Finding the Future of Food: Sustainable Consumption Lessons from and for Veganism

by

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ABSTRACT

Advancing sustainable food systems requires holistic understanding and solutions-oriented approaches that transcend disciplines, so expertise in a variety of subjects is necessary. Proposed solutions are usually technically or socially oriented, but disagreement over the best approach to the future of food dominates the dialogue. Technological optimists argue that scientific advances are necessary to feed the world, but environmental purists believe that reductions in consumption and waste are sufficient and less risky. Life cycle assessment (LCA) helps resolve debates through quantitative analysis of environmental impacts from products which serve the same function. LCA used to compare dietary choices reveals that simple plant-based diets are better for the environment than diets that include animal products. However, analysis of soy protein isolate (SPI) demonstrates that certain plant-based proteins may be less preferable for the environment than some unprocessed meats in several categories due to additional impacts that come from industrial processing. LCAs' focus on production risks ignoring consumers, but the food system exists to serve consumers, who can be major drivers of change. Therefore, the path to a sustainable food system requires addressing consumption issues as well. Existing methods for advancing sustainable food systems that equate more information with better behavior or performance are insufficient to create change. Addressing food system issues requires sufficient tacit knowledge to understand how arguments are framed, what the supporting content is, the findings of primary sources, and complex and controversial dialogue surrounding innovations and interventions for food system sustainability. This level of expertise is called interactional competence and it is necessary to drive and maintain holistic progress towards sustainability. Development strategies for interactional competence are informed by studying the motivations and strategies utilized by vegans. A new methodology helps advance understanding of expertise development by assessing levels of expertise and reveals insights into how vegans maintain commitment to a principle that influences their daily lives. The study of veganism and expertise reveals that while providing information to debunk fallacies is important, the development of tacit knowledge is fundamental to advance to a stage of competence.

This dissertation is dedicated to my family, friends, and other supporters.

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INTRODUCTION

Overview:

Disagreement regarding what a sustainable food system should be is a product of the intersection of two wicked problems: food systems and sustainability. Advocates for competing solutions to these issues endeavor to convince a skeptical public of the legitimacy of their view while some also intentionally undermine the efforts of their opposition through attacking their credibility (e.g. “Food Babe” vs. “SciBabe”). To make progress towards a sustainable food system, holistic understanding and a solutions-oriented approach that transcends disciplines is necessary. This dissertation seeks to advance sustainable consumption by finding lessons both from and for veganism that enhance the quality of dialogue from advocates, scholars, and consumers engaged in discussions regarding the food system. This does not reflect an assumption that vegans are sustainable consumers, but rather that they exhibit behaviors which are conducive to the advancement of sustainable consumption, including following a lifestyle based on ethical principles, practicing reflexive consumption, and using life cycle thinking. In fact, as demonstrated in chapter 3, this work is skeptical of the environmental benefits claimed by some vegan products. The structure of this dissertation is meant to first demonstrate that sustainable food is a wicked problem, assess how objective quantitative information can help inform better choices, and finally describe why information must be coupled with expertise to achieve goals of sustainable consumption. In chapter 2, an overview of the issues involved with food systems is presented to demonstrate the necessity of addressing them as sustainability problems and wicked problems. Reducing environmental burdens, increasing food security, and ensuring worker and animal welfare are just a few of the complex issues that must be resolved for a sustainable food system. Diverse perspectives are problematized and grouped into two the broad categories of technological optimist and environmental purist in an effort to bring clarity to the intractable debates regarding controversies in development of a sustainable food system. Such dogmatic arguments distract from productive dialogue on resolvable food sustainability issues. In chapter 3,

a quantitative approach using LCA is used to illustrate an example where the intuitive assumption that plant-based foods are always more sustainable than animal-based foods they might replace is not supported. Production of SPI, a common ingredient in realistic plant-based meat substitutes, results in higher environmental impacts when considering global warming potential, water use, and fossil fuel depletion than soybeans, soymeal, tofu, chicken, pork and some beef. In chapter 4, a methodology created for this dissertation to assess development of expertise called TURINEX (Test of Ubiquitous through Real or Interactional Expertise) is described and applied to a case study of expertise in veganism. TURINEX trials support the idea that expertise grows along a continuum, advanced by the acquisition of tacit knowledge from linguistic socialization, and that a level between no expertise and interactional expertise (IE) exists and can be tested for. Chapter 5 draws connections between investigations performed and results found to address the question of how to advance a sustainable food system. This dissertation does not claim to resolve specific problems facing the food system, but rather is an attempt to clarify them, identify methods for investigating them, and shift dialogue from bitter antagonism and dogmatic advocacy (e.g. debate over genetic modification of food) to rational discussion and calm examination through understanding the usefulness and limits of explicit information as well as the roles of tacit knowledge and expertise.

Introduction:

The myriad of issues to be resolved in creating a sustainable food system can only be addressed through understanding all phases of the food life cycle in a holistic manner. Some of the most significant issues include worldwide hunger juxtaposed with obesity epidemics, significant environmental damage and resource depletion, food insecurity, and numerous ethical concerns. There is no shortage of work by scholars addressing these issues (see chapter 2) and yet they continue to worsen partially because the scholarly and public discourse on food is distracted by a focus on controversial topics such as genetically modified foods versus organic agriculture (Levinovitz, 2015).

Feeding the world:

One of the largest challenges the food system faces is to feed the growing population of the world while dealing with the effects of and trying not to worsen climate change, deplete natural resources, or reduce biodiversity (Godfray et al., 2010).

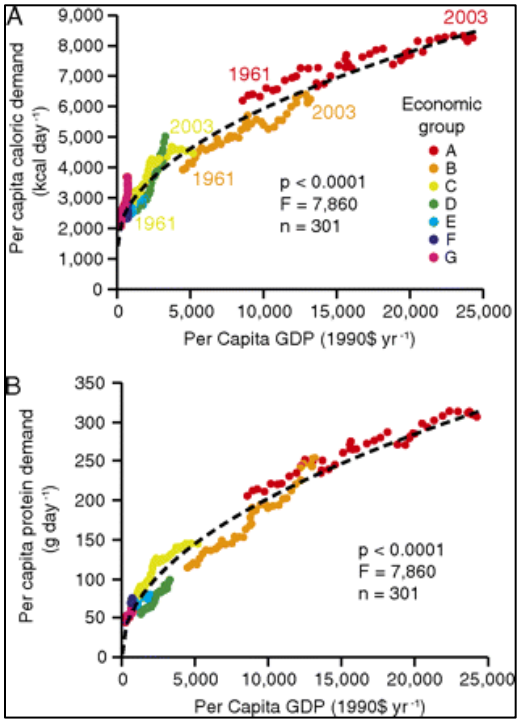

Figure 1: GDP Growth Correlates to Increased Caloric & Protein Consumption per Capita. Taken from (Tilman, Balzer, Hill, & Befort, 2011).

As people around the world become more affluent, their caloric and protein demands increase (Figure 1), leading to rising meat consumption and greater overall environmental impacts (Tilman et al., 2011). There is a predictable transition from traditional grain-based diets to diets with more animal products and added sugars and fats as countries become more affluent (Drewnowski, 2003; Du, Mroz, Zhai, & Popkin, 2004). While it is not necessarily the case that everyone in the world wants to eat like US citizens, there is an undeniable increase in meat consumption around the world (Drewnowski & Popkin, 1997; Koneswaran & Nierenberg, 2008; Vinnari & Vinnari, 2013). The result of these trends is a need to expand agricultural production of high protein foods while also decreasing total environmental impacts.

Obesity and malnutrition:

A paradox exists in which obesity rates exist at epidemic proportions in the United States at the same time that many U.S. households are food insecure (Adams, Grummer-strawn, & Chavez, 2003; Goldberg et al., 2004). Obesity is also increasing in countries where dietary patterns shift as a result of rapid income growth (Du et al., 2004). One study finds that food insecurity is the most important risk factor for being obese, despite poverty alone not being a risk factor (Martin & Ferris, 2007). Food insecurity is associated with increased likelihood of obesity especially in nonwhites, and increasing severity of food security is associated with increased risk for obesity (Adams et al., 2003). A plethora of health problems associated with obesity and malnutrition coexist in a country with some of the highest food waste, most affordable food, and lowest percentage of income as food expenditures in the world (Drewnowski, 2003; Hall, Guo, Dore, & Chow, 2009). Federal guidance and supplemental assistance programs fail to shift consumption towards healthier foods (Drewnowski, 2003; Goldberg et al., 2004).

Resource depletion and environmental damage:

Environmental degradation and resource use in agriculture are two clear threats to continued food production. An accelerating and complex feedback loop occurs in which greenhouse gas emissions from agricultural production exacerbate global climate change, which in turn destabilizes agricultural yields (Schlenker & Roberts, 2009; Vermeulen, Campbell, & Ingram, 2012). This in turn reduces the ability of small farmers to invest in better technologies, especially in developing countries, and expansion of resources, further increasing vulnerability (Vermeulen et al., 2012). Vulnerability leads to consolidation, which typically means more intensive practices, which then leads back to increased greenhouse gas emissions and inertia which hinders rapid adoption of sustainable growing practices (Vermeulen et al., 2012). Although estimates vary, food systems contribute between 19 and 29% of global anthropogenic greenhouse gas emissions, the majority of which come from agriculture, including indirect emissions from land-cover change (Vermeulen et al., 2012). Food production relies on fertilizers including phosphorus derived from a non-renewable source that may be depleted within 100 years (Cordell, Drangert, & White,

2009). Water and land use are two significant concerns for food systems which if not addressed will continue to cause problems preventing sustainable food systems (Odegard & van der Voet, 2014).

Unethical practices for humans and animals across politics and production:

Ethical concerns related to the food system include how hunger from poverty is addressed, consequences of policies in rich countries effecting poor countries, agricultural research and technology reducing viability of smallholder farms or increasing potential for economic exploitation through transgenic seeds, food safety standards, and animal welfare concerns (P Pinstrup-Andersen, 2005). Factory farming in particular is identified as an immoral practice not only for its treatment of animals, but also dangers to human health and the environment which can include animal confinement and abuse prior to slaughter, emotional effects from this on workers, more rapid spread of pathogens and diseases, and pollution from operations from animal waste and energy use (Pluhar, 2010).

A Wicked Problem:

The unique challenges facing food systems as a whole make it clear that achieving food system sustainability meets the criteria for a wicked problem as defined by Rittel and Webber (Rittel & Webber, 1984).

Table 1: Sustainable Food Systems Meet the Characteristics of Wicked Problems

Wicked Problem Characteristic	Sustainable Food System Examples
Essentially unique symptom of other problems	Issues relate to poverty, production efficiency, ethics
Ill-defined	Sustainability is an essentially contested concept
No stopping rule and can't be proven true or false	Food system must continue for humanity's survival
Cannot be tested because that changes situation	Alterations to the food system may result in permanent changes such as the introduction of new genes to plants
No right to be wrong	Potentially millions of lives and ecosystems at stake
Problem explanation determines nature of solution	Framing as production or distribution problem determines if improving efficiency can solve or if other efforts are needed

Wicked problems are essentially unique and ill-defined symptoms of other problems, have no stopping rule, and cannot be solved or proven true or false. Food systems issues are also symptoms of poverty, poor production efficiency, and ethical dilemmas described in chapter 2, and sustainability is an essentially contested concept because there is still no consensus regarding what counts as sustainable development (Connelly, 2007). Wicked problems cannot be tested because each solution is an attempt from an endless possible set of solutions each of which could change the situation significantly. Therefore proposed solutions have no right to be wrong because alterations to the food system may result in permanent changes, but the food system's continued success is vital for humanity's survival and there are potentially billions of lives and entire ecosystems at stake. Finally, the choice of explanation determines the nature of the wicked problem's resolution. If hunger is posed as a production issue, the solution is increased yield, but if it is posed as a distribution problem, the solution is better infrastructure or policy. Therefore, it is important that stakeholders are involved in the decision-making process to advance towards a sustainable food system, and consumers are important stakeholders because the food system exists to serve them.

Utility and limitations of information:

Investigation of the issues of sustainability and food systems leads to better information and understanding of the consequences of decisions. Green labeling and other approaches to advancing sustainability through providing information meet with some success in the building industry, implying that providing accessible and trustworthy information may be sufficient. For example, Energy Star and LEED certified offices provide higher rental premiums, occupancy rates, and reputation benefits, as well as lower operating costs (Fuerst & McAllister, 2011). However, information overload can result when many competing entities attempt to advance their agenda by focusing on certain characteristics of a product they wish to improve. There are over one hundred labels for products advertising environmental preferability, many of which focus on a single attribute, which can confuse or mislead consumers (Golden et al., 2010). The motivations for such labels are sometimes questionable. Green marketing environmental claims are often

exaggerated or opportunistic, making it difficult for consumers to make choices that align with their values (Ellen, Wiener, & Cobb-Walgren, 1991). As a result, consumers may be skeptical of sustainability claims from products and manufacturers.

Consumers can vote, protest, grow food in gardens, participate in community supported agriculture and choose foods which reflect their values, but most of these activities require some level of expertise to engage in. Expertise also increases confidence in decision-making as it enables easier judgments and identify tradeoffs (Dreyfus, 2004).

Attitudes towards sustainable consumption also are not always consistent with consumer behavior. Perceived consumer effectiveness (PCE) couples with personal values and needs, information and knowledge, uncertainty, social norms, and behavioral control to help explain the gap between attitude and behavioral intention (Vermeir & Verbeke, 2006). The variety of factors influencing behavior help explain why information alone is not enough to cause change. Veganism is selected as an appropriate topic for study in this dissertation because it has characteristics amenable to the advancement of sustainable behaviors regarding food. PCE is to some extent tied to perceived ability to solve a problem through activity, and should increase willingness to take action to solve problems (Ellen et al., 1991) Vegans want to make a change, believe that it is possible, and have means to take action, all of which come together to support behavioral change. Expertise develops over time as they repeat behaviors, making them easier to follow. Veganism is not examined to validate sustainability claims of veganism (see Chapter 3), but rather to provide lessons in how practices can support commitment to a value system that might be applicable to sustainable consumption.

Federal food guidelines as a case study:

Information provided from a trustworthy source may still not be enough to yield a desired change. The USDA food guidelines and the evolution of the food pyramid (now MyPlate) provide a historical example where expert guidance and efforts to communicate clear information to

improve the health of the US population fails. The Food Guide Pyramid is the target of numerous critiques due to the increasing obesity rates in America, yet nutritionists insist that people not following the pyramid, rather than the pyramid itself, are to blame (Goldberg et al., 2004). As demonstrated in Figure 2, the degree of obesity in the United States actually increases over time despite advances in nutritional education and guidance. Between 1960 and 2002, the average weight in the US increases by over 24 pounds or about 3 BMI points even though five major changes in food guidance occur between 1946 and 2011 (Figure 4).

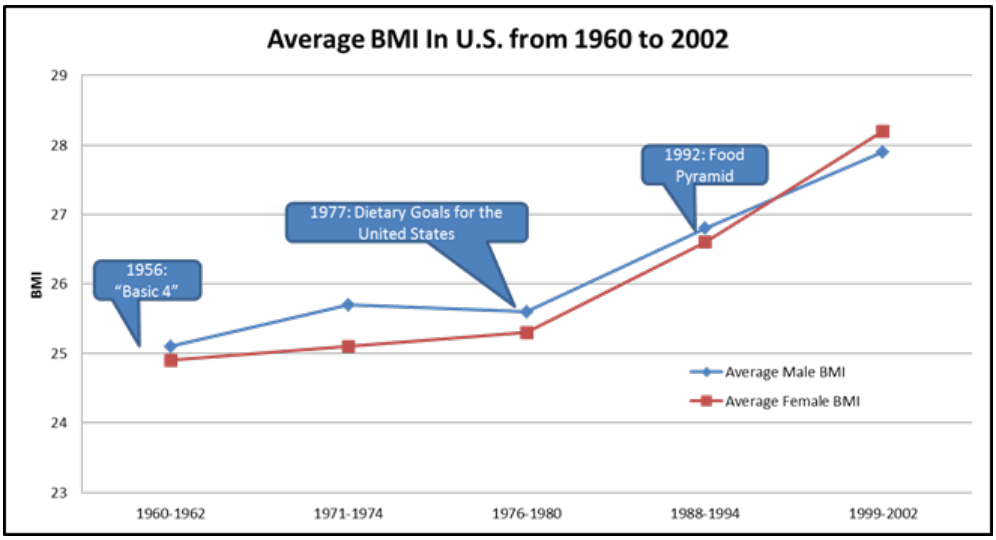

Figure 2: Average BMI in U.S. from 1960 to 2002. Between 1960 and 2002 there is a BMI increase of about 3 points, which means that people are about 25 pounds heavier despite three major advances in food guidance (Longley, 2002).

The USDA introduction of the Food Guide Pyramid in 1992 to provide accessible guidelines for nutrition fails to prevent the obesity epidemic because the majority of Americans do not adhere to those guidelines (Goldberg et al., 2004). MyPyramid is a 2005 attempt to simplify the food pyramid and encourage physical activity and moderation in addition to the historical focus on balance (FoodPyramid.com, 2013).

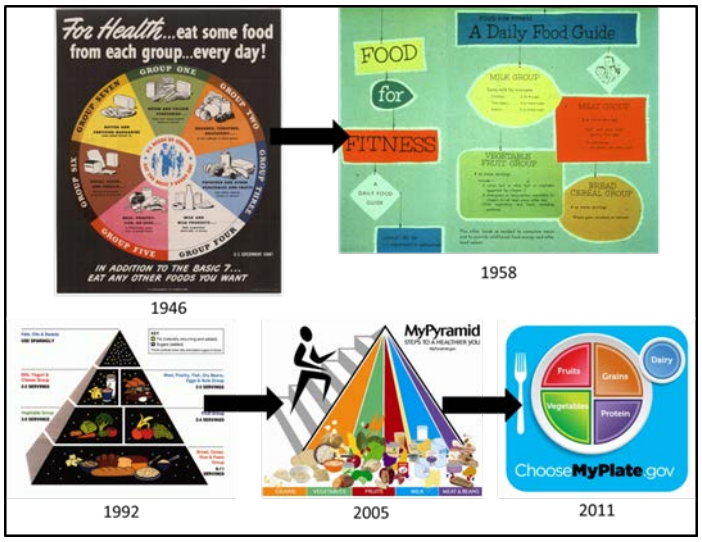

Figure 3: Food Guidance Visuals over Time. USDA continues to encourage variety and balance in food choice.

MyPlate is a 2011 replacement for MyPyramid that provides a simple graphic intended to encourage healthy food choices through a balance of fruits, grains, vegetables, protein and dairy (http://www.choosemyplate.gov/about.html). Despite the introduction of MyPlate, which represents the most recent recommendations from the USDA, obesity continues to climb in the United States (Centers for Disease Control and Prevention, 2013). Information, even when prepared by experts and conveyed in an accessible and intuitive way, is insufficient to cause behavioral change.

Incentives for change:

When information fails, another option that some believe can change consumer behavior is taxation. Consumers are not rational actors who act according to neoclassical economic principles, but rather display bounded rationality due to limited cognitive abilities, bounded willpower where people take actions they know conflict with their long-term interests in favor of short-term satisfaction, and bounded self-interest in which people care about others, including strangers in some circumstances (Jolls, Sunstein, & Thaler, 1998). These characteristics demonstrate that people do not always know what is best for them and even when they do, it sometimes fails to elicit the expected action of a rational actor because of more immediate

desires or concern for others. Despite opposition from consumers who wish to preserve freedom of dietary choices, proponents of so-called “sin taxes” argue that they discourage unhealthy choices and that promoting public health is the right of the federal government (Cummings, 2010). Junk food and soda, both of which are assumed to be associated with obesity and other health problems, are recent targets for sin taxes. A 2% junk food tax levied in the Navajo Nation coupled with the elimination of a 5% sales tax on healthy produce is hoped to help address health concerns including diabetes and obesity (Toppa, 2015). Researchers investigating the effects of the soda tax model found that the expected impacts of a nationwide penny-per-ounce excise tax on sugar-sweetened beverages, if implemented, would reduce consumption of such beverages by 15 percent and over 10 years prevent 26,000 premature deaths and save over $17 billion in medical costs (Wang, Coxson, Shen, Goldman, & Bibbins-Domingo, 2012). However, analysis of historical data fails to demonstrate a statistically significant association between state-level soda taxes and adolescent BMI (Powell, Chriqui, & Chaloupka, 2009).

Although information is helpful, it is not enough on its own to create behavioral change. Consumer expertise, acquired through experiences that provide tacit knowledge to complement explicit information, is also necessary. Life cycle assessment can provide explicit information useful for debunking fallacies, such as plant-based foods being inherently better than animal-based foods for the environment. Tacit knowledge helps consumers make sense of the extensive contradictory information regarding food and feel like they can be effective in making a change. To advance these goals and work towards a more sustainable food system, this dissertation is comprised of two primary investigations, one of which supports advancement of explicit information and the other of which supports development of expertise.

Hypotheses:

First, the degree of processing required for production of a food item has a positive correlation with the environmental impacts associated with that food.

Second, the extent of exposure to a given discipline or social group has a positive correlation with an individual's level of expertise in that domain.

Methods:

The first hypothesis is tested through an investigation of SPI using life cycle assessment, which has the added benefit of answering whether or not a processed plant-based food can be considered worse for the environment than an equivalent unprocessed animal-based food. The second hypothesis is examined through testing of the development of veganism expertise in omnivores, vegetarians and vegans through a new method developed for this purpose known as TURINEX and text analysis of TURINEX sessions. Transcript analysis provides evidence of the role of tacit knowledge in demonstrating veganism expertise and an understanding of the nature of veganism from the perspective of multiple vegans, vegetarians and omnivores. This examination has the added benefit of demonstrating the effectiveness of TURINEX as a tool for assessing development of expertise in any subject and providing evidence that veganism is an expertise. Chapter 2 provides an overview of the current state of sustainable food systems to establish the need for a new approach to sustainable food. Chapter 3 presents an LCA of SPI as an example of how explicit information can debunk existing fallacies regarding plant-based diets and to illustrate some shortcomings of processed vegan products. Chapter 4 introduces a new expertise development assessment tool called TURINEX which is used together with text analysis to evaluate the role of tacit knowledge and self-perception in veganism and provide lessons from this understanding relevant to advancing sustainable consumption through experiential education. Chapter 5 weaves together insights from these three examinations to provide recommendations for advancing sustainable food systems.

Principle Dissertation Findings:

Intellectual products from this dissertation include a literature review of challenges to sustainable food systems, an LCA of SPI, and TURINEX, a new sociological methodology to assess levels of linguistic expertise. Principle findings of this dissertation include results from an LCA of SPI that and that veganism is an expertise in which vegans have more tacit knowledge than vegetarians, who in turn have more tacit knowledge than omnivores.

Literature review shows that the US food system and the global food system it is tied to have significant flaws despite efforts to advance agendas for creating more efficient, resilient and ecologically benign food production systems (see Chapter 2). Attempts to understand or influence decisions of consumers in food systems are insufficient to create positive behavioral change. Some literature advances dogmatic viewpoints with minimal consideration for the arguments of opposing sides. Technological optimism and environmental purism frame the majority of these debates, in which the arena for discussion shifts based on the perspective of the author(s). Technological optimists emphasize the need to feed the world while optimizing efficiency to preserve resources and combat global warming. Environmental purists emphasize the need to preserve vital ecological functions to prevent an irreversible catastrophe in the food system and solve hunger by fixing distribution and food waste issues, while reducing overall consumption.

LCA of SPI demonstrates that plant-based products can be processed to the extent that they are quantitatively worse for the environment with regard to global warming potential, water use, and fossil fuel depletion than soybeans, soymeal, tofu, and unprocessed meats including chicken, pork and some beef. Tradeoffs between impacts from farm level processes and manufacturing level processes should be considered in a comparison between alternatives even if life cycle assessment details are unavailable.

Expertise in veganism is determined by the degree of exposure to the domain of practice whether through personal adherence to the lifestyle or close relationships with vegans. TURINEX tests demonstrate the importance of tacit knowledge in evaluating levels of expertise and that a level of expertise between none and IE exists and can be tested for. IE is the ability to communicate with experts at their level of linguistic expertise. Transcript analysis shows that tacit knowledge can be expressed through anonymous text based question and answer interactions online, that veganism is a choice that encompasses multiple dimensions of the vegan's life, and that maintaining a vegan lifestyle or a close relationship with a vegan leads to the development of vegan expertise. Understanding the development of veganism expertise and the demonstrating the ability to test for a level of expertise between none and IE advances sustainable consumption by providing an example of how food related expertise can be supported and providing an assessment instrument for educational efforts.

Discussion:

Advancing a sustainable food system requires comprehensive changes across dimensions of production, distribution and consumption that are both mediated by and influenced by consumers. To be sustainable, decision makers must develop tacit knowledge to navigate the complex landscape created through contradictory and controversial research findings and dogmatic opinions. Intuitive assumptions regarding the sustainability of dietary choices may be wrong and should be investigated using quantitative and objective methodologies. However, explicit information should not be the only basis for sustainable decision-making. Expertise is required to enable consumers who are concerned with their food choices to sort through what information is valid and relevant to make choices that better align with values representing a sustainable food system. Success of training and educational programs intended to promote sustainable consumption can be evaluated for effectiveness using the TURINEX methodology and software.

CHAPTER 2

THE FUTURE OF FOOD

Abstract:

Two perspectives dominate competing visions regarding the future of sustainable food systems. Technological optimists argue that embracing scientific advancement is necessary because only efficiency improvements can feed the world. Environmental purists believe that nature must be preserved and favor cutting back consumption and improving distribution to solve hunger. Consumers exposed to these viewpoints are likely to not know which side to trust or what arguments are valid, which leads them to either not care or become zealots for one side or the other. Sustainable consumers need tacit knowledge – unstated understanding not easily written or verbalized, but necessary for tasks where explicit information would be insufficient – to gain enough expertise to understand tradeoffs, context, and motivation in ways that explicit information alone can't provide. This chapter provides a literature review that attempts to fairly represent and critique the perspectives and arguments in the debate over the future of sustainable food. Issues exist in and across all six stages in the life cycle of food, from production to disposal, and abundant research is performed in most of these areas. However, dogmatic viewpoints on controversial issues distract the public from significant issues with the food system which deserve more attention.

Introduction:

The U.S. food system is unsustainable, as is the global food system it is tied to (Godfray et al., 2010; Heller & Keoleian, 2003; Vinnari & Vinnari, 2013). Problems range from food security and resource depletion to an obesity epidemic, eutrophication and global warming (Mokdad et al., 2001; Ronald, 2011; Vermeulen et al., 2012; Xue & Landis, 2010). Solutions from numerous perspectives are proposed, but these typically fall into one of two broad categories. Technological optimists believe scientific advances are the necessary to feed the world with lower

environmental impacts. They seek efficient production and low environmental impacts through technologies like genetic modification and lab-grown meat (Ronald, 2011; H. L. Tuomisto & de Mattos, 2011). For the opposing view, environmental purists argue that nature must be preserved or even more severe consequences will occur. They are in line with Aldo Leopold's land ethic and the deep green point of view (Connelly, 2007; Leopold, 1966) Both of these types of arguments are presented to consumers due to recognition of the important role they play in shaping the food system because of consumer sovereignty and ethical purchasing preferences (Korthals, 2001).

Problem Statement:

People attempting to make sustainable choices are likely to be frustrated by debates over sustainable food because they can't tell which arguments are trustworthy or valid. They cannot get sufficient relevant information, and may not trust the institutions providing it (Korthals, 2001). This isn't cynical or misguided, as greenwashing is a serious concern for consumers who have to deal with at least 150 different eco-labels for consumer products (Golden et al., 2010). Labelling schemes and certification programs are ineffective because consumers are suspicious of greenwashing, meaningless claims, and corrupt regulation. Consumers may also experience upsetting revelations about the way their food is made (e.g. pink slime), or discover that companies were lying to them with a label (e.g. "natural" Naked Juice), causing mistrust of the entire industry (Choi, 2013; Pollan, 2012). Frustration may either cause people to stop caring, or to give in to one side and follow it blindly, but neither choice will lead to a sustainable food system.

The nature of the food system means that nearly every relevant issue represents a wicked problem (see Chapter 1, Table 1). Actors hoping to create a more sustainable food system must find balance between directly opposing macro-ethical sustainability values, including longevity vs. adaptability, the needs of nature vs. humanity, local vs. global risks and benefits, strong vs. weak sustainability, equitable allocation of resources vs. distribution of benefits, and the balance of

current and future needs, all of which must be addressed in dealing with any sustainability problem (T. Seager, Selinger, & Wiek, 2011). It is dangerous to consider only some of these tensions, or address only one part of a wicked problem, because the remaining issues or threats still exist (Churchman, 1967). Although there is variation between advocates, in general technological optimists focus on the needs of humanity in the present or immediate future and are willing to accept weak sustainability through the substitutability of resources. Environmental purists tend to see themselves more as defenders of nature over a longer time horizon and are willing to sacrifice to insist on strong sustainability through conservation of resources.

Motivation:

Consumers and actors motivated to address these wicked problems need the ability to understand tradeoffs on both sides to make sustainable choices. Providing explicit information is not enough to accomplish this. Information does not automatically cause consumers to make better choices, as other factors such as affect and cognitive processing resources available play a strong role in choice (Shiv & Fedorikhin, 1999).

Methodology:

This chapter consists of a literature review on the subject of sustainable food. This encompasses six primary activities in the life cycle of food represented in the inner circle of Figure 4. These are production, manufacturing, distribution, shopping, consumption and disposal.

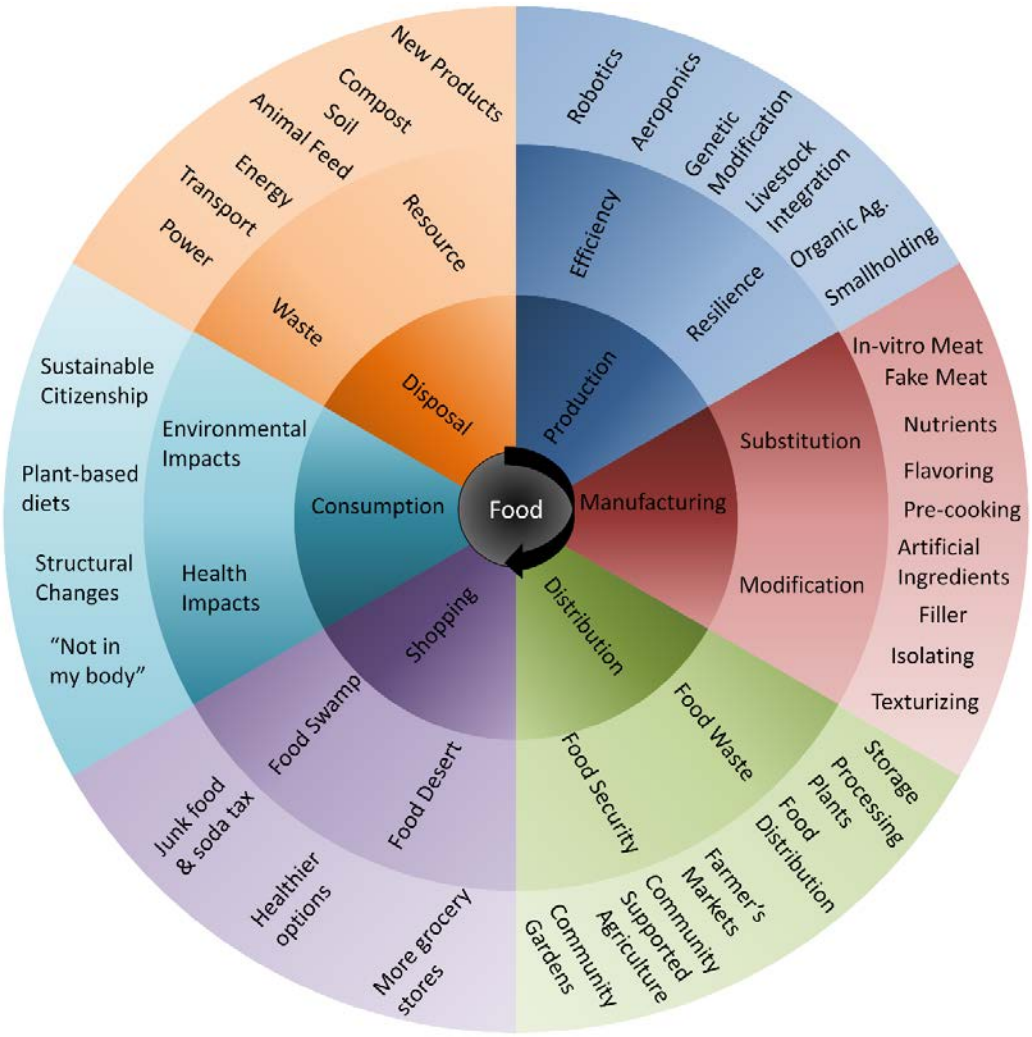

Figure 4: Visual Representation of the Arguments in Dimensions of Sustainable Food. Phases represented through the life cycle of food from production to disposal.

Figure 4 is a visual representation of the food system, with three layers representing life cycle stages in the inner circle, competing visions in the middle circle, and ways to achieve those visions in the outer circle. For example, in the manufacturing phase, fake meat lines up with substitution, which is an attempt to make food more sustainable by using lower impact plant-based ingredients in the place of unsustainable animal products. Some solutions in the outer circle may align with both visions and are therefore placed between them. Solutions representing the extreme of the vision they are associated with are placed on the outer edges of the segment.

Definitions of the life cycle stages for food:

Production consists of growing crops and/or raising livestock. Manufacturing is the processing necessary to make food that is appropriate for human consumption. Distribution is how food is delivered to points where consumers can obtain it. Shopping is the process of consumers obtaining food. Consumption includes the various ways that consumers can eat food. Disposal is what happens to inedible components and food waste. Although these steps typically happen in order, some can be skipped. For example, if a consumer goes to a farm and picks their own apple, buys it, then washes and eats it, and finally throws out the core, this only involves production, shopping, consumption, and disposal, but skips manufacturing and distribution.

Results:

Efforts to create sustainable food systems must consider every stage of the life cycle of foods. Therefore, this literature review is structured according to the six main stages involved in the food life cycle. An overview of issues is provided at the start of each stage. Where possible, articles are arranged so that issues raised with one paper are addressed by the subsequent publication.

First Stage, Production:

At the production stage, the primary concerns for sustainability include meeting demands for food, reducing environmental impacts and resource depletion, improving worker conditions, maintaining resilience of the production system, and ensuring farmer livelihoods. Genetic modification and organic agriculture are issues which cause significant debate within the context of production. Environmental purists resist genetic modification, but technological optimists embrace and defend it.

Binder et al. develop a framework for evaluating sustainability assessment methods and find through reviewing seven different approaches that definitions of sustainable agriculture include characteristics such as productivity to meet society's needs for food and fiber, protection and

improvement of the natural environment and socio-economic conditions of local communities, economic viability, social livability, environmental reproducibility, enhancing farmer's quality of life, resilience, biological diversity, and competitiveness (Binder, Feola, & Steinberger, 2010). This holistic view of the production system demonstrates the range of concerns relevant to the production stage of the food system and the effort evident in attempts to improve it. However, meeting all of these criteria places a heavy burden on decision makers including politicians and farmers.

Tilman et al. predict that by 2050, global crop demand will be more than double the 2005 level, but argue that environmental impacts can be minimized through focus on moderate intensification of existing croplands and technology transfer to boost productivity of under-yielding nations (Tilman et al., 2011). The authors assume that a fitted curve from 1961 to 2007 they plot would continue the existing relationship between GDP and calorie and protein consumption, though they provide a range of estimates as extrapolations of that curve (Tilman et al., 2011). They also assume a 2.5% per capita GDP growth and acknowledge another forecast for increased global crop production of only 70% growth that conflicts with their prediction of 100-110% growth in global crop production (Tilman et al., 2011). However, the focus of the paper is not on the exact amount of growth, but rather how to meet increased demand in a sustainable way through production efficiency. The recommendations provided to increase yield through technology transfer do not address economic considerations that might prevent agribusinesses from cooperating in this goal and the potential for problem shifting as increased use of fertilizer could lead to problems with eutrophication and larger energy demands due to its use in production of fertilizer.

Godfray et al. assume the world will reach a population of about 9 billion people by around 2050 and argue that food production must supply food for a larger and more affluent population in environmentally and socially responsible ways while also ending world hunger (Godfray et al., 2010). The authors propose several solutions to problems identified, including sustainable

intensification through rigorous application of best management practices like precision agriculture, closing the yield gap through technology transfer, increasing maximum yields in existing systems through scientific advances like genetic modification, reducing waste throughout the system, reducing meat consumption, and expanding aquaculture (Godfray et al., 2010). The majority of the authors' recommendations focus on either production or distribution challenges, with issues relevant to consumers including food waste reduction and dietary change receiving less attention. The authors argue that meat consumption is not inherently bad, as many cows are fed with grass from land that is not arable, and pigs and poultry are fed with what would otherwise be waste from human foods (Godfray et al., 2010). However, this argument ignores significant environmental impacts resulting not from feed production, but from enteric fermentation and animal waste.

Jules Pretty claims that it is over-optimistic to assume progress in agricultural productivity will continue to rise based on increased use of fertilizer, irrigation, machinery, pesticides and land, and that new approaches that integrate ecological processes into food production, minimize non-renewable inputs, and make use of human capital and collective capacities are needed to attain sustainable agricultural outcomes (Pretty, 2008). Some researchers hope that genetic modification will help agricultural productivity keep pace with increased demand for food (Pontin, 2013; Rotman, 2013; Uzogara, 2000). This is a viewpoint held by technological optimists.

Stella Uzogara performs a review of research concerns on both sides of the debate over genetic modification and finds a long list of concerns and potential benefits regarding GM crops. The opponents of GM crops have concerns that can be grouped into categories of detrimental changes to crops both in nutrition quality and possible health impacts, potential for GM technology to spread unintentionally or cause new agricultural problems, seed patenting, and religious, cultural, or ethical concerns (Uzogara, 2000). Potential benefits of GM technology can be grouped into categories of beneficial changes to crops in nutrition quality, taste, and health impacts as well as yield, reduced need for various inputs, and use of GM plants or livestock to

serve innovative non-food purposes (e.g. growing human organs in livestock for transplant, using plants as bio-factories for raw materials for industrial use, and removing industrial waste with plants) (Uzogara, 2000). While the review covers a wide variety of topics relevant in the GM crop debate, the tone is biased towards GM crops from the start, noting early on that genetic engineering was an agricultural practice since early historical times, opponents of GM technology are motivated by fear of the unknown, and benefits of GM foods far outweigh the risks (Uzogara, 2000). Uzogara does not mention food sovereignty concerns and provides only a passing reference to problems faced by farmers in India due to the introduction of GM seeds.

Glenn Stone looks at the influence of biotechnology introduced to India, home to one of the world's most notable opponents of GM crops, Vandana Shiva. Stone finds that GM crops have a disruptive effect on cultural agricultural practices that lead to agricultural deskilling – the loss of information and management practices for agriculture due to lack of consistency in the effectiveness of a technology, difficulty recognizing the technology, and rapid introduction of a technology (Stone, 2004). These deskilling factors are all present in genetically modified cotton, leading to a notable loss of capabilities for Indian smallholders which may be responsible for improper use of pesticides and crop failures leading to farmer suicides (Stone, 2004). The connection of crop failures to farmer suicides is not well established in Stone's article.

Cormac Sheridan reports that an investigation into farmer suicides' alleged link with Bt cotton finds no evidence that the GM crop is a major factor, noting that the introduction of Bt cotton in 2002 occurs after the major increase in farmer suicides, which are also a constant portion of the national suicide rate since 1997 (Sheridan, 2009). Despite this, the ongoing use of GM crops and potential introduction of new seeds to India are a matter of intense debate for a broader range of issues, including those outlined by Uzogara. One of the arguments dividing those on both sides of the genetic modification and organic agriculture debates is whether or not GM crops are actually necessary, but this is beyond the scope of Sheridan's article.

Badgley and Perfecto claim that it is possible to feed the world using organic agriculture based on analysis of a global dataset of nearly 300 yield ratios for plant and animal production, which matches findings of two other studies which examine the developed world and the developing world for yield ratios and the potential of organic agriculture (Badgley & Perfecto, 2007). The authors fail to define organic agriculture, but distinguish it from non-organic agriculture by noting that it does not use “agricultural biocides” and synthetic fertilizer (Badgley & Perfecto, 2007). The article does not address critiques of organic agriculture outside of yield gaps. For example, organic agriculture may be associated with higher environmental impacts per weight of food produced (Leinonen, Williams, Wiseman, Guy, & Kyriazakis, 2012). Also, organic systems still have the potential to exhibit the characteristics consumers dislike about factory farming because they only require adherence to the law, not the original intention, for organic farming (Cross, Edwards, Hounsome, & Edwards-Jones, 2008; Guthman, 1998).

Julie Guthman points out that the original spirit of organic farming as a set of production practices explicitly against trends in industrialized agriculture faded over time as the appeal grew and conventional agribusinesses adopted organic food production that only met the regulatory requirements for organic certification, but not the desire to optimize the agro-ecological system as a whole (Guthman, 1998). Another potential issue in not just organic farming but any farm system is treatment of workers. Heavy labor needed to substitute human capital for chemical fertilizers and pesticides may represent a trade-off between environmental and social considerations, especially if workers are not treated fairly or paid well.

Cross et al. examines the health of workers in conventional and organic systems using four assessment instruments: SF-36, EuroQol EQ-5D, Visual Analogue Scale, and Short Depression Happiness Scale. Cross et al. determine that although three out of four assessment instruments indicate no difference between workers on organic and conventional farms, the fourth instrument shows that workers on organic farms score higher on the Short Depression Happiness Scale due to the variety of tasks the organic farm workers performed each day (Cross et al., 2008).

However, the large number of farms that exist precludes close examination and the potential for mistreatment of workers exists in a variety of contexts.

Richard Marosi reports on a March 2015 Mexican farmworkers strike over low wages, due to employees earning as little as about $8 US a day working for BerryMex, which grows both conventional and organic strawberries and raspberries (Marosi, 2015). Workers complain about stagnant wages and increased costs of living (Marosi, 2015). Economic viability in the food system must maintain balance between farmer and worker livelihoods, affordability for consumers, and profitability of the company, making it difficult to please all stakeholders involved. Mobed et al. find that migrant and seasonal farm workers must perform strenuous tasks and are exposed to numerous occupational risks resulting in farm-work related health problems which are made worse by lack of access to health care (Mobed, Gold, & Schenker, 1992). The magnitude of exposure to these health risks is unknown, but anecdotal evidence points to significant risks of work related injuries, illness due to pesticide exposure, problems associated with heavy physical labor, dermatitis, respiratory illness, reproductive health problems, and health problems in children of farm workers (Mobed et al., 1992). Although the authors provide a thorough description of problems facing farm workers, they do not offer viable recommendations for how to reduce those problems, but instead call for additional investigation.

Inwood and Sharp investigate factors for persistence of farmers at the intersection of rural and urban space, finding that the most important factor in continuing or expanding the farm is the identification of an heir, and that some farms in these contexts are actually able to grow through horizontal or vertical expansion strategies (Inwood & Sharp, 2012). However, persistence of family farms may not be enough to ensure sufficient income for farmer livelihood as a worthwhile endeavor. It is also not clear whether small farms are conducive to sustainability goals or not.

More LCAs than can be discussed here examine environmental impacts in a variety of contexts for production systems to create a wide range of foods. In the context of production, some LCA

studies compare conventional systems with organic or other systems supposedly closer to nature (Baroni, Cenci, Tettamanti, & Berati, 2007; Boggia, Paolotti, & Castellini, 2010; Cederberg & Mattsson, 2000; Leinonen et al., 2012; Nathan Pelletier, Pirog, & Rasmussen, 2010; Roy et al., 2009; Williams, Audsley, & Sandars, 2006). In general, findings from these studies indicate that higher yield and production efficiency in conventional systems outweigh the reduced inputs in organic systems so that quantification of environmental impacts favors conventional systems.

However, other aspects of organic systems may address sustainability concerns not captured in LCA due to its focus on environmental impacts rather than social or economic issues. Some LCAs focus on global warming potential, potentially ignoring other environmental impacts, such as the fossil resources needed to create fertilizer (H Risku-Norja, Kurppa, & Helenius, 2009). Other LCAs provide a comparison of environmental impacts associated with different dietary choices, but still rely primarily on data regarding agricultural production to make their claims (Baroni et al., 2007; Carlsson-Kanyama, 1998; Farshad, Lepik, Ng, Pedro, & Tsao, 2010; Heller, Keoleian, & Willett, 2013; Meier & Christen, 2013; Reijnders & Soret, 2003; Helmi Risku-Norja, Kurppa, & Helenius, 2009; Weber & Matthews, 2008). The majority of these LCAs find that diets have lower environmental impacts when they have lower or no consumption of animal products due to the lack of efficiency in conversion of animal feed to the final product of a given system as well as enteric fermentation and manure management. It is worth noting that some animal production systems can make use of non-arable land through livestock grazing and food waste as feed, potentially reducing the associated environmental impacts of meat from those systems and providing a food source from resources that otherwise might not be used.

Judith Capper provides a comparison of historical and modern carbon footprints for animal agriculture, finding that the past century has seen improved productivity in beef and dairy production and that intensive rather than extensive systems are more environmentally friendly due to reduced resource use, waste and greenhouse gas emissions per unit of food (J. L. Capper, 2011). Although she notes the concern for animal welfare and worker conditions, this is

only a passing reference to Singer and Mason's 2006 book on ethical consumerism, "The Way We Eat: Why Our Food Choices Matter".

Second Stage, Manufacturing:

At the manufacturing stage, worker conditions dominate sustainability concerns, though there is recognition for the potential of this stage to increase environmental impacts of food products. Manufacturing within the food system receives little attention, but insights from other industries may still be useful to inform sustainable food systems. Manufacturing and production can be conflated within the context of food because many products require little or no processing after the farm-level processes, but this dissertation considers them as separate steps. Here production is assumed to include agricultural activity, but post-harvest or post-slaughter activity such as packaging, combining ingredients, and cooking to create finished products ready for distribution are considered part of the manufacturing stage.

Westkamper et al. discuss the application of life cycle management principles to manufacturing, emphasizing the need to consider the entire life cycle as a whole and encouraging application of LCA to identify ways to increase efficiency (Westkamper, Alting, & Arndt, 2000).

Heilala et al. present several strategies to design sustainable manufacturing systems including lean manufacturing, reducing waste and production loss, and environmental considerations through appropriate metrics (Heilala et al., 2008). Efficiency oriented approaches will not result in changes from the status quo, but rather reinforce existing systems through optimization. Therefore, transformative sustainability requires a broader view of the system.

B. Smith identifies sustainable manufacturing priorities including safe, healthy products, viable livelihoods, operation within limits of natural resources, minimized inputs, worker welfare, training, safety and hygiene, and high standards of animal health and welfare (Smith, 2008).

Jayal et al. maintain that a holistic view of the entire supply chain across multiple systems and life cycles is necessary to achieve sustainability in manufacturing (Jayal, Badurdeen, Dillon, & Jawahir, 2010). They point out that sustainable manufacturing requires innovation that meets the six R's (remanufacture, redesign, recover, recycle, reuse and reduce) as opposed to green manufacturing, which only meets the last three R's (Jayal et al., 2010). In the context of food systems, the six R's can include remanufacturing outdated machinery for new products, redesigning food products and packaging for minimal environmental impacts, recovering waste materials to be repurposed, recycling pre-consumer waste, reusing chemicals used for processing to the extent allowable by food safety standards, and reducing wasted materials through processes like just in time manufacturing. When implemented properly, just in time manufacturing is found to increase competitive advantage (McLachlin, 1997). This method may reduce waste by only producing what is necessary, but could be difficult to implement due to time constraints on inputs (e.g. crop growing season, viability of long-term storage).

Sundkvist et al. argue that tightening feedback loops between and within food production chains, ecosystems, and consumers is necessary to ensure sustainable development of food systems due to the importance of feedback in signaling unhealthy ecosystems and potential usefulness of enhanced communication between actors (Sundkvist, Milestad, & Jansson, 2005). Feedback can be masked by lack of perception or failure to act, resulting in missed opportunities for learning and sustainable management (Sundkvist et al., 2005). Enhanced communication and feedback within the system may provide signals useful in improving sustainability concerns, but only if the actors within the system are willing to make necessary changes.

B. Smith examines opportunities for developing sustainable food supply chains, which include encouraging consumers to eat healthier diets, investing in sustainable manufacturing and distribution systems, and enabling farmers to adopt sustainable agricultural practices through cooperation across entities throughout the food system (Smith, 2008).

Third Stage, Distribution:

Distribution is a stage dominated by social and economic concerns, especially food security, though infrastructure and government investment are also significant. Food security has significant overlap with the shopping stage as it relates to accessibility and affordability of food. Food waste is also a significant issue within the context of distribution.

Parfitt et al. examine food waste across food supply chains and find that there is a lack of data on this topic, and a significant gap exists in understanding food waste in developing countries and the BRIC (Brazil, Russia, India, and China) economies (Parfitt, Barthel, & Macnaughton, 2010). Parfitt et al. note that losses are much higher at immediate post-harvest stages in developing countries and higher for perishable foods in general (Parfitt et al., 2010). Strategies for reducing food waste at the distribution stage include large scale investment in infrastructure, technological skills and knowledge, storage, transport and distribution (Parfitt et al., 2010).

Fourth Stage, Shopping:

The shopping stage underscores food security concerns, though discussions of food security may also include production issues. Shopping is where consumers exhibit strong potential to influence the food system, though their ability to do so is debated (Sanne, 2002). There is overlap between shopping and consumption areas, as it is expected that consumers typically buy products they intend to use. These stages are differentiated here by examining factors limiting choices in the context of shopping while examining actual product choices in the context of consumption.

Per Pinstrup-Andersen identifies food security as the condition in which “all people at all times have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for a healthy and active life,” which entails food safety and nutrition, as well as food consistent with social, cultural, religious and ethical values (Per Pinstrup-Andersen, 2009). He estimates that there are at least 2 billion food insecure people in the world just on the basis of iron deficiency as the lower bound (Per Pinstrup-Andersen, 2009). Although he argues there is a need for policy interventions and behavioral change (e.g. changed

consumption patterns and ensuring sufficient household resources) as ways to address food insecurity, these approaches should be combined with production improvements as well.

Falkenmark and Rockstrom argue that a major shift in thinking equivalent to a “New Green Revolution” is required to meet food security needs because of the massive water requirements to provide enough food to feed the world (Falkenmark & Rockström, 2004). The analogy with the Green Revolution reflects faith in technological solutions and skepticism regarding the ability of people to reduce consumption, but a combination of both may be necessary to address global hunger.

Evenson and Gollin discuss the history of the Green Revolution, arguing that it lasted from 1961 to 2000, with significant gains in productivity and overall yield with only moderate increases in planted area and inputs of fertilizer and irrigation (Evenson & Gollin, 2003). Some countries suffer from decreased commodity prices because of lack of development in suitable modern high yielding crop varieties for regions such as Sub-Saharan Africa while farmers in most other areas of the developing world benefited (Evenson & Gollin, 2003). In this way, the Green Revolution demonstrates the importance of ensuring equity while pursuing a sustainable food system.

Cummins and Macintyre define food deserts as “urban areas where residents do not have access to an affordable and healthy diet,” and note that residents of poor communities blame the lack of supermarkets in their area for not eating healthy foods, which implies responsibility for retailers that do not establish shops in poor communities (Cummins & Macintyre, 2002). The authors warn against using “factoids” (assumptions reported so often that they are considered true) to support policy decisions however, noting that the supposed existence of food deserts in the United Kingdom is not supported by strong empirical evidence regarding the availability and price of healthy foods in investigated areas (Cummins & Macintyre, 2002). The critical view taken by the authors in analyzing food system issues is important and should be applied across a variety of

food sustainability topics, but skepticism regarding motivations should be moderated by evaluation of known tradeoffs from implementation of new policies or procedures.

Rose et al. object to the term “food desert,” preferring instead “food swamp”, which is an area in which healthy options are inundated by large amounts of energy-dense snack foods, masking the availability of healthy options (Rose et al., 2009). The difference in terminology reflects the role consumers have to play in eating choices when a variety of healthy and unhealthy foods are available.

Patricia Allen identifies an approach to food security called community food security (CFS) which can serve as an addition to, but not substitute for a governmental safety net to protect against food insecurity (Allen, 1999). CFS links production and consumption and considers issues related to food security on a larger spatial and temporal scale, with a focus on community building (Allen, 1999). A focus on community support is a promising way to supplement federal or state programs and enhance citizenship values and sustainability.

LCA has some difficulty dealing with shopping and consumption stages for food because there is so much potential variation, but cradle to grave LCA can capture significant impacts not included in cradle to gate. For example, an LCA of an Italian lager beer found that car use to travel and purchase the beer added significant fossil fuel use to the life cycle impacts, resulting in higher emissions (Cordella, Tugnoli, Spadoni, Santarelli, & Zangrando, 2008).

Fifth Stage, Consumption:

The consumption stage is dominated by health impacts, but food waste is also a significant problem. Consumption as a political act is also addressed within this context.

Micheletti and Stolle regard sustainable citizenship as an important role for consumers, corporations, and governments in which these entities work towards sustainability (Micheletti & Stolle, 2012). Sustainable citizenship is when individuals or companies address concerns about

past and current injustices, address worldwide responsibilities, and emphasize responsibility to nature and animals (Micheletti & Stolle, 2012). However, the authors find that self-interest dominates decision-making, preventing these concerns from changing behaviors (Micheletti & Stolle, 2012). The demands they place on sustainable citizenship include supporting social justice and nature, considering how their beliefs, policies and practices might reproduce injustices of the past or have a negative impact on other people, nature and animals in the future, and practicing daily responsibility for economic, environmental and equitable development (Micheletti & Stolle, 2012). Despite the high demands the authors place on sustainable citizenship, they find an example of commitment to these principles in vegetarians and vegans, who make purchases that align with their beliefs regarding how to solve sustainability problems, discuss and problematize food choices related to animal welfare and the environment, and make changes to their daily lives to preserve animal well-being (Micheletti & Stolle, 2012).

However, not all vegetarians and vegans engage in these practices. For example, a study of veganism in Sweden found that although expected reasons of ethics, health, or distaste for meat were common, friends, family, school, media, and music also influenced the decision to become vegan (Larsson, Ronnlund, Johansson, & Dahlgren, 2003). There are many other potential activities consumers can engage in that would meet principles of sustainable citizenship.

E. DuPuis examines the rise of organic milk as a case study for consumption as a form of politics, arguing that it is a challenge to the widespread use of recombinant bovine growth hormone (rBGH) which many consumers are wary of and responded with a “Not-in-my-Body” (NIMB) politics of refusal (DuPuis, 2000). Consumers buying organic milk are therefore engaged in a political activity that molds the industry through the process of reflexive consumption, in which choices are made after careful reflection of claims made by a variety of groups and sources around a particular issue which may include those of activists, mainstream media, experts, and personal networks (DuPuis, 2000). However, the effectiveness of consumers attempting to change the industry is questionable (Sanne, 2002).

Christer Sanne focuses on structural issues driving consumer behavior rather than social and psychological factors. Sanne argues that business cooperates with or pressures government to create conducive conditions for increasing consumption, which lock consumers in to work and spend lifestyles and that a more effective approach to encouraging sustainable consumption would be to shorten working hours to allow for more leisure time while reducing discretionary income, preventing overconsumption (Sanne, 2002). More available time outside of a job could also provide an opportunity for individuals to work in other capacities which might reduce the need for certain products like pre-cooked meals, though cooking is not necessarily a leisure activity. Therefore it is possible that existing patterns of high demand work combined with excessive consumption are a product of structural factors rather than individualism and selfish behavior. If that is the case, a top-down approach may be needed to break the cycle, but would be regarded by many as a loss in productivity coupled with a reduced standard of living. However, more people living with less consumption may be necessary to achieve a sustainable and equitable world.

An LCA of food products and production systems considered the consumer phase as transportation from retailer to household and storage in a refrigerator or freezer if necessary and found that the consumer phase contributed between 13 and 50% to total energy use based on the storage time (Andersson, 2000). The author also found that the consumer phase contributed 12% to global warming potential, and 29% to VOC emissions, and minor amounts to other environmental impacts such as acidification and eutrophication (Andersson, 2000).

Sixth Stage, Disposal:

Although the disposal stage comes at the end of the food life cycle and its name implies that it is the final step, disposal through food waste occurs across all other stages of the life cycle. Food waste can be repurposed as animal feed, compost for growing new crops, or biofuel. For these reasons, food waste dominates the discussion of sustainability for the disposal stage of the food life cycle.

Lin et al. analyze potential uses for food waste, and note that at the post-consumer stage it comes from stock management at home, poor food preparation, and confusion over expiration dates (Lin et al., 2012).

Hall et al. provide an estimate of historical trends in food waste within the US since 1974, noting that there was a progressive increase of about 50% to about 1400 kcal per person per day of waste and that food waste now represents a quarter of freshwater consumption and 300 million barrels of oil per year (Hall et al., 2009). The authors argue that obesity in the US is the result of a push effect of increased food availability and marketing resulting in people unable to match food intake with overabundant cheap and accessible food (Hall et al., 2009). If these assertions are correct, food waste and obesity may actually be symptoms of the same problem, which is the overproduction of food.

Kumar Venkat examines the climate change and economic impacts of food waste in the United States using life cycle assessment methodology and retail prices of the food waste. He finds that food wasted is about 29% of annual production, which represents life cycle greenhouse gas emissions of equivalent to about 2% of national emissions and costs $198 billion (Venkat, 2011).

Cuellar and Webber calculated energy intensity of food production and food waste in the United States, finding that in 1995, about 27% of edible food was wasted, representing 2% of annual energy consumption in the United States (Cuéllar & Webber, 2010). These findings closely match those of Venkat, so it is reasonable to believe that food waste in the US holds at between a quarter and a third of total food production. With such a large magnitude of loss, it would be expected that there is significant room for improvement in this aspect of the food system.

Parfitt et al. assert that there is a lack of data on the topic of food waste, but some general trends are observed. Affluent countries experience loss from post-consumer waste while developing countries have higher post-harvest losses, while both types of countries have high rates of

perishable food loss overall (Parfitt et al., 2010). Strategies for reducing food waste at the consumption and disposal stage include a cultural shift in consumers' relation to food, improved food labelling and innovative packaging technology (Parfitt et al., 2010). Food waste is likely to remain an ongoing problem, so considering food waste as a resource rather than burden may help make the food system more sustainable.

Han and Shin identify one potential solution for food waste as anaerobic fermentation to produce bio hydrogen, which might be used as a sustainable substitute for fossil fuels and serve the dual purpose of waste reduction and energy production (Han & Shin, 2004). The authors identify food waste in Korea as a major environmental burden which accounts for nearly a quarter of municipal solid waste, but note its high energy content makes it ideal for energy generation. Technology and infrastructure to support hydrogen as a substitute for fossil fuel would be needed for this strategy to be successful, so other options for food waste conversion should be considered.

Lin et al. provide an overview of current and innovative uses for food supply chain waste, including the production of chemicals, materials and fuels including flavor and fragrances, antioxidants, coatings, food additives, synthetic fibers, plastics, and rubbers (Lin et al., 2012). The authors deliberately avoid conventional food waste processing strategies such as incineration for energy, feed, or composting and instead focus on strategies for production of higher value and marketable products (Lin et al., 2012). Although this approach emphasizes the economic value of food waste, quantification of environmental impacts associated with this type of production are not provided.

Khoo et al. apply a life cycle assessment approach to examine the environmental performance of food waste conversion scenarios and find that the environmentally favorable options are, in order of preference, anaerobic digestion coupled with composting of digestate material, small-scale aerobic composting, and incinerators (Khoo, Lim, & Tan, 2010). However, the EPA notes that several preferable uses for food waste besides incineration and composting include industrial use

of food scraps, feeding animals and feeding hungry people, and that reducing surplus food generated is the most preferable (US Environmental Protection Agency, 2014).

Synthesis of articles:

For production, controversy centers on genetic modification, with the safety and productivity of GM crops a central point for technological optimists while environmental purists focus on potential social impacts and alternative methods to meet demands for food and reduce environmental impacts. Productivity of organic crops and livestock compared to conventional or genetically modified is contested, but worker treatment across all systems is a significant concern. Dietary choice is a major driver of environmental impacts, with the most preferable choice being a plant-based diet, but other articles point to the advances in efficiency of animal production and their utility on non-arable land.

Despite relatively few articles focusing on food manufacturing sustainability, there is significant potential for improvement by applying principles from other types of manufacturing to food systems. Supply chain thinking and system optimization are the focus, with tightened feedback loops as a potential mechanism for achieving these goals. Treatment of workers and animals is also a concern.

Distribution issues discussed are limited to improvements in infrastructure to reduce food waste and environmental impacts, and a concern for food security.

Food security is also a concern in the shopping stage, though the concept of food swamps may be more relevant in most American cities. Technological optimists claim that a New Green Revolution is needed to ensure food security, but environmental purists might object that the Green Revolution also caused significant problems, including worsening inequality in some regions of the world.

In the consumption stage, the focus is on choices consumers make and the messages that these send. Vegans are identified as a potential model for sustainable citizenship, but motivations for veganism can be quite varied. There is tension between arguments that consumers can drive change in the food system and counterpoints that there are larger structural issues driving consumer behavior which lock them in to a pattern of overconsumption and waste.
Waste, and how to deal with it, is the central issue in the last stage, disposal. Although food waste has grown over time, is a problem for all countries, and is associated with significant environmental impacts and economic loss, some scholars treat it as a renewable feedstock and examine potential uses ranging from incineration for energy to production of fragrances.

Discussion:

Sustainable food systems require significant and innovative improvements at every stage in the life cycle of food, from production to disposal. Dialogue regarding production and consumption is dominated by controversy over the best approach to take for these two phases. Less attention is paid to other phases, especially disposal, possibly due to lack of available data. Across all stages where conflict emerges, the two dominant discourses demonstrate views of technological optimists clashing with those of environmental purists. Competing stakeholder interests exist in nearly every suggested scenario for improving the food system, which may hinder progress. Literature regarding controversial issues may distract from problems that might be more easily fixed if the same level of effort was applied to their resolution.

CHAPTER 3

LIFE CYCLE ASSESSMENT OF SOY PROTEIN ISOLATE

Abstract:

Close examination of the consequences of diet is necessary to achieve sustainable consumption because food choice constitutes a significant portion of an individual's environmental impact. Life cycle assessment (LCA) is the best tool available to evaluate environmental impacts from food in a holistic manner. Existing food LCAs and footprinting tools for consumers indicate that plant-based diets (vegetarian or vegan) are less harmful to the environment than diets that include meat. However, these conclusions are based on a simplified view of plant-based diets that ignores the growing number of sophisticated meat substitutes available and assumes that plant-based diets just substitute meat with more vegetables or simple alternatives like tofu. This view misrepresents the potential range of environmental impacts associated with plant-based diets, which depends in part on the foods people choose to fulfill their protein requirements. Many realistic plant-based meat alternatives (e.g. Beyond Meat, Quorn, Gardein, and Boca products), use SPI, seitan (a wheat based protein), or both to replicate the texture and nutritional profile of meat. SPI requires more processing and use of chemicals not needed in the production of seitan. SPI uses soybean meal (soymeal) as a feedstock, but also requires modifications made through mechanical and chemical processes which increase the environmental impact of the final product. SPI and other specialty food ingredients (SFI) require additional manufacturing level processing after farm level agricultural activities to grow the raw material. The environmental impacts of SPI per kilogram are estimated using LCA techniques and expressed in terms of greenhouse gas emissions, freshwater eutrophication, land use, water depletion, fossil fuel use, and energy use. Publically available data, published literature and SimaPro with the ecoinvent database are used to estimate the environmental impacts associated with the production of one kilogram of SPI. Results indicate that SPI has global warming potential higher than unprocessed chicken and pork, and similar to beef. Freshwater eutrophication associated with SPI is well below impacts associated with chicken, pork and beef. Water depletion and fossil fuel depletion are higher in SPI

than chicken, pork and beef. Energy use for SPI is lower than energy use for chicken, pork and beef. Land use associated with SPI is negative because of environmental credits due to allocation with the byproduct of soymeal, soy oil, which displaces palm or rapeseed oil and therefore represents a lower impact than chicken, pork, and beef. These findings demonstrate that realistic fake meat may not always be an environmentally preferable alternative to chicken, pork, or beef, depending on the impact categories considered.

Introduction:

Consumers who choose plant-based diets typically do so to promote better health, conform with their ethical beliefs, and/or preserve the environment (Fox & Ward, 2008). These consumers as well as a growing number of omnivores concerned with their environmental impact sometimes consume animal product substitutes, believing that following a plant-based diet reduces their environmental footprint. Online footprinting calculators which include dietary choice, such as Nature.org's free carbon footprint calculator or vegetariancalculator.com, confirm the environmental benefits of reducing meat consumption by reporting a lower carbon footprint for vegetarian or vegan diets or reduced meat consumption than for typical omnivores. This is accurate in most cases where consumers shift away from processed animal foods towards whole plant-based foods. The low environmental impacts of plant-based diets are supported by food systems sustainability scholars and a growing body of dietary LCA literature supporting the idea that plant-based diets are better for the environment (de Boer, Schösler, & Aiking, 2014; Pimentel & Pimentel, 2003; Westhoek et al., 2014).

Dietary LCA

LCAs of dietary choice assess the environmental implications, usually as global warming potential, of several diet types and usually find that the lower on the trophic scale a person eats (e.g. vegetarian or vegan), the lower the associated environmental impacts are (Baroni et al., 2007; H Risku-Norja et al., 2009; Sanfilippo, Raimondi, Ruggeri, & Fino, 2012). These LCAs use

definitions of vegetarian or vegan to determine the foods used in comparisons, taking care to ensure they are comparing functionally equivalent foods. For example, Baroni et al. assess vegetarian (defined as excluding animal flesh) and vegan (defined as excluding all animal products) nutritionally equivalent diets compared to omnivores' diets in Italy, considering conventional and organic variations on these diets. Environmental impacts are expressed with Eco-indicator 99 points, which represent resource depletion, ecosystem quality, and human health impacts. The lowest normalized environmental impact is from the vegan and organic diet, while the highest environmental impact is from the omnivore and conventional diet, which is exceeded only by the "actual or normal" Italian diet (based on statistics on average Italian food consumption) (Baroni et al., 2007). Risku-Norja et al. examine the difference in Finland for greenhouse gas emissions between the average Finnish diet (about 33% of calories from milk and beef, less than recommended vegetable consumption, and above recommended animal product consumption), a diet with reduced meat and 60% reduced milk consumption, a diet with no milk, beef or mutton (replaced by pork and poultry), and a vegan diet (which replaced milk with oat-based milk) and again the vegan diet is the clear environmental preference, at about half of the greenhouse gas emissions of the typical Finnish diet (Helmi Risku-Norja et al., 2009). Finally, Sanfilippo et al. compare different lunch options for workers with beef, chicken, pork or peas as the entrée and all else held the same, and the vegetarian option (which was also vegan) has the lowest environmental impacts in every category investigated, including energy use, global warming potential, ozone layer depletion, photo-chemical oxidation, acidification potential and eutrophication potential (Sanfilippo et al., 2012).

There are two trends that emerge from these papers. The first is that dietary LCAs conclude that plant-based diets are better for the environment than those which include animal products. The second is that dietary LCAs assume that vegan and vegetarian diets are the same as omnivores' diets, with the exception being that animal products are replaced with simple plant based products. The reason for this simplification may be a lack of available data for use in dietary life cycle assessments.

Problem Statement:

Assumptions used in LCAs regarding plant-based diets do not always reflect reality. Vegans and vegetarians, especially while in transition from an omnivore diet, may include plant-based realistic meat substitutes that undergo extensive processing but provide a familiar taste and texture without being from an animal. Omnivores may decide to eat plant-based realistic meat substitutes in some meals. However, the benefit of such substitutions is unclear until an investigation into the environmental impacts associated with the substitute is performed. Just as there is a range of environmental impacts associated with an omnivore's diet, there is a range of impacts associated with a vegan diet.

Mapping the food LCA literature

A conceptual representation of the life cycle assessment literature space in Figure 5 shows why oversimplification of plant-based foods is problematic. Additional processing causes additional environmental impacts that may make plant-based alternative products just as harmful to the environment as some unprocessed animal products. Figure 5 should be viewed as a partial conceptual representation of the LCA literature space and it is not intended to serve as a literal or direct comparison of values or an exhaustive list of LCAs performed.

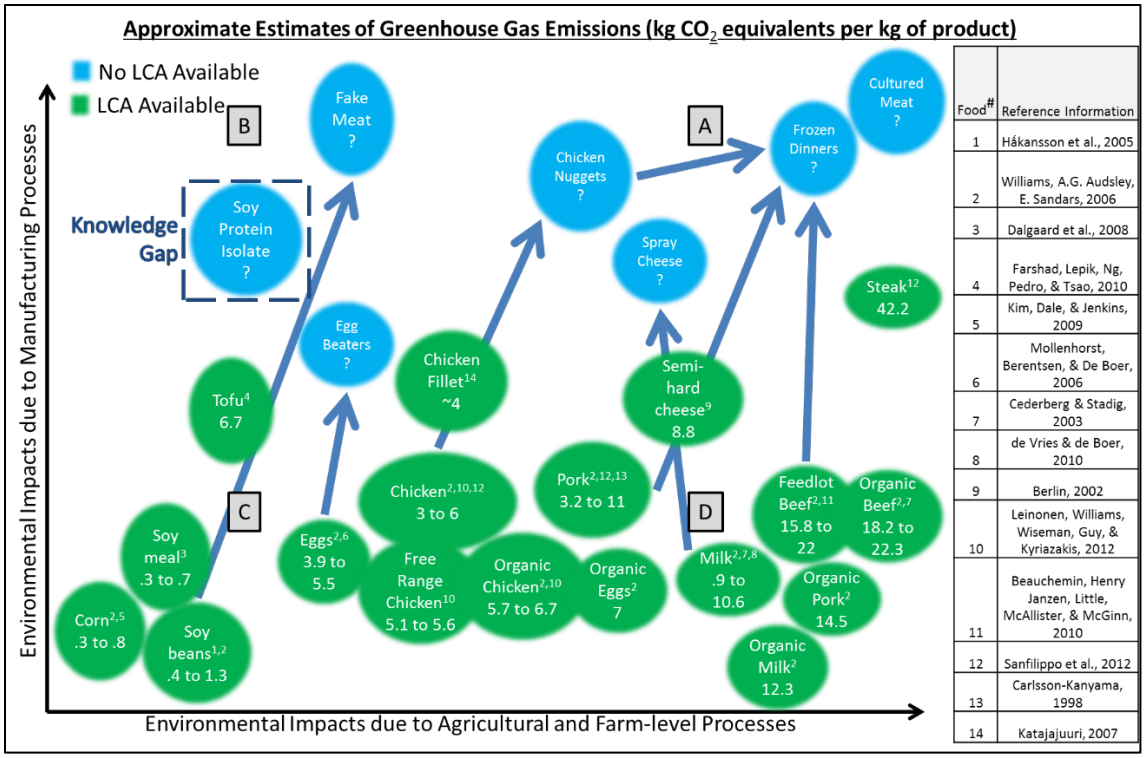

Figure 5: Vegan Products can Have Tradeoffs Between Farming and Manufacturing. Areas A, B, C and D are quadrants of the figure labeled for later reference in the text. Global warming potential for each product is indicated within its circle for items in green, and supporting references are in superscript. Question marks and blue shading indicate products for which no LCA data exists.

Figure 5 shows a variety of products for which LCA data exists (shown in green) and products for which no LCA data exists (shown in blue) to visually demonstrate the knowledge gap this paper intends to help fill. Superscript numbers by food products indicate the relevant reference(s) in the table on the right side of Figure 5 from which greenhouse gas emissions estimates were sourced. The X-axis represents environmental impacts that occur as a result of farm level activities including growing crops and raising livestock, as well as harvest and slaughter. The Y-axis represents environmental impacts that occur as a result of manufacturing activities including processing or refining ingredients, combining foods with additives, and otherwise preparing food from raw ingredients. For example, when considering tofu, impacts on the X-axis would be from growing and harvesting soybeans while impacts on the Y-axis would be from the transformation

of soybeans into soymilk through soaking, boiling, centrifuging and extracting and then making that into tofu through heating and adding coagulant (Jackson et al., 2002).

Quadrants of Figure 5 are labeled A, B, C and D to represent different characteristics of available food products. Quadrant A is the area with highest expected environmental impacts due to high impacts from both farming and manufacturing level activities. Quadrant B is an area with low environmental impacts due to farming, but high environmental impacts due to manufacturing. Quadrant C is the area with the lowest expected environmental impacts due to low impacts from both farming and manufacturing level activities. Quadrant D is an area with high environmental impacts due to farming, but low environmental impacts due to manufacturing.

References used in Figure 5 and for comparisons in the results section (unless specified) meet the following criteria, which are adapted from a review of life cycle assessments and modified to allow comparison with organic products (de Vries & de Boer, 2010):

- LCA studies from OECD countries
- LCA of non-organic systems considered separately from organic systems
- Attributional LCA (i.e. evaluation of the status quo rather than potential changes)
- Economic allocation or system expansion for multiple outputs
- Cradle to gate or cradle to grave system boundaries

Impacts from additional processing apply not only to individual meat alternatives from tofu to lab-grown meat, but also ready-made meals and other products for any diet. For example, an LCA compared home-made and ready-made meals, finding that home-made meals had lower environmental impacts across all five impact categories considered due to avoiding meal manufacturing, reduced refrigeration time and less waste (Schmidt Rivera, Espinoza Orias, & Azapagic, 2014). Consumers must make tradeoffs between time, money, the environment, and their health. Therefore consumers should be informed regarding potential tradeoffs to enable decisions better aligned with personal values and beliefs.

Purpose:

The purpose of this paper is to investigate the environmental tradeoffs involved when a person shifts part of their diet from items in Figure 5, quadrant D that have high environmental impacts from agricultural and farm level processes (x-axis) and low environmental impacts from manufacturing processes (y-axis) to quadrant B, which is low on the x-axis and high on the y-axis. This is as opposed to a comparison between high on the x and y axes (quadrant A) and quadrant B as this type of comparison has an intuitive conclusion that quadrant A will almost always be worst for the environment, and many items in quadrant B are in fact attempts to reproduce items in quadrant D. Quadrant C, which is low on both axes, is expected to be the most preferable area for minimizing environmental impacts.

SPI as a case study

The specific aim of this study is to carry out an LCA of one ingredient from quadrant B of Figure 5 – SPI – and to examine its associated environmental impacts. SPI is selected for examination because it is a common ingredient in fake meat and is derived from soy beans through an industrial process involving caustic chemicals and significant processing. Although the feedstock of soymeal has low impacts from agricultural and farm level processes, there is potential for high impacts from manufacturing processes. Therefore it serves as an appropriate representation of Figure 5, quadrant B.

SPI can be used in protein bars, meal replacement shakes, bottled fruit drinks, soups, sauces, meat analogs, baked goods, breakfast cereals, dietary supplements, and weight gain powders, bars and shakes (Mercola, 2011). SPI is primarily used to provide high protein and desirable texture in meat substitutes (Thrane, Hansen, Fairs, Dalgaard, & Schmidt, 2014). Although basic products such as fake chicken breasts are made with SPI, some of the products also made with SPI are substitutes for processed animal products, such as chicken nuggets, so care should be

taken when making comparisons. As mentioned earlier, products in area A such as chicken nuggets are expected to have the highest impacts of any functionally equivalent product. Tradeoffs between farm-level and manufacturing based environmental impacts lead to skepticism regarding the environmental benefits of reducing meat consumption when the substitute is made with SPI or other specialty food ingredients (SFI). SFI are usually used in small amounts, but SPI is one exception where it constitutes a large proportion of the final product (Thrane et al., 2014). Therefore, the majority of environmental impacts from a product using SPI as the primary ingredient will in fact be a result of using SPI.

Hypothesis:

The hypothesis motivating this research is that there is a positive correlation between the processing required to create a food product and the environmental impacts of that food product. Further, it is possible that a plant-based food product may be so processed that it is equivalent to or worse than an unprocessed animal product in terms of environmental impacts.

Goal and Scope Definition:

The objectives of this study are to examine the life cycle of SPI and identify environmental hotspots in the cycle, compare environmental impacts with products SPI is intended to provide a substitute for, and determine the importance of processing to the overall environmental impacts of SPI. Expected outcomes include identification of environmental hot spots in the life cycle, gaps in data available, and an answer to the question of whether plant based products can be worse for the environment than animal based products.

Methods:

This is an attributional LCA as it relies on data from existing systems rather than analyzing possible changes to the system if certain decisions are made.

Functional Unit:

The functional unit is set as 1 kg of a soy based protein feedstock. This translates to a reference flow of 1 kg of SPI, which is compared to 1 kg of soybeans, soymeal, tofu, chicken, pork, and beef for reference. A comparison of nutritional values from nutritiondata.self.com is in Table 2.

Table 2: Nutritional information for products compared based on a 100 gram serving. All data is from nutritiondata.self.com

Product	Protein (g)	Calories	Amino Acid Score	Fat (g)	Cholesterol (mg)	Sugars (g)
Soybeans	11	122	93	5	0	2
Soymeal	45	339	118	2	0	0
Tofu	12	122	?	6	0	1
SPI	81	338	108	3	0	0
Chicken Breast	30	197	134	8	84	0
Pork Chop	24	142	151	5	53	0
Ground Beef 90% lean	26	217	79	12	85	0

SPI is defined as having at least 90% protein per dry matter as opposed to soy protein concentrate, which is at least 65% protein per dry matter (Thrane et al., 2014). A weight based functional unit is selected for this analysis because it allows for simple conversion of impacts to any nutrient based on another functional unit such as protein or calories, as nutritional data for these products is available. Also, each one of the products under comparison is part of the

protein food group according to the USDA and has complete amino acids based on an amino acid score of 100 or over, with the exception of soybeans and ground beef (USDA, 2014). This meets the obligatory property of the food being a good source of complete protein. Obligatory properties are those which a product must have (e.g. beverage containers must not leak) in order to be considered a comparable alternative (Weidema & Wenzel, 2004).

Product:

It is assumed that SPI is made in the US with components grown or manufactured in the US. However, life cycle data for US grown soymeal is not available, so it is approximated using an LCA of soymeal grown in Argentina and delivered to Rotterdam Harbor in Netherlands which is available in the LCA Food Database (Dalgaard et al., 2008; Nielsen et al., 2003). Transportation values are changed to reflect transportation within the United States as described in the "Transportation" section, but growing processes are assumed to be representative and are not changed. Editing existing entries or making new entries in the LCA software used to perform the assessment allows for use of the best estimates for the relevant component or process in the SimaPro model.

System Boundaries:

System boundaries include life cycle stages from farming to production of SPI as shown in Figure 6. Data for comparison products comes from life cycle assessments that also have cradle to gate boundaries. The further distribution, use of SPI by food manufacturers or consumers, and disposal are not considered here as there is substantial variation in the potential use for SPI. It could be shipped to a variety of manufacturers for inclusion in their products, or packaged and sold directly to consumers. See "Modeling" for examples of products containing SPI. Due to data gaps the production of capital goods (machinery and buildings) is left outside the system boundaries.

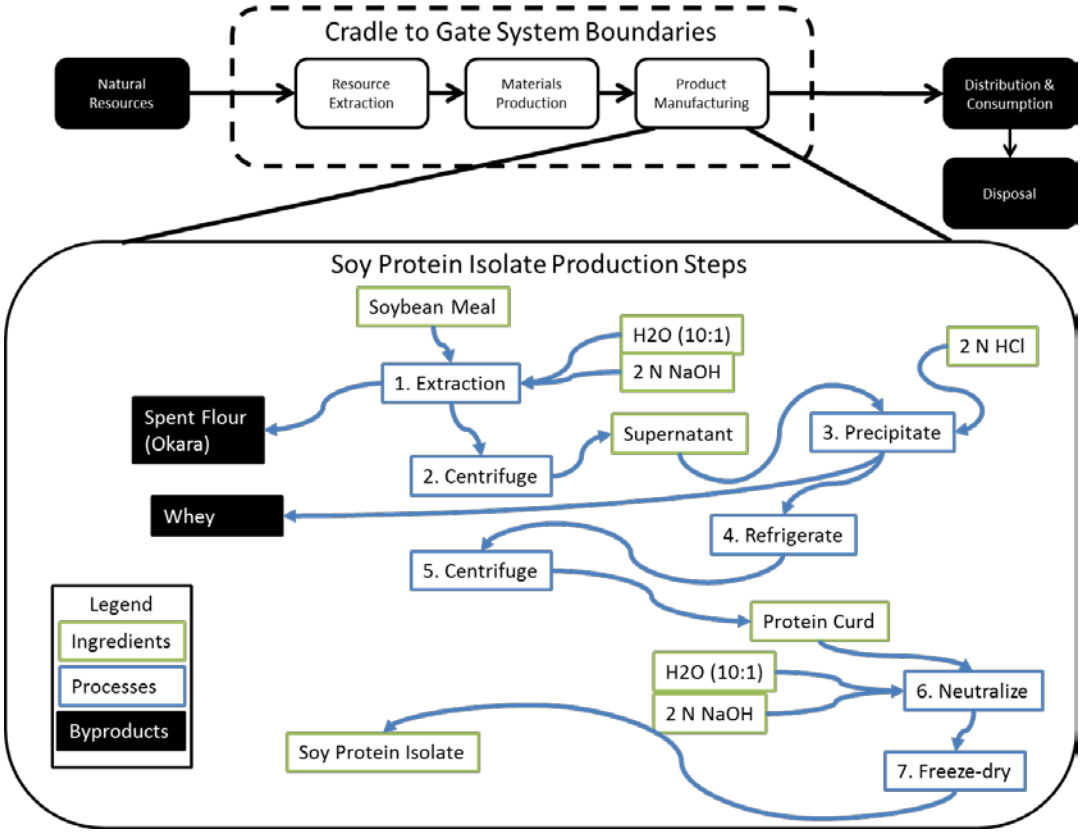

Figure 6: System Boundaries and Process Flow Diagram for SPI Manufacturing

Allocation:

This study uses system expansion to deal with allocation of byproducts that result from the conversion of soymeal into SPI. The SPI whey (about 25% of the original soymeal weight) is toxic to animals and is highly diluted, which means that it is not financially viable to concentrate and dry it for use, and it is therefore considered a waste stream and included as an associated burden for SPI ("Isolated Soybean protein," 1992). However, SPI extraction residue (okara) is about 40% of the original soymeal weight, and is usually pressed, dried and sold as a protein source for animal feed or dietary fiber in food products for humans ("Isolated Soybean protein," 1992). This study assumes that the okara is used as a substitute for soy animal protein feed, so the avoided environmental impacts of 0.4 kg of soy animal protein feed per kilogram of soymeal used are credited against the environmental burden of creating SPI. The remaining material is SPI, which is about 35% of the original material weight.

Life Cycle Inventory (LCI): Data for the life cycle inventory is primarily from the ecoinvent database in SimaPro. Other sources are listed in the “Assumptions and Simplifications” section.

Life Cycle Impact Assessment (LCIA): The RECIPE midpoint model, with hierarchist cultural perspective, is used as the method for impact assessment. The hierarchist model is considered the default scientific model as it captures a consensus view regarding the relative severity of environmental impact categories (Pre Consultants, n.d.). This LCA includes comparison of global warming potential in terms of kilograms carbon dioxide equivalents (kg CO2 eq), freshwater eutrophication in kg of Phosphorous equivalents (kg P eq), water depletion in meters cubed (m^3), fossil depletion in kg of oil equivalents (kg oil eq), energy use in mega joules (MJ), and land use in terms of meters squared of land occupation per year (m^2/year). Water depletion refers to actual water usage, as recommended by RECIPE (Goedkoop et al., 2013).

Assumptions and Simplifications:

The following documentation is for the production of 1 kilogram of SPI. Inputs to SPI include soymeal, water, sodium hydroxide, and hydrochloric acid. Processes for SPI include extraction, centrifuging, precipitating, heating, refrigerating, and freeze-drying (Z. Nazareth, 2009). Amounts of materials used and processes necessary are taken from Nazareth 2009, unless otherwise stated.

Overview:

The process of creating SPI starts with soymeal as a feedstock. A supernatant is extracted by adding water in a 10:1 ratio with the soymeal and 2N NaOH (sodium hydroxide) at 60° C for 45 minutes and then centrifuging for 30 minutes at 20° C. Waste at this step is referred to as spent flour and the product is the supernatant. The supernatant is then precipitated using 2 N HCl and refrigerated at 4° C overnight. The exact time of refrigeration is not provided by the reference used, but this analysis includes an assumption of 1 day (24 hours) of refrigeration. It is

centrifuged again for 30 minutes at 20° C, creating the byproduct of whey and the product of protein curd. The curd is then neutralized to a pH of 6.5 using water in a 10:1 ratio and 2N NaOH again and then freeze-dried, finally creating SPI.

Step 1: Extraction

Soymeal / Soybean Flour:

The amount of soymeal required is based on assumptions regarding byproducts and waste products. The amount of soymeal needed is based on the statement, “Nearly 3 tons of defatted soybean are needed to produce one ton of protein isolate,” meaning that 1 kg of SPI would need 3 kg of soymeal to produce (“Isolated Soybean protein,” 1992). This aligns well with the additional statements in this document that Okara is a by-product which is about 40% of the original raw material and that whey is a waste product that is about 25% of the original raw material. The soymeal input is converted into about 1/3 final product (SPI) and 2/3 waste material or by-product. A paper comparing methods for soy protein extraction found that SPI production resulted in solids yield percentages between 30.4% and 38% of the original material (Z. M. Nazareth, Deak, & Johnson, 2009). Finally, trials at lab scale for an extraction technique that minimized time in alkaline condition resulted in soy protein yield percentages between 24.3% and 32% of the original material (Joshi, Londhe, Bhosale, & Kale, 2011). Therefore, it is reasonable to assume that about 3 kg of soymeal are needed for production of 1 kg of SPI. This value is important because the other materials used in production of SPI are determined by ratios found in literature between soymeal and the other materials. Materials used also determine the characteristics of required processing. Therefore, all materials and processes are based on the assumption of using 3 kg of soymeal as the starting feedstock.

Life cycle data for US grown soymeal is not available. The data used for soymeal are from the LCA Food Database, which uses data from a previous study that avoided co-product allocation through system expansion, which ascribes inputs and outputs to soybean meal, but also expands the product system to include avoided production of palm oil and rapeseed oil due to the

byproduct of soy oil (Dalgaard et al., 2008; Nielsen et al., 2003). System expansion includes consideration of palm oil and rapeseed oil as products displaced by the coproduct of soymeal, soy oil (Dalgaard et al., 2008). The geographic context for the data used is soymeal grown in Argentina and transported to Rotterdam Harbor in Netherlands (Dalgaard et al., 2008). Transportation values are changed to reflect transportation within the United States as described in the "Transportation" section, but growing processes are assumed to be representative and are not changed.

Transportation:

Transportation occurs via diesel truck and railway freight to get soymeal to the manufacturing facility for creating SPI. Typical transportation distances for soy are 20 to 40 miles on highway in a diesel truck and 900 miles on railway in a freight car (Soy Transportation Coalition, 2013). Translated to ton-kilometers, this means between 0.032 and 0.193 ton-kilometers of transportation are by diesel truck and between 1.448 and 4.345 ton-kilometers of transportation are by freight rail. Detailed calculations are in Appendix A.

Data for transportation via diesel powered truck in the US is taken from the US Life Cycle Inventory (USLCI) database, which does not model infrastructure processes as part of this inventory, but does account for diesel use and tailpipe emissions (National Renewable Energy Laboratory, 2012). Further details regarding modelling assumptions for this data are not available. Transportation via railway is modeled after diesel powered European freight transport and includes production, maintenance and disposal of vehicles and railway tracks. Therefore the entire transportation life cycle is included and burdens are allocated based on gross ton per kilometer performance. US data for this process is extrapolated from the European data as part of the ecoinvent system process.

Water:

The amount of water used is based on a ratio with the soymeal used of 10:1 (Z. Nazareth, 2009). Therefore, between 30 kg of water is used. The RECIPE model used includes a mix of water use from lakes, rivers, wells and unspecified natural origins (Goedkoop et al., 2013).

Data for water is based on a cradle to gate inventory for drinking water from groundwater, including the purification processes. There are no assumed byproducts or coproducts. This data is from the European reference Life Cycle Database (ELCD).

Sodium hydroxide:

The amount of sodium hydroxide required to produce 1 kilogram of SPI is based on ratios used in a paper describing methods for reducing time the soy mixture has to be alkaline for processing. Three ratios of soy to 0.05 N NaOH are used (1:8, 1:40, and 1:5) (Joshi et al., 2011). For NaOH, 1 N is the same as 1 mol. The weight of 1 mol NaOH is 40 grams, to for every kg of water, 2 grams of NaOH is necessary to achieve a 0.05 N NaOH solution (Barrans & Bradburn, 2012). For 3 kg soymeal, 240 grams are necessary because 0.05 N NaOH is added in a 1:40 ratio to soymeal, so 120 liters of 0.05 N NaOH are required. 17 grams of NaOH is also used to raise the pH of water used, assuming that the pH is raised from 7 to 12 for 42.5 kg of water. Sodium hydroxide data is taken from the SimaPro Industry data 2.0 dataset, which does not provide system boundaries or allocation methodology. So, about 0.257 kg of NaOH per kg of SPI is necessary. More details are available in Appendix B.

Heating:

The extraction step requires the material to be at 60° C for 45 minutes. Calculations for heating are based on instructions in a paper intended to close data gaps of food LCA based on energy demand for food processing (Sanjuán, Stoessel, & Hellweg, 2014). The temperature is raised from room temperature, about 15.5° C to 60° C. The specific heat of soymeal is approximated by wheat flour which is 1.85 kJ/kg C, the specific heat of water is 4.186 J/gm K (Sanjuan, Stoessel,

& Hellweg, 2014) and the specific heat of sodium hydroxide is 59.66 J/mol K. Therefore these calculations represent the thermodynamic minimum for energy required in this step.

The total energy required to raise the mixture from 15.5° C to 60° C is 11.47 kWh of energy. Detailed step by step calculations for this heating energy requirement are in Appendix B.

Electricity is assumed to be used in Iowa, meaning that it comes from the Midwest Reliability Organization West (MROW) grid area. The MROW grid mix is about 65% coal, 14% nuclear, 10% wind, 6% hydroelectric, and the remaining 5% is divided between biomass, gas, oil, other fossil fuels, and other unknown or purchased fuel (Environmental Protection Agency, 2014).

Step 2: Centrifuge

The amount of material centrifuged is based on the assumption that the soymeal will hold its weight in water because SPI can hold 1.2 times its weight in water, so water is expected to double the weight of the soymeal to 6 kg (Z. M. Nazareth et al., 2009). The process of centrifuging results in a waste product of spent flour along with water. After this process the weight of the material should be 3 kg again.

Centrifuging data is based a paper with supporting information to close LCA data gaps which indicates that 2.69 MJ/kg product is used, which translates to 0.747 kWh of energy (Sanjuan et al., 2014). This data reflects energy used for centrifugation, but not upstream impacts.

Step 3: Precipitate

Hydrochloric acid:

The amount of hydrochloric acid is based on an experiment to reduce the time in alkalinity for SPI, which uses 0.1 N HCl in the amounts 22, 98, and 14 ml and 1 N HCl in the amounts of 2, 6, and 1 ml for 10 grams of soy in trials using 1:8, 1:40, and 1:5 ratios of soy to NaOH respectively (Joshi et al., 2011). The amount of HCl necessary is calculated based on the 1:40 ratio because this is used for NaOH. The HCl used needs to be multiplied by 30 to be appropriate for use in 3 kg of soymeal mixture because it is in reference to 10 grams of soy. There is 98 ml .1 N HCl and 6 ml 1 N HCl for the 1:40 ratio, which means for 3 kg soymeal, there is 2.94 L .1 N HCl and .180 L

1 N HCl used. HCl has a molecular weight of 36.46094 g/mol and 1 N is equivalent to 1 M HCl. Therefore, 2.94 L .1 N HCl uses 10.7195 grams HCl and 0.18 L 1 N HCl uses 6.563 grams HCl. The total amount of HCl required is 17.2825 grams, which is about 0.0172825 kg.

Hydrochloric acid data is taken from the ecoinvent database, which includes a cradle to gate inventory including raw materials and chemicals used for production, transport to manufacturing plant, emissions to air and water from production, and energy demand and infrastructure of the plant, with solid wastes omitted. The Mannheim process creates hydrochloric acid with the byproduct of sodium sulphate. Economic allocation is used for sodium sulphate and hydrochloric acid. Data is based on stoichiometry and therefore not associated with a certain geographic area.

Step 4: Refrigerate

The amount of material refrigerated is based on assumptions regarding additions and losses in previous processes and the material is refrigerated overnight (Z. Nazareth, 2009). Spent flour removed in centrifuge is about 40% of the total weight of the starting soymeal (3 kg of soymeal). With 60% of the starting weight left, this is 1.8 kg of material, but some water is left from the precipitation process, so this results in 2 liter days of refrigeration (equivalent to refrigerating 2 liters of mixture for 24 hours). Details regarding refrigeration are based on (“Isolated Soybean protein,” 1992).

Refrigeration data is taken from the LCA Food database. This data reflects energy used for refrigeration, but not upstream impacts such as infrastructure or manufacturing. This data assumes the geographic location of Denmark and modern cooling technology for cold storage.

Step 5: Centrifuge

The amount of material centrifuged in this step is based on the calculations for the refrigeration step, so 2 kg of material is centrifuged.

Centrifuging data is based on a paper with supporting information to close LCA data gaps which indicates that 2.69 MJ is used to complete centrifuging of a kilogram of product (though time to do

so is not discussed), which translates to 0.747 kWh of energy used per kilogram of product (Sanjuan et al., 2014). This data reflects energy used for centrifugation, but not upstream impacts.

Step 6: Neutralize

Neutralizing occurs by adding water in a 10:1 ratio and 2 N NaOH. The amount of water is based on a 10:1 ratio with 1.25 kg of material, which is assumed to be left after centrifuging based on a 25% loss subtracted from the weight after the first centrifuge. Therefore, 12.5 kg of water is added. The amount of NaOH added is discussed in more detail in Appendix B.

Step 7: Freeze-dry

Freeze drying is the process of freezing a material and reducing surrounding pressure, allowing frozen water to sublimate (Harris, n.d.). A study of vacuum cooling for vegetables found that between .16 and .26 kWh was necessary to cool between 23 and 27 kg of lettuce, which translates to between .006 and .011 kWh per kg to vacuum cool 1 kg of lettuce (Thompson, Chen, & Rumsey, 1987). Vacuum cooling reduces pressure to lower the boiling point of water, allowing for rapid cooling, which is similar to the steps in freeze drying, except in reverse, so the impacts from the processes are similar (Coldmax Europe, 2013; Harris, n.d.). Most of the energy was used for a compressor, rather than the vacuum pump, meaning that cooling used more energy than creating a vacuum (Thompson et al., 1987). The freeze-dry process is therefore approximated using the energy requirements of a freezer. The amount frozen material is based on the weight calculated for the neutralizing step. So, 1.25 liter days are required to freeze the material.

Freezing data is taken from the SimaPro ecoinvent database, which in this case contains data from lcafood.dk. Freezing detail is based on (“Isolated Soybean protein,” 1992). This data reflects energy used for freezing, but not upstream impacts.

Steps 1 through 7 yield the final SPI product. SPI contains roughly 75% of the protein from the starting material (“Isolated Soybean protein,” 1992).

Results:

Environmental impacts including global warming potential, energy use and land use are presented in this section for SPI in both the lower (SPI low) and upper (SPI high) bound of uncertainty regarding actual inputs and processes at manufacturing scale. Impacts from several other products including soymeal, chicken, pork, and beef are noted for the purpose of comparison. The reason for including soymeal is to demonstrate the difference in impacts based on additional processing utilized to create SPI from soymeal. Values for soymeal environmental impacts are derived from the same source used in the LCA of SPI and reflect 1 kg of soymeal. The difference between soymeal and SPI demonstrates the additional environmental impacts from manufacturing processes for SPI.

These results are specific to SPI, but food products using SPI will have different impacts because of additional ingredients. As mentioned in the “Purpose” section, the comparison between SPI and unprocessed meats is meant to investigate the tradeoffs involved when a person shifts part of their diet from items that have high environmental impacts from agricultural and farm level processes and low environmental impacts from manufacturing processes to items that have low environmental impacts from agricultural and farm level processes and high environmental impacts from manufacturing processes. Processed meats are likely to have higher environmental impacts than either of these types of items, as they have high environmental impacts from agricultural and farm level processes, as well as from manufacturing processes.
Some LCAs used for comparison report impacts per kg of dead weight rather than edible meat. Therefore, impacts are converted using estimates of edible meat available from dead weight. For beef, pork, and poultry, the edible meat percentages of the dead weight are 38.56, 44.55, and 51.47 percent (H. Tuomisto & Roy, 2012).

Global warming potential:

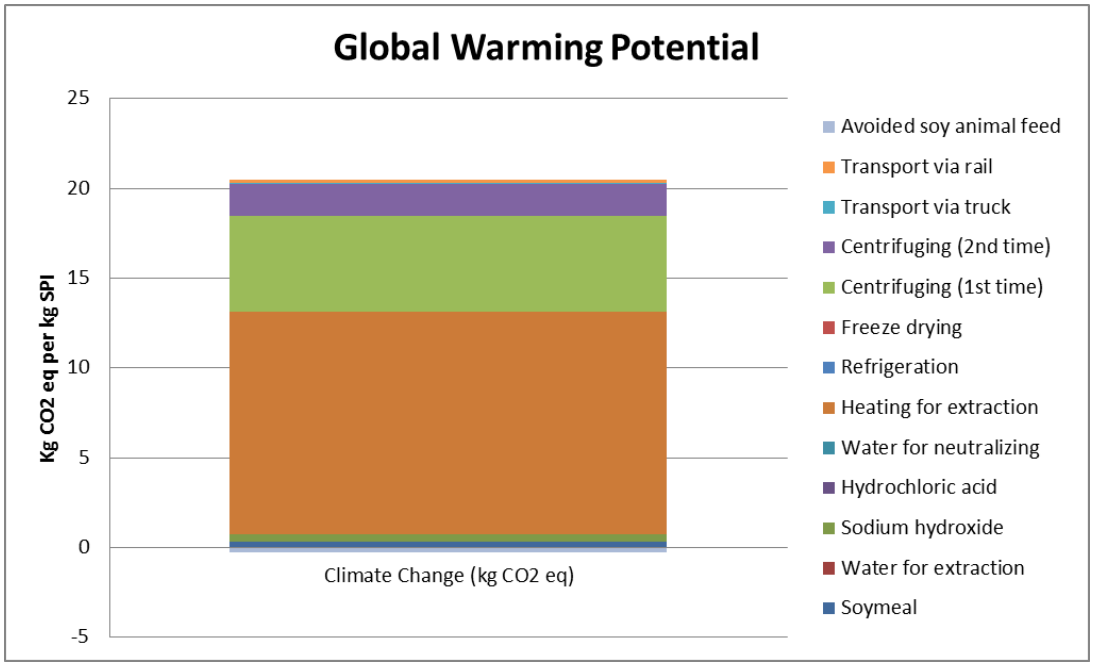

Figure 7: Global Warming Potential

Global warming potential for SPI is approximately 20.23 kg CO_2 equivalents per kg. The largest contributions to this total are heating and centrifuging. It is clear from this breakdown that the manufacturing process converting soymeal to SPI is the primary reason for the relatively high impact. The high global warming potential for heating is driven by the heavy reliance on coal in the MROW grid used to supply electricity for heating. Energy requirement calculations for SPI are available in Appendix B.

Impacts Comparison:

Figure 5 in the problem statement section contains several global warming potential values from the literature for comparison, all meeting the characteristics outlined for the review of life cycle assessments (de Vries & de Boer, 2010), but SPI is associated with higher global warming potential than chicken and pork, but not beef.

Soymeal by itself contributes 0.327 kg CO_2 equivalents per kg to global warming potential. A cradle to gate life cycle assessment of soymeal imported to Rotterdam from Argentina using system expansion meal finds that 1 kg of soymeal is responsible for emitting between 0.344 and 0.721 kg CO_2 equivalents per kg to global warming potential after considering credits for displacement of either palm oil or rapeseed oil (Dalgaard et al., 2008). The same LCA finds that production of 1 kg of soybeans emits 0.642 kg CO_2 equivalents per kg (Dalgaard et al., 2008).

A cradle to gate life cycle assessment of soybean production in the United States using economic allocation finds global warming potential of -.0000012 kg CO_2 equivalents per kg of soybeans (Omni Tech International, 2010). Soybeans are credited with carbon sequestration in this study because they are assumed to be used in soybean-based industrial products (Omni Tech International, 2010). Soymeal is intended for consumption by humans or animals, which is why it is not credited with carbon sequestration.

A cradle to gate life cycle assessment of soybean production in Canada finds global warming potential of .02476 kg CO_2 equivalents per kg of soy produced (N. Pelletier, Arsenault, & Tyedmers, 2008).

A cradle to grave life cycle assessment of tofu production in Canada finds that tofu causes 0.67 kg CO_2 equivalents per kg of production, with the majority of emissions coming from natural gas use (Farshad et al., 2010).

A cradle to gate study of three types of chicken reports that global warming potentials for the three systems were 3.14, 3.69, and 4.08 kg CO_2 equivalents per kg of edible carcass for standard, free range and organic production systems respectively, with the majority of impacts coming from feed and water for the chickens (Leinonen et al., 2012).

A review of life cycle assessments which are primarily cradle to gate indicates that pork has global warming potential ranging from 4 to 11 kg CO_2 equivalents per kg of product, with the majority of impacts coming from feed production (Nijdam, Rood, & Westhoek, 2012). It should be noted that this review includes production systems from non-OECD countries, but studies reviewed are consistent in using economic allocation for coproducts and are cradle to farm gate or cradle to grave. The same review finds that chicken has a global warming potential of between 2 and 6 kg CO_2 equivalents per kg of product while beef produced in industrial systems (as opposed to meadows or pastoral systems) has a larger and wider ranging global warming potential of between 9 and 42 kg CO_2 equivalents per kg of product. The authors note that the wide range of values for beef are a result of the wide variety of beef production and farming systems considered, from intensive to extensive, and lack of activity for cattle in intensive systems (Nijdam et al., 2012). The large range of values for beef also stem from the fact that the studies reviewed consider different operations, such as intensive milk production where steers born in dairy production systems are culled as a byproduct as opposed to beef cattle, where the entire production system is devoted to making beef (Nijdam et al., 2012). For example, culled steer from dairy operations have global warming potential of between 9 and 12 kg CO_2 equivalents per kg of product. The difference in systems considered influences all other impacts associated with production of beef because it determines the allocation of burdens to beef in the system.

A cradle to gate study using a simulated farm for beef production calculated that global warming potential of that system is approximately 22 kg CO2 equivalents per kg of edible carcass, with the majority of impacts (63%) coming from CH_4 due to enteric fermentation and 27% of impacts coming from soil and manure emissions of CH_4 and N_2O (Beauchemin, Henry Janzen, Little, McAllister, & McGinn, 2010). The cow-calf system accounts for 80% of GHG emissions while the feedlot system accounts for 20%, and the simulation includes cropland and native prairie pasture for grazing to supply feed to the animals (Beauchemin et al., 2010).

Table 3: Summary of comparisons for global warming potential in kg CO_2 equivalents

SPI	Soybeans	Soymeal	Tofu	Chicken	Pork	Beef
20.22	0 – 0.64	0.1 – 0.72	0.67	2 – 6	3.2 – 11	15.8 – 22

References for Table 3 are described in the impacts comparison section.

Eutrophication potential:

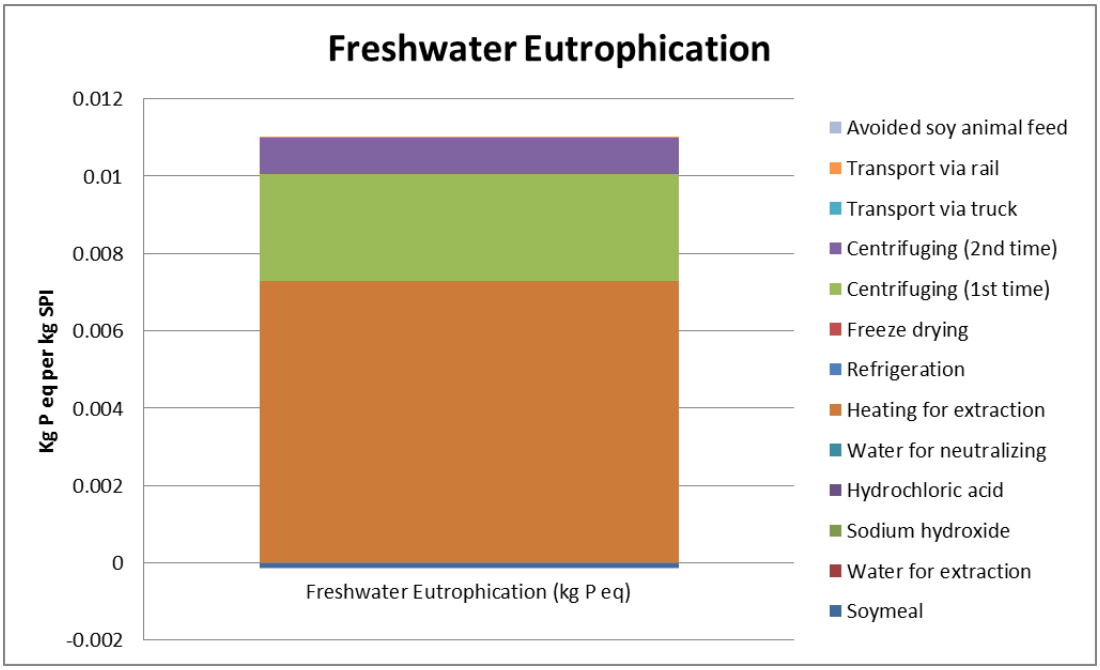

Figure 8: Freshwater Eutrophication Potential

Freshwater eutrophication potential for SPI is approximately 0.0109 kg P equivalents per kg. The largest contributions to this total include heating and centrifuging, while the lowest contribution comes from growing soymeal, which is considered a negative value due to the byproduct of soy oil causing displacement of rape seed oil production. Agricultural sources of eutrophication are discussed in the impacts comparison section.

Impacts Comparison:

Soymeal by itself contributes about -0.00013 kg P equivalents per kg to freshwater eutrophication potential, based on the assumption that the byproduct soy oil displaces rape seed oil production.

LCAs including eutrophication potential based on nitrogen and phosphorous inventories are limited, as few studies systematically evaluate these life cycle flows, but the farming stage of the food life cycle is expected to have the following emissions of concern: NH_3, NO, N_2), NO_x, NO_3^-, PO_4^{-3}, NH_4^-, BOD, and COD (Xue & Landis, 2010). LCAs that report eutrophication potential tend to aggregate emissions and express them in equivalents or as points, so eutrophication potentials from other LCAs must be converted to a standard eutrophication potential if possible, which is expressed here in terms of kg P equivalents. PO_4 is converted to P by dividing by 3, which is based on a discussion of phosphorus by the US Environmental Protection Agency (US EPA, 2012). NO_3 is converted to N by multiplying by 0.225897 based on unit conversions provided online (International Council for the Exploration of the Sea (ICES), n.d.). N is converted to P by multiplying by 1.07 based on a paper analyzing fate and transport for characterization and normalization factors in sources of aquatic eutrophication (Huijbregts & Seppälä, 2001). Therefore, NO_3 is converted to P by multiplying by 0.24170979. Although sources will differ across systems, common agricultural sources of eutrophication include fertilizer runoff, while processing of food generates eutrophication potential through combustion processes and generation of large amounts of organic materials (Xue & Landis, 2010).

A cradle to gate life cycle assessment of soymeal imported to Rotterdam from Argentina using finds that 1 kg of soymeal is responsible for between -2 and -81 grams of NO_3 equivalents per kg to eutrophication potential after considering credits for displacement of either palm oil or rapeseed oil (Dalgaard et al., 2008). This converts to between -0.0005 and -.0196 kg P per kg soymeal. The same LCA finds that production of 1 kg of soybeans causes 1 gram of NO_3 equivalents per kg, which converts to 0.0002 kg P per kg soybeans (Dalgaard et al., 2008).

A cradle to gate life cycle assessment of soybean production in the United States using economic allocation finds eutrophication potential of .003 kg P equivalents per kg of soybeans (Omni Tech International, 2010).

Values for eutrophication from tofu are not available in the literature investigated.

A cradle to gate study of three types of chicken (standard, free range and organic) finds that eutrophication potential varies from about .01 to .02 kg P equivalents per kg of edible carcass, with the majority of impacts coming from feed and water for the chickens and manure and bedding (Leinonen et al., 2012). Manure also has relatively high eutrophication potential as a result of ammonia emissions, especially in the organic system due to a long production cycle. Nitrogen content of the feed and manure is higher in the organic system as well. Exact emissions for ammonia (NH_3) and nitrous oxide (N_2O) emissions are not provided in the paper, but aggregated into environmental impact reporting across relevant categories, such as “feed + water” or “manure + bedding” (Leinonen et al., 2012).

A review of life cycle assessments for livestock products finds eutrophication potential of 0.03 kg P equivalents per kg of dead weight for pork (de Vries & de Boer, 2010). The dead weight of pork provides about 44.55% edible meat. Therefore, the eutrophication potential per kg of edible meat is approximately 0.07 kg P equivalents.

The same review finds eutrophication potential for beef of 0.05 kg P equivalents per kg dead weight of beef. The dead weight of beef provides about 38.56% edible meat. Therefore, eutrophication potential of the edible meat is approximately 0.13 kg P equivalents per kg edible beef.

Table 4: Summary of comparisons for freshwater eutrophication in kg P equivalents

SPI	Soybeans	Soymeal	Tofu	Chicken	Pork	Beef
0.011	0.0002	-0.00013 – -0.00005	No Data	0.02 – 0.05	0.03	0.05

References for Table 4 are described in the impacts comparison section.

Water Depletion:

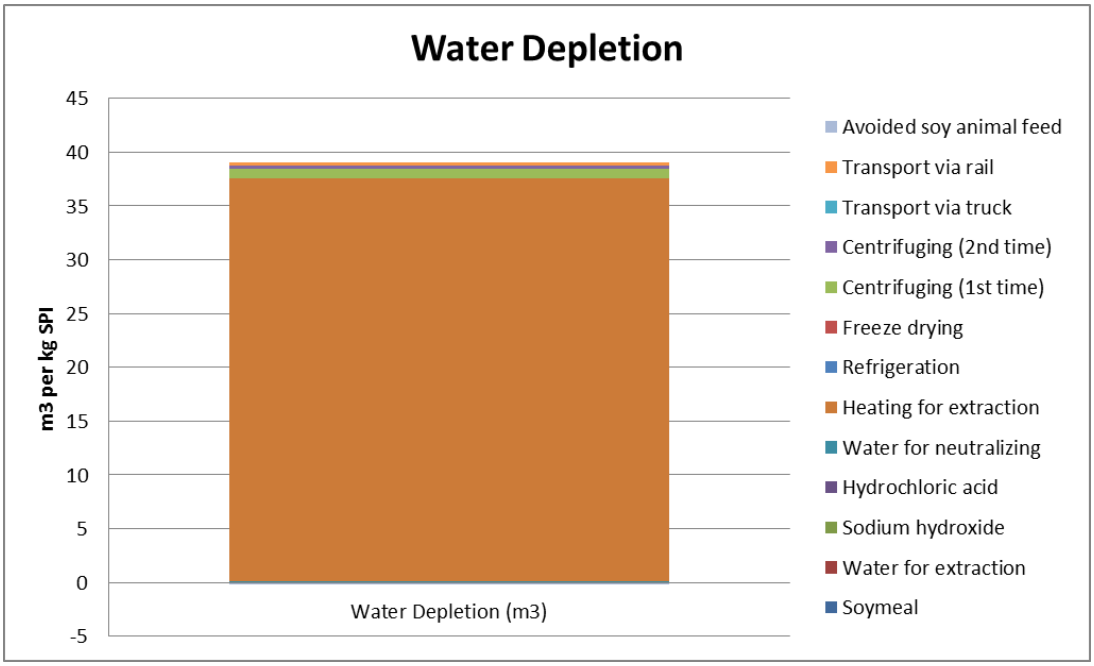

Figure 9: Water Depletion

The water depletion for SPI is approximately 38.94 m^3 of water per kg. The largest contribution to this total is heating, while the lowest contribution comes from growing soymeal, which is considered a negative value due to its displacement of rape seed oil. The significant water use for heating is driven by water use in electricity production.

Impacts Comparison:

Soymeal by itself contributes approximately -0.04 m^3 per kg to water depletion. A cradle to gate life cycle assessment of soybean production in the United States using economic allocation finds a value of 0.05 m^3 water depletion per kg of soybeans (Omni Tech International, 2010). This is a positive amount while soymeal is a negative amount due to soymeal having the coproduct of soy oil credited against its environmental impact, while soybeans have no coproduct.

A cradle to grave life cycle assessment of tofu production in Canada finds that tofu requires 0.64 m^3 of water per kg of production, though this is only direct consumption and does not account for

agricultural use (Farshad et al., 2010). Soybeans require 0.05 m^3 of water for production, so the total water requirement may be closer to 0.7 m^3 of water (Omni Tech International, 2010).

A cradle to gate LCA shows that tofu requires input of .003 m^3 of water to produce 1 kg, though this is only water used in production, not agriculture (Hǻkansson, Gavrilita, & Bengoa, 2005). A cradle to farm gate LCA of beef finds wide variation in water usage for six different beef production systems in Australia. The consumptive water use ranges from 0.05 to 0.234 m^3 of water per kg live weight of beef cattle (Ridoutt, Sanguansri, & Harper, 2011). This converts to about 0.13 to 0.61 m^3 of water usage per kg edible beef. The high variation in water footprint is due to selection of farms with diverse practices, product, environment and local water stress. The relatively low water usage for beef is surprising, but a subsequent publication regarding the same systems explains that those values include water flows for irrigation of pasture and crops for feedlot use, reduction in flows based on dams for livestock watering, and water use associated with production of inputs to farming such as fuel and fertilizer and transportation processes (Ridoutt, Sanguansri, Freer, & Harper, 2012).

For comparison purposes, another LCA finds that direct water consumption per kg of milk in a production system in Germany is about 0.004 m^3, but the authors note that indirect water consumption used in the production of feed can represent up to 99% of the water used for beef production (Drastig, Prochnow, Kraatz, Klauss, & Plöchl, 2010). A cradle to gate LCA using mass based allocation finds that direct water use for beef is 0.49 m^3 per kg of conventional beef, 0.57 m^3 per kg of natural beef, and 2 m^3 per kg of organic beef (Judith L. Capper, 2012). However, the estimated average global water footprint for beef is 15.5 m^3 (A. Y. Hoekstra & Förare, 2008). Another paper estimates the water required to produce 1 kg of boneless beef at 155 m^3 despite direct water consumption of only 1.5 m^3 per kg (A. Hoekstra & Chapagain, 2007). Either the 1.5 or 155 meters cubed values may be the result of a decimal error by the authors because the amount is ten times that reported in the subsequent study with one of the same authors. The same paper

finds the associated water consumption for chicken meat and pork to be 3.9 and 4.9 meters cubed per kilogram of meat respectively (A. Hoekstra & Chapagain, 2007).

The results reported in studies referenced here and discussions of water in other contexts lead to the conclusion that there is significant inconsistency in the way in which water use or footprints are reported for products, and caution is recommended when comparing water impacts. This is confirmed by an article discussing the role of water footprints and use in LCA, which states that the development of methods to account for freshwater use is still in its infancy and has received very little attention in LCA and therefore reporting of water use is inconsistent and based on varying assumptions that cause large differences in results (Koehler, 2008).

Table 5: Summary of comparisons for water depletion in m^3

SPI	Soybeans	Soymeal	Tofu	Chicken	Pork	Beef
38.95	0.05	-0.01 – -0.04	0.003 – 0.7	3.9	4.9	0.13 – 15.5

References for Table 5 are described in the impacts comparison section.

Fossil Depletion:

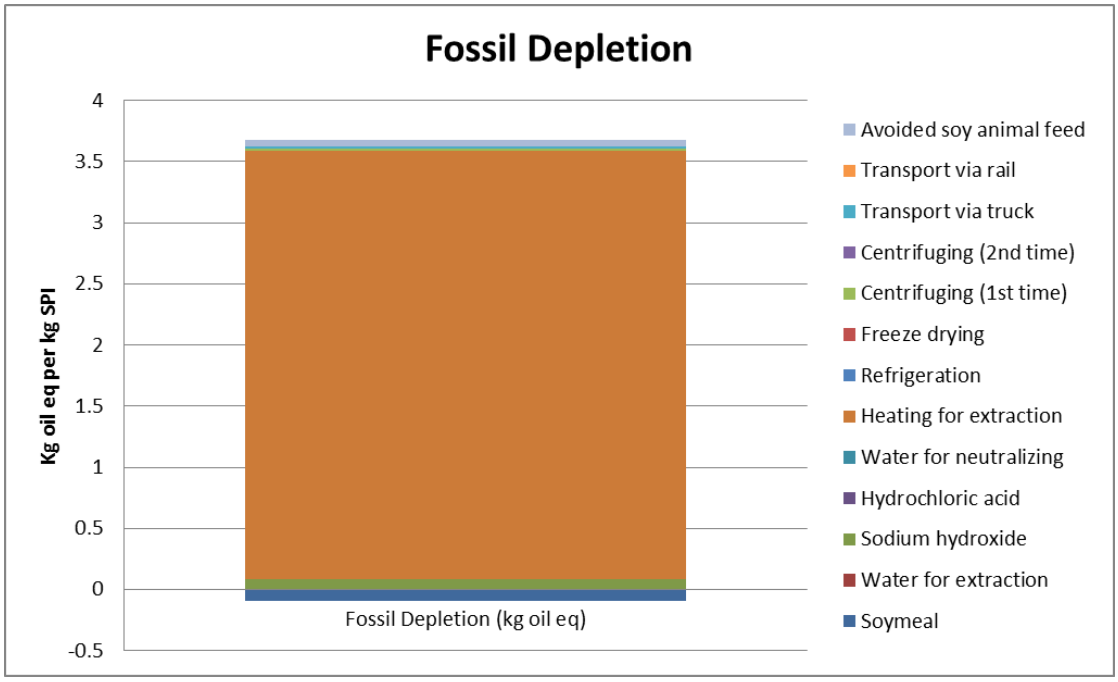

Figure 10: Fossil Depletion

Fossil depletion for SPI is approximately 3.59 kg oil equivalents per kg. The largest contribution to this total is heating, while the lowest contribution comes from growing soymeal, which is considered a negative value due to its displacement of rape seed oil.

Impacts Comparison:

Soymeal by itself contributes -0.09 kg oil equivalents per kg to fossil depletion. Impacts per kilogram or unit weight of soybeans were only available as normalized points. A cradle to gate LCA indicates that fossil fuel depletion for soybeans contributes 4.17 Ecoindicator 99 points to the total 12.37 points for tofu, which is about six times higher than the 2.22 points for pork (Hǻkansson et al., 2005). Therefore, for Hǻkansson et al., soybean production uses about double the fossil fuels of pork production.

Fossil depletion impacts per kilogram or unit weight of chicken are not available in the literature examined. However, the broiler production systems are arguably the most efficient for animal

protein production, and there is about a 17.7% protein energy return on investment (N. Pelletier, 2008). A cradle to gate LCA of poultry production systems uses Eco-Indicator 99 points to express normalized fossil fuel depletion per kilogram of poultry meat and finds a negligible value of about 0.0002 points for conventional systems, organic systems and organic-plus systems (Boggia et al., 2010). All of the emissions associated with the systems are primarily from feed production, except methane, which is primarily from the breeding phase (Boggia et al., 2010).
A cradle to gate LCA of pork production in Northwest Europe using system expansion finds that there is about 19.5 MJ of fossil energy use per kilogram of pig meat slaughter weight (Nguyen, Hermansen, & Mogensen, 2010). Using the estimated percentage of 44.55% edible meat from dead weight, the fossil energy use is approximately 43.8 MJ per kg of pork meat, which converts to approximately 1.05 kg of oil equivalents.

A cradle to gate LCA using mass based allocation finds that beef production requires fossil fuel energy inputs equivalent to 0.21 kg oil equivalents per kg of beef (Judith L. Capper, 2012).
A cradle to grave life cycle assessment of tofu production in Canada finds that tofu requires between 0.09 and 0.11 kg of oil equivalents per kg of production from natural gas use (Farshad et al., 2010).

Table 6: Summary of Fossil Depletion in kg Oil Equivalents

SPI	Soybeans	Soymeal	Tofu	Chicken	Pork	Beef
3.59	No Data	-0.03 to -0.09	0.09 – 0.11	No Data	1.1	0.21

References for Table 6 are described in the impacts comparison section.

Energy use:

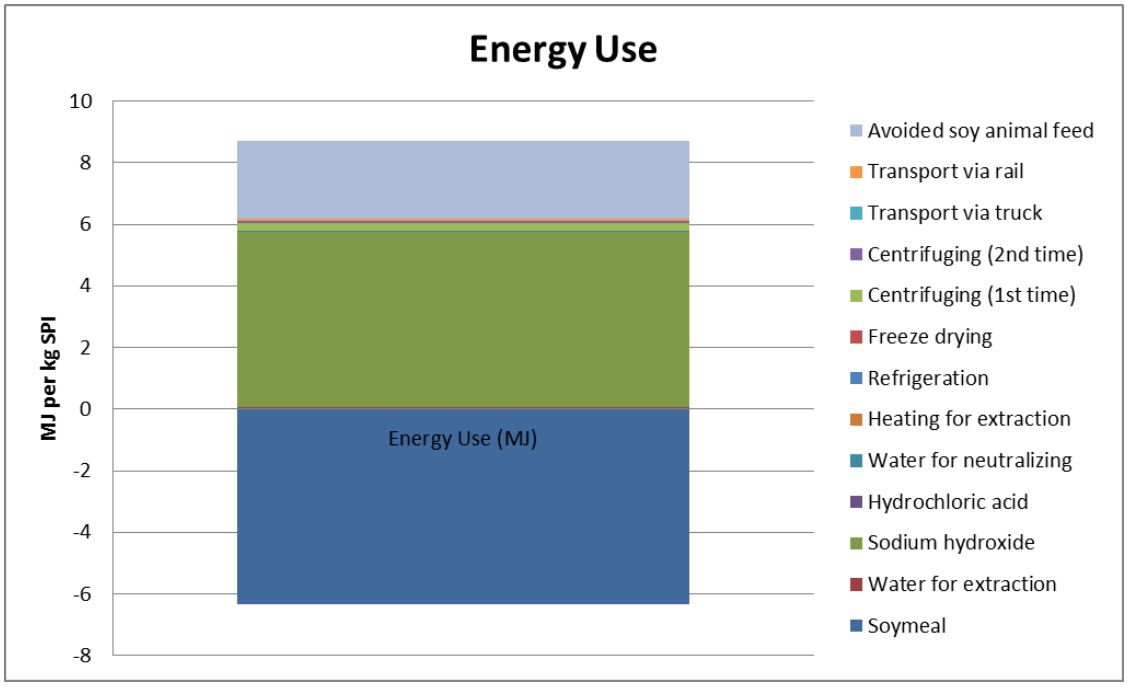

Figure 11: Energy Use

Energy use for SPI is approximately 2.5 MJ of energy use per kg. The largest contribution to these totals comes from centrifuging, while the lowest contribution comes from soymeal production, which is a negative value due to displacement of rape seed oil. A detailed explanation for sodium hydroxide usage and impacts is provided later in a discussion of uncertainty, and in Appendix B. It is clear from this breakdown that the manufacturing process converting soymeal to SPI is the primary reason for the relatively high impact.

Impacts Comparison:

Soymeal by itself contributes -6.35 MJ of energy use per kg to energy use. A cradle to gate life cycle assessment of soybean production in Canada finds energy use of 2.3 MJ per kg of soy produced (N. Pelletier et al., 2008). As there is no coproduct of soybean production, it does not receive the environmental credits that soymeal does, which explains why soybeans have a positive energy use value while soymeal has a negative energy use value.

A cradle to grave life cycle assessment of tofu production in Canada finds that tofu requires between 0.8 and 1.4 MJ of energy per kg of production (Farshad et al., 2010). The two values for energy use in tofu production come from two different tofu manufacturers, one of which has larger production volume leading to higher energy efficiency (Farshad et al., 2010).

A cradle to gate LCA shows that tofu requires 43.2 MJ to produce 1 kg, but this amount reflects the entire factory operation, not just energy directly used in tofu production, which may explain why it is so high (Hǻkansson et al., 2005).

A cradle to gate study of three types of chicken (standard, free range and organic) finds that energy use varies from about 25 to 40 MJ of energy use per kg of edible carcass, with the majority of impacts coming from feed and water for the chickens (Leinonen et al., 2012).
A review of life cycle assessments for livestock products finds that energy use for pork was between 16,700 MJ of energy use per ton dead weight (or 16.7 MJ per kg dead weight) and 22 MJ of energy use per kg bone and fat free meat (de Vries & de Boer, 2010). The same study finds between 27,800 MJ of energy use per ton dead weight (27.8 MJ per kg) and 40 MJ of energy use per kg meat for beef. A cradle to gate LCA using mass based allocation finds that beef production requires 8.8 MJ energy per kg beef (Judith L. Capper, 2012).

Table 7: Summary of comparisons for energy use in MJ

SPI	Soybeans	Soymeal	Tofu	Chicken	Pork	Beef
2.36	2.3	-2.11 – -6.35	1.4 – 43.2	25 – 40	16.7 – 22	27.8 – 40

References for Table 7 are described in the impacts comparison section.

Land use:

Land use is divided here into agricultural and urban land occupation per year.

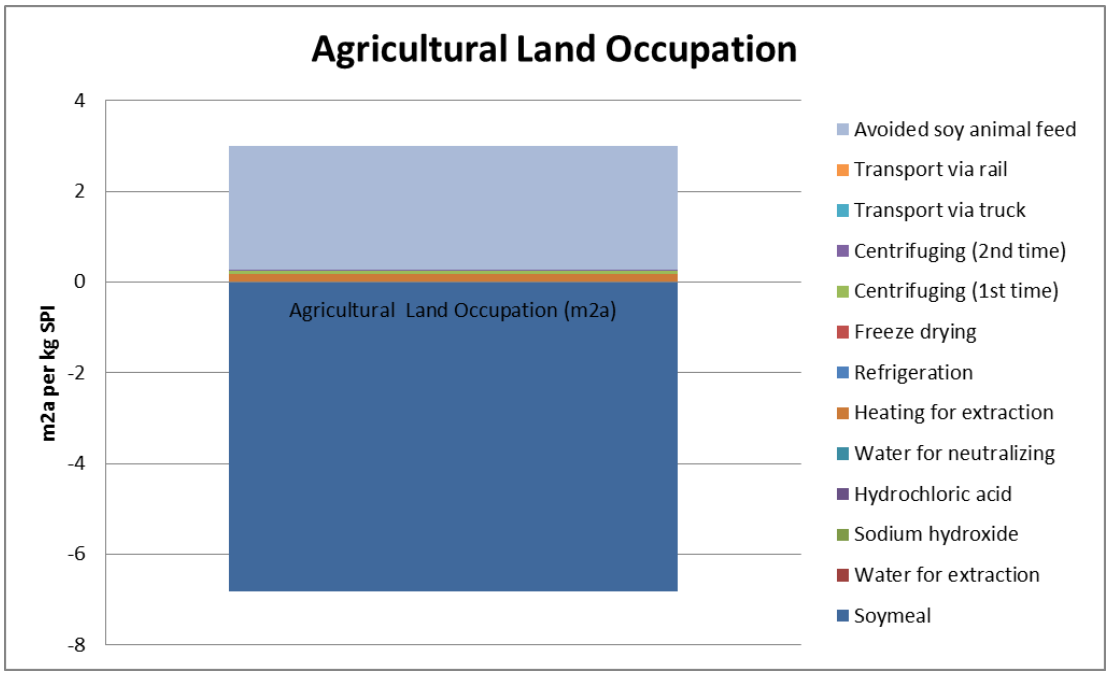

Figure 12: Agricultural Land Occupation

Agricultural land occupation for SPI is approximately -3.83 m2a (meters squared per year) per kg. These are negative values due to displacement of rape seed oil, which is captured in the large negative value for growing soymeal.

Impacts Comparison:

Agricultural land occupation and urban land occupation are not distinguished in most LCAs reviewed, so the comparison comes after urban land occupation impacts.

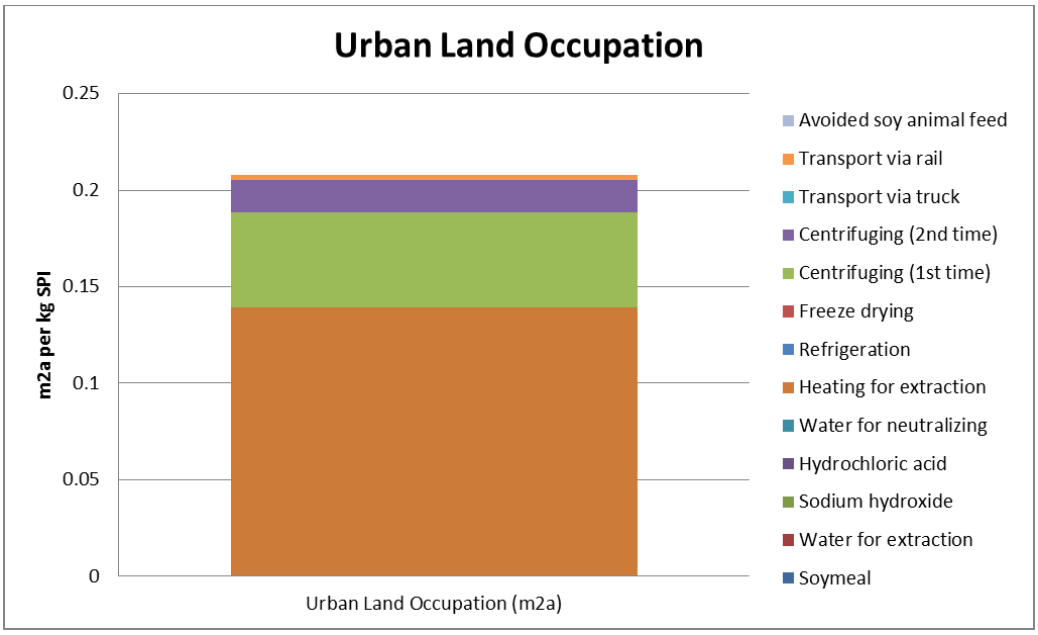

Figure 13: Urban Land Occupation

Urban land occupation for SPI is approximately 0.21 m2a (meters squared per year) per kg. The largest contributions to these totals come from heating and centrifuging, while the lowest contribution comes from transportation via rail.

Impacts Comparison for Agricultural and Urban Land Occupation:

Soymeal by itself contributes between -2.3 and -6.8 m2a to agricultural land occupation, but does not contribute to urban land occupation. Land occupation for tofu was not found in the literature. However, the value is expected to be similar to that of soymeal, as tofu is also made from processing soybeans in a facility. The size of the facility may vary based on production scale, but the majority of land occupation is expected to come from growing soybeans.

A cradle to gate study of three types of chicken finds that land occupation varied from about 5.6 to 25 m^2 per kg of edible carcass, and though there is not a breakdown of individual contributions to this impact, land for production of feed is the major driver of this impact (Leinonen et al., 2012). A review of life cycle assessments which are primarily cradle to gate finds that pork has land use ranging from 8 to 15 m^2 per kg of product (Nijdam et al., 2012). The same review finds chicken

has land use ranging from 5 to 8 m^2 per kg of product while beef has a larger and wider ranging land use ranging from 7 to 420 m^2 per kg of product.

A review of life cycle assessments for livestock products found that land use for pork ranges from 7.4 m^2 for 1 kg dead weight to 15 m^2 for 1 kg bone and fat free pork (de Vries & de Boer, 2010). The same study finds values for beef between 23 m^2 for 1 kg dead weight and 33 m^2 for 1 kg beef.

A cradle to gate LCA using mass based allocation finds that beef production requires 54.57 m^2 per kg beef (Judith L. Capper, 2012).

Table 8: Summary of Comparisons for Land Use in m^2. Note that SPI shows agricultural and urban land use separately.

SPI	Soybeans	Soymeal	Tofu	Chicken	Pork	Beef
-3.83 and 0.21	3.3	-2.3 - -6.8	No Data	5 – 25	7.4 – 15	23 – 33

References for Table 8 are described in the impacts comparison section.

Potential sources of uncertainty and system improvement:

Sodium hydroxide is a source of significant global warming potential and energy use per kilogram used. It is therefore worth investigating the accuracy of data provided by the ecoinvent databased in SimaPro for this material. Appendix B contains an explanation regarding the amount of sodium hydroxide used and a comparison with several other LCA database entries and one LCA publication. It is concerning then that a published LCA of sodium hydroxide indicates a value of about 3.5 MJ per kg for sodium hydroxide while the value provided by the ecoinvent database is 22 MJ per kg (Thannimalay, Yusoff, & Zawawi, 2013). The reported value for global warming potential (about 0.6 kg CO_2 eq per kg) in the published LCA of sodium hydroxide is also about half that of the value reported by ecoinvent (about 1.4 kg CO_2 eq per kg) (Thannimalay et al.,

2013). One potential explanation for this is that the published LCA is for a Malaysian production scenario, and the majority of impacts come from consumption of electrical energy and natural gas, which the authors note are different than the sources of electricity, crude oil, and natural gas used in Europe, where most prior LCA data was generated (Thannimalay et al., 2013). Ecoinvent values come from European production data using three different manufacturing processes (Althaus et al., 2007).

Heating is the most significant driver of global warming potential in SPI manufacturing, due to its significant energy use. Electricity used is assumed to be from the MROW, which has significant coal based power production. If instead renewable energy sources were available or if waste heat was used instead of electricity or fossil fuels, the global warming potential could be reduced. Nearly half of industrial energy input in the US is lost as waste heat, but recovery technologies are available which can provide both heating and power for other processes and reduce energy consumption by between 10 and 50% (US Department of Energy, 2008). If a 50% improvement in efficiency for heating were achieved, the global warming potential of SPI would be cut by up to 6 kg CO_2 equivalents per kg. Heating is also a significant driver of fossil fuel depletion, urban land occupation, freshwater eutrophication and water use in SPI production, so these impacts would be reduced considerably by utilizing waste heat.

Discussion:

Results from this analysis indicate that SPI may match or exceed the environmental impacts of chicken, pork and beef in several categories. This supports the hypothesis that there is a positive correlation between the processing required to create a food product and the environmental impacts of that food product. It also demonstrates that it is possible for a plant-based food product may be so processed that it is equivalent to or worse than an unprocessed animal product. This is consistent with the expectation that a food in quadrant B of Figure 1 may be similar to a food in quadrant D in terms of environmental impacts. SPI has a much higher environmental impact than the feedstock used to create it, soymeal. This is consistent with the expectation that food in

quadrant C of Figure 1 is likely to have the lowest environmental impact. It is worth noting that SPI is simply a component of most fake meats and is usually not consumed on its own. Therefore, the actual environmental impacts associated with a product using SPI will differ based on the other ingredients included in that product. However, in products where SPI is the main ingredient, the impacts associated with SPI may be sufficient to make the overall environmental impacts similar to or worse than animal products.

Relevance for stakeholders in sustainable food:

Results from this work may be useful in informing decision makers in a variety of contexts, such as policy makers seeking to encourage production and consumption of low environmental impact food products, non-profit activist organizations advocating for sustainable food, marketing specialists for competitive brands of fake meat using other less processed protein sources such as tofu or seitan, and individual consumers seeking to lower their own environmental impacts (Andrew Berardy, 2012).

The prevalence of SPI in a wide variety of food products and the impact demonstrated from additional processing of soymeal to create SPI make this research relevant not just to vegetarians and vegans, but anyone concerned with environmental implications of processed food products. SPI is an ingredient used not only in realistic plant-based meat substitutes, but in “health foods”, soups, sauces, baked goods, cereals and more (Mercola, 2011). Consumers are urged to make more sustainable choices, and increased sustainable consumption is a common international policy goal (Seyfang, 2006). Vegetarians make up between roughly 3 to 5 percent of the US population, while vegans are about 2%, but many omnivores are interested in reducing their meat consumption (Hopkins, 2014). Among vegetarians and vegans, a significant portion find the idea of any meat substitute repulsive, and others eat only plant-based foods because they believe it provides health benefits (Hopkins, 2014). However, as awareness of the environmental impacts of food choice grows, widespread acceptance and prevalence of meat substitutes also increases. Significant work is published on increasing acceptance of soy foods in the mainstream market

(Wansink, Sonka, & Cheney, 2002; Wansink, Sonka, Goldsmith, Chiriboga, & Eren, 2005; Wansink, 2002).

Some meat substitutes like Quorn or Beyond Meat are marketed towards average consumers rather than niche vegetarians and vegans, and most meat substitutes are assumed to be environmentally more sustainable alternatives to meat (Elzerman, Boekel, & Luning, 2013; Noguchi, 2012). Many omnivores concerned with potential health effects of high fat meat centered diets increased their consumption of vegetarian meat substitutes, helping lead to a growth rate of 100 to 125% in vegetarian food companies in the United States from 2001 to 2007 (Nath & Prideaux, 2011). In 2012, only 12 percent of American households consumed meat alternatives according to Mintel, a market-research firm, and the US market for meat alternatives was $340 million (Noguchi, 2012). However, 36 percent of consumers polled in 2013 by Mintel said they buy meat substitutes, even though only 7 percent claimed to be vegetarian, and sales of meat alternatives were up to $533 million in 2012 (Barclay, 2013). The most common reasons respondents provided for eating fake meat were health, reducing meat consumption, and taste (Barclay, 2013). Despite SPI's status as a specialty food ingredient, it reaches a large number of consumers due to its versatility in a number of products, actually posing an obstacle for people with soy allergies to avoid it.

Other sustainability considerations:

Although environmental damage and resource use are the focus of this work, they are just two considerations within the broader framework of sustainability. The most efficient production system meeting a common functional unit should not be the only basis for sustainability claims. Social and economic concerns must be addressed for sustainable food as well, though that is outside the scope of this LCA.

Consumers balance their environmental concerns with other considerations including nutrition and health impacts, animal welfare, affordability, taste, and food security. In these areas, SPI

provides a mix of advantages and disadvantages. For nutrition and health, SPI based fake meats are likely to have similar nutrient profiles, as they are intended to be a 1:1 substitute for consumers looking to replace meat, which theoretically should improve animal welfare by reducing the demand for animal protein. The price of fake meat has significant variation, as does the price of real meat, so this should be evaluated on a case by case basis. Finally, food security concerns may favor real meat, as this is available in more stores, restaurants and other food providers, though fake meat may be more culturally acceptable for some religions and cultures and its popularity and availability is growing. For people transitioning from an omnivore diet to a plant-based diet, fake meat can provide a product to help bridge the gap and make the experience easier, in which case long term environmental benefits will outweigh impacts from fake meat used in this time.

Conclusion:

Life cycle assessments of plant-based diets provide confirmation of the intuitive assumption that eating fewer animal products is an effective way to reduce environmental impacts associated with food choice. However, these LCAs do not include consideration of people who may choose to eat fake meat instead of real meat. The example of SPI demonstrates that the industrial processing associated with the production of realistic meat alternatives can result in large environmental impacts in several categories that may exceed the impacts of some unprocessed meats. Therefore, it should not be an assumption that every plant-based food will be better than an equivalent animal-based food in terms of environmental impacts. Understanding the amount of processing involved after production may help provide insight into potential environmental impacts without the necessity of performing a full life cycle assessment.

CHAPTER 4

TURINEX AND VEGANISM

Abstract:

Expertise develops in a continuum, advancing through education, experiences, and social interactions. Large collaborative scientific endeavors, interdisciplinary communication, and journalism all have in common the need for IE (interactional expertise is being able to speak the language of a specialist group even without being a member of that group). This ability develops through acquisition of tacit knowledge, gained by linguistic immersion in culture of the specialist group. The standard test for IE is the imitation game, in which a judge evaluates answers to questions of their own formulation to determine which of two respondents belongs to the target expertise and which does not. If the respondent pretending to have expertise successfully fools the judge, they are said to have IE. However, individual sessions of the imitation game only produce binary results of either interactional or no expertise, despite agreement that expertise develops across stages. TURINEX is a modification of this practice developed to create a new expertise assessment technique which includes an intermediate stage called interactional competence. Interactional competence is the stage of expertise development when a person has sufficient conceptual understanding to converse with an expert at their level, but not sufficient linguistic competence to convince them that they are also an expert. TURINEX judges interact with three respondents who represent a positive control, a negative control, and an experimental subject for the target expertise. They must determine for each of the three respondents if they are a contributory expert (what people normally think of as expert), not an expert at all, or someone with interactional competence. The first iteration of TURINEX software provides case studies, which include testing the understanding of energy needs for Ugandans and testing the ability of omnivores and vegetarians to pretend to be vegan. TURINEX 1.0 has significant technical and logistical difficulties in the first iteration due to the necessity to coordinate four participants per trial across time zones and to use unstable software. TURINEX 2.0 is a response to these difficulties developed through a shift to asynchronous rather than simultaneous testing and developing more

stable software on a new platform. It is used to continue research regarding veganism. In this case study, TURINEX 2.0 is used to investigate two hypotheses. First, veganism is an expertise, meaning that subjects can be accurately differentiated by a judge based on their responses to questions. Second, as exposure to veganism and related practices increases, likelihood that a participant will pass the veganism TURINEX test increases. This is divided into three variables for study. First, the highest likelihood of passing the TURINEX test comes from actually being a vegan. The second highest likelihood for passing comes from having vegan friends or family, due to frequent conversations concerning veganism. The third highest likelihood for passing comes from being a vegetarian, due to shared experiences with vegans. Omnivores without vegan friends or family are expected to not pass the TURINEX test as vegans. Vegetarians are expected to be rated at the level of interactional competence. Results support the expectations for the first and second variables, but not the third. 60% of vegans, 20% of vegetarians and 20% of omnivores are judged as vegans. 40% of vegans, 20% of vegetarians and 20% of omnivores are judged as vegetarians. 0% of vegans, 60% of vegetarians and 60% of omnivores are judged as omnivores. Transcripts from tests are also analyzed using script analysis and intentional analysis to find evidence for the role of tacit knowledge in formulating, answering, and evaluating questions. The most common themes emerging from text analysis include food choice, social situations, interacting with omnivores, and lifestyle. Establishing TURINEX as a valid methodology and using it to examine practices that enable adherence to principals of veganism are intended to support sustainable consumption by providing an innovative assessment methodology for training programs in sustainability and potential support mechanisms that might translate to sustainable consumption from veganism.

Introduction:

TURINEX is software developed by the author for the purpose of testing levels of linguistic expertise (A Berardy, Seager, Selinger, & Uhl, 2013).

> "Between formal propositional knowledge and embodied skill lies 'interactional expertise' – the ability to converse expertly about a practical skill or expertise, but without being able to practice it, learned through linguistic socialisation among the practitioners" – (Harry Collins, 2004)

Interactional Expertise:

IE is a tacit knowledge-laden and context specific product of successful linguistic socialization that allows communication across domains without the necessity of becoming expert in them or developing new terminology (H Collins, Evans, & Gorman, 2007). Someone with IE in a discipline or experience should be able, at a linguistic level, to pass as a member of that discipline or as having had that experience, and this claim can be tested using the imitation game (H Collins, Evans, Ribeiro, & Hall, 2006).

The imitation game relies on an expert judge asking questions intended to differentiate between a pretender and non-pretender in a given topic (target expertise). The judge evaluates responses and makes a determination and confidence rating for each respondent. If the judge thinks the pretender belongs to the target expertise, then the pretender has IE in that subject (H Collins et al., 2006). IE is especially useful for scientific peer review and specialist journalism because it allows complete understanding of an expertise without the necessity of practicing that expertise. The importance of IE is evident when it is recognized as central to the development of expertise itself and vital for genuine interdisciplinary collaborations (T. Seager et al., 2011). IE is vital for collaboration across disciplines because it allows people to converse at a sophisticated level across expertise types, without having to simplify their conversations or frequently explain concepts and terminology.

On the "periodic table of expertise," IE is polymorphic specialist tacit knowledge, which means that it is implicit understanding within a specific domain of practice not captured by replication of physical activities (Harry Collins, 2011). A polymorphic action is performed with different behaviors based on social circumstances requiring tacit knowledge, while a mimeomorphic action

is consistent across circumstances and can be mechanically replicated without tacit knowledge (Ribeiro & Collins, 2007).

The modern imitation game is designed by Harry Collins to demonstrate the concept of IE and test if an individuals' communicative ability in a given domain qualifies as IE. It operates on the same principle as the original imitation game, a parlor activity where a man pretending to be a woman and a woman answering honestly, both hidden behind a screen, provide written or typed answers to questions asked by a female judge. If the judge thinks the man is a woman based on his answers, then that man has IE in being a woman (H Collins et al., 2006). A modification to this procedure which replaces the man with a computer is the basis for the current standard test of artificial intelligence, known as the Turing test (Mauldin, 1994; Turing, 1950). Modern imitation games are used to assess color blindness, people with perfect pitch hearing, gravitational wave physics, thermodynamics, chronic obstructive pulmonary disease, sexuality, gender, and Christianity (Andrew Berardy, Seager, & Selinger, 2011; H Collins et al., 2006; H. Collins & Evans, 2013; Wehrens, 2014). In fact, the imitation game is the primary investigative method employed in a large European Research Council Advanced Research Grant from 2011 to 2016 under the direction of Professor Harry Collins (Cardiff University, n.d.). The purpose of this grant is to compare cultural differences between European countries by investigating the success of pretenders in imitation games regarding sexuality, religion and gender across nations. The expectation is that countries which have worse social inclusion of minority groups will also have lower success rates among pretenders for those minority groups due to lower tacit knowledge in the majority population from lack of exposure when compared to more inclusive countries.

Problem Statement:

Expertise is based upon the exposure to tacit knowledge of a domain, the "esotericity" of the domain, and accomplishment within that domain, all of which pass through stages (Harry Collins, 2011; Dreyfus, 2004).

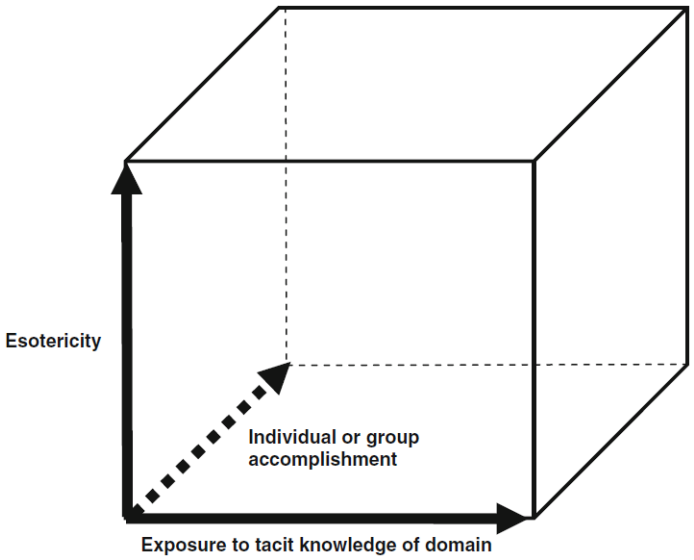

Figure 14: Expertise Space Diagram

Expertise can be represented as areas and expertise development can be shown as a trajectory, both within a three dimensional space with axes that represent esotericity of the domain, exposure to tacit knowledge of the domain, and individual or group accomplishment within the domain (Harry Collins, 2011). However, the imitation game cannot capture expertise development in an individual test, as the definition of IE requires that a judge not be able to tell the difference between a contributory expert and interactional expert. This is because an interactional expert is so “well socialized in the language of a specialist group” that they are “indistinguishable from those with full blown practical socialization but distinguishable from those who are not well socialized” (H Collins et al., 2006). Some studies of expertise create a dichotomy between novices and experts, but there are stages of development in between which are useful to consider as well (Alexander, 2003). Imitation games can only test for the presence or absence of IE in an individual trial. This type of expertise assessment is useful for sociological understanding and large scale experimentation across cultures. However, expertise develops along a continuum of levels or stages. Understanding stages of expertise development can facilitate training and education efforts to improve tacit knowledge and expertise development. Expertise causes higher levels of perceived consumer effectiveness by removing capability barriers, which leads to increased sustainable behavior (Ellen et al., 1991). It is necessary to modify the imitation game to

create a new expertise assessment technique that includes an intermediate stage, which is interactional competence.

Research Goal and Methodology:

Consumer expertise development:

Consumers have several potential methods for influencing the food system including voting, protesting, growing their own food, supporting local agriculture, and choosing foods that reflect their value system. However, most of these activities require some level of expertise in the food system, which also increases confidence as it becomes easier to make judgments and identify important tradeoffs. While some expertise is ubiquitous and acquired by most members of a society through daily interactions and practices, other expertise is more esoteric and must be gained through extensive linguistic socialization and immersion (H Collins et al., 2006; Harry Collins, 2004, 2011). For example, first language learning occurs as a ubiquitous expertise as a matter of socialization within a society, but second language learning is more esoteric within a society and requires that a person seek out education and experience to develop it (Harry Collins, 2011). Car driving is another example of a ubiquitous expertise, at least in the United States, because it is an expected skill necessary to operate normally in society (Harry Collins, 2011). Some expertise can be acquired simply through repeated experience. People who use mass transit, often travel through airports, or live with Celiac disease all develop expertise in these areas of practice without the need for formal education.

As the topic of this dissertation is sustainable food consumption, an appropriate expertise to study should demonstrate characteristics amenable to the advancement of sustainable behaviors regarding food. PCE is linked to socially conscious attitudes and certain pro-ecological behaviors, leading to the conclusion that motivating consumers to change behavior to some extent depends upon increasing their perception that individual actions make a difference (Ellen et al., 1991). If an individual believes a problem can be solved by a specific activity, then this belief should influence

their willingness to engage in that activity, but not other actions (Ellen et al., 1991). PCE should increase consumer willingness to take action to solve problems. A two-pronged approach in convincing a consumer to change may be effective by convincing the consumer they are able to make a difference and then providing them with information and a means to achieve that action (Ellen et al., 1991). Therefore, expert consumers have higher perceived consumer effectiveness and are more likely to engage in behaviors aligned with their values. Vegans demonstrate this dynamic of wanting to make a change, believing that it is possible, and having a means to take action coming together to result in behavioral change. Development of expertise occurs over time as vegans repeat this behavior, making the process more manageable. Therefore, vegans are analyzed using TURINEX to find insights into sustainable food consumption.

Veganism is an expertise that encompasses all aspects of a person's life, from food to entertainment, and there are claims that veganism is a sustainable dietary choice (Cherry, 2006; Larsson et al., 2003; Page, 2004; Zamir, 2004). Selection of veganism for analysis is not meant to be a validation of the sustainability claims of veganism (see Chapter 3) but rather an acknowledgment of the need for lessons in how practices can result in commitment to a value system expressed through mindful consideration of daily activities because that is what is necessary for sustainable consumption.

Consumer expertise grows through increased familiarity with a product, especially if there is variation in the types of experiences, which can include repetition of a task to reduce cognitive effort required or analyzing information to isolate what is task-relevant (Alba & Hutchinson, 1987). Increased expertise allows consumers to generate accurate knowledge beyond what is supplied by the product labeling, identify important product characteristics and differentiate between products(Alba & Hutchinson, 1987). However, the majority of consumers do not gain a high enough level of disciplinary linguistic expertise to pass an imitation game demonstrating that they possess IE. That would be more than required to make better decisions regarding food

consumption choices. An earlier stage of expertise development known as competence would be sufficient.

Competence is an expertise stage described as when individuals “not only demonstrate a foundational body of domain knowledge, but that knowledge is also more cohesive and principled in nature,” which contrasts with proficiency/expertise, where individuals are contributing new knowledge to the domain (Alexander, 2003). Dreyfus describes competence as a stage where individuals require a plan or perspective to determine what elements are important and decision-making becomes easier, but there are risks involved if it turns out to be wrong and there is an emotional investment in the choice leading to an action and responsibility for that choice (Dreyfus, 2004). Similarly, research on an educational model for expertise development describes the stage of competence as one where the practitioner has increased organizational ability and technical skills, with more responsibility and the recognition that colleagues are fallible and an increased ability to handle familiar complex situations (Dunphy & Williamson, 2004). However, individuals with competence are uncomfortable in atypical situations (Dunphy & Williamson, 2004).

Interactional competence is defined here as a cohesive understanding of domain knowledge which promotes easier decision-making and confidence as well as knowledge of fallibility of experts. As it is a linguistic ability, it excludes organizational ability, technical skills, and emotional investment in choices because these are within the domain of practice, not socialization.

Evolution of TURINEX:

TURINEX is developed as a method to test for interactional competence. Testing using TURINEX revealed several difficulties both in coordination of judges and respondents and in actual implementation of testing using the software. As illustrated below, the TURINEX test requires four respondents, each of which must be logged on to the software simultaneously. This proved extremely difficult when attempting to coordinate tests across time zones.

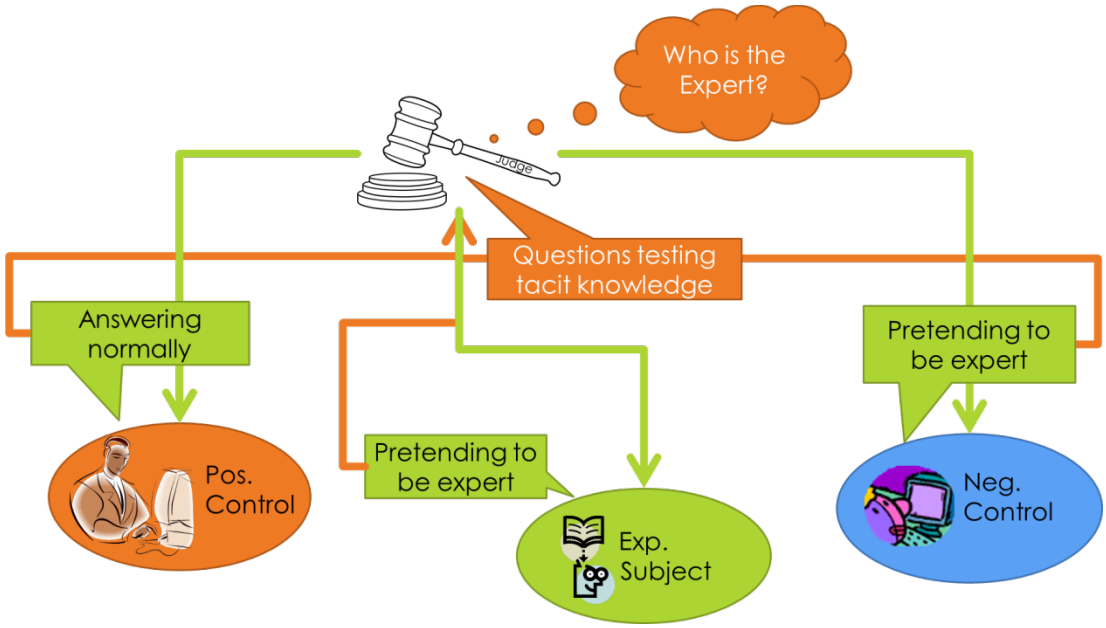

Figure 15: TURINEX Structure

TURINEX 2.0 was devised in response to the logistical and technical difficulties experienced while implementing TURINEX tests. The main change was implementing asynchronous testing. Judges and respondents now only log in when they are needed to complete an action such as asking or responding to a question, or judging a response. They can freely log in and out of the software and multiple sessions. This results in the same nature of dialogue exchanges as those in TURINEX, but with more time in between questions and answers. Judges are able to refer back to a transcript of the dialogue so far to help them keep track of previous exchanges and build upon them. TURINEX 2.0 is applied to a case study in veganism as a proof of concept both to ensure the software is functional and to examine the notion of interactional competence – a stage of expertise development in between none and IE.

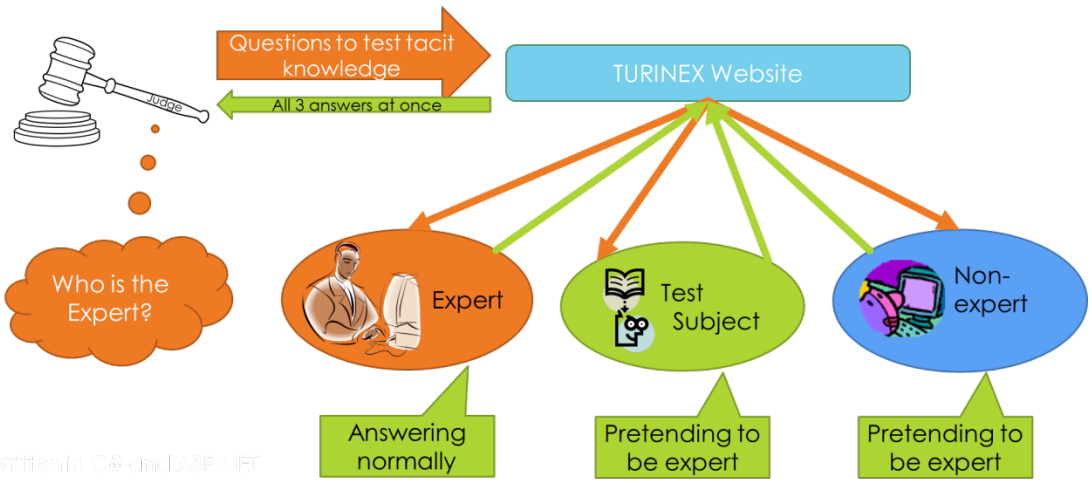

Figure 16: TURINEX 2.0: Asynchronous Testing for Levels of Expertise Development

Recruitment and demographic data

Snowball sampling, posted flyers around vegan restaurants, natural food stores, and college campuses, and online recruitment advertisements on a variety of websites including vegan discussion groups are utilized to recruit participants for TURINEX testing. Although many participants express interest, only 20 are utilized due to the requirements of TURINEX testing, which needs 2 vegans, 1 vegetarian and 1 omnivore for each session. 1 vegan required to be the judge as they are an expert. 1 vegan acts as a positive control and 1 omnivore acts as a negative control, to ensure that the judge is making accurate evaluations. The vegetarian is considered the experimental subject. The vegan respondent (positive control) is told to answer honestly because they are expected to have expertise in veganism. The other two respondents are told to answer the way they think a vegan would, or in other words to pretend to be vegan. The judge is told to ask questions that test tacit knowledge rather than explicit information. Before testing, participants provide data regarding their dietary preference, exposure to veganism, dietary restrictions, and other potentially confounding factors in a survey available in Appendix D. Research is considered IRB exempt approved and the letter is available in Appendix E.

Hypothesis:

TURINEX testing of vegans, vegetarians, and omnivores is used to investigate two hypotheses. First, as a proof of concept it is expected that the TURINEX method allows judges to successfully differentiate between respondents based on their answers to the judge's questions. Second, there is a positive correlation between the level of exposure to veganism and likelihood that a participant will be judged as a vegan. Three corollaries are proposed. First, the highest likelihood of being judged as a vegan is when the respondent is actually a vegan. The second highest likelihood of being judged as a vegan is when the respondent has vegan friends or family, due to frequent conversations concerning veganism. The third highest likelihood of being judged as a vegan is when the respondent is a vegetarian, due to shared experiences with vegans. However, vegetarians are expected to be judged at the level of interactional competence. Omnivores without vegan friends or family are expected to not be judged as vegans.

Null hypothesis

The null hypothesis is that there is no correlation between the level of exposure to veganism and likelihood that a participant will be judged as vegan. Evidence supporting the null hypothesis would include inability of judges to make accurate determinations of diet for respondents or omnivores and vegetarians without significant exposure to veganism or vegan practices being judged as having higher linguistic expertise than vegans.

Text Analysis Methods:

Transcripts are analyzed using two analysis methods – script analysis and intentional analysis, described below. The combination of these methods provides a framework for analyzing the role of tacit knowledge in the questions, answers and judgments. Script and intentional analysis are supplemented by coding intended to capture evidence of tacit knowledge. Tacit knowledge is defined here as understanding gained through experience or extensive linguistic socialization

which is not easily expressed, as opposed to explicit knowledge which is acquired simply by reading facts. The criteria for tacit knowledge include that the question has multiple technically correct answers, the answer is not easily found online, or it relates to personal experiences that vary among populations such as emotions, tastes, and preferences.

Answers that only use explicit knowledge are either correct or incorrect, can easily be found online, or don't relate to personal experiences. Answers only using explicit knowledge typically are straightforward, in that they provide factual statements without much elaboration or explanation that are not likely to be subject to debate. For example, if a judge asks, "Would a vegan eat beef?" and the response is "No" or "No, because it is an animal product" these would be considered straightforward answers. If the response was "It depends on the situation" or "Maybe by accident" these would not be considered straightforward answers. In veganism, tacit knowledge is expected to be expressed mainly in understanding of food and interactions related to food, but may extend to lifestyle choices and relationships, as well as entertainment and social situations. For example, in the question "Is Daiya a good cheese alternative?" the idea of good is subjective and therefore relies on tacit knowledge to answer. However, the question can be answered with a simple yes or no, which are responses that do not allow expression of tacit knowledge, or it could be answered by describing the texture, taste, and other sensory characteristics of the product, which is an answer using tacit knowledge.

Script Analysis:

Script analysis identifies common scripts, or "structures that describe appropriate sequences of events in a particular context" and set expectations for appropriate behaviors (Lacity & Janson, 1994). Analyzing dialogue at a restaurant using script analysis divides participant interactions into a logical sequence of events from being seated to ordering and finally paying the bill and describes expectations at each stage for participants such as the server expecting to be tipped and the customer expecting to be seated by a host or hostess (Lacity & Janson, 1994). Text analysis in this case does not necessarily reveal any surprising insight, but demonstrates the role

expectations play in daily situations that make interactions easier. Another example of script analysis includes differences in decentralization caused by introducing new technology in a hospital. The intent is to explain the paradox that identical technologies can cause similar dynamics, yet lead to different structural changes when introduced (Lacity & Janson, 1994). Conversations are coded by the authors into unsought validation, anticipatory questioning, preference stating, clandestine teaching, and role reversals. Correlation is found between frequency of certain scripts and the degree of decentralization caused in the hospital (Lacity & Janson, 1994).

An article discussing critical decisions under uncertainty used script analysis to identify the overall structure of the reasoning process, argument or explanation used by doctors in deciding whether to perform a biopsy to test for fungal pneumonia or simply give antifungal drugs without a biopsy despite the risk associated with such treatment (Kuipers, Moskowitz, & Kassirer, 1988). These examples provide a better understanding of script analysis, but do not capture evidence of tacit knowledge, so the procedure must be modified for TURINEX analysis.

Script Analysis for TURINEX:

In the context of TURINEX testing, transcripts are analyzed in a similar fashion to the restaurant script analysis example to determine the answer type the judge expected and compare this to the actual answers provided by respondents. Expected answers are defined as those which provide the type of information the judge is seeking. For example, if the judge asks what the respondent's favorite vegan food is, the expected answer will be a specific food item or perhaps cuisine type. Answers that subvert the question such as "I don't eat anything" or absurd answers such as "the color red" are considered unexpected answers. If the expected and actual answers match, the judge may be more likely to think that the respondent is vegan. Correlation between expected and actual answers is related to the concept of common knowledge, in which there is recursive belief where two people know that the other person knows something, and so on (Thomas, DeScioli, Haque, & Pinker, 2014). A vegan respondent may understand the intent of the judge in

asking a specific question if they both share common knowledge regarding the concept. For example, if a question asks “Do you eat honey?” most vegans know that this is a controversial issue and that strict vegans do not eat it, but some who identify as vegan do eat it. The respondent can use this common knowledge in the formulation of their response, which should make it more convincing than a respondent who might reply “yes” or “no” without explanation. Therefore, transcripts are analyzed to find what type of responses is expected for each question and compare to the actual response from respondents. Whether the response matches the expected answer type is then compared to the dietary preference the judge determines for that respondent to help understand how this relates to judgment.

Intentional Analysis:

Intentional analysis is meant to understand a speaker’s intentions and is appropriate for transcribed interviews where the researcher has much in common with the subject (Lacity & Janson, 1994). As the researcher performing the intentional analysis is vegan and the subjects are vegan, this is an appropriate method. A possible criticism is that being an insider might lead to bias in interpretation, but insider status is an assumption built into the methodology that enables the researcher to understand cultural and historical backgrounds that influence the dialogue (Lacity & Janson, 1994).

Intentional analysis is divided into four steps. First, the researcher describes the facts, or socially shared realities agreed upon by participants. Second, the researcher determines the way participants perceive cause and effect. Third, the researcher identifies themes that emerge from the text to develop common interpretations for the entire class of phenomena. Finally, the researcher finds the essence of the text (“gestalt”), learned from studying the phenomenon as a whole. This means that the researcher interprets the whole transcript on the basis of the first three steps and any other relevant insights gained from studying the text. Insights must be validated with descriptions of interviews and direct quotes from participants, though findings cannot be quantitatively verified or tested by hypotheses (Lacity & Janson, 1994).

Intentional Analysis for TURINEX:

The procedure for intentional analysis is applied to interpret transcripts from TURINEX sessions.

Step 1, Shared Realities:

For TURINEX test analysis, the first step analyzes the shared realities established by the question. Shared realities are another example of common knowledge. If the judge and respondent have common knowledge regarding an aspect of veganism, they share the same reality for aspect. For example, if the judge asks “Where do you like to go out to eat?” then this implies that this is an option for vegans to partake in. If the respondent does not believe this to be an option, then the judge is less likely to consider them a vegan, as they thought it was a valid option but the respondent did not. This is demonstrated in a test where the judge asks about fake meat and milk alternatives and an Indian respondent replies that they don’t consume them and also refers to soymilk as soya milk, leading the judge to rank a vegetarian as an omnivore. There is not a shared reality in this situation because the respondent does not recognize the prevalence of fake meat and has a different custom of calling a soy beverage soya milk rather than soy milk because the reality in India is different than that of the judge in the United States. This disruption of expectations leads the judge to determine the respondent has no expertise in veganism. It is expected that similar mismatches would lead to the judge assigning no expertise to the respondent.

Step 2, Cause and Effect:

The second step interprets perceptions of cause and effect where relevant. Judges sometimes ask leading questions, which could be answered briefly or with extensive explanation. Respondents who provide reasoning for their answer allow the judge to evaluate their reasoning and compare it with their own. For example, in a question “Do you like going to the zoo?” several layers of cause and effect analysis are possible. First, any answer reveals whether or not a person extends the vegan philosophy beyond their dietary choices. Further explanation may reveal underlying reasons for being vegan. Answers that align with the judge’s own philosophy

are more likely to be judged as coming from a vegan respondent. For example, an answer that states they don't mind the zoo, but that it is expensive has a different cause and effect structure than an answer that states they dislike the zoo because it keeps animals in cages. One refers to price as a barrier, while the other brings up the ethical issue of captivity.

Step 3, Themes:

The third step identifies themes that emerge from the text and aggregates them. Identification of themes draws upon discourse in the relevant literature and dialogue around veganism, including the work of book authors, blog writers, and scholars. A grounded theory approach is used in aggregating similar themes after initial analysis. For example, every transcript collected contains at least several food-related questions, so actual food consumption is (not surprisingly) a common theme when considering veganism. This collection of themes is useful in describing what veganism means to judges, how they practice it, and how they view it. If veganism was nothing more than a dietary choice, then it would be expected that food would be the only common theme emerging. However, ethics and lifestyle choices also are common themes. Themes are useful in script analysis because certain types of questions are associated with certain types of answers. Just as certain question types invite certain response types as described in script analysis, certain themes invite certain responses. A session with a dominant theme of food choice would have several questions about food, with the expectation that answers would also be about food.

Step 4, Holistic Interpretation:

Finally, the last step is a holistic interpretation of the text, including insights into veganism as a practice, supported by direct quotes and descriptions of TURINEX sessions. The final determination made by judges is helpful in this step, as the judge is responsible for making a final ranking based on the whole session, providing their confidence rating, and explaining their rationale. For example, in one session, the judge mentions the responses to their question about zoos in justifications for judgments regarding two of the respondents. Restaurants are considered

in two justifications, and a lifestyle choice is considered in just one. From this, it seems that this judge is primarily concerned with food and entertainment choices, meaning that these constitute a significant portion of the vegan experience. This interpretation also has the advantage of available demographic data from a pre-test survey which may help explain anomalies. For example, an omnivore is able to pass as a vegan, but demographic data reveals that this respondent has a close vegan family member known for 10 years. This provides extensive linguistic socialization in veganism to the omnivore, which allows the omnivore to replicate the answers the vegan family member would give and pass as a vegan themselves.

Predictions:

There are five predictions regarding the findings from text analysis. First, answers demonstrating use of common knowledge (coinciding with shared realities) are more convincing to judges than those which do not and therefore are ranked as higher in veganism expertise. Second, answers demonstrating a mismatch in shared realities are ranked as lower in veganism expertise because the judge may disagree with the answer provided. Third, cause and effect inferences that align with those of the judge result in a higher ranking for the respondent. Fourth, common themes that emerge from the text include food choice, ethics, and lifestyle choices. Finally, anomalies in testing results have logical explanations based on demographic data.

Results:

Rankings from TURINEX tests provide some support for the case study hypotheses. First, vegans are the most frequent group to be judged as vegan, with 60% of respondents identified as vegan. Tests indicate that omnivores are just as successful as vegetarians in convincing the judge they are vegan. However, part of this success is due to an omnivore who had frequent exposure to a vegan family member for 10 years prior to the test. This supports the second corollary that respondents with vegan family members have higher tacit knowledge of veganism and are more likely to be judged as vegans. Tacit knowledge through frequent interactions with

the vegan family member make the omnivore an interactional expert in veganism, allowing them to convince the judge that they were vegan even though they were in fact an omnivore. Although this is anecdotal evidence, it is consistent with theories of tacit knowledge and interactional expertise (H Collins et al., 2006; Harry Collins, 2004).

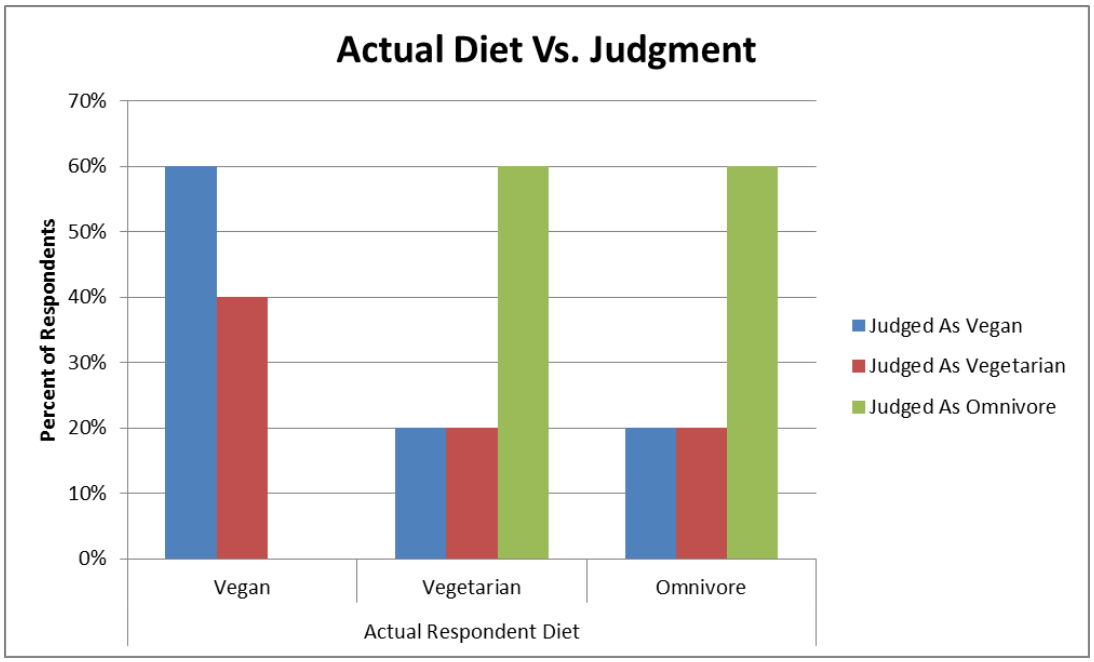

Figure 17: Results of VVO Tests. n=20 participants over the course of five sessions.

Script analysis results:

Script analysis relates primarily to the themes emerging from questions and answers, and how well respondents' answers match the judges' expectations. The determination of the judge is expected to be partially based on how well expectations and answers align. Script analysis results are available in Appendix F. Instances where the responses do not match the expected answer are reported and explained here.

In the first session, first question, the second respondent does not match the expected answer type (a specific type or name of restaurant is expected, but the response is vague), and the judge ranks their expertise for that question as omnivore, with a confidence rating of 5 out of 5. In the third question, the second respondent provides an answer that does not explicitly address the yes

or no question asked by the judge. The judge ranks their expertise as omnivore, with a confidence rating of 4 out of 5. The final determination of the judge in the first session is that respondent 2 is an omnivore and in their reasoning, they explicitly refer to their response being too vague to be believable. This shows how mismatch between expectations and answers can cause a lower expertise judgment for the respondent.

In the second session, second question, the third respondent does not match the expected answer type because they answer a question about food with a service instead. The judge ranks their expertise as intermediate with a confidence rating of 3. In the fifth question, the second respondent does not match the expected answer type because when asked for a description of seitan they instead say they have never tried it. The judge ranks them as intermediate with a confidence rating of 2. In the sixth question which expects an answer of a vegan product replacing a non-vegan product, respondent 3 does not match the expectation because they imply they don't eat any and don't remember meat. The judge ranks them as intermediate with a confidence rating of 3. In the seventh question the expected answer type is a choice of tofu or tempeh for grilling, but the second respondent answers that they do not use either. The judge ranks them as an expert respondent with a confidence rating of 3. The overall determination for the second respondent is expert, with the judge referring to the mismatched answers sounding like those of a raw foodie, which they associate with veganism. Although the judge is incorrect, this provides evidence that mismatch can result in a higher expertise ranking than is accurate. The third respondent is judged as intermediate, noting specifically that they haven't heard of a product the respondent mentions, leading them to rank the vegan as a vegetarian instead. In this case, mismatch between expectations may be part of the reason for a lower expertise ranking than is accurate.

In the third session there are no questions with mismatch between expectations and answers. In the fourth session, the fourth question has an expected answer type of a brand name for a vegan meat substitute, but the second respondent responds that they do not use any. The judge

ranks their expertise as none with a confidence rating of 3. The second respondent receives a final determination of omnivore even though they are vegetarian, with the judge noting that they provide the vaguest answers. The mismatch between expected and received information may cause the determination to be lower than accurate. In fact the reason provided for the third respondent being ranked as a vegan even though they are an omnivore is that they give the most specific answers.

In the fifth session, the first and third respondents' answers to the first question do not match the expectation of the judge because the information sought is a brand name of a vegan substitute product and the response in both cases is that they do not use any. The judge ranks both of these answers as from omnivores, with confidence ratings of 3. Respondent 3's answer to question 2 regarding non-dairy milk does not match the expectation of a type of milk as they answer instead that they only drink tea. This results in a judgment of omnivore, with a confidence rating of 3. Question 3 seeks a sensory description of plain tempeh, but respondents 1 and 3 respond that they never have it, leading the judge to rank both respondents as omnivores with confidence ratings of 3. The final determinations for respondents 1 and 3 are omnivore, and the judge specifically mentions their lack of familiarity with vegan products as reasons for these determinations. The judge is correct for respondent 1, who is an omnivore but not respondent 3, who is a vegetarian. Cultural differences between Americans and Indians may be the reason that the judge makes these determinations, as they mask any expertise in veganism that respondent 3 may have and emphasize the lack of familiarity with American vegan experiences in respondent 1. In this case, the judge may have been assessing veganism through the cultural lens of an American, not considering the variety of practices engaged in by vegans in other cultures.

Anecdotal insights from script analysis seem to demonstrate a tendency for mismatch between expected answers and provided responses to cause inaccurate judgments. However, the judge may determine a higher or lower expertise ranking based on their interpretation of the mismatched response. This may be a result of the judge trying to fill in missing information by

making assumptions about the respondent that can be false. When the information requested is not provided as expected, the judge must evaluate whether this is a result of a different experience or understanding of veganism, or a result of not being vegan. Tacit knowledge of veganism is vital for the judge to differentiate between possibly feigned vegan experiences and genuine lack of vegan knowledge.

Intentional analysis results:

Intentional analysis is performed for all five completed sessions. Procedures for this analysis are available in Appendix C. Results from the final step of script analysis are reported here. See Appendix F for the complete transcript of each TURINEX session.

Session 1 consists of six rounds of question and answer. The first respondent is a long term vegan. The second respondent is a vegetarian who has known a vegan for less than a year and attempts to eat in a somewhat vegan manner. The third respondent is an omnivore who knows a vegan for less than a year and has no dietary restrictions. The first respondent gives an answer to a question about zoos which throws off the judge by not reflecting common vegan views, but the judge still correctly determines that they are vegan. The second respondent provides answers the judge views as eccentric, which reduces the judge's confidence in them, resulting in the incorrect determination that they are an omnivore. The third respondent's detailed responses for the zoo question and a question about toothpaste convinces the judge that they are a vegetarian, even though they are an omnivore. The questions, judgments, and reasons for determinations show that this judge considers veganism a commitment across all parts of life, but recognizes that it presents some difficulties and gray areas for ethical questions. The confidence in their final determinations is not very high, but they judge the vegan correctly.

Session 2 consists of seven rounds. Respondent 1 is an omnivore who has only known a vegan for less than a year. Respondent 2 is a vegetarian who has known a vegan less than a year, but eats a mainly plant-based diet. Respondent 3 is a vegan who has known another vegan for 15

years. The judge is not convinced by respondent 1's answer to a question because it does not match the judge's tacit knowledge that milk substitutes are common and suitable replacements for real milk. Responses regarding food choice and sensory experiences further convince the judge that respondent 1 is an omnivore, which is correct. Respondent 2 throws off the judge with several answers that do not fit their expectations, view of reality, and view of cause and effect. However, the judge believes that the answers sound like those of a "raw foodie" which the judge associates with a type of veganism. Although there are raw food vegans, the judge is incorrect to assume a "raw foodie" would be vegan and makes the wrong determination as respondent 2 is vegetarian. Respondent 3 expresses some experiences which are not familiar to the judge because although they are legitimate vegan experiences they are different than the limited experiences of the judge. Therefore respondent 3 is only able to convince the judge that they are vegetarian, not vegan. Overall this judge looks for responses that best match their vegan experience, rather than what they imagine vegans could be like. Because of this they make a mistake in judging a vegan as vegetarian and vice-versa. However, the omnivore was clear to them. Their confidence in final determinations is fairly high.

Session 3 is four rounds long. Respondent 1 is an omnivore who has known a vegan for 2 years and has no dietary restrictions. Respondent 2 is a vegetarian who has known a vegan for 2 years and has experience living in India. Respondent 3 is a vegan who has known a vegan for 9 years and is gluten free. The judge finds the answers provided by respondent 1 to be "too uptight" to be from a vegan and believes that some of the answers sound like they are taken from a website. Respondent 2 sounds like a vegetarian to the judge because they show priorities reflected in their answers that match well with those of a vegetarian, but not vegan. Their focus on the problems with the meat industry without mentioning associated dairy or egg production industries and their confidence in the abilities of servers both reflect vegetarian experiences and viewpoints, but not vegan tacit knowledge. Respondent 3 is skeptical in their answers and provides several believable responses that utilize tacit knowledge, such as their reaction to dating omnivores and having conversations with omnivores.

Session 4 is six rounds of question and answer. Respondent 1 is vegan for nine years and gluten free, which helps convince the judge that they have some expertise. However, the judge is bothered by some vague answers, which leads them to believe that they are just a vegetarian pretending to be vegan. Respondent 2 provides responses influenced by being a vegetarian in India and not knowing any vegans. These responses lead the judge to determine that they are an omnivore even though they are vegetarian. Respondent 3 gives responses that come from the tacit knowledge built up over 27 years of knowing a vegan, which results in answers that realistically replicate those expected to come from a vegan, convincing the judge that this omnivore is a vegan. This is the only instance where an omnivore convinces a judge that they are a vegan. It is explained well by expertise theories that indicate tacit knowledge which grows from linguistic socialization can be sufficient to convince a judge that a person belongs to the target expertise (H Collins et al., 2006).

Session 5 consists of four rounds. Respondent 1 is a vegetarian who lives in India but does not know any vegans. Respondent 1 is judged as an omnivore because the judge had a mismatch in shared reality regarding fake meat and tempeh and the correct way to identify a beverage made from soy (soya milk vs. soymilk). Respondent 2 is a vegan who knows a vegan for 10 years. Respondent 2 is judged as a vegan because the judge has confidence in their brand-specific and detailed answers. Respondent 3 is an omnivore who lives in India and has no dietary restrictions and does not know any vegans but is a former vegetarian. Respondent 3 is judged as an omnivore because they are not familiar with any of the experiences with products the judge questions them about. Interpretation of this session reveals two important findings. First, judges are willing to rank respondents in a way not consistent with the intuitive assumption that there would be one vegan, one vegetarian and one omnivore respondent for each session. In this session they instead judge that there are two omnivores and one vegan. Second, cultural differences may be a stronger influence on the determination of expertise ranking from the judge than the actual experience of veganism. It is clear from the transcript that it is not common in

India to have fake meat products, but the judge finds the Indian respondents' lack of familiarity with fake meat to be a signal that they have no veganism expertise.

Themes:

Themes emerging from TURINEX sessions are dominated by food choice. Social interactions are also a common category, including interacting with omnivores, lifestyle, and relationships.

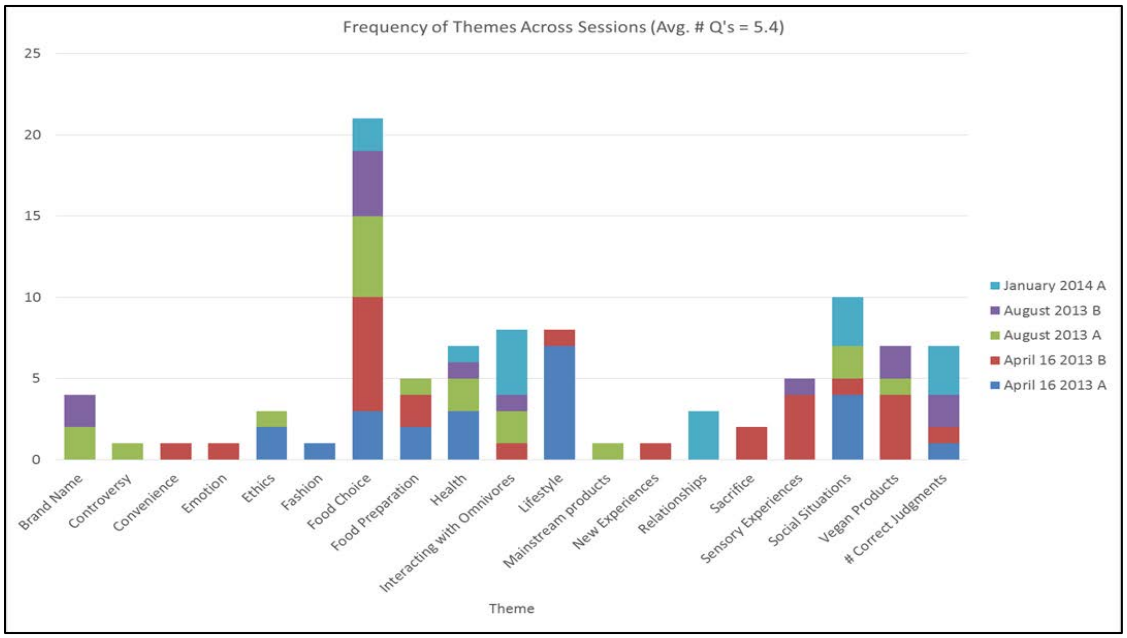

Figure 18: Frequency of Themes in Transcript Analysis. n=27 questions.

The analysis process for themes shows overlap between categories. The categories are then aggregated together where there is significant overlap. Aggregation is based on themes that can be logically classified as subsets of other themes. Therefore, "ethics" includes "ethical choices", "health" includes "nutrition" and "hygiene", "interacting with omnivores" includes "omnivore knowledge", "lifestyle" includes "non-food purchases" and "entertainment", "relationships" includes "dating", and "social situations" includes "special occasions".

Null hypothesis

Results from TURINEX testing do not have a large enough sample size (n = 27 questions) to prove statistically significant, but within the sessions performed not a single vegan is judged as an omnivore, and the only omnivore judged as a vegan knew a vegan closely for a long period of time. Neither of these support the null hypothesis. Vegetarians and omnivores have the same judgement ratios for vegan, vegetarian and omnivore rankings, but demographic data again helps explain this. Further, judgments all have confidence ratings that indicate a high level of certainty regarding the expertise of respondents. One potential are piece of evidence for the null hypothesis is that out of 15 total respondents judged, 8 were judged incorrectly. However, in one case this is evidence of interactional expertise in veganism demonstrated by an omnivore, and in another case this is a result of cultural differences that makes an Indian vegetarian sound like an omnivore in the United States.

Discussion:

Theoretical descriptions of tacit knowledge align with empirical results supporting the hypotheses regarding judgment of actual vegans and judgments of respondents with significant exposure to veganism. The hypothesis regarding vegetarians and individuals with other dietary restrictions is not supported by the evidence. It may be that the original assumption that vegetarians have sufficient shared experiences with vegans to convince a judge that they are vegan does not hold. In this case, veganism and vegetarianism should be considered two different types of expertise, rather than two stages along the same continuum. However, a much larger sample size is needed before making any conclusive statements regarding the nature of veganism expertise, especially as compared to that of omnivores and vegetarians.

Results of predictions:

Of five predictions made regarding TURINEX testing, text analysis supports three, while two others have mixed results.

First, judges rank answers demonstrating use of common knowledge higher in veganism expertise. Common knowledge helps respondents give answers that match the expected answer type of the judge. However, some unexpected responses can fool the judge into thinking the respondent is a vegan. This is demonstrated in an example where responses from a vegetarian who eats mostly raw food fool a vegan judge into thinking the respondent is vegan even though they are vegetarian because the judge associates eating raw food with veganism. This prediction is not verified due to mixed evidence which is both supporting and refuting it.

Second, judges rank answers with mismatch in shared realities lower in veganism expertise. Answers that do not reflect an understanding of the implicit meaning behind some questions lead to lower rankings for that question. Some respondents provide answers that are not just unexpected, but in fact irrelevant or based on different understanding of the world. This is demonstrated in an example where responses from an Indian vegetarian regarding fake meat convince the judge that they are an omnivore because they do not share any of the experiences that the judge has with fake meat. This prediction is found to be supported by the evidence.

Third, judges rank answers that align with their cause and effect inferences higher in veganism expertise. Answers that do not reflect an understanding of the cause and effect rationality of the judge lead to lower rankings for that question. This is demonstrated in a response regarding a leather band wristwatch where the respondent does not realize the cause and effect relationship implied between being vegan and not using leather. The judge determines they have a lower level of expertise because of this. This prediction is found to be supported by the evidence.

Fourth, common themes in the text include food choice, ethics, and lifestyle.
Food choice is a theme 21 times out of 27 questions. Ethics is a theme only 3 times, which was surprising. Lifestyle is a theme in 8 questions. Social situations, health and vegan products are

also common themes, appearing 10, 7 and 7 times respectively. This prediction is not verified due to mixed evidence which is both supporting and refuting it.

Fifth, anomalies in testing results are logically explained based on demographic data.
The only test where the judge is incorrect about all three respondents is one in which the omnivore knows a vegan very well and the vegetarian respondent is an Indian living in India. The difference in degree of exposure to tacit knowledge about veganism that leads to the incorrect judgments is easily explained by the demographic data. Being a vegan living in India is far different than being a vegan living in the United States, so there are fewer shared experiences to draw from. Cultural differences are therefore a barrier to successfully pretending to be vegan. The omnivore who knows a vegan very well has extensive linguistic socialization with them, discussing a myriad of topics related to veganism and sharing some of the everyday life experiences of a vegan. Therefore the prediction regarding demographic data is supported.

Results show only one session with a perfect judgment. Themes show that this judge focuses on interacting with omnivores, relationships, and social situations, followed by food choices and health. The only judge to get all three wrong focuses on food choices, with just a couple questions about health, interacting with omnivores and social situations. These differences in focus may help explain why some judges do better than others even though they are all vegan. The judge with the highest emphasis on food choice only correctly identifies one respondent. A focus on food misses numerous aspects of the vegan experience, many of which are captured in questions about relationships and social situations. Therefore, there is less of an opportunity to evaluate tacit knowledge in a variety of categories if the judge focuses on food choice. However, it is the easiest question to think of, and by far the most commonly asked in sessions.

Conclusion:

Tacit knowledge is essential for the development of expertise. Although expertise develops in stages, imitation games cannot capture this at the individual level. TURINEX allows researchers to test development of tacit knowledge before the stage of IE. The stage of interactional competence exists between no expertise and IE. Interactional competence is useful for sustainable consumption because it allows a consumer to understand the concepts, terminology and tacit elements of a domain without having to be an expert or interactional expert in the domain. It is more feasible to gain interactional competence in several domains related to food sustainability than expertise, reducing the demand on consumers to enable better behavior related in relation to the food system.

A case study of veganism finds that vegans typically exhibit higher tacit knowledge in veganism than both vegetarians and omnivores. Script analysis of transcripts and aggregated themes show that the many aspects of daily life extended beyond food choice which may be influenced by practice of veganism. Intentional analysis demonstrates the importance of expressing tacit knowledge in convincing a judge that the respondent is vegan. Demographic data helps to explain an anomaly where an omnivore is judged as vegan, demonstrating successful transfer of tacit knowledge. These findings may be helpful for advancing sustainable consumption by supporting the idea that leading by example can be effective. Outside of veganism, TURINEX research can be used to advance sustainable consumption by examining other groups which exhibit desirable behaviors. TURINEX as a methodology may also help support assessment of educational efforts through evaluation of linguistic expertise.

CHAPTER 5

CONCLUSION

This work advances sustainability research by investigating the role of explicit information and tacit knowledge in food systems, demonstrated by a case study in veganism. Explicit information serves the purpose of debunking misconceptions, which in turn is useful in supporting expertise development, which is necessary to understand the wicked problems present in the food system. Sustainable consumption lessons from and for veganism emphasize the importance of holistic understanding of food systems informed by quantitative evaluation of intuitive claims tempered by competence developed through acquisition of tacit knowledge in a variety of relevant expertises. These findings are useful for sustainability education because it requires students to form holistic understanding to address wicked problems through the application of a variety of disciplines (T. Seager et al., 2011). Part of the reason for this is the publicity associated with a focus on controversial issues with fundamentally different arguments on either side making them unlikely to be resolved, but likely to be noticed and gain advocates. Both explicit information and tacit knowledge are needed to help people on both sides move past dogma to productive dialogue and to help consumers understand when intuitive claims do not hold up to objective quantification and the meaning and validity of persuasive arguments from advocates.

The original contributions of this dissertation include advancement in understanding of the environmental implications of a vegan diet through LCA of SPI and a new sociological methodology to study the development of linguistic expertise through tacit knowledge. These contributions are complementary in that they both help support sustainable consumption through both information and tacit knowledge to advance expertise. Principle findings of this dissertation include results from an LCA of SPI that demonstrates an example of where additional processing can result in a plant-based product that is worse for the environment than an unprocessed animal-based product meant to serve the same function and that veganism is an expertise in which vegans have more tacit knowledge than vegetarians, who in turn have more tacit

knowledge than omnivores, but demographic differences can distort testing results. LCA of SPI starts to fill an important knowledge gap in food LCA of highly processed foods and demonstrates the significant potential for increased environmental impacts from manufacturing level processes. This counters the dominant trend of LCAs which risk masking trade-offs in environmental impacts by emphasizing farm-level agricultural activities and examining food products with a minimal number of components and ingredients. Understanding impacts of processing is important when many plant-based foods which are promoted as having environmental benefits are highly processed and may have more significant environmental impacts than unprocessed animal-based products they are intended to replace. This research demonstrates the necessity of balanced and unbiased investigation of claims to ensure intuitive assumptions are not incorrect.

Consumers should be more effective in aligning with sustainability values if they have interactional competence in a variety of relevant disciplines. Education and training efforts to promote sustainability can be supported through TURINEX testing of participants in programs meant to remove barriers to sustainable consumption. Different pedagogical strategies should be informed by consideration of tacit knowledge development, but this is not captured by traditional educational assessment instruments. In fact, the only established measure of tacit knowledge is the imitation game, which is not useful for educational assessments because it can only determine if a participant is linguistically an expert or not, leaving out an intermediate stage (H Collins et al., 2006). In contrast, TURINEX based assessment can test for interactional competence, which should be the goal of educational and training programs that are intended to help understanding of various disciplines relevant to sustainability and which support holistic understanding.

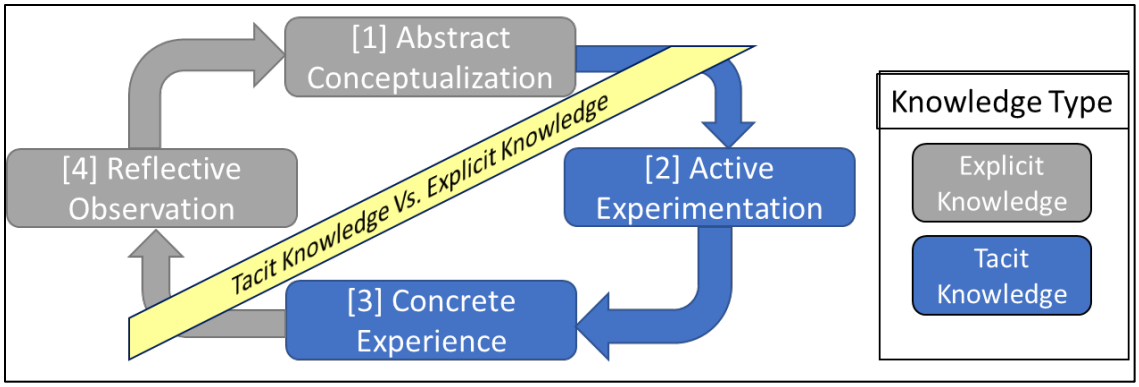

Figure 19: The Kolb Learning Cycle. Active experimentation and concrete experience are vital for tacit knowledge development.

Development of tacit knowledge is supported by including the full Kolb Learning Cycle in educational activities (Clark et al., 2015). Stages 2 and 3 (active experimentation and concrete experience) are especially helpful in forming tacit knowledge regarding the subject (Clark et al., 2015). For example, a class in LCA will provide students with better understanding of the operations and limitations of LCA software, challenges in inventory collection, and other practitioner knowledge if it engages them through guiding students through an activity which includes the complete Kolb learning cycle by having them form hypotheses (stage 1), gather data (stage 2), utilize LCA software to generate results (stage 3), and make conclusions based on their findings (stage 4). The explicit and tacit knowledge gained through this exercise are complementary dimensions of interactional competence.

The same principle can be applied to any education or training exercise intended to support expertise development. Active and experiential learning are promoted as more effective ways to educate students (Kolb & Kolb, 2005; Prince, 2004). TURINEX may provide a new way to assess these claims through comparisons of linguistic expertise between control groups and students in active or experiential learning classes. For example, many educational approaches meant to support ethical behavior reinforce the fallacy of the individual decision-maker through information based case studies, which imply that people engage in individualistic decision-making rather than recognizing the context of an ethical dilemma (T. P. Seager et al., 2010). The case study

approach makes it difficult to connect and draw relevant lessons, but active, experiential and participatory activities leads to deeper consideration of ethical issues and greater deliberative discourse (T. P. Seager et al., 2010). Ethics education leading to understanding of the need for intergroup cooperation may also support the ability to address fundamental sustainability problems (Sadowski et al., 2014). Some experiential learning activities do not lend themselves to quantitative interpretation of understanding relevant to the issues meant to be addressed by the experience. For example, a case study of “The Externalities Game” intended to extend ethics education to a global perspective and see ethical decision-making as participatory has anecdotal evidence supporting claims and a discussion of deliberative challenges students face, but no quantitative measure of success and metric for evaluating student learning (Hannah, Berardy, Spierre, & Seager, 2013). Evidence for effectiveness of these types of experiential learning might be supported through TURINEX testing.

TURINEX testing of veganism and LCA of SPI provide two complementary case studies which demonstrate the complementary roles of information and expertise in advancing sustainable consumption efforts. Veganism demonstrates a lifestyle practice that is reflected in tacit knowledge from repeated experiences, which are associated with higher perceived consumer effectiveness (Ellen et al., 1991). While this behavior may seem to support sustainable food systems at an intuitive level, information gained through LCA of SPI demonstrates that some vegan products may be worse for the environment than those used by omnivores if the level of processing is high enough. Understanding this counterintuitive example at a level of interactional competence should support tacit knowledge development by understanding that it is likely to apply to other processed foods, not just SPI, which in turn might lead to behavioral change. In this way there is a continuum of development from LCA to behavior, which requires support along the way from experiences that promote tacit knowledge acquisition. LCA provides information, which is a complementary component of expertise with tacit knowledge gained from experience. Expertise, as well as information, increases PCE, which is linked to increased socially and environmentally responsible behavior (Ellen et al., 1991).

Findings from this dissertation have the potential to improve the way society views and engages in sustainable consumption by encouraging holistic understanding of the food system as a wicked problem, giving more consideration to the role of consumers and the need to supplement information with competence and move past dogmatic arguments. TURINEX as a methodology represents an assessment instrument unique in its capability to assess levels of tacit knowledge through linguistic interaction that can be applied to any type of expertise and support development of better pedagogical strategies for tacit knowledge growth and expertise formation. Application of the lessons found through this dissertation research and principles of sustainable consumption can help move food systems away from endless controversy and towards sustainability through consensus.

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APPENDIX A

TECHNICAL DESCRIPTION OF TURINEX SOFTWARE

TURINEX is written in C# and ASP.NET. The host server facilitates interaction between users through a web-based interface. Judges create sessions to join and respondents join them. Users may log in and out of the website as they please without disrupting the ongoing session. All exchanges are text-based and anonymous. The judge receives responses simultaneously to avoid potential bias based on faster answers from individual respondents. Respondents are allowed to use internet searches and the judge is aware of this. This encourages judges to ask questions of a more tacit nature that can't be easily researched online.

APPENDIX B

CALCULATIONS FOR ASSUMPTIONS REGARDING SOY PROTEIN ISOLATE

Calculations for energy requirements of heating:

Energy required to raise the mixture temperature from 15.5 C to 60 C is 11.1840409753 kWh of energy.

30 kg of water requires 11.0806908 kWh of energy to rise from 15.5 C to 60 C. The calculations are below.

Heat added = specific heat (J/gK) * mass (g) * change in temperature (K)

Heat added = 4.186 J/g K * 30 kg * 44.5 C

Unit conversions: 30 kg = 30000 grams and 44.5 C = 317.65 K

Heat added = 4.186 J/g K * 30000 g * 317.65 K = 39,890,487 J = 39,890.487 KJ = 11.0806908 kWh.

3 kg of soymeal requires 0.0686041667 kWh of energy to rise from 15.5 C to 60 C.

Heat added = 1.85 kJ/kg C * 3 kg * 44.5 C = 246.975 kJ

246.975 kJ = 0.0686041667 kWh.

0.264 kg of sodium hydroxide requires 0.0347460086 kWh of energy to rise from 15.5 C to 60 C.

Specific heat of sodium hydroxide is 59.66 J/mol K

Heat added = 59.66 J/mol K * 0.264 kg * 44.5 C

Unit conversions: .264 kg = 6.600476884452 mols and 44.5 C = 317.65 K

Heat added = 59.66 J/mol K * 6.600476884452 mols * 317.65 K = 125,085.630836772967548 J.

125,085.630836772967548 J = 0.0347460086 kWh.

Calculations for transportation requirements of the final SPI product:

Calculations for ton-kilometers of transportation for 1 kg of SPI, assuming 1 to 3 kg of soymeal is transported typical distances for soy transportation in the US, are below.

20 to 40 miles by diesel truck must be converted to ton-kilometers. 1 to 3 kg soymeal are transported. 20 to 40 miles converts to 32.1869 and 64.3738 kilometers and 1 to 3 kg converts to .001 to .003 metric tons. Therefore 0.0321869 to 0.1931214 ton-kilometers of transportation by diesel truck are required.

900 miles by freight rail must be converted to ton-kilometers. 1 to 3 kg soymeal are transported. 900 miles converts to 1448.41 kilometers and 1 to 3 kg converts to .001 to .003 metric tons. Therefore 1.44841 to 4.34523 ton-kilometers of transportation by freight rail are required.

Calculations for amount of sodium hydroxide (NaOH) used:

The description of SPI processing indicates that during extraction and neutralizing steps, 2 N NaOH (sodium hydroxide, or lye) is added to the mixture along with water in a 10:1 ratio, with the purpose of the NaOH being to adjust the pH to the right level (Cunningham & Ogale, 2000; Z. M. Nazareth et al., 2009; Z. Nazareth, 2009). Unfortunately the exact amount of NaOH added is not provided, except in a paper describing an experimental method to reduce the time necessary for the mixture to be alkaline, which only has one step using NaOH (Joshi et al., 2011). This is used as the reference for the amount of sodium hydroxide necessary for SPI manufacturing. The authors describe a procedure to extract SPI from soy flakes that reduces the time in alkaline condition while maintaining high protein yield. They perform three trials with varying ratios between soy flake and NaOH (1:5, 1:8, 1:40). They use 10 grams of soy flakes for the trials. Percentage protein yield is about 25 for two ratios, but 32% for the 1:40 ratio. Since this LCA assumes a 1/3 yield from the original soymeal input, the 1:40 ratio is used to calculate NaOH required. 400 ml for 10 grams of soy flakes translates to 120 liters used for treating 3 kg of soymeal. NaOH is 40 grams per mole, so 0.05 N NaOH has 2 grams NaOH per liter of water. Therefore, 240 grams of NaOH are needed for 3 kg of soymeal. This is 0.24 kg NaOH per kg SPI.

10 milliliters of 1 M NaOH raises the pH of 1 liter of water from 7 to almost 12. 2 M NaOH only needs 5 milliliters of NaOH. 5 milliliters of 2 M NaOH contains 0.4 grams NaOH. Therefore, each liter of solution requires .4 grams NaOH. 30 liters of the solution used in extraction therefore contains 12 grams of NaOH. 12.5 liters of solution are needed for neutralizing, which contains 5 grams NaOH. So, 17 grams of NaOH is needed for water in the entire SPI production process. So, in total, 0.24 kg + 0.017 kg = 0.257 kg NaOH per kg SPI are needed.

APPENDIX C

TRANSCRIPT ANALYSIS METHODOLOGY

The following is the text analysis procedure used in the interpretation of TURINEX session transcripts.

1. Script analysis

1.1 Write expected answer type (e.g. a specific food) for each question, based on common knowledge of veganism. For each answer, write if it matches the expected answer type or not. Note the ranking of the judge. Consistency is expected to increase ranking. Note any anomalies.

2. Intentional analysis

2.1 Write the implied shared reality (e.g. assumptions about vegan practices) for each question. For each answer, write if it matches the shared reality or not. Note the ranking of the judge. Consistency is expected to increase ranking. Note any anomalies. Provide explanation for mismatch if possible.

2.2 Write the cause and effect explanation (i.e. why the judge expects a certain answer) for each question. For each answer, write if it matches the shared reality or not. Note the ranking of the judge. Consistency is expected to increase ranking. Note any anomalies. Provide explanation for mismatch if possible.

2.3 Write the theme or category (e.g. food choice, lifestyle, and ethics) for each question. At the end of the transcript, provide a tally for each unique theme. Aggregate similar themes together and re-evaluate the themes for transcripts to provide a new tally. Repeat as necessary.

2.4 Write an explanation of the judge's determination based on a holistic reading of the transcript informed by demographic data.

3. Evidence of tacit knowledge

3.1 Write an explanation explaining if each question relies on tacit or explicit information, or both. Tacit knowledge is needed to answer a question based on personal experiences and when there are multiple technically correct answers (e.g. "what is the best substitute for beef?"). Explicit knowledge is needed to answer a question with a clear right or wrong answer that can be easily found online (e.g. "Is casein vegan?").

APPENDIX D

SURVEY QUESTIONS FOR TURINEX RESPONDENTS

The text below is from the survey sent to respondents to complete prior to beginning TURINEX testing.

TURINEX Vegan Vegetarian Omnivore Test

Andrew Berardy (TURINEXVVO@gmail.com)

Please complete the following survey regarding your dietary preferences and background. Your responses will be kept confidential, and will be connected to your interactions in the TURINEX test using a unique identifier code, never your real name.

1. What is your dietary preference?* (see end of survey for definitions)

Vegan (including only those who abstain from all animal products)

Vegetarian (including ovo-, lacto-, ovo-lacto-, and those who consume honey or non-flesh animal products)

Semi-vegetarian (including pescatarian and flexitarian)

Omnivore (those who consume any animal flesh)

2. Do you know anyone who is vegan?

Yes

No

3. If you know anyone who is vegan, how long have you known them as a vegan (if you know more than one, answer using the one you have known as a vegan the longest)?

_____

4. Have you previously followed a vegan diet?

Yes, and I have been since starting.

Yes, and I am now after taking a break.

Yes, but I am no longer a vegan.

No.

5. Have you previously followed a vegetarian diet?

Yes, and I have been since starting.

Yes, and I am now after taking a break.

Yes, but I am no longer a vegetarian.

No.

6. Do you have any dietary restrictions other than those listed above?

_____

7. Do you have any food allergies?

_____

8. Are any of your family members vegan?

Yes

No

9. Are any of your family members vegetarian?

Yes

No

10. Do you think you could convince someone who is vegan that you are also a vegan?

Yes

No

Maybe

I don't know

*Definitions of dietary preferences in order of decreasing strictness:

Vegan – does not consume or use any products or foods derived from animals (including all meat, fish, poultry, dairy, eggs, cheese, honey, gelatin, and other products with animal origins)

<u>People below this line should not indicate in the survey that they are vegan.</u>

Vegetarian – does not consumer or use any products or foods that come from animal flesh.

Ovo-vegetarian – vegetarian who consumes eggs, but not dairy.

Lacto-vegetarian – vegetarian who consumes dairy, but not eggs.

Ovo-lacto vegetarian – same as vegetarian above.

<u>People below this line should not indicate in the survey that they are vegetarian. They should indicate that they are omnivores.</u>

Pescatarian – vegetarian who eats fish or other seafood but not red meat or poultry.

Flexitarian – omnivore who eats primarily plants, but occasionally eats meat

Omnivore – person who eats meat and plants

APPENDIX E

IRB EXEMPT APPROVAL LETTER

ASU Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	Thomas Seager ISTB4
From:	Mark Roosa, Chair Soc Beh IRB
Date:	03/01/2013
Committee Action:	**Exemption Granted**
IRB Action Date:	03/01/2013
IRB Protocol #:	1302008879
Study Title:	Test of Ubiquitous through Real / Interactional Expertise (TURINEX)

The above-referenced protocol is considered exempt after review by the Institutional Review Board pursuant to Federal regulations, 45 CFR Part 46.101(b)(2) .

This part of the federal regulations requires that the information be recorded by investigators in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects. It is necessary that the information obtained not be such that if disclosed outside the research, it could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

You should retain a copy of this letter for your records.

APPENDIX F

TRANSCRIPTS FROM TURINEX TESTING

Transcripts are altered to remove any identifying information and preserve confidentiality in accordance with IRB exempt guidelines.

Unless otherwise noted, the TURINEX sessions transcribed here involved 2 vegans, a vegetarian and an omnivore. The judge is always a vegan. All dietary preferences are self-identified in demographic data provided by the respondents in response to a survey, which provides definitions for vegan, vegetarian and omnivore.

Text immediately following identifiers such as “Q#”, “R#”, or “reasons” and in *italics* is from original transcripts. Other text is notes from analysis or logistical information. Judgments are selected by judges through clicking a radial button indicating the expertise level and another indicating their confidence on a 1 to 5 scale, with 5 being the highest.

Note regarding misspelling: Any incorrect grammar, punctuation, or spelling is left intact from original transcripts when reported here. Typographical errors in transcripts are not corrected but left intact because they might have influenced judgment. Variations in formatting and references to the judge and respondents are due to changes in the software output over the course of its development.

Transcripts start below:

Test One: Respondent 1 is vegan, respondent 2 is vegetarian, and respondent 3 is omnivore.

First Question (Q1): *What restaurants do you go to when you go out to dinner?*

Expected answer type: Specific restaurant or chain, perhaps type of restaurant

Shared reality: Restaurants appropriate for vegans exist, vegans visit such restaurants

Cause and effect: Veganism determines restaurant choice.

Themes: food choice, food preparation, social situations, special occasions

Tacit or explicit: Both. Web search could provide explicit information about popular vegan restaurants, but tacit knowledge required to know that vegans prefer vegan restaurants to vegan options at mainstream restaurants. This can be culturally biased because vegan restaurants are not present everywhere.

Respondent 1 (R1) (vegan): *Green New American Vegetarian, zPizza, Loving Hut*
Judgment (J): Expert 4

This judgment indicates a rating of expert / vegan, with a confidence rating of 4 out of 5.

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit information given as an answer, but reflects tacit knowledge of popular local vegan restaurants. Includes one vegan friendly, but not all vegan, restaurant, which is realistic since vegans don’t exclusively eat at vegan restaurants.

Respondent 2 (R2) (vegetarian): *Vegan restaurants*
J: None 5

This judgment indicates a rating of not expert / omnivore, with a confidence rating of 5 out of 5.

Matches expected answer type? No. Not a specific restaurant, too vague to be a type of restaurant.

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit information given as an answer, but is very vague and requires no tacit knowledge to provide the answer. It could be interpreted as a joke answer, but not one an insider (vegan) would make.

Respondent 3 (R3) (omnivore): *Big Bowl Asian Kitchen, Café Rio, Spaghetti Factory*
J: Intermediate 4

This judgment indicates a rating of interactional competence / vegetarian, with a confidence rating of 4 out of 5

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit information given as an answer, but specific restaurants are all not vegan, and might not even be vegan friendly. This list shows the incorrect assumption that vegans will be able to and happy to eat anywhere omnivores do.

Q2: *What are you going to have for dinner tonight?*

Expected answer type: Specific food type, dish or menu item

Shared reality: Vegans plan dinner or can at least think of a dinner they would like to have. If respondents did not match this shared reality they might think that vegans don't plan ahead or don't enjoy eating.

Cause and effect: Vegan dinners require planning

Themes: Food choice, food preparation, lifestyle

Tacit or explicit: Both. Web search could provide explicit information about vegan recipes, but tacit knowledge required to know what a normal vegan dinner might look like, since not all vegans will make recipes they find online every night – sometimes they want a simple or easy to make dinner.

R1: *I'm going to put some carrots, zucchini, bell pepper, garlic, and ginger in a wok with some tempeh and stir-fry it with some peanut sauce, and have some brown rice.*
J: Expert 5

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Includes ingredients list as if from recipe, but leaves out things a recipe wouldn't like oil, heat, and other specifics that someone with tacit knowledge would know to include automatically. Therefore, despite being explicit information, this reflects tacit knowledge in that it didn't need to include those specifics. It also mentions a common vegan meat alternative most omnivores are not familiar with.

R2: *I like Mexican food a lot. I'll probably make a Mexican salad or stew tonight.*
J: None 5

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit – states a desire for a type of cuisine, then mentions possibilities for meals in that type. Doesn't mention the frequent use of meat and cheese in Mexican cuisine and how they plant to substitute for those ingredients.

R3: *Don't know, I haven't* [sic] *planned it yet. But I love Baked Potaotes* [sic] *with either corn or green beans.*
J: Intermediate 4

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit – states that they do not have a plan, but mentions items they might eat.

Q3: *Do you like going to the zoo?*

Expected answer type: Yes or no answer with explanation

Shared reality: Zoos present a potential ethical challenge for vegans

Cause and effect: Animal confinement and possible mistreatment, as well as zoo practices and exploitation of animals for entertainment are potential ethical violations for vegans.

Themes: Lifestyle, entertainment, social situations, special occasions, ethical choices

Tacit or explicit: Tacit. Veganism doesn't have a strict rule about zoos that forbids going there, but many vegans have compassion for the animals and feel guilt for contributing to their continued captivity. Some may even object to zoos feeding the animals meat, or serving meat on the property.

R1: *I do... I try to only visit zoos that I know rescue animals who cannot be re-released due to age or injury, versus zoos that breed or capture animals just for human entertainment.*
J: None 3

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Ellipsis after "I do" indicates hesitation, followed by a justification for why they go despite their hesitation. Indicates a desire to support help for the animals rather than enjoy them for entertainment.

R2: *I love the variety of animals present at the zoo and the preservation of endangered animals; although, I don't like the way they are treated. Typically animals are held in exhibits that are too small for them (causing mental and physical trauma to the animals), or humans manipulate their power over the animals maliciously. I don't like this abuse of power and the imprisonment of animals for the sake of human curiousity and entertainment.*
J: None 4

Matches expected answer type? No. Not an explicit answer of yes or no.

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit. Lists reasons why they object to zoos.

R3: *Not particularly. I do think some zoos do a good job helping sustain endangered species. And it's expensive, so there's another reason.*
J: Intermediate 4

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? No. Doesn't address ethical concerns against zoos.

Tacit or explicit: Explicit. Despite the short answer and conflicting reasons, the answer didn't show evidence of picking up on the tacit reasons why vegans would not go to a zoo.

Q4: *Would you purchase a watch with a leather band?*

Expected answer type: Yes or no answer with explanation

Shared reality: Leather is an animal product, and vegans typically avoid wearing animal products

Cause and effect: Leather is part of an animal and a byproduct of the meat industry, so vegans avoid it.

Themes: Lifestyle, fashion, purchases (non-food), ethical choices

Tacit or explicit: Explicit. Veganism explicitly requires people to not consume or wear animal products. An argument could be made for second-hand leather not harming animals directly, or a health-motivated vegan might not care, but this should be a straightforward answer for any vegan.

R1: *Nope.*
J: Expert 4

Matches expected answer type? Partially

Matches shared reality? Unknown – not enough detail

Matches cause and effect? Unknown – not enough detail

Tacit or explicit: Explicit. There is no doubt in this person's answer.

R2*: I actually own a Vegan wristwatch (composed of plastic). It was sort of pricey in my opinion, but worth it. I also considered purchasing a vegan leather watch, but chose the plastic watch for aesthetic appeal.*
J: None 5

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Unknown – not enough detail

Tacit or explicit: Tacit. They do not explicitly answer the question, so the judge has to infer that they would or wouldn't buy a leather watch based on their answer.

R3: *If its fake leather. Otherwise, no.*
J: Intermediate 4

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Unknown – not enough detail

Tacit or explicit: Explicit. There is a direct answer to the question.

Q5: *What kind of toothpaste do you use?*

Expected answer type: Brand or format of toothpaste, possibly with explanation

Shared reality: Vegans maintain oral hygiene, but consider implications of toothpaste choice for veganism.

Cause and effect: Toothpaste can have animal ingredients or may have utilized animal testing.

Themes: Lifestyle, purchases (non-food), hygiene

Tacit or explicit: Tacit. Some toothpaste may be a product of animal testing, which is not forbidden in a vegan diet, but it is against vegan norms of preventing animal suffering.

R1: *Eco-Dent tooth powder.*
J: None 3

Matches expected answer type? Yes

Matches shared reality? Unknown – not enough detail

Matches cause and effect? Unknown – not enough detail

Tacit or explicit: Explicit. They provide a straightforward answer.

R2: *Neem toothpaste (with Pomegranate - tasty!*
J: Expert 3

Matches expected answer type? Yes

Matches shared reality? Unknown – not enough detail

Matches cause and effect? Unknown – not enough detail

Tacit or explicit: Explicit. They provide a straightforward answer.

R3: *Baking soda and salt mostly. I like the Natural Dentist, but its expensive, so I don't get it very often. They have it at Whole Foods.*
J: Intermediate 3

Matches expected answer type? Yes

Matches shared reality? Unknown – not enough detail

Matches cause and effect? Unknown – not enough detail

Tacit or explicit: Explicit. They explain what they use and why they prefer one or the other.

Q6: *How do you get the calcium you need?*

Expected answer type: Food, beverage, or supplement source of calcium

Shared reality: Calcium intake is a common concern for vegans and they make an effort to ensure adequate supply

Cause and effect: Avoiding dairy products is considered by some to reduce calcium intake, so it is necessary to seek calcium from other sources.

Themes: Nutrition, food choice, health

Tacit or explicit: Explicit. Vegan sources of calcium are easily found using a web search.

R1: *Most of my vegan milks are fortified, and I also take a Deva calcium and magnesium supplement.*
J: Expert 3

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit. This is a straightforward answer.

R2: *It sounds gross, but I mix molasses and water to get my iron and calcium. Otherwise I drink this really yummy enriched Chocolate Rice Dream Milk, or add a salad to the menu.*
J: None 3

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit. They provide several detailed options for how they get calcium.

R3: *Calcium enriched Orange Juice, beans, Broccolli, and brussell sprouts. They taste good on sandwiches. I hate Soy Milk.*
J: Intermediate 4

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit. They list several sources of calcium, as well as one they know of but dislike.

Final Determinations: At the end of the session the judge is asked to make an overall determination, rating each respondent based on the entire session and providing an explanation for their judgments.

Respondent 1: Expert -> 3

Reasons: *Resturants, dinner tonight*

I hesitate because of their response to zoos

Judge is correct – Respondent 1 is vegan. The judge's reasoning includes food choice and preparation, social situations, entertainment, and lifestyle choices.

Respondent 2: None -> 3

Reasons: *Their response to Question 1 was too vague to be believable, I think Mexican food has a lot of meat in everything*

My confidence is 3 because their response to the zoo question was thorough & believable, their toothpaste response was believable

Judge is incorrect – Respondent 2 is vegetarian. The judge's reasoning includes food choice and preparation, health and hygiene, social situations, entertainment and lifestyle choices.

Respondent 3: Intermediate -> 4

Reasons: *This person eats at normal resturants*

Judge is incorrect – respondent 3 is omnivore. The judge's reasoning includes food choice and preparation, and social situations.

Interpretation of session: R1 was a long term vegan. R2 was a vegetarian who knew a vegan less than a year and attempted to eat somewhat vegan. R3 was an omnivore who knew a vegan less than a year and had no dietary restrictions. R1's response to zoos threw off the judge as it does not reflect common vegan views, but they still correctly determined that they were vegan. R2's eccentric choices and vague answers reduced the judges confidence in them, resulting in the incorrect ranking of omnivore. The detailed responses for zoos and toothpaste from R3 convinced the judge they were intermediate. Overall this judge considers veganism a commitment across all parts of life, but recognizes that it presents some difficulties and gray areas. The confidence in their final determinations was not very high.

Question total: 6

Theme counts from session: Food choice (3), food preparation (2), social situations (2), special occasions (2), lifestyle (4), entertainment (1), ethical choices (2), fashion (1), non-food purchases (2), hygiene (1), nutrition (1), health (1). This judge had a fairly even spread among categories, with a slight emphasis on lifestyle, divided into entertainment, fashion, and hygiene, with the remaining questions focused on food. Revision to themes based on aggregation results in "ethical choices" categorized as "ethics", "nutrition" and "hygiene" are added to "health", "non-food purchases" and "entertainment" are added to "lifestyle", and "special occasions" is added to "social situations".

Second test: Standard setup. Respondent 1 is omnivore, respondent 2 is vegetarian, and respondent 3 is vegan.

QUESTION 1: *What was the last non-vegan food you gave up before going 100% vegan?*

Expected answer type: A specific non-vegan food.

Shared reality: Most vegans started as vegetarians or omnivores, and will remember the last non vegan food they ate before becoming vegan.

Cause and effect: Transitioning from vegetarian or omnivore to vegan involves eating one last non vegan food product before being fully vegan. Conscious decision to go vegan might make people remember it.

Themes: Food choice, sacrifice, omnivore knowledge

Tacit or explicit: Tacit. Easy to find non-vegan foods to answer with, but a believable answer depends on experience.

RESPONSE 1 (omnivore): *Milk. I just couldn't stand the substitutes. I've gotten used to them though.*

intermediate : 3

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit. This is a simple answer but doesn't refer to tacit elements such as taste or texture.

RESPONSE 2 (vegetarian): *Cheese!*

intermediate : 4

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit. This is a simple answer. The exclamation point implies they still love cheese, but give it up for veganism.

RESPONSE 3 (vegan): *Milk/cheese.*

none : 4

Matches expected answer type? Yes

Matches shared reality? Yes

Matches cause and effect? Yes

Tacit or explicit: Explicit. This is a simple answer, but doesn't refer to tacit elements.

QUESTION 2: *When you first went vegan, what product were you the most excited to find/try?*

Expected answer type: A specific vegan food or type of food.

Shared reality: Most omnivores don’t bother seeking out vegan products, but after going vegan people explore alternatives.

Cause and effect: Omnivores that go vegan will either miss things they used to eat or want to find more enjoyable foods than the vegan food they used to eat by coincidence. They will be excited to try these.

Themes: Food choice, emotion, new experiences, vegan products

Tacit or explicit: Explicit and tacit. Many vegan oriented products exist, but what is exciting for someone is a tacit experience.

RESPONSE 1: *Tofu. I had never tried it before. I tried it before I went, and it was alright. If I didn't like it, it would have been a deal-breaker.*

none : 3

Matches expected answer type? Yes

Matches shared reality? No. This person already had the vegan product before going vegan.

Matches cause and effect? No. They decided to try the new food to decide if they would go vegan.

Tacit or explicit: Explicit. The answer doesn’t mention any tacit elements.

RESPONSE 2: *Well before being a vegan I dabbled in the Amy's product line...A LOT. I still enjoy their non-dairy or black bean burritos and vegan pot pie a lot. Now that I think about it, I might have one for dinner tonight.*

intermediate : 3

Matches expected answer type? Yes

Matches shared reality? No. This person already had the vegan product before going vegan.

Matches cause and effect? No. This person used to eat the vegan product anyway.

Tacit or explicit: Explicit. The answer doesn’t talk about what they like in the product line or why.

RESPONSE 3: *I was most excited to find Chow Share. Of course we knew of CSA's before but we were excited to have local in-season food with recipies included that are vegan or can easily be made vegan. Oh & the vegan parmesean cheese at Whole Foods...mmmmmmm!*

intermediate : 3

Matches expected answer type? No. They mention a service rather than food.

Matches shared reality? Yes. They sought alternatives after going vegan, even within the same service.

Matches cause and effect? Yes.

Tacit or explicit: Explicit and tacit. Rather than a food, this response mentions a service as the main answer. It also mentions why it was exciting, and also indicates their enjoyment of vegan parmesan cheese with “mmmmmmm!”

QUESTION 3: *What non-vegan food is there no good vegan substitute for yet?*

Expected answer type: A specific vegan food or type of food that replaces a non-vegan food.

Shared reality: Vegans eat products intended to replace animal-based foods.

Cause and effect: Omnivores are used to eating animal-based foods, so when they go vegan they want to find similar tastes or functionality in a vegan alternative.

Themes: Food choice, sacrifice, vegan products, sensory experiences

Tacit or explicit: Tacit. There are vegan products intended to replace just about everything made from animals, but some are far better than others, and this requires a sensory experience and subjective interpretation.

RESPONSE 1*: In my opinion, Milk.*

none : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. The response acknowledges that it is a subjective matter.

RESPONSE 2: *Cheese. Cheese. Cheese. Oh have I mentioned Cheese yet?*

intermediate : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. The response is intended to show enthusiasm in their answer.

RESPONSE 3: *cheese! I am kind of on the fence about that though. I was vegetarian since 2001 & since we became vegan I think our foods have become much more exciting tasting. Cheese kind of limits how much you experiment since you just throw it on everything.*

intermediate : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. The response includes description of an experience they shared with an implied partner regarding cheese and living without it.

QUESTION 4: *What is your favorite fast food treat?*

Expected answer type: A fast food item, or possibly a fast food restaurant the respondent likes.

Shared reality: Vegans also eat fast food for a variety of reasons.

Cause and effect: Being vegan doesn't automatically increase time available for food preparation or make it easier, so sometimes vegans go out to eat at fast food places that provide vegan options.

Themes: Food choice, convenience, lifestyle, social situations.

Tacit or explicit: Explicit and tacit. Fast food chains typically have ingredient lists online, but many do not specify shared fryer or cooking surfaces or not, which is of concern for vegans worried about cross-contamination.

RESPONSE 1: *Chipotle has some pretty good options for their burrito bowls.*

none : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit or explicit: Explicit. Calls out Chipotle as a chain they enjoy for burrito bowls.

RESPONSE 2: *I try my best to avoid fast food at all costs - it can be pretty disgusting. If I had to eat something from a fast food restaurant, I'd probably settle for a bean burrito from Taco Bell with their fire sauce.*

intermediate : 3

Matches expected answer type? Yes.

Matches shared reality? No. They avoid fast food at all costs.

Matches cause and effect? No. They must be able to eat elsewhere instead.

Tacit or explicit: Explicit and tacit. Expresses disgust with fast food, but also mentions an item they would eat.

RESPONSE 3: *Umm..fast food? I consider Green to be "fast food" so I guess that would be it.*

expert : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit or explicit: Tacit. The response indicates the subjective nature of the question. The judge also had to know what “Green” was. In this case it was Green New American Vegetarian Restaurant.

QUESTION 5: *Describe the texture and/or consistency of seitan in at least 3 words.*

Expected answer type: 3 words or more describing seitan.

Shared reality: Most vegans have eaten seitan

Cause and effect: The majority of fake meat is made with soy or wheat. The wheat protein is seitan. So, if a person has had much fake meat they have eaten seitan.

Themes: Food choice, food preparation, sensory experiences

Tacit or explicit: Tacit. Describing seitan’s texture and/or consistency requires tacit knowledge as it is a sensory experience.

RESPONSE 1: *I make it at home, and it turns out kinda spongy, like Meatloaf.*

none : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. The answer refers to another food item and uses a sensory experience word to describe seitan.

RESPONSE 2: *I've never had seitan. I try to avoid the artificial, processed "meats" (like tofu etc.) on the market - I prefer a plant-based diet.*

intermediate : 2

Matches expected answer type? No.

Matches shared reality? No.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Their response indicates they've never had seitan.

RESPONSE 3: *I make the seitan I use so I think the texture is a little different from store bought stuff. So mine is..rubbery, stinks like meat, and does not roll out very easily.*

intermediate : 2

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. The answer uses two sensory experience words to describe seitan and compares their home made product to store bought.

QUESTION 6: *What vegan product tastes the most like the non-vegan product it is trying to mimick/replace?*

Expected answer type: A specific vegan product replicating a non-vegan product

Shared reality: Most vegans have had non-vegan products as vegetarians or omnivores, and have tried replacements for those products.

Cause and effect: Many vegan products attempt to replicate animal products, and vegans who are previous omnivores compare these with their memory of non-vegan products.

Themes: Food choice, vegan products, sensory experiences

Tacit or explicit: Tacit. There are vegan products intended to replace just about everything made from animals, but some are far better than others, and this requires a sensory experience and subjective interpretation.

RESPONSE 1: *Vegan Margarine. Earth Balance makes a good one.*

intermediate : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. No sensory description.

RESPONSE 2: *I feel like rice milk does a pretty good job. It's a little watery in comparison, but at least the taste is correct!*

intermediate : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. They describe the taste and texture and compare to the original product.

RESPONSE 3: *Honestly, I don't know. We try to eat fresh unprocessed foods & since I haven't tasted meat since 2001 I don't really remember what it tastes like enough to compare. They all seem to do a pretty good job at being yummy though!*

intermediate : 3

Matches expected answer type? No. They don't describe a vegan product.

Matches shared reality? No. They haven't tried vegan products to replace animal products.

Matches cause and effect? No. They don't think they remember the taste of meat well enough to compare.

Tacit or explicit: Tacit. They subjectively assert that their food is yummy.

QUESTION 7: *If you wanted to grill a tasty vegan protein, would you choose tofu or tempeh, and why?*

Expected answer type: Tofu or tempeh and an explanation of why one is better for grilling.

Shared reality: Most vegans have tried tofu or tempeh, and understand how they would grill.

Cause and effect: Tofu and tempeh are the two most common basic soy protein meat alternatives, and both are suitable for grilling if prepared correctly.

Themes: Food choice, food preparation, vegan products, sensory experiences

Tacit or explicit: Tacit. Knowing how these products react to grilling and how best to grill them is based on experience.

RESPONSE 1: *Tempeh. I'm too lazy to press Tofu right.*

intermediate : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. They mention the need to press tofu before grilling, and that there is a fine art to it that is easy to get wrong. Someone who hasn't pressed tofu might not understand what laziness has to do with pressing it "right".

RESPONSE 2: *To be honest, I stick with the plant-based/raw diet. So on this occasion, I would grill a mushroom. It's not a ton of protein, but it's the closest substitute to a real burger.*

expert : 3

Matches expected answer type? No. They chose a mushroom instead.

Matches shared reality? No. They don't eat tempeh or tofu.

Matches cause and effect? Unknown – not enough detail.

Tacit or explicit: Tacit. They argue that a mushroom is closest to a burger.

RESPONSE 3: *Grill? If you actually mean on a grill, I would imagine tempeh would hold together better. Tofu is more of a frying thing huh? Sorry I don't grill often.*

intermediate : 3

Matches expected answer type? Yes.

Matches shared reality? No. Hasn't grilled and isn't sure how the products would hold up on a grill.

Matches cause and effect? No. Doesn't think tofu can be grilled.

Tacit or explicit: Tacit. They mention the consistency of tempeh being better for grilling and tofu better for frying.

Final Determinations:

Respondent 1:

None -> 5

Answers were vague, gave milk for several reasons and as a vegan expert I personally feel milk is very easily replaced.

Judge was correct – respondent was an omnivore. The judge's reasoning included food choice, sensory experiences, and being vague.

Respondent 2:

Expert -> 4

Their answers sound like a raw foodie, which would be vegan..

Judge was incorrect – respondent was a vegetarian. The judge's reasoning included food choice, food preparation, and lifestyle.

Respondent 3:

Intermediate -> 4

Sounds like a typical food-loving vegetarian, and mentioned being vegetarian "previously." Also, as a vegan expert I have not heard of the vegan parmesean cheese at Whole Foods.

Judge was incorrect – respondent was a vegan. The judge's reasoning included food choice, lifestyle, explicit information, and vegan food products.

Interpretation of session: R1 was omnivore whose only exposure to veganism they knew someone for less than a year, R2 was vegetarian who knew a vegan less than a year that eats a mainly plant-based diet, and R3 was vegan, who knew a vegan for 15 years. The judge doubted R1 because they did not demonstrate the judge's tacit knowledge that milk substitutes are common and suitable replacements for real milk. Their responses regarding food choice and sensory experiences further convinced the judge that they were an omnivore, which was correct. R2 threw off the judge by giving several answers which did not fit their expectations, view of reality of cause and effect. However, the answers made them think they were a raw foodie, which the judge associated with a brand of veganism. While this is true, in this case the respondent was a vegetarian, which is also a common dietary preference for raw foodies. However, the overlapping tacit knowledge was sufficient to convince the judge that they were vegan. R3 had

some experiences expressed that were not familiar to the judge, which although legitimate vegan experiences where different than those of the judge. It was only enough to convince the judge they were vegetarian. Overall this judge looked for responses that best matched their vegan experience, rather than what they imagined vegans could be like. Because of this, they made a mistake in judging a vegan and vegetarian and vice-versa. The omnivore was clear to them though. The confidence in their final determinations was fairly high.

Question total: 7

Theme counts from session: Food choice (7), sacrifice (2), omnivore knowledge (1), emotion (1), new experiences (1), vegan products (4), sensory experiences (4), convenience (1), lifestyle (1), social situations (1), food preparation (2). This judge had a heavy emphasis on food choice and sensory experiences, but covered a wide variety of categories. Aggregation of themes results in “omnivore knowledge” reclassified as “interacting with omnivores”.

Session 3. Standard setup. Respondent 1 is omnivore, respondent 2 is vegetarian, and respondent 3 is vegan.

Respondent 1: omnivore. No notable restrictions, but knew a vegan almost 2 years.

Respondent 2: vegetarian. Knew a vegan 2 years. Lived in India.

Respondent 3: Vegan for 9 years. Knew a vegan 9 years. Also gluten-free.

QUESTION 1: How would you ensure that food you ordered in a restaurant was vegan?

Expected answer type: Method to ensure food ordered at a restaurant is vegan.

Shared reality: When vegans eat at restaurants they want to make sure they are eating vegan food.

Cause and effect: Shared surfaces, hidden ingredients and other practices make it possible that a menu item that sounds vegan will in fact not be vegan. Vegans would like to prevent this.

Themes: Food choice, social situations, interacting with omnivores

Tacit or explicit: Tacit. There are several possible methods, but a balance must be struck between too much effort and not enough, or the vegan risks either upsetting the waiter or company they are with, or eating non-vegan food.

RESPONSE 1: *There are several options. You could ask for an ingredient list, inform the waiter/waitress you are highly allergic to various foods, etc. Additionally, knowing ahead of time that the restaurant in question has a good reputation for serving vegan food.*

expert : 5

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Lists several options including one that is not intuitively obvious – allergic reactions.

RESPONSE 2: *By asking the waier/waitress whether the dishes that I wish to order have any dairy products/animal derivatives in any form (e.g. cheese, cod liver oil, diary products)*

intermediate : 4

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? No. Only mentions dairy and animal products in the dish, not the potential for cross-contamination on shared cooking surfaces.

Tacit or explicit: Explicit. It's a simple request to the server without acknowledging that the waiter may not know or care. Also strange to mention cod liver oil, not a common ingredient at a restaurant.

RESPONSE 3: *I would be selective about what restaurant I chose to eat at, and then ask the waiter/ess for assistance with the menu. If the waiter/ess was clueless, I would ask to speak with a chef.*

intermediate : 4

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Acknowledges that the server can be unhelpful, and that the chef will know exactly what's in a dish and how it's prepared.

QUESTION 2: *Where do you get your protein?*

Expected answer type: Vegan source of protein.

Shared reality: Vegans require protein and must ensure they have an adequate supply in their diet.

Cause and effect: Every vegan is asked this at some point, usually many times by different people. Therefore even if they don't care about it, they will have had to answer this question before.

Themes: Food choice, nutrition, interacting with omnivores

Tacit or explicit: Tacit. Many sources of protein exist, but there are certain foods with protein that are mainly eaten by vegans, which an omnivore might not think of. Also this may be considered an insider joke since vegans are asked this so much.

RESPONSE 1: *Legumes, soy products, peanuts.*

none : 4

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Sounds like an answer from a website, especially "legumes". Doesn't elaborate on soy products.

RESPONSE 2: *Mushrooms, Soy*

intermediate : 4

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Just lists two items, does not elaborate on soy.

RESPONSE 3: *Soy products such as tempeh and tofu, as well as nuts, seeds, and legumes.*

expert : 5

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Provides examples of soy products rather than leaving it open-ended.

QUESTION 3: *Would you date someone who wasn't vegan? Why or why not?*

Expected answer type: Yes or no answer with explanation.

Shared reality: There are enough vegans in the world to date just other vegans, but many potential partners are omnivores.

Cause and effect: Ethical reasons for being vegan might make omnivores repulsive to some vegans, but health reasons for being vegan might not.

Themes: Dating, relationships, interacting with omnivores, social situations

Tacit or explicit: Tacit. Asks for an explanation. Also, there is no rule in veganism about how you may interact with other people, including dating.

RESPONSE 1: *yes, but it would make cooking more difficult, to ensure that there was no cross-contamination. Additionally, I could introduce that person to a style of food with which they may not be familiar*

none : 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Acknowledges the problem of cross-contamination and describes an opportunity to share vegan cooking.

RESPONSE 2: *I wil date a person irrespective of their dietary choices .According to me, a person's dietary choice is personal and should not influence dating choices.*

intermediate : 5

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. This response is a clear personal philosophical view on dating, with no concern for veganism.

RESPONSE 3: *No, kissing someone who at meat would be gross!*

expert : 5

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. The idea of gross is subjective, and a reaction to the physical experience of kissing an omnivore is a feeling, not a description.

QUESTION 4: *How would you respond if an omnivore realized you're vegan and started talking about anything in their life that relates - they used to be vegetarian, or they want to be, or they have a friend who is, etc. ?*

Expected answer type: Description of an emotional or intellectual reaction and perhaps a verbal or physical response.

Shared reality: Omnivores are curious about vegans.

Cause and effect: Most vegans encounter people who try to relate their experiences to the vegan's in an attempt to either make sense of the person or make them seem more compatible or likeable.

Themes: Interacting with omnivores, social situations, relationships

Tacit or explicit: Tacit. This is something that does not have a correct answer, and can't easily be found online. However, it is a common experience for vegans.

RESPONSE 1: *If it was an actual conversation, where that person was curious, then I would engage in that conversation. If, on the other hand, they were simply going on about said event, I would simply proceed politely until the opportunity to change the subject arose.*

none : 5

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Doesn't provide explanation of motivation for reactions or how conversation might proceed.

RESPONSE 2: *I would ask them if there was any impact of these events/facts on their current eating choices (eg if his friend told him about cruelty in the meat industry or increased risks of exposure to diseases like the mad cow). If he says he was not ipacted then I would follow up with questions on why he/she is indifferent to these issues and posssible alternatives to eating healthier.*

Again, I would only enquire without trying to enforce my view points on Veganism.

intermediate : 5

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Provides several steps in conversation advancing a personal agenda of veganism, but notes that they would not force their views on the other person.

RESPONSE 3: *I'd listen, smile, and nod, and maybe ask them why they stopped eating vegan or what their favorite vegan foods were or still are.*

expert : 5

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Describes physical reaction and potential follow up questions to encourage reflection.

Final Determinations:

Respondent 1:

None -> 5

Citing legumes as protein - common on websites, but most people don't talk about legumes. Cross-contamination concern doesn't seem like a typical vegan. Talking with a person based on genuine conversation or not seems like a normal person thing to do, but I think vegans are usually more tolerant even if it seems fake.

Judge was correct – respondent was omnivore. Judge used reasons including food choice and interactions with omnivores, and seemed to think R1 was too uptight to be vegan.

Respondent 2:

Intermediate -> 5

Asking waitress is a classic move, but there is confidence that they will know for sure. A vegan knows there is variation. Mushrooms and soy are common, but not specific. Dietary choice question not helpful for this person. Asking about meat industry reflects vegetarian priorities, not vegan.

Judge was correct – respondent was vegetarian. Judge used reasons including food choice and interactions with omnivores, and thought the responses reflected vegetarian priorities and experiences, not vegan. It's easy to make sure there's no meat in a dish by asking a server, but a lot harder to make sure it's vegan. Also, concern with just the meat industry ignores the connected dairy and egg industries, not to mention other vegetarian but not vegan products like honey.

Respondent 3:

Expert -> 5

Choosy about restaurant, skeptical of waitress - both typical vegan practices. Mentioned tempeh, a very vegan product. Mentioned legumes last - didn't even notice until now. Mentioned a physical experience for why not to date non-vegans. Assumption that they would be a meat eater, but still valid. Polite response and steering conversation to positive areas would be vegan actions.

Judge was correct – respondent was vegan. Judge used reasons including interactions with omnivores, food choice, and personal physical experiences.

Interpretation of session: R1 was omnivore whose only exposure to veganism they knew someone for almost 2 years and had no dietary restrictions, R2 was vegetarian who knew a vegan 2 years and lived in India, and R3 was vegan, who knew a vegan for 9 years and was gluten free. The judge doubted R1 because they seemed uptight and gave some answers that sounded like they were from a website. The judge thought R2 was a vegetarian because of priorities reflected in their answers, such as concern with the meat industry and confidence in the abilities of servers. The judge believed R3 because they were skeptical and provided several believable responses that utilized tacit knowledge, such as the reaction to dating omnivores and having conversations with omnivores.

Question total: 4

Theme counts from session: Food choice (2), interacting with omnivores (4), relationships (2), dating (1), social situations (3), nutrition (1). This judge had a fairly even spread, but emphasis on interactions with people and intimate relationships. Aggregation of themes results in "dating" added to "relationships" and "nutrition" reclassified as "health".

Session 4. Standard setup. R1 is vegan, R2 is vegetarian and R3 is omnivore.

R1: vegan with 9 years knowing a vegan and gluten free.

R2: vegetarian who does not know a vegan and lives in India.

R3: omnivore who knew a vegan 27 years with no dietary restrictions.

QUESTION 1: *Where do you get your protein?*

Expected answer type: Vegan source of protein.

Shared reality: Vegans require protein and must ensure they have an adequate supply in their diet.

Cause and effect: Every vegan is asked this at some point, usually many times by different people. Therefore even if they don't care about it, they will have had to answer this question before.

Themes: Food choice, nutrition, interacting with omnivores

Tacit or explicit: Tacit. Many sources of protein exist, but there are certain foods with protein that are mainly eaten by vegans, which an omnivore might not think of. Also this may be considered an insider joke since vegans are asked this so much.

Ans1: *Mainly from tofu and soy products like tempeh, but also from some veggies and nut butters*

EXPERT -> 4

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Simple list of typical products.

Ans2: *Vegetables, chick peas, apples, breads*

NONE -> 4

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Simple list of products, but apples which are low in protein are a strange choice.

Ans3: *I get protein from tofu, edamame, nuts, and beans of many types.*

INTERMEDIATE -> 4

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Simple list of typical products.

QUESTION 2: *When you go out to eat, where do you usually like to go?*

Expected answer type: Specific restaurant or chain, or other eatery.

Shared reality: Eateries appropriate for vegans exist, vegans visit such establishments

Cause and effect: Veganism determines food choice and therefore eatery choice.

Themes: food choice, food preparation, social situations, special occasions

Tacit or explicit: Both. Web search could provide explicit information about popular vegan eateries, but tacit knowledge required to know that vegans prefer vegan establishments to vegan options at mainstream eateries. This can be culturally biased because vegan options are not present everywhere.

Ans1: *I can usually find something at any restaurant, but prefer ones that cater to vegans*

INTERMEDIATE -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Implies that they can go to most restaurants and find something vegan.

Ans2: *A restaurant that has a South Indian cuisine.*

EXPERT -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Identifies a specific cuisine and nothing more.

Ans3: *I like to eat at organic restaurants that serve mostly vegan and vegetarian food options. Sometimes farmer's markets have good choices, too.*

INTERMEDIATE -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Points out that farmers' markets have vegan options for eating out.

Question 3: *How do you get the RDA of calcium?*

Expected answer type: Vegan food products or supplements that provide calcium.

Shared reality: Vegans require calcium and must ensure they have an adequate supply in their diet.

Cause and effect: Every vegan is asked this at some point, usually many times by different people. Therefore even if they don't care about it, they will have had to answer this question before.

Tacit or explicit: Tacit. Many options for getting calcium, but some are more common for vegans. Also, RDA is not spelled out, so the respondent must interpret this as recommended daily allowance to understand the question correctly.

Themes: Food choice, nutrition, interacting with omnivores.

Ans1: *I drink fortified soymilk and eat lots of green veggies, so I think that gets me enough*

INTERMEDIATE -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Expresses some doubt regarding whether or not they get enough calcium.

Ans2: *Spinach, Orange Juice, Beans and other vegetables*

NONE -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Just a list of food items with calcium or fortified with calcium (orange juice).

Ans3: *Many milk alternative drinks, such as almond, rice, and soy milks are calcium-fortified. Even orange juice is fortified with calcium. I also get calcium from green leafy vegetables.*

EXPERT ->3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. As if reacting to an omnivore asking the question, this respondent points out that milk alternatives and orange juice are fortified with calcium.

Question 4: *What is your favorite vegan meat substitute brand name?*

Expected answer type: Brand name of a vegan meat substitute and maybe an explanation for why.

Shared reality: Vegans have particular brands that they prefer over others.

Cause and effect: Vegans eat fake meat, and sometimes discover products they like better, leading to loyalty to a brand name.

Tacit or explicit: Tacit. There are many vegan products, but knowing the brand name and providing a good reason for the loyalty is based on personal experience.

Themes: Food choice, vegan products, brand name

Ans1: *Tofurky*

INTERMEDIATE -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Just the brand name.

Ans2: *Not applicable. I don't use any vegan meat substitute.*

NONE -> 3

Matches expected answer type? No.

Matches shared reality? No.

Matches cause and effect? No.

Tacit or explicit: Explicit. Doesn't elaborate on why they don't use vegan meat substitutes.

Ans3: *I like Tofurkey or Field Roast the best, but I like to also eat Westsoy seitan.*

EXPERT -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Several brand names, but no explanation.

Question 5: *Do you eat honey? Why or why not?*

Expected answer type: Yes or no answer and explanation.

Shared reality: Honey is not vegan, although some self-proclaimed vegans may eat it. This is a controversial topic for some vegans.

Cause and effect: Honey is technically not vegan because it comes from animals, but some people think honey is harmless or that bees don't count.

Tacit or explicit: Tacit. The definition of veganism would clearly indicate that no animal products may be consumed, and honey clearly comes from an animal, so the explicit answer would just say no and leave it at that. Realizing there is controversy and reacting to that represents tacit knowledge.

Themes: Food choice, controversy, ethics

Ans1: *Honey isn't vegan since it's derived from animals. They can be hurt in the process of making honey, and it's taking something away from them that they need.*

EXPERT -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Provides several reasons as if countering opposition in advance.

Ans2: *I do. Because its tasty and healthy! I don't see a reason why I shouldn't eat.*

EXPERT -> 3

Matches expected answer type? Yes.

Matches shared reality? No.

Matches cause and effect? No.

Tacit or explicit: Tacit. Describes sensory experience, but ignores ethical dimension.

Ans3: *I don't eat honey because it is a source of food for the bees.*

INTERMEDIATE -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Strange answer because honey as a source of food for bees doesn't make it not vegan, in the same way that corn is vegan even though cows can eat it.

Question 6: *What commercial mainstream food product do you still enjoy since going vegan that most people probably don't realize is even vegan? (i.e. if Cheetos or Chips Ahoy were vegan)*

Expected answer type: Brand name or common term for popular food that people might not expect to be vegan but is.

Shared reality: Many mainstream products are vegan without advertising it.

Cause and effect: Including animal products in food without any reason is pointless, so some mainstream products are vegan unintentionally and therefore don't advertise this fact.

Tacit or explicit: Tacit. Identifying something that doesn't seem vegan is subjective.

Themes: Brand name, food choice, mainstream products

Ans1: *Frito's corn chips*

Missing expertise rank judgement data due to technical error.

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Provides a brand and item, nothing else.

Ans2: *Lay's Potato Chips*

Missing expertise rank judgement data due to technical error.

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Provides a brand and item, nothing else.

Ans3: *Cracker jacks are vegan, but most people would not know that*

Missing expertise rank judgement data due to technical error.

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Points out that most people don't know cracker jacks are vegan.

Final Determinations:

FINAL JUDGEMENT:

Respondent 1: INTERMEDIATE -> 4. *Close match to respondent 3, but respondent 3 was more specific.*

Judge was incorrect. R1 was vegan, but the judge thought their answers were unclear. More specific answers might have convinced the judge this respondent was vegan.

Respondent 2: NONE -> 4. *Vaguest answers*

Judge was incorrect. R2 was vegetarian, but the judge thought they had very vague answers and that did not match with their view of how a real vegan would answer.

Respondent 3: EXPERT -> 4. *Most specific answers.*

Judge was incorrect. R3 was an omnivore, but their specificity in answers convinced the judge they were vegan.

Interpretation of session. R1 being vegan for 9 years and being gluten free helped convince the judge they had some expertise, but the judge was bothered by their vague answers, and thought they were just a vegetarian pretending to be vegan. R2's responses were influenced by being a vegetarian in India with no vegans that they know. This led to the judge assigning them a rank of omnivore even though they were vegetarian. R3's responses were based on 27 years knowing a vegan, which allowed that person to achieve a high enough level of tacit knowledge to duplicate responses they thought would come from a vegan despite being an omnivore.

Question total: 6

Theme counts from session: Food choice (5), nutrition (2), interacting with omnivores (2), food preparation (1), social situations (1), special occasions (1), vegan products (1), brand name (2), controversy (1), ethics (1), mainstream products (1). This judge focused primarily on food, though they did bring up one controversy and a bit of social interaction. Aggregation of themes results in "nutrition" reclassified as "health" and "special occasions" added to "social situations".

Session 5. Standard setup. R1 is omnivore, R2 is vegan and R3 is vegetarian.

R1: Omnivore who doesn't eat meat at home and used to be vegetarian. Lives in India.

R2: vegan with 9 years knowing a vegan and gluten free.

R3: vegetarian who does not know a vegan and lives in India.

QUESTION 1: *What is your favorite brand of vegan faux products?*

Expected answer type: Brand name of a vegan substitute product and maybe an explanation for why.

Shared reality: Vegans have particular brands that they prefer over others.

Cause and effect: Vegans eat fake animal products, and sometimes discover products they like better, leading to loyalty to a brand name.

Tacit or explicit: Tacit. There are many vegan products, but knowing the brand name and providing a good reason for the loyalty is based on personal experience.

Themes: Food choice, vegan products, brand name

Ans1: *Not applicable. I don't use any.*

NONE -> 3

Matches expected answer type? No. Doesn't provide a product name.

Matches shared reality? No. Doesn't have a brand they like.

Matches cause and effect? No. Doesn't eat fake animal products.

Tacit or explicit: Explicit. Doesn't elaborate on why they don't use any.

Ans2: *Earth Balanace makes great dairy alternatives.*

INTERMEDIATE -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Provides the type of product and the product it is substituting for.

Ans3: *I don't use vegan faux products*

NONE -> 3

Matches expected answer type? No. Doesn't provide a product name.

Matches shared reality? No. Doesn't have a brand they like.

Matches cause and effect? No. Doesn't eat fake animal products.

Tacit or explicit: Explicit. Doesn't elaborate on why they don't use any

QUESTION 2: *What is your favorite non-dairy milk?*

Expected answer type: Type or brand of vegan milk, possibly with explanation.

Shared reality: A variety of products attempt to replicate or replace milk, but vary in quality.

Cause and effect: Vegan milk can be made using virtually any seed or nut as well as several other ingredients. Therefore a wide variety of tastes, textures, and nutritional content can be found in vegan milks.

Tacit or explicit: Tacit. There are many vegan milk products, but knowing the brand name or base type and providing a good reason for the choice is based on personal experience.

Themes: Food choice, vegan products, brand name

Ans1: *Soya Milk*

NONE -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Just a type of milk.

Ans2: *Earth balance chocolate soy*

EXPERT -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Specific brand and flavor but nothing else.

Ans3: *I don't drink milk. Just tea without milk*

NONE -> 3

Matches expected answer type? No. Drinks tea instead.

Matches shared reality? No. Doesn't discuss milk alternatives.

Matches cause and effect? No. Doesn't discuss milk alternatives.

Tacit or explicit: Tacit. Provides an example of an instance they think is normal to use milk in.

Question 3: *Describe the taste and texture of plain tempeh*

Expected answer type: Sensory description of unflavored tempeh.

Shared reality: Tempeh has a fairly consistent and unique texture across brand names and is a common meat substitute.

Cause and effect: The process of making tempeh ensures that it is fairly consistent, with minor variations across manufacturers. The unique texture of it makes the description easier to separate from other products.

Tacit or explicit: Tacit. The sensory experience of eating tempeh is not easy to describe, especially if the respondent never tried it.

Themes: Food choice, sensory experience

Ans1: *I have not tasted a plain tempeh*

NONE -> 3

Matches expected answer type? No. Doesn't describe texture.

Matches shared reality? No. Haven't eaten any.

Matches cause and effect? No. Haven't eaten any.

Tacit or explicit: Explicit. Simply answers that they have not tasted it. Strange that they include "a" before plain tempeh, as this is not the normal practice, even visible in the judge's question.

Ans2: *It has a firm but crumbling texture, and not much of a taste. Maybe a little nutty, but very mild. I usually have something else on it.*

EXPERT -> 3

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Tacit. Points out that tempeh doesn't have much of its own taste and they usually have something else on it. This is common practice for vegans eating tempeh.

Ans3: *I have never tasted it*

NONE -> 3

Matches expected answer type? No. Doesn't describe texture.

Matches shared reality? No. Haven't tasted any.

Matches cause and effect? No. Haven't tasted any.

Tacit or explicit: Explicit. Simply answers that they have not tasted it.

Question 4: *Where do you get your protein?*

Expected answer type: Vegan source of protein.

Shared reality: Vegans require protein and must ensure they have an adequate supply in their diet.

Cause and effect: Every vegan is asked this at some point, usually many times by different people. Therefore even if they don't care about it, they will have had to answer this question before.

Themes: Food choice, nutrition, interacting with omnivores

Tacit or explicit: Tacit. Many sources of protein exist, but there are certain foods with protein that are mainly eaten by vegans, which an omnivore might not think of. Also this may be considered an insider joke since vegans are asked this so much.

Ans1: *Vegetables, Apples, Chickpeas, Breads*

Missing expertise rank judgement data due to technical error.

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. A list of foods. Apples is a strange response because they are low in protein.

Ans2: *Mainly from soy products*

Missing expertise rank judgement data due to technical error.

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Indicates a type of product for their answer.

Ans3: *Pulses*

Missing expertise rank judgement data due to technical error.

Matches expected answer type? Yes.

Matches shared reality? Yes.

Matches cause and effect? Yes.

Tacit or explicit: Explicit. Pulses is a strange answer because it is a large category and is a word not commonly used.

Final Determinations:

FINAL JUDGEMENT:

Respondent 1: NONE -> 4. *Didn't eat faux products of tempeh, called soymilk "soya milk"*

Judge was correct. Respondent was omnivore. Despite not eating meat at home and previously being vegetarian, living in India may have influenced the answers that led the judge to rank this respondent correctly as an omnivore. This includes not eating fake meat or tempeh and using the term "soya".

Respondent 2: EXPERT -> 4. *Brand-specific answer, detailed answers.*

Judge was correct. Respondent was vegan. The judge relied on the detailed answers with recognizable brands to correctly identify the vegan. The answers were based on 9 years knowing a vegan and being gluten free.

Respondent 3: NONE -> 4. *Complete lack of familiarity/experiences with products questioned about.*

Judge was incorrect. Respondent was vegetarian. This is an exceptional case where the judge thought there were two omnivores. This may have been because both of them lived in India, and therefore did not demonstrate familiarity with the vegan experience of an American, which the judge was used to.

Session interpretation: This session demonstrates two key findings. First, judges are willing to rank respondents in a way besides 1 vegan, 1 vegetarian and 1 omnivore. Second, cultural differences may be stronger influence on the determination of expertise rank from the judge than actual experience of veganism. For example, it is clear from the transcript that it is not common in India to have fake meat products, but the judge took the lack of familiarity with them as an indication that the respondent had no veganism expertise.

Question total: 4

Theme counts from session: Food choice (4), vegan products (2), brand name (2), sensory experience (1), nutrition (1), interacting with omnivores (1). This judge relied heavily on food choice and brands of substitute vegan products. Aggregation of themes results in "nutrition" reclassified as "health".