Institution: Swansea University
Unit of Assessment: Unit 04 : Psychology, Psychiatry and Neuroscience
Title of case study: The development of food items to benefit cognition and mood
1. Summary of the impact

An approach was developed that allowed the design of food items to facilitate psychological functioning: the key insight was that food items that slowly and continuously release glucose have a beneficial impact on mood and cognition. The work has impacted on public policy and is used, for example, to justify recommendations made by the European Food Information Council and the US Department of Agriculture and Food. Globally the findings have stimulated significant interest from food and ingredient manufacturers as they can reformulate food items to make claims about mood and cognitive functioning. This is reflected in the funding received from multi-national corporations, based in six different countries, to exploit the key research findings for the development of novel food formulations. In one instance a patent was established.

2. Underpinning research

The case study reflects the research of David Benton, Professor of Psychology at Swansea University, aided by research students (Owens PhD 1994; Parker, PhD 1995) and research assistants (Donohoe (1994-2000); Maconie (2007), Nabb (2000-2006), Young (2007-2013); Williams (2007)). Although there is world-wide academic interest in the role played by the level of blood glucose on mood and cognition, much of the systematic human study of the topic can be traced back to the work of Benton who, in the 1990s, produced the initial series of papers. He had noticed that in rodents an injection of glucose improved memory and for the first time began to systematically examine a similar phenomenon in humans. In several dozen well cited papers the influences of raising and falling blood glucose levels on memory, attention, reaction times and mood were reported (e.g. R1, R2).

This basic research led to the consideration of the influence of diet, as the macro-nutrient composition influences the pattern of blood glucose release. The Benton and Parker (R3) paper played a key role. It had been established previously by others, that missing breakfast resulted in a poorer mood and a disruption of cognitive functioning. It was, however, reported for the first time that raising blood glucose levels reversed the negative consequences of fasting. This finding led naturally to a consideration of the composition of meals with the aim of establishing an optimal formulation that provided glucose over a prolonged period. Therefore the macro-nutrient composition of breakfast was manipulated to see how dietary induced changes in blood glucose impacted on mood and cognition. A promising line of research was that modifying a food, or a meal, so that energy is slowly released over a prolonged period, improved functioning: a **first controlled intervention** demonstrated this phenomenon in adults (R4), a finding extended to children (R5). Essentially a meal that slowly releases glucose benefits memory and mood. A review published in 2009 (R6) identified eight papers that had, at that time, related the carbohydrate content of meals to cognition, four of these were from Swansea, including the **first study to systematically vary the nature of a meal based on its glycaemic (glucose releasing) properties** (R4). Putting the research terms glycaemic index (measure of the ability of food to release glucose) and memory into Scopus found that Benton (R4) reported such an association for the first time.

3. References to the research (Swansea staff in bold)

R1. **Benton D, Owens DS, Parker PY** (1994). Blood-glucose influences memory and attention in young adults. Neuropsychologia 32, 595-607. Times cited 143 Scopus. DOI: 10.1016/0028-3932(94)90147-3

R2. **Benton D, Owens DS** (1993) Blood glucose and human memory. Psychopharmacology 113, 83-88. Times cited: 100 Scopus. DOI: 10.1007/BF02244338

R3. **Benton D; Parker PY** (1998) Breakfast, blood glucose, and cognition. American Journal of Clinical Nutrition 67, 772S-778S. Times cited: 108 Scopus.

R4. **Benton, D**., Ruffin M-P, Lassel T., **Nabb, S**, Messaoudi N., Vinoy, S, Desor D. & Lang V. (2003). The delivery rate of dietary carbohydrates affects cognitive performances in both rats and humans. Psychopharmacology 166, 86-90. Times cited 83 Scopus. (Swansea dealt exclusively with the human research) DOI: 10.1007/s00213-002-1334-5

R5. **Benton, D., Maconie, A. & Williams, C** (2007). The influence of the glycaemic load of breakfast on the behaviour of children in school. Physiology and Behavior, 92, 717-724 Times cited: 38 Scopus. DOI: 10.1016/j.physbeh.2007.05.065

R6. Gilsenan MB, de Bruin EA, Dye L. (2009). The influence of carbohydrate on cognitive performance: a critical evaluation from the perspective of glycaemic load. Br J Nutr. 101: 941-9. DOI: 10.1017/S0007114508199019

4. Details of the impact

The work satisfies two of examples of impact suggested by Panel A. Firstly under the general category '**Impact on public policy and services'** the research has been widely quoted. As one of many examples the Benton and Parker (R3) study was used in by the **European Food Information Council** (C1) to support the view that "*Breakfast breaks the overnight fast and provides energy to kick-start the body and sharpen the mind*". Of the nine papers quoted, Swansea work published in 1998 was the oldest, with the next oldest paper dated 2005. Similarly the **US Department of Agriculture Food and Nutrition Service**, when they recommended a School Breakfast Program (C2), quoted Swansea research to support the view that "*Children who eat breakfast are more likely to behave better in school and get along with their peers than those who do not*".

Although a general benefit of breakfast has been more widely studied, the more specific contribution of the Swansea research (R4, R5) has been to recommend consuming a low glycaemic meal (releases energy slowly). The UK **School Food Trust**, that advised schools on the meals they provided, offered the view that "*Foods with a lower Glycaemic Index (GI) …. have been shown to sustain attention and time spent on task when doing class work, as well as reducing frustration*" (C3) quoting only Swansea research (R5) as justification for this advice. In 2010 the impact of the Swansea research was acknowledged by the **Education Committee of the House of Commons** when they considered Behaviour and Discipline in Schools (C4). It was noted that there is good evidence that eating breakfast is beneficial to the performance and behaviour of school children, a view "*reinforced by … Professor David Benton … who had conducted research which found that eating breakfast improved the cognitive performance of some children…*".

The second type of impact falls under the heading '**Impacts on commerce'.** More specifically "**Industry (including overseas industry) has invested in research and development**": indeed the research is characterized by the level of industrial funding it has attracted. As it offered a theoretical underpinning to the development of novel food items, over the 1993 to 2012 period funding was attracted on **eleven occasions** from multi-national, food and ingredient manufacturers based in **France, Germany, Netherlands, Japan, USA as well as the United Kingdom**: both during the stage when the ideas were developed (**text removed for publication**) and during the REF period when this information was exploited **(text removed for publication).** Often industrial funding since 1993, but prior to the REF, resulted in impact during the REF period (see Danone / Kraft example below).

The research has been, and continues to be, of great interest to both ingredient and food manufacturers, as by varying the nutritional profile of products they can potentially make claims about mood and cognitive functioning, with the consequence that a premium can be charged for novel products. This widespread interest reflected both the decision to draw attention to the findings by speaking at commercially orientated meetings and the fact that commercial organizations had read academic reports of the work. By their nature commercial organizations need to be aware of research throughout the world and can choose to fund work where ever they wish. Without exception the offers of research funding were unsolicited – contact was always initiated by the company. During the period the nature of the questions asked varied and included the consideration of particular products such as breakfast cereals, biscuits, milk products and energy drinks and ingredients such as milk, cereals and different sugars. The work has considered children and both younger and older adults.

The funding from (text removed for publication) reflected their prior knowledge of Swansea research that found varying the glycaemic load of breakfast improved children's memory and increased the time spent on school tasks (R5). They wished to explore whether one of their products had a similar influence: this was a scientifically attractive proposition as for the first time it allowed the glycaemic response to a meal to be distinguished from the macro-nutrient composition. Based on these findings **a patent was established** that claimed that isomaltulose can be used to enhance mental performance in the postprandial phase (C5). The evidence quoted in the patent application was previous work from Swansea (R4) and a summary of their funded research, carried out in Swansea, that found in schools that both the mood and memory of children were better in the late morning after consuming an isomaltulose rather than glucose-based meal.

(T**ext removed for publication**) has twice funded research based on prior Swansea research (R4), with the aim of developing a product that slowly releases glucose and hence facilitates mood and memory. The final report was delivered in 2011 and there are plans to launch a product, based on the findings, although the time-scale is uncertain and relies on the development of items that are acceptable to the consumer (**text removed for publication**).

An example of industrial funding prior to the REF, resulting in impact during the REF, is offered by the funding of **Danone**, **France** that resulted in the first report of cognition being facilitated by a product that slowly releases glucose (R4). The product, Petit Déjeurner Lu, was subsequently sold to Kraft and now retails under the trade name Belvita. The biscuit is sold in the USA, Australia, Belgium, Czech Republic, France, Portugal, Hungary, Poland, the United Kingdom and Brazil. In 2013, in the UK alone, the biscuit achieved £50m year-on-year sales, having grown 60 per cent over the previous year (C6). It is said to have "*revolutionised the biscuit category*" by establishing a new section of the market. It is clear from the advertising that Swansea research plays a key role in the positioning of the product: it is claimed that the biscuit benefits mood and cognition in the late morning. In fact Swansea research is consistently mentioned when advertising the product; often it is the only supporting evidence quoted. The current **French** website for 'Belvita Petit Déjeuner', a breakfast biscuit, states: "*The breakfast has a beneficial effect on cognitive functioning. Studies have shown that people who eat breakfast score higher on memory tests than those who did not*" (C7: translated from French). Only two studies are listed (R3, R4) to support this assertion, both carried out in Swansea. The latter (R4), the first study to report a positive response to a low-glycaemic meal, had been funded by Danone. Of many international examples, the **Australian** website for Belvita has a video of a nutritionist stating that the product results in "better concentration and memory throughout the morning" and the Polish advertisement for Belvita lists Swansea findings (C8). In 2012 (**text removed for publication**) provided funds to evaluate the association between individual differences in the ability to control blood glucose and

cognition. The aim was more basic; to explore novel means of monitoring the response to food so in the future the glucose profile produced could be used to predict cognitive outcomes.

The principles developed, as opposed to specific results with a product, have also had a wide impact. In 2013 alone Benton was asked by firms (**text removed for publication**) to address new products meetings by examining the possibility of using these ideas to develop novel food items. There are a number of other instances where the ideas developed in Swansea have provided the underpinning research quoted in product information, although the product as such had not been studied. For example **Dutch Lady Milk** is the market leader for follow-on formulae in **Malaysia**: in their advertisements they quote only Swansea research, emphasising the small reserves of glucose in the brains of children (C9). In 2012 (**text removed for publication**) funded a study that used the ideas of this case study (C10) by examining the impact of a low glycaemic index milk-powder on the behaviour and cognition of young children.

As the decision to launch a product is complex and multi-facetted, it would be naïve to expect that any line of research, by itself, was decisive. The case being made is that the present research has played a role critical in this complex process: that is with an increasing number of firms, on four continents, there is **evidence that "Industry (including overseas industry) has invested in research and development**" and have used Swansea research to promote their products.

5. Sources to corroborate the impact

C1. http://www.eufic.org/article/en/page/FTARCHIVE/artid/Regular-breakfast-healthy-habit-in-childhood/ (viewed June 2012)

C2. http://www.fns.usda.gov/sites/default/files/toolkit_benefitsflyer.pdf

C3. www.schoolfoodtrust.org.uk/download/documents/pdf/csa_benefits_of_a_school_lunch.pdf+school+breakfasts+benton&hl=en&gl=uk&pid=bl&srcid=ADGEEShGg6YTVsXlG9JFOf6KxuM932hg2ez_23LJpmhVgGIFn7eu4j_EftVjajU_dL2YGZTI9fJuDQmUvHjsYbjjU3wGuMN0aNChXM0qc2w_T3jwUVNAFoaUAj1p9zc7ueNsxHb0qw7&sig=AHIEtbSKX0LLYj1rfo1NRlpysQtL9rw8Zg (Viewed May 2012: this quango was closed recently by the government)

C4. http://www.publications.parliament.uk/pa/cm201011/cmselect/cmeduc/516/516vw40.htm

C5. **Text removed for publication**

C6. http://www.talkingretail.com/products/product-news/belvita-breakfast-celebrates-50m-sales-milestone

C7. http://www.lupetitdejeuner-belvita.be/lupetitdejeuner/page?siteid=lupetitdejeuner-prd&locale=befr1&PagecRef=647 (references bottom left first page)

C8. http://cytrynowo.pl/2013/03/19/nowosc-belvita-pyszne-nadzienie-kakaowe-z-jogurtem-naturalnym-pomysl-na-szybkie-i-zdrowe-sniadanie

http:/www.belvitabreakfast.com.au/#sustainedEnergyRelease danie/

C9. http://www.dutchlady.com.my/en/home.asp?page=brand&subpage=activgold (reference bottom right of opening page

C10. **Text removed for publication**