retrieve/pii/S0033350649815241.

Graafland, M. et al., 2014. How to systematically assess serious games applied to health care. *JMIR serious games*, 2(2), p.e11. Available at:

http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=4307812&tool=pmcentrez&rendertype=abstract.

Gregor, S. & Hevner, A.R., 2013. Positioning and Presenting Design Science Research for Maximum Impact. *MIS Quarterly*, 37(2), pp.337–355.

Grunert, K.G., Wills, J.M. & Fernández-Celemín, L., 2010. Nutrition knowledge, and use and understanding of nutrition information on food labels among consumers in the UK. *Appetite*, 55(2), pp.177–189.

GS1, 2016. GS1 trustbox. Available at: https://www.gs1.ch/gs1-system/das-gs1-system/gs1-l%C3%B6sungen/gs1-source/trustbox [Accessed April 19, 2016].

Hamari, J., 2011. Framework for Designing and Evaluating Game Achievements. *Proceedings of DiGRA 2011 Conference: Think Design Play*, p.20. Available at: http://www.mendeley.com/catalog/framework-designing-evaluating-game-achievements/.

Hamari, J. & Koivisto, J., 2013. Social motivations to use gamification: an empirical study of gamifying exercise. *Proceedings of the 21st European Conference on Information Systems SOCIAL*, (JUNE), pp.1–12. Available at: http://aisel.aisnet.org/cgi/viewcontent.cgi?article=1328&context=ecis2013_cr.

Hamari, J., Koivisto, J. & Sarsa, H., 2014. Does gamification work?--a literature review of empirical studies on gamification. *System Sciences (HICSS), 2014 47th Hawaii International Conference on*, pp.3025–3034. Available at: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=6758978.

Hassan, M.M. et al., 2012. A cloud-based serious games framework for obesity. *Proceedings of the 1st ACM multimedia international workshop on Cloud-based multimedia applications and services for e-health - CMBAS-EH '12*, p.15. Available at: http://dl.acm.org/citation.cfm?id=2390906.2390912.

Hebden, L. et al., 2012. Development of smartphone applications for nutrition and physical activity behavior change. *Journal of Medical Internet Research*, 14. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84872403394&partnerID=40&md5=4f346de980cda236f71fd45571b2d43e.

Hebden, L. et al., 2012. Development of Smartphone Applications for Nutrition and Physical Activity Behavior Change. *JMIR Research Protocols*, 1(2), p.e9.

Van der Heijden, H., 2004. User acceptance of hedonic information systems. *MIS Quarterly*, 28(4), pp.695–704.

Hevner, A.R. et al., 2004. Design Science in Information Systems Research. *MIS Quarterly*, 28(1), pp.75–105. Available at: http://dblp.uni-trier.de/rec/bibtex/journals/misq/HevnerMPR04.

Kamel Boulos, M.N. et al., 2015. Digital Games for Type 1 and Type 2 Diabetes: Underpinning Theory With Three Illustrative Examples. *JMIR Serious Games*, 3(1), p.e3. Available at: http://games.jmir.org/2015/1/e3/.

Kapp, K., 2012. Interactivity, Games and Gamification: Creating Engaged Learners. *Training Magazine Network*.

Koivisto, J. & Hamari, J., 2014. Demographic differences in perceived benefits from gamification. *Computers in Human Behavior*, 35, pp.179–188.

Kroll, J.F. & Potter, M.C., 1984. Recognizing words, pictures, and concepts: A comparison of lexical, object, and reality decisions. *Journal of Verbal Learning and Verbal Behavior*, 23(1), pp.39–66.

Kushner, R.F., 1995. Barriers to providing nutrition counseling by physicians: a survey of primary care practitioners. *Preventive medicine*, 24(6), pp.546–52. Available at: http://www.ncbi.nlm.nih.gov/pubmed/8610076.

Landers, R.N. et al., 2011. Serious Games and Edutainment Applications. *Serious Games and Edutainment Applications*, (July 2015), pp.9–23. Available at: http://www.springerlink.com/index/10.1007/978-1-4471-2161-9\nhttp://link.springer.com/10.1007/978-1-4471-2161-9.

Lappalainen, R., Kearney, J. & Gibney, M., 1998. A pan EU survey of consumer attitudes to food, nutrition and health: an overview. *Food Quality and Preference*, 9(6), pp.467–478.

Leahey, T. & Rosen, J., 2014. DietBet: A Web-Based Program that Uses Social Gaming and Financial Incentives to Promote Weight Loss. *JMIR serious games*, 2(1), p.e2. Available at: http://games.jmir.org/2014/1/e2/.

Lister, C. et al., 2014. Just a Fad? Gamification in Health and Fitness Apps. *JMIR Serious Games*, 2(2), p.e9. Available at: http://games.jmir.org/2014/2/e9/.

Lu, Z.-L. et al., 2011. Visual perceptual learning. *Neurobiology of learning and memory*, 95(2), pp.145–51. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3021105&tool=pmcentrez&rendertype=abstract.

Majumdar, D. et al., 2015. Nutrition Science and Behavioral Theories Integrated in a Serious Game for Adolescents. *Simulation & Gaming*, 46(1), pp.68 –97. Available at: http://sag.sagepub.com/cgi/doi/10.1177/1046878115577163.

Okumus, B., Bilgihan, A. & Ozturk, A.B., 2015. Factors Affecting the Acceptance of Smartphone Diet Applications. *Journal of Hospitality Marketing & Management*, pp.1–22. Available at: http://www.tandfonline.com/doi/full/10.1080/19368623.2016.1082454.

Omran, A., 1982. The Epidemiological Transition. *International Encyclopedia of Population*, pp.172–175.

Payne, H.E., Lister, C., et al., 2015. Behavioral functionality of mobile apps in health interventions: a systematic review of the literature. *JMIR mHealth & uHealth*, 3(1), p.e20.

Payne, H.E., Moxley, V.B. & MacDonald, E., 2015. Health Behavior Theory in Physical Activity Game Apps: A Content Analysis. *JMIR Serious Games*, 3(2), p.e4. Available at: http://games.jmir.org/2015/2/e4/.

Peffers, K. et al., 2008. A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, 24(3), pp.45–77.

Pereira, P. et al., 2014. A Review of Gamification for Health-Related Contexts. *Design, User Experience, and Usability. User Experience Design for Diverse Interaction Platforms and Environments.*, 8518, pp.742–753.

Popkin, B.M., 2002. An overview on the nutrition transition and its health implications: the Bellagio meeting. *Public Health Nutrition*, 5(1a), pp.93–103. Available at: http://www.journals.cambridge.org/abstract_S1368980002000149.

Popkin, B.M., 2001. The Nutrition Transition and Obesity in the Developing World. *The Journal of Nutrition*, 131(3), p.866S–870S.

Puska, P., 2002. Nutrition and global prevention on non-communicable diseases. *Asia Pacific Journal of Clinical Nutrition*, 11(SUPPL. 8), pp.755–758.

QuizUp, 2013. QuizUp. *Website*. Available at: https://www.quizup.com [Accessed January 23, 2016].

Rysdale, L., 2008. Evaluation of a nutrition education component nested in the NutriSTEP Project. *Can J Diet Pract Res*, 69(1), pp.38–42.

Sassi, F. et al., 2009. The obesity epidemic: analysis of past and projected future trends in selected OECD countries. *OECD Health Working Papers*, 45(45). Available at: http://www.oecd-ilibrary.org/docserver/download/fulltext/5ksm2rwz9z7k.pdf?expires=1335660961&id=id&accname=guest&checksum=810A08955CEFC70CFA1ABE438A79E8C5.

Schilling, M. a. et al., 2003. Learning by doing something else: variation, relatedness, and the learning curve. *Management Science*, 49(1), pp.39–56.

Schneider, K.L. et al., 2012. Acceptability of an Online Health Videogame to Improve Diet and Physical Activity in Elementary School Students: “Fitter Critters.” *Games for health journal*, 1(4), pp.262–268. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3833367&tool=pmcentrez&rendertype=abstract.

SGE-SSN, 2015. Mein Kalorienbedarf. *Swiss Society for Nutrition*. Available at: http://www.sge-ssn.ch/ich-und-du/tests-zur-ernaehrung/mein-kalorienbedarf/.

Spronk, I. et al., 2014. Relationship between nutrition knowledge and dietary intake. *The British journal of nutrition*, 111(10), pp.1713–26. Available at: http://journals.cambridge.org/abstract_S0007114514000087.

Srinath Reddy, K. & Katan, M.B., 2004. Diet, nutrition and the prevention of hypertension and cardiovascular diseases. *Public health nutrition*, 7(1A), pp.167–186.

Swinburn, B., Sacks, G. & Ravussin, E., 2009. Increased food energy supply is more than sufficient to explain the US epidemic of obesity. *The American Journa of Clinical Nutrition*, (90), pp.1453–1456.

Tate, D.F., Wing, R.R. & Winett, R. a, 2001. Using Internet technology to deliver a behavioral weight loss program. *JAMA, Journal of the American Medical Association*, 285, pp.1172–1177.

Thomas, J.G., Leahey, T.M. & Wing, R.R., 2015. An Automated Internet Behavioral Weight-Loss Program by Physician Referral: A Randomized Controlled Trial. *Diabetes Care*, 38(1), pp.9–15. Available at: http://care.diabetesjournals.org/lookup/doi/10.2337/dc14-1474.

Thompson, D. et al., 2007. In pursuit of change: youth response to intensive goal setting embedded in a serious video game. *Journal of diabetes science and technology (Online)*, 1(6), pp.907–917.

Thompson, D., 2014. What Serious Video Games Can Offer Child Obesity Prevention. *JMIR Serious Games*, 2(2), p.e8. Available at: http://games.jmir.org/2014/2/e8/.

Turner-McGrievy, G. & Tate, D., 2011. Tweets, Apps, and Pods: Results of the 6-month Mobile Pounds Off Digitally (Mobile POD) randomized weight-loss intervention among adults. *Journal of medical Internet research*, 13(4), p.e120. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3278106&tool=pmcentrez&rendertype=abstract.

Vignerová, J. et al., 2011. Reducing obesity and related chronic disease risk in children and youth: a synthesis of evidence with "best practice" recommendations. *Obesity Reviews*, 7 Suppl 1(7), pp.7–66. Available at: http://www.ncbi.nlm.nih.gov/pubmed/16371076\nhttp://www.ncbi.nlm.nih.gov/pubmed/19619261\nfile:///C:/Users/Almanara/AppData/Local/Mendeley Ltd./Mendeley Desktop/Downloaded/Cattaneo et al. - 2010 - Overweight and obesity in infants and pre-school children.

Vorster, H.H., 2002. The emergence of cardiovascular disease during urbanisation of Africans. *Public health nutrition*, 5(1A), pp.239–243.

Wardle, J., Parmenter, K. & Waller, J., 2000. Nutrition knowledge and food intake. *Appetite*, 34(3), pp.269–75. Available at: http://www.ncbi.nlm.nih.gov/pubmed/10888290.

Wattanasoontorn, V., Hernández, R.J.G. & Sbert, M., 2014. Serious Games for e-Health Care. In *Simulations, Serious Games and Their Applications*. pp. 127–146.

WHO, 2003. Diet, nutrition and the prevention of chronic diseases. *World Health Organization technical report series*, 916. Available at: http://eutils.ncbi.nlm.nih.gov/entrez/eutils/elink.fcgi?dbfrom=pubmed&id=12768890&retmode=ref&cmd=prlinks\npapers3://publication/uuid/734F6B31-260B-4545-A8E4-57F7D35DDEB8.

WHO, 2015. Obesity and overweight. *Website*. Available at: http://www.who.int/mediacentre/factsheets/fs311/en/ [Accessed January 23, 2016].

Williamson, D.A. et al., 2006. Two-year internet-based randomized controlled trial for weight loss in African-American girls. *Obesity (Silver Spring, Md.)*, 14(7), pp.1231–1243.

Worsley, A., 2002. Nutrition knowledge and food consumption: can nutrition knowledge change food behaviour? *Asia Pacific J Clin Nutr*, 11, pp.579–585. Available at: http://hdl.handle.net/10536/DRO/DU:30001547.

Xu, R. et al., 2014. Tell Me What to Eat – Design and Evaluation of a Mobile Companion Helping Children and Their Parents to Plan Nutrition Intake. In *Ambient Intelligence*. pp. 100–113. Available at: https://svn.icts.sbg.ac.at/literature/Context Basic/Context/literature/crowley2003.pdf.

Young, K. et al., 2011. Nutritional education for community dwelling older people: A systematic review of randomised controlled trials. *International Journal of Nursing Studies*, 48(6), pp.751–780. Available at: http://dx.doi.org/10.1016/j.ijnurstu.2011.03.007.