Jarmo Heinonen

CONJOINT-FMRI IN NEUROMARKETING RESEARCH

ACTA UNIVERSITATIS LAPPEENRANTAENSIS 1252

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Abstract

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Neuromarketing studies consumers' sensorimotor and cognitive responses to marketing stimuli. Neuromarketing methods measure brain activation when customers evaluate and view different advertisements, services, and products. First labelled as such by Smidts (2002), neuromarketing is a multidisciplinary approach that connects marketing with statistics, medicine, economics, and psychology.

Marketers serve products as bundles of benefits that are treated as attributes or tied packages of characteristics. Human brains process objects as collections of parts and features, yet individuals experience these as a seamless whole. Conjoint cards show attributes as bundles, and fMRI analyses the brain's reactions to them. To date, this is the first method to utilise individual attributes or features from objects in neuroscience, the benefit of which has yet to be fully appreciated.

This dissertation engages with two research methods and models these in conjoint-fMRI for neuromarketing studies. Furthermore, it asks under which circumstances the conjoint-fMRI method can be of advantage in the field of neuromarketing. The methodological section of this dissertation focuses in particular on the conjoint-fMRI analysis model.

The conjoint-fMRI method resolves a number of neuromarketing research problems, including participants' concentration levels, fatigue, and honesty in answers, thereby helping to diminish costs and increase the quantity of attributes used in research.

Keywords: Neuromarketing, Conjoint, fMRI

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These studies were conducted in the Aalto University AMI lab and Laurea University of Applied Sciences NeuroLab during 2012–2019. This work was carried out in the LUT Business School at Lappeenranta-Lahti University of Technology LUT, Finland, between 2021 and 2025. This has been a long journey, and I am grateful for this opportunity to complete my doctoral dissertation, and I specifically wish to thank my supervisors Professor Dr. Olli Kuivalainen and Professor Dr. Anssi Tarkiainen.

My inspiring partners in the NeuroLab and night-time colleagues in the AMI lab induced me to think of new ways for analysing fMRI materials. Docent Yevhen Hluschuk, Docent Jussi Numminen, PhD student Henrik Antell, and Dr. Vesa Taatila discussed methodological aspects and potential novel studies during our fMRI measurements. I especially want to thank Docent Jyrki Suomala, with whom I had long conversations between studies and lectures—his support and generous time have consistently motivated me to investigate neuromarketing.

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Last, but certainly not least, I thank my lovely wife Marina for her understanding and for standing by my side. Our daughters Satu, Meri, and Sara have been with us during these hectic years and have hopefully been understanding of their parents' passion as researchers.

Jarmo Heinonen
December, 2025
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Contents

List of Publications

This doctoral dissertation consists of a summary of the following publications alongside additional data. Original publications are printed with the kind permission of the copyright owners. Rights have been granted by publishers to include the papers in this dissertation.

I. Heinonen, J. 2016. *Conjoint analysis with fMRI: A Novel Analytical Approach to Neuromarketing*. In Handbook of Research on Neuroeconomics and the Decision-Making Process. Christiansen Bryan & Lechman Ewa (eds.). Advances in Psychology, Mental Health, and Behavioral Studies book series. IGI Global. 1, 4, 147–162.

II. Heinonen, J. 2015. *Analyzing E-services and Mobile Applications with Accompanied Conjoint Analysis and fMRI Technique*. In International Journal of E-Services and Mobile Applications. IJEASMA e-health. IGI Global. 7, 57–72.

III. Heinonen, J., Numminen, J., Hlushchuk, Y., Antell, H., Taatila, V. and Suomala J. 2016. *Default Mode and Executive Network Areas: Association with the Serial Order in Divergent Thinking*. PloS ONE 11, 9, 1–16.

IV. Suomala, J., Palokangas, L., Leminen, S., Westerlund, M., Heinonen, J. and Numminen, J. 2016. *Neuromarketing: Understanding Customers' Subconscious Responses to Marketing*. In Best of TIM Review 7. 2016/27/1 (and 2012/2/12).

Author's contribution

Jarmo Heinonen is the principal author and investigator in Publications I and II.

Publication III's contributions were conceived and experiments designed by J. Heinonen, J. Numminen, V. Taatila, and J. Suomala. Experiments were performed by J. Heinonen, J. Numminen, H. Antell, and J. Suomala. Data were analysed by Y. Hluschuk. Publication III was written jointly by J. Heinonen, J. Numminen, Y. Hlushchuk, H. Antell, V. Taatila, and J. Suomala. Henrik Antell may use Publication III in his own dissertation yet has granted permission to publish it in this dissertation.

In Publication IV Jarmo Heinonen's contributions consisted of interviews, making corrections, and providing expertise for the study.

Nomenclature

Conjoint Analysis (CJ) terms and Functional Resonance Magnetic Impedance (fMRI) terms

(CJ) **ACA**, Adaptive Conjoint Analysis; computer-based conjoint method (Johnson, 1987).
(fMRI) **ACC**, Anterior Cingulate Cortex; connects the emotional limbic scheme with the cognitive prefrontal cortex and plays a major role in neuronal connection circuity (Stevens et al., 2011).
(fMRI) **AG**, Angular Gyrus; language skill and semantic refinement ability (Van Ettinger-Veenstra et al., 2016).
(fMRI) **Amygdala**; threat-detector region of the brain (Troiani et al., 2014).
(CJ) **Attribute**; used in conjoint analysis to characterise essential features or forms. *Attributes level* consists of features for specific attributes and can be continuous (numeral) or discrete (descriptive or nominal).
(fMRI) **BOLD**, Blood Oxygen Level-Dependent; measures contrasts with the fMRI as its key element. The fMRI function relies on MRI scanners to show blood flow reversal in the brain. The subject's brain receives more *oxygenated blood* when stimulated rather than resting. The oxygenated transition causes distortions in the magnetic field similar to water molecules protons in blood (Morin, 2011).
(CJ) **CA**, or **CVA**, Conjoint analysis; a rating-based full-profile approach (Green et al., 2004).
(CJ) **CBC**, Choice-based Conjoint; a full-profile approach (Lenk et al., 1996).
(fMRI) **CBF**, Cerebral Blood Flow: responds to the spent glucose variously in diverse brain areas (Huettel et al., 2008).
(CJ) **Conjoint cards**; used in conjoint analysis for data collection from subjects (Meulman et al., 2001).
(CJ) **Data collection method** with conjoint; often full-profile or trade-off methods (Green & Srinivasan, 1978).
(fMRI) **DHb**, deoxygenated haemoglobin; highly magnetic rather than oxygenated haemoglobin (Hb), due to its tolerance of magnetism. This occurring difference delivers a better magnetic reference signal because the diamagnetic interferes with fewer magnetic remittances (Huettel et al., 2008).
(fMRI) **dlPFC,** dorsolateral prefrontal cortex; in primate brains the cortical area responsible for motor planning, provision, and control. It helps switch attention, maintain abstract rules, aid memory, and inhibit improper responses. Humans indulge in imagination when external challenges intensify by aligning cognition with their personal goals using dlPFC (Turnbull et al., 2019).

(fMRI) **DMN**, default mode network; plays an important role in creative thinking (Geary, 2005).
(fMRI) **EEG**, Electroencephalography; an electro-physiological technique that records electrical activity in the human brain (St. Louis et al., 2016).
(fMRI) **EPI,** Echo Planar Imaging; a magnetic resonance (MR) imaging science that produces an MR image in less than a second. An echo-planar imaging shot can be detected from a single radio frequency excitation (Poustchi-Amin et al., 2001).
(CJ) **Estimation method** used in conjoint analysis; can be non-metric (such as in MONANOVA, LINMAP, PREFMAP or Johnson) or metric, such as in multiple regression or the choice probability models of e.g. logit and probit (Green & Srinivasan, 1990).
(fMRI) **fMRI**, Functional Magnetic Resonance Imaging: a blood oxygenation rate dependent or BOLD converse. The best fMRI can reveal underlying brain physiology and search the brain under an MRI scanner combined with computer analysis (Jezzard et al., 2001).
(CJ) **Fulfilment**; necessitates that a satiation level is good in terms of food, water, and shelter. Human behaviouralists argue that these need levels can be overturned in several instances. Consumer studies can be shifted from the intention of satisfaction or fulfilment and focus on how customers feel or describe this (Rust & Oliver, 1994).
(fMRI) **Hippocampus**; each hippocampal and parahippocampal subregion contributes uniquely to the retrieval, encoding, and consolidation of declarative memories, yet their precise roles remain unclear (van Strien et al., 2009).
(CJ) **HR**, Hierarchical Bayes conjoint method (Lenk et al., 1996).
(fMRI) **IFG**, the Inferior Frontal Gyrus; a component in the brain of the mirror neuron system. This model of responses is coherent with those predicted by mirror neurons and can be seen in the human IFG (Kilner et al., 2009)
(fMRI) **IPC**, Interior Parietal Cortex; studied through visual processing. Hands and mouth motions cause neurons to fire extensively. Neurons in these areas are activated while hands and mouth motion is observed in others (Johnstone, 2010).
(fMRI) **IPL**, Inferior parietal lobe; in auditory memory the rightward IPL has two roles: entangled updating and monitoring the sound position for motor responses, and connecting to motor and integration operations (Alain et al., 2008).
(fMRI) **LEI,** Lorentz effect imaging; electrical activity in a magnetic field uses displacement encoding to detect spatial displacement induced by the Lorentz force on the conducting material (Song & Takahashi, 2001).
(fMRI) **MEG,** Magnetoencephalography; imaging and measuring the magnetic fields in the brain that are built up through the activity of neurons (Singh, 2014).

(fMRI) **MNI**, Montreal Neurological Institute state (Evans, Collins, Mills, Brown Kelly & Peters, 1993); the background for the functional data from fMRI, which is motion-corrected and incorporated with structural data (Yiming Xiao et al., 2019).
(CJ) **Models of preferences** used with conjoint analyses; part-worth, ideal point, vector, and mixed models (Green & Srinivasan, 1978). Mentioned *part-worth* is supposed to describe an increasing operation of a worth's or components' values or attribute levels (Cattin & Wittink, 1982).
(fMRI) **mPFC**, Medial Prefrontal Cortex; has a part in the default mode network. The ubiquitous relation of mPFC works in both decision-making and memory, as well as the best emotional response or action in exceptional occasions. In certain mPFC needs the hippocampus for rapid learning and memory stabilisation (Euston et al., 2012).
(fMRI) **MRI**, Magnetic Resonance Imaging; evaluates activity in the brain from blood flow. MRI scans the brain in a static, standing magnetic field to line up nuclei in the brain area (Jezzard et al., 2001).
(fMRI) **OFC**, Orbitofrontal cortex; participates when needed in representing value strengthening and integration with sensories, decision-making, and wishes. Parts of the OFC activates through pleasant touch or smell, painful touch or taste, and through more abstract reinforcements such as winning or losing money (Rolls, 2004).
(fMRI) **PCC**, Posterior Cingulate Cortex; supports directed cognition. The PCC is a part of the default mode network, increasing activity in planning for the future or retrieving autobiographical memories, as well as in resting when the brain's activity is idle (Leech & Sharp, 2014).
(fMRI) **PCU**, Praecuneus; plays a key role broadly through engaging in a variety of processing. The praecuneus has a systematic state-dependent functional connection in the brain (Utevsky et al., 2014).
(fMRI) **PFC**, Prefrontal Cortex; implicated in complicated actions, such as planning and personality development. The prefrontal cortex assists people set and reach goals (Sharma et al., 2013).
(fMRI) **RF**, radiofrequency wave; causes the hydrogen nuclei to resonate in a magnetic field, which can electrically alter the body with electric wires. The magnetic field alters these increments, and the body resonates with these variable frequencies. As soon as the RF is turned down, the magnetic rate will recover to a resting state, which emit a signal (Berger, 2002).
(fMRI) **SMG**, Supramarginal Gyrus; plays a role in the default mode network. This area of the brain is known as the Brodmann area, which works with the phonological and articulatory processing of words (Silani et al., 2013).
(fMRI) **SPM**, Statistical Parametric Mapping; a software for brain imaging data analysis. There could be a series of images with a different series of time and the same subject (Wellcome Department of Imaging NeuroScience).

(CJ) **Stimulus construction set**; in conjoint analysis with the full-profile this can be a full factorial or fractional factorial model (Green & Srinivasan, 1978). Master designs *fractional factorial design* is a fraction reflected in the attribute (Bont, 1992). The *full factorial design* presents all possible attribute combinations (Green & Srinivasan, 1978).
(fMRI) **Striatum**; arranges several aspects of cognition, action- and motor-planning, motivation, decision-making, confirmation, and reward cognition. The striatum relates to decision-making, function selection, and dedication, with sensorimotor, cognitive, motivational, or emotional information through corticostriatal circuits that are discrete regions of striatum. (Balleine et al., 2007)
(fMRI) **TPJ**, Temporo Parietal Junction; shifts attention to understand others' mental state and to unexpected stimuli (Krall et al., 2015).
(CJ) **Utility**; a conjoint analysis term that describes received results, for example perceived attributes and desired expectations.
(CJ) **Value**; in the subject this is the evaluation of the utility of expectations for obtained things (Zeithaml et al., 1990). Value is situational and relativistic, depending on the context in which someone evaluates something (Holbrook, 1994). Value is a product, good, service, event, or idea that provides services with consumption experience (Holbrook, 1994, 42; Holbrook & Hirschman, 1982). Consuming behaviour engages with many kinds of values and blurs the distinctions amongst them (Holbrook, 1994, 57). Values are not the same amongst all customers who engage in evaluating.
(fMRI) **vmPFC**, ventromedial Prefrontal Cortex; processes risk and fear. It is responsible for multiple aspects of social cognition, facial sensation recognition, and analysing self-relevant data (Hiser & Koenigs, 2018).

Declarations

Turnitin

The originality of this dissertation has been reviewed with the Turnitin similarity checking service.

Commercial software

This dissertation was prepared with the help of the following commercial software:

IBM SPSS Statistics 29, a statistical software designed for data management, advanced analytics, multivariate analysis, and business intelligence. IBM SPSS licensed software is provided by Laurea University of Applied sciences for researchers. We used IBM SPSS for data analysis.

Matlab1v7.8.0347 (TheMathWorks Inc., Natick, MA, USA) based on SPM8 (http://www.fil.ion.ucl.ac.uk/spm/software/spm8/; Welcome Department of Imaging Neuroscience London). Data analysis for fMRI material was performed with Matlab1v7.8.0347 version in the Publications III and IV.

Functional Data Processing Assistant. All preprocessing in Publications III and IV was performed by using the functional Data Processing Assistant (fDPA) toolbox developed by Yevhen Hlushchuk and Eerik Puuska, based on the DPARSF toolbox. In addition to DPARSF, the fDPA toolbox incorporates the ArtRepair toolbox.

We acquired the MRI data on a 3 Tesla SiemensMagnetom Skyra (SiemensMedical Solutions, Erlangen, Germany) for the imaging sequence in Publications III and IV. The fMRI scanner is located in the AMI laboratory at Aalto University, Espoo, Finland.

AI use

Jarmo Heinonen, the author of thus dissertation, did not use any AI tools during the preparation of this doctoral dissertation.

1 Introduction

Methodological contributions generally revolve around two intertwined themes, namely improving theory and refining methods. While many guides exist on making a theoretical contribution, only some spell out what exactly constitutes a methodological contribution (Bergh, Boyd, Byron, Gove & Ketchen, 2022). This dissertation focuses on methodologies used in the fields of marketing research and neuromarketing.

The present dissertation brings together two different types of marketing research methods, both of which mutually improve each other (Chapter 4). Conjoint analysis helps researchers understand objects' attributes and values for customers, and fMRI helps understand consumers' subconscious decisions as they occur within the brain. Here, conjoint cards can separate attributes that have been united in the brain. Taken together, these methods correct each other and offer a new tool for the investigation of conscious and subconscious issues.

Some writers differentiate neuromarketing from commercial market research tools, and consumer neuroscience from academic work (Javor et al., 2013; Lee et al., 2018; Plassmann et al., 2015). This dissertation uses the term neuromarketing because it serves to model a new method for marketing and neuroscientific studies.

1.1 Background of the dissertation

A gap exists in marketing research methods that becomes evident in the existence of high product failure rates, some of which have been reported to amount to 80-90 % (Hill, Schilling, & Jones, 2020) or 40-90 % (Gourville, 2006), although Crawford's (1987) literature review reports only empirically verified failure rates, finding these to be around 35 %. Here, the calculation procedure is crucial, especially when executives reject a product already as a concept or in its material construction phase (Crawford, 1987, 21). Novel products move customers to change their attitudes, thus representing a psychological cost. According to Gourville (2006), many products fail because customers overvalue the benefits of the things they own over those they do not; on the other hand, however, executives overvalue their innovations (Gourville, 2006). It stands to reason that a product's real value may be simpler to discover when robust marketing research is conducted prior to product launch.

Conjoint analysis formed the heart of my first project in 1997, and I further developed this in another thesis in 2006. At a neuro-economics conference in 2009 ("Expectation of wage offer inherits the properties of prospect theory value function and behavioural evidence of it") I connected this to fMRI. During a conference in 2011 ("Value signals in

the human OMPFC network distinguish Maximisers from Satisfiers during goal decision-making") I subsequently developed the idea of shortening fMRI measurement times, upon which the article "Neuromarketing: understanding customers subconscious responses to marketing" was published in Technology Innovation Management Review in 2012 on the theme of fMRI methodologies. As fMRI studies carry high costs and new methods have been in high demand, at a 2014 NeuroPsychoEconomics conference in Munich the researcher presented a model of "companied conjoint analysis and fMRI technique", subsequently publishing the first article about the conjoint-fMRI method in the International Journal of E-services and Mobile Applications in 2015. This model's structure was enhanced in 2016 with the publication of "A novel analytical approach to neuromarketing" in a neuro-economics handbook. In the 2016 PloS One article "Default mode and executive network areas, association with the serial order in divergent thinking" researchers formulated the novel insight that the left insula activates when there is unspoken information regarding creativity—the prior literature had hitherto only mentioned the right insula in research. This presented a new way for collecting material in the fMRI environment. A 2018 publication in Cogent described the conjoint-fMRI model in greater detail. One discovery led to another, finding for example that, while subjects evaluate things as bundles and subsequently put these together as a whole product or service, conjoint analysis separates attributes in subjects' utility preferences. This helps for instance sellers to discover simultaneously the correct value for an individual attribute as well as for the entire product.

Marketing generates a bundle of services and goods offered by a firm to its consumers at a certain price. The bundle is made up of a concrete good, an inexplicable service or benefit, and the cost. Companies may not have a precise understanding of all attributes of the offering, which are the same as products' features. At the subconscious level, consumers cannot explain the reasons for their behaviour. Furthermore, consumers' sensibility to social impact is often difficult to observe immediately and may be subliminal in nature. Moreover, while customers see merely a car, sellers see colour, engine size, interior, and different variations. Sellers offer products as bundles of benefits (Lancaster, 1966) and goods can be regarded as attributes or bound packets of characteristics (Varian, 2016). Importantly, brains process objects as collections of parts and features, yet experience them as a seamless whole (George, 2022, 45).

Traditional marketing focuses on the competitive advantages and evaluations of an offering or service, but modern marketing considers the purchasing system and evokes a positive shopping experience (Levy et al., 2014). Marketing research prefers self-reported measures to easy and cheap stimuli, yet has been criticised for twisting emotional

responses to become socially inviting, weakly capturing subliminal emotional responses (Li et al., 2015). All in all, customer value models are not easy to develop when attempting to define customers' valuations.

One marketing research method is that of conjoint analysis, which works with a bundle of attributes in its conjoint cards. Importantly, this is one of the few methods that can evaluate monetary value for all individual attributes and the entire product at the same time (Green & Srinivasan, 1990). I return to a more detailed discussion of conjoint analysis later (Chapter 2.4.)

An important difference pertains between neuromarketing and marketing. While marketing researchers typically gather behavioural measures according to process-based evaluations of consumer behaviour and operate within the field of consciousness (Camerer & Yoon, 2015, 424), neuromarketing focuses on the mind and deeper subconscious events. Even well-trained participants are not always competent and may not know their conscious and subconscious thinking processes precisely. Marketing brings together researchers from different academic backgrounds, borrowing methods and theories from economics, anthropology, sociology, and psychology, hence relying on social science; yet marketing research consists of big data, neuroscience, and artificial intelligence (Sung et al., 2019). Neuromarketing companies have underlined that neuromarketing research offers better tools than common surveys to evaluate consumer preferences. Psychophysiological measures provide objective results on participants' understanding (Li et al., 2018), following up on real-time replies instead of cognitive processing or drawing on memory (Wang & Minor, 2008). Colin Camerer (14.8.2019) has claimed at a Neuroeconomics and Financial Decision conference in Philadelphia that of the 15000 economists there are 100 neuroeconomists; moreover, only a minority of neuromarketing researchers are economists (Almiron, 2014).

Neuromarketing is an area of marketing research where researchers study consumers' sensorimotor, cognitive, and emotional responses to marketing impulses. Neuromarketing relies on new knowledge gleaned from brain activity about individuals' emotional responses and preferences (Plassmann et al., 2012), working with unconscious decision-making processes that cannot be captured by other research models. Neuroscientific methods recognise the neural incidents that affect consumers' responses (Camerer & Yoon, 2015). By removing methodological barriers (Fugate, 2008) to peer inside the skull, neuroscience provides researchers with a means to follow customers' expectations and decisions. Neuroscientific models are valuable for examining implicit processes (Camerer & Yoon, 2015, 424), and I return to differences and connections between neuroscientific methods in its own chapter (Chapter 2.3.1).

Methodologically, functional Magnetic Resonance Imaging (fMRI) analyses the blood oxygenation rate and seeks to understand the brain by using computer analyses (Jezzard et al., 2001). Brains activate in 1.2 seconds in response to a stimulus, which we can show for example with conjoint cards. fMRI is a well-known method in neuroscience (Ariely & Berns, 2010) and will be discussed in more depth (Chapter 2.3.2). for example, to develop neural correlations of customers' brand preferences, such as in Samuel McClure's (2004) neuromarketing study where that shows how a larger area of the hippocampus, the dorsolateral prefrontal cortex, and the midbrain activate when participants enjoy Coca-Cola more than an unlabelled soft drink. Here, a high utility score means more activation in the brain because the Ventral Striatum (VS) and ventromedial Prefrontal Cortex (vmPFC) in the brain show higher activity for more valuable items (Yoon et al., 2012). The connections between biases and brain activity areas are explained more precisely in its own chapter (Chapter 2.1.5).

Customers have many decision-making biases due to a belief in their ability to make decisions on their own. Individuals are unable to recognise their own mistakes when they rely on their own rule systems. Importantly, the views held by others affect how highly we value things (Wei et al., 2019) as people compare themselves to other individuals. Prospect theory indicates that people are more risk averse and prefer to avoid losses than to make gains, thus leading them to act in such a way as to minimise losses and avoid actions that lead to losses (Kahneman & Tversky, 1979). Furthermore, individuals value things they own too highly, which is known as the endowment effect (Thaler, 2016) and this relates to consumer utility. Individuals commonly act quickly yet do act economically if they have enough time (Kahneman, 2012). People think they are reasonable and objective, but they cannot strip down their emotions (Overskeid, 2000). These are but some of the biases that neuromarketing studies seek to cover, and I return to this in more detail (Chapter 2.1.4).

Conjoint methods are well suited for identifying a proper price for attributes, yet customers might nevertheless like or dislike a product. Attributes are identical to a product's traits, and utility scores show a customer's keenness for all attributes and the entire bundle, but the brain's amygdala or striatum reveals if a customer desires to have that product. While fMRI alone cannot examine preferences for individual attributes because the brain deals with these in their entirety, conjoint cards' utility scores can accomplish this. Hence, these two methods mutually support each other. Rising activation in the insula cortex and amygdala shows that there a high likelihood exists that the consumer may change their mind or whether they resist change (Sapolsky 2017, 459), however, learning is also modulated by interactions between the amygdala and insular cortex (Moraga-Amaro & Stehberg, 2012). Conjoint cards show which attributes are the

most suitable, and how highly the subject values them. Uniquely, this neuroscience method can utilise single attributes or features of an item, in contrast to other neuroscience methods, which have been used for whole objects. Concretely, conjoint-fMRI is able to analyse individual parts and the entire set of the object simultaneously, alongside brain functions.

Problems with fMRI. These include difficulties associated with subjects' fatigue (Nakagawa et al., 2013; Masicampo & Baumeister, 2008) in fMRI scanners, concentration (Laufs & Tagliazucchi, 2014), and ethical issues (Lin et al. 2018). Moreover, fMRI is an expensive method (Meyerding & Mehlhose, 2020; Ruanguttamanun, 2014) and does not directly separate single attributes from the bundle. Some studies indicate that variations exist between findings, which at times have been difficult to replicate (Patil et al., 2016). Chapter 2.5 outlines these issues.

Problems with conjoint methods. Many conjoint methods exist (Green & Srinivasan, 1990), yet it remains unknown whether subjects are honest in their answers and whether they understand attributes in the same way (Ramsøy, 2015). Numerous attributes are needed for research tasks, but these should be identical at the same time (Iyengar & Lepper, 2000; Green & Srinivasan, 1978). Conjoint cards can neither show subliminal influences arising from a product, nor which opinions are conscious or subconscious. I return to these issues in its own chapter (Chapter 2.5).

These two methods can mutually benefit each other (Stanton et al., 2017) and we can examine a certain quantity of attributes in an fMRI scanner with conjoint cards (Ivengar & Lepper, 2000). Orthogonality in conjoint cards helps to reduce the time needed in the fMRI, thereby preventing fatigue (Nagawa et al., 2013) and helping a subject concentrate on the task at hand (Laufs & Tagliazucchi, 2014); at the same time, this reduces the costly time spent on conducting the fMRI. Subjects' honesty in their answers (Bercea, 2015) can be seen from brain activity on the fMRI with conjoint cards. Conjoint analysis can evaluate individual attributes and the entire bundle thereof through customers' valuations (Green & Srinivasan, 1978), which is not possible by using only fMRI. Together, conjoint analysis and fMRI can tackle neuromarketing research problems that are difficult to approach with only one of these methods. I discuss these problems in more detail in (Chapter 2.5) and present the entire model (Chapter 4.1) and practical application (Chapter 4.2).

The conjoint-fMRI method reveals if there are areas of pain or keenness that are activated in the brain, thereby helping to evaluate whether a customer is willing or not to buy an item with a specific feature or at a particular price. It follows that marketers can adjust offering to reflect this, which is particularly important as individuals' decisions are made

85 % unconsciously (Zaltman, 2003) and their choices are often made emotionally. In this way, costly product failure rates can be reduced.

This dissertation is divided into two main parts, the first of which consists of a literature review and the second of original publications. Following this introduction and the background of the various neuroscience fields and aim of the dissertation at hand, the second chapter outlines theories connected to neuromarketing and discusses fMRI and conjoint analysis, including their various advantages and drawbacks. Chapter 3 presents the four articles included in this dissertation, two of which revolve around the conjoint-fMRI model, and two studies on neuromarketing and the research world. The fourth chapter presents my model and its practical application. Finally, Chapter 5 and 6 formulate my conclusions and the managerial implications, respectively.

1.2 Aim of the study

Bergh et al. (2022) mention that often reviewers, authors, and editors struggle to assess methodological contributions and, therefore, proffer a typology for describing models (Figure 1). This typology contains two dimensions, namely those of potential audience and change. In modest methodological contributions, both potential audience and change are limited, while potentially large audiences and major change represent a significant methodological contribution. The typology defines a major methodological contribution as one "dramatically changes practice as reflected in indicators" (Bergh et al., 2022, 1837). This dissertation provides comprehensive suggestions for a different approach in neuromarketing studies and, hence, fits the category of a major methodological contribution and major change, concretely by connecting two different kinds of methods. Conjoint analysis and fMRI mutually help each other but also need to be understood individually from the point of view of fields that include neuroscience, statistics, cognitive science, and consumer behaviour.

		Potential audience	
		Limited	Large
Extent of Change	Major	Modest methodological contribution	Major methodological contribution
	Minor	Minor methodological contribution	Incremental methodological contribution

Figure 1. Typology of methodological contributions (Bergh et al., 2022)

Brains process things as entities, but marketers demand information on how customers evaluate a single attribute. Conjoint cards can accomplish this, yet neither subconscious nor conscious decisions can be detected without fMRI. Importantly here, while fMRI does not single out specific attributes from the bundle, and conjoint analysis does not ensure that subjects are truthful, these two methods together serve to compensate each other's weaknesses.

This dissertation aims to address the link between two research methods and asks: Under which circumstances can the conjoint-fMRI method be an advantage in neuromarketing? How can we model conjoint-fMRI for neuromarketing studies? Answers to these two questions will extend conjoint-fMRI to apply specifically to marketing studies.

Orthogonality in conjoint cards diminishes the time needed to complete a given task (Green & Srinivasan, 1978) because of the reduced number of questionnaires and subjects' participation time, but can it do the same in an fMRI scanner? Numerous conjoint models exist (Green & Srinivasan, 1978; 1990) but which of these is suitable for fMRI? Lieberman (2009) uses six steps to conduct fMRI data analysis, and Dimoka (2012) employs three steps, but which of these can work with conjoint cards? What does an optimal conjoint-fMRI model look like, and differences in brain activity exists if material is presented in either audio or written form? Where do valuation circuits occur, and which areas should we follow in the brain (Damasio, 1989)? These specific research questions are linked in the four publications included in this dissertation (Table 1). The circumstances and advantages of conjoint-fMRI can be demonstrated through the following questions: If orthogonality reduces conjoint cards, can this reduce fMRI analysis time? Do attributes in conjoint cards differ when used in fMRI? What order should we follow in conjoint-fMRI? Are there different ways to collect material in fMRI? Which action areas should we follow in the brain? Answers to these questions will be presented (Chapter 5).

Table 1. Specific research questions

Question	Publication number
How can conjoint cards shorten fMRI analysis time?	1
How can we set attributes for fMRI in the conjoint cards?	1
What should the order of actions be in the research framework?	1
Which is the best conjoint model for fMRI?	2
Is there a difference between collecting material (fMRI) through audio or in writing?	3
Where in the brain do the valuation circuits occur?	4

Solving these problems (Table 1) will help resolve problems associated with fMRI and conjoint. As many methods are available in neuroscience (Stanton et al., 2017) and conjoint analysis (Green & Srinivasan, 1990), the task at hand is to discover their best combination. In fMRI does not showing a sufficient number of attributes due to a lack of time (Iyengar & Lepper, 2000), yet conjoint analysis can help by identifying more suitable attributes and diminishing the time required, as Green and Srinivasan (1978) achieved with orthogonal arrays. The meaning of attribute is not universally agreed upon in neuroscience and conjoint analysis (Ramsøy, 2015, 2019), as many research fields leverage the same methods yet label them differently (Table 2). Consensus in neuroscience is necessary regarding concepts and notions (Liebermann, 2007; Kahnemann, 2009; Thaler & Sunstein, 2009; Morin & Renvoisé, 2018), in order to overcome confusion that arises from using different terms to designate the same phenomenon, such as System 1 and System 2 (Kahnemann, 2012) versus Econ and Human (Thaler & Sunstein, 2016). In this vein, recently published works on consumer neuroscience and neuromarketing have been described as fragmented (Harris et al., 2018; Lee et al., 2018).

Prior research juxtaposes two groups with each other in order to compare results: the main group and the comparison group. Inter-groups analysis is needed both in fMRI and conjoint analysis (Lieberman, 2007) for more precise research. Subconscious mental processes can be analysed in fMRI (Pop & Iorga, 2012), and conscious processes with conjoint analysis. As costs are high in fMRI studies (Meyerding & Mehlhose, 2020; Ruanguttamanun, 2014), amounting to over € 200 per person, conjoint analysis can help by shortening the required time. However, without fMRI, conjoint cards cannot separate subjects' subconscious and conscious answers, and, hence, both methods need each other. There have been difficulties in repeating fMRI studies (Lieberman, 2007), but conjoint significance tests and holdout cards help to prove results' significance. Early on, ethical issues pertained in the context of fMRI studies (Lin et al., 2018) as subjects were required to spend a long time alone in the fMRI scanner; this was compounded by fatigue experienced in fMRI (Nakagawa et al., 2013; Masicampo & Baumeister, 2008), and subjects' concentration in fMRI studies has been a problem (Laufs & Tagliazucchi, 2014). On the other hand, conjoint analysis is unable to confirm subjects' honesty in their answers (Bercea, 2015). Some fMRI studies have had reverse inference problems (Plassmann, 2012) and, sometimes, fMRI studies have necessitated several attempts (Lieberman, 2007). Finally, because laboratory times are costly, sample sizes have necessarily been too small in fMRI studies (Nee, 2019; Berns et al., 2010).

In the future fMRI studies with conjoint cards will be able to evaluate single parts or attributes through activations in the brain, thus helping to identify which parts of the brain are blinking with a conjoint card combination. This will enable an analysis of specific particles or attribute values, thus pricing every attribute of an object separately and concomitantly measuring its effect. By means of fMRI scanning we can observe whether the striatum (Balleine et al., 2007) activates, meaning that something is liked, or whether the amygdala (Troiani et al., 2014) activates, meaning that it is disliked. This can be observed for all attributes through conjoint utility scores and fMRI activity figures. As brains show more activation when an object is liked, conjoint cards' utility scores can help identify this.

Conjoint-fMRI presents us with a solution that can help identify from the brain and conjoint cards what people want, understand how people make choices in a research situation, and provide insight into how to analyse different opinions and valuations as well as how individuals like a given product.

1.3 Structure of the dissertation

This dissertation consists of two parts. The first presents an overview and summary of the theoretical background and the method used in the studies that form the basis for this dissertation. The second part contains the studies themselves, connecting these to the conjoint-fMRI model and neuromarketing (Figure 2).

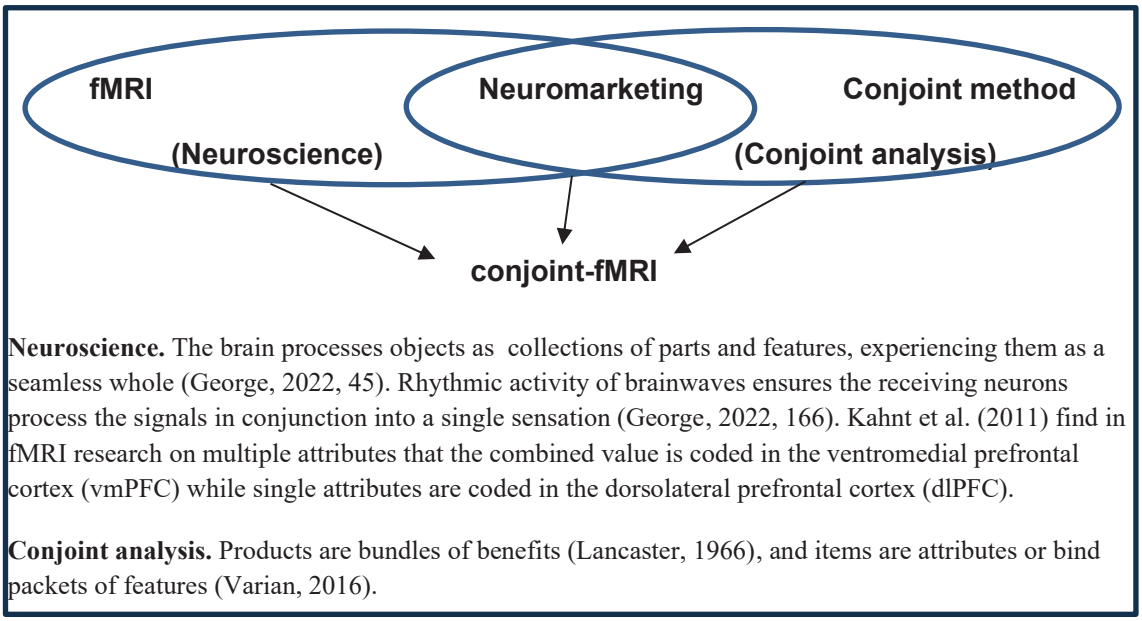

Figure 2. Structure of the dissertation

Three different types of problem are discussed in this dissertation. How to separate subconscious from conscious decision-making is a *theoretical problem*. Marketers do not always understand customers' behaviour and sometimes their decisions do not appear rational but emotional. Finding an analytical method to ensure truthful information and understanding the market's needs is a *real-world problem*. Finding a method to explain marketing effects and consumers' decision processes at both the subconscious and conscious levels with measurable material and time for analysis is *a methodological problem*. These problems in regard to the conjoint-fMRI model (Figure 3) affect the structure of this study and I return to this in conclusions (Chapter 5).

	Problem	Solution
Real-world problem	Conjoint analysis is either excellent or very bad	fMRI helps find salient attributes (dlPFC or vmPFC) from bundles
	Brain constructs things as a whole	Conjoint analysis splits a thing's attributes into parts
Theoretical problem	Conjoint articles lean on rational decision-making	fMRI analyses the brain as it is emotional and rational
Methodological problem	fMRI is costly and time-consuming	Conjoint cards' orthogonality diminishes time and reduces costs

Figure 3. Real-world, theoretical, and methodological problems with the model

Conjoint analysis has high goodness-of-fit or low badness-of-fit (Louviere, 1988) but its practitioners have yet to discuss the meaning of salient attributes and bundles of attributes' effect in the brain. However, single attributes are coded in the dlPFC and group values in the vmPFC in the brain (Kahnt et al., 2011), and the cognitive dlPFC and emotional vmPFC can be dissociated (Sapolsky, 2018). These elements in individuals' brain can help analyse conjoint utilities (Figure 3) in decision-making with the help of fMRI.

Conjoint articles and consumer theory sometimes mention customers' rational thinking, arguing that they choose the best bundle of things that can be obtained (Varian, 1992). However orthogonal arrays only help reduce the material needed (Green & Srinivasan, 1978), and fMRI analyses both emotional and rational thinking as it occurs in the brain (Jezzard et al., 2001). The method of fMRI is expensive (Meyerding & Mehlhose, 2020) and time-consuming but conjoint cards' orthogonality reduces the time needed for subjects to spend in the fMRI scanner (Figure 3), as discussed more specifically (Chapter 2.4.4).

2 Neuromarketing Research and Theories

Neuromarketing studies have used the techniques of neurology to understand the customers' subliminal responses to marketing brands, materials, products, and product groups (Wilson et al., 2008) and there has been an increase in the amount of research using neuroscientific methods in scientific marketing journals (Lee et al., 2018). This burgeoning interest in neuromarketing has been accompanied by a growth in the number of scholars entering the field.

2.1 Theory and neuromarketing

The connection of neuromarketing to other scientific fields is broad and the research literature in consumer neuroscience can be described as fragmented and lacking in operator-friendly and sophisticated handbooks (Harris et al., 2018; Lee et al., 2018). Various terms that label the same phenomenon cause confusion and an operator-friendly model stands to be beneficial here (Chapter 4).

2.1.1 Neuromarketing and customer preferences

Frequently two areas in neuroscience or titles of research have the same focus yet differ in their terminology. Neuromarketing revolves around System 1 and System 2 (Kahneman, 2012), as well as the concepts of primal brain and rational brain (Morin & Renvoisé, 2018). Behavioural economics discusses Humans and Econs (Thaler, 2016), and neurocognitive sciences utilises the C-system and X-system (Lieberman, 2007). To date, these terms have not been connected to each other and I now proceed to do so.

Table 2. Connection examples between neuromarketing and other neuroscientific fields

Automatic	*Controlled*		
System 1	System2	(Kahneman, 2012)	Neuromarketing
Humans	Econ	(Thaler & Sunstein, 2016)	Behavioural economics
X-system	C-system	(Lieberman, 2007)	Neurocognitive
emotional vmPFC	cognitive dlPFC	(Sapolsky, 2018)	Neuroscience
primal brain	rational brain	(Morin & Renvoisé, 2018)	Neuromarketing
--	rational	(Mankiw et al., 2017)	(old) Economics

System 1 and System 2 have been used in neuromarketing to typify decision processes and consumer information (Table 2). Alternatively, this has been labelled *dual-process* theory (Kahneman, 2012), a psychological heuristic describing how people process information in two separate ways. System 1 and System 2 have also been characterised

as fast vs. slow thinking. Kahneman (2012) outlines how the psychologists Stanovich and West (2008) originally reviewed two processes in the psyche. Moreover, Epstein (1990) introduces the experiential system, which is fast, automatic, and emotionally driven, and the rational system, which is slow, naming this the cognitive-experiential self-theory (Epstein, 1998). Evans (2003) formulates a theory on Type 1 and Type 2, which is identical to fast and slow, respectively, in dual process theories. Darlow and Sloman (2010) present their two systems reasoning framework, which explains the connection between intuition (System 1) and deliberation (System 2) in terms of how subjects decide, form attitudes, and prioritise goals. Here, intuitive processing occurs in the long-term memory, and deliberation suppresses intuition.

System 1 is rapid and automatised, easily and involuntarily regulated. System 2 requires mental activities, including complex data processing, and is associated with the personal emotions of intensity, concentration, and choice. The automatic System 1 generates intricate models of thoughts, while the slow System 2 focuses ideas into an organised set of steps (Kahneman, 2012, 20–21). Mental processes are characterised as based on instinct or automatic responses (System 1), or as being more prudent in nature (System 2). The assumption that individuals abuse classic maximisation techniques - that is, sift through information related to all alternatives does not hold for System 1 decisions. Preferably, individuals rely on what is previously knows and, ideally, use *heuristics* (Hanoch & Barnes, 2017, 25).

By means of the **C-system and X-system** (Table 2) in neurocognitive research**,** Lieberman (2007) explicates differences between automatic and reflexive cognition in neurocognitive analysis. Controlled and automatic events are assisted by separate systems (Smith & DeCoster, 2000), which have been argued to support the two aforementioned constructs of social awareness. The C-system responds to monitored social awareness, while the X-system responds to automated social cognition; and the difference between controlled and automatic cognition has been leveraged in social psychological studies (Lieberman, 2007, 279).

Thaler and Sunstein (2009) compare **Humans**, who encounter real-world alternatives, with **Econs,** who make choices based on theoretical principles (Thaler & Sunstein, 2009, 6–8). Using different labels, Morin and Renvoisé (2018) argue for the dominance of the **primal brain** in our decisions and that the **rational brain** contributes to the confirmation process of our decisions. These authors relabel Kahneman's System 2 as the rational brain, and System 1 as the primal brain, yet they consider the primal brain not only to rule individuals' decisions but also to dominate the persuasive process (Table 2).

Liebermann (2007) and Kahnemann (2012) discuss similar concepts with their slow vs. fast thinking and System 1 vs. System 2, respectively, vis-à-vis the X- and C-systems. Thaler and Sunstein's (2009) Humans and Econs, and Morin and Renvoisé's (2018) primal brain and rational brain also have clear similarities. These researchers label their approaches differently, naming these e.g. behavioural economics, neurocognitive, neuroscience, or neuromarketing (Table 2). However, economists generally assume that people are rational beings (Mankiw et al., 2017) without considering alternatives, although this approach has shifted. In this dissertation I focus on methodology and neuroscientific tools, using neuromarketing to open up the complex scholarly world of neuroscientists' phraseology and wording.

Furthermore, a connection exists between the brain and its frontal area. At the side of the face lies the prefrontal cortex (PFC), that section of the front cortex which is essential to executive functions. The PFC decides and chooses between conflicting options, often resolving such conflict through decision-guiding cognition and under direction by emotion (Sapolsky 2018, 46-47). Notably amongst humans, the greater an individual's social net, the larger a certain PFC subregion is (Cao & Smith, 2021).

The PFC is divided into two major areas, both of which perform different functions. The lateral PFC consists of the dorsolateral PFC (dlPFC) and ventrolateral PFC, and the ventromedial PFC (vmPFC), known also as the orbitofrontal PFC. Lesions in the dlPFC provoke a loss of working memory and the inability to perform delayed response tasks. Lesions in the ventromedial PFC can cause emotional volatility, mental disorder, and poor judgment (Hathaway & Newton, 2025). The dorsal area of the PFC, particularly the decision-making region of the dorsolateral PFC, which is the decision maker area, is an extremely rational, pragmatic, cognitive, insensitive region of the PFC and connected to other cortical regions (Sapolsky 2018, 54). In contrast to the dlPFC, the ventral area of the PFC is the ventromedial PFC, where emotions meet decision-making (Figure 4). It seems that many behaviours induce interactions in the vmPFC via the dlPFC and the limbic apparatus (Sapolsky, 2018, 55). However, importantly, the brain relies on networks rather than on single areas (Pessoa, 2014; Plassmann et al., 2012).

Kahnt, Heinzle, Park and Haynes (2011) collected fMRI data while subjects integrated multiple reward predictions' attributes into a combined value, finding that the united value was coded in divided fMRI figures in the vmPFC and the variety of value expectations of the individual attributes were coded in the dlPFC. Here, dysfunction in the dlPFC has been implicated in schizophrenia, which indicates a range of alterations in emotional and cognitive functioning, such as selective attention (Perlstein et al., 1998).

Kahnt et al. (2011) assume that the combined value guides choices when the value predictions of individual attributes indicate an ambiguous value unification. Outcomes show separate characteristics of multi-attribute items' coding in non-related brain areas, thus pointing to separate roles for the vmPFC and dlPFC in multi-attribute decision-making (Kahnt et al., 2011). There is also opposite study, that vmPFC does not necessarily work as assumed referring to Santos, Seixas, Brandão and Moutinho (2011). More specific information about vmPFC and dlPFC connections, their activity, and their relation to biases (Chapter 2.1.5).

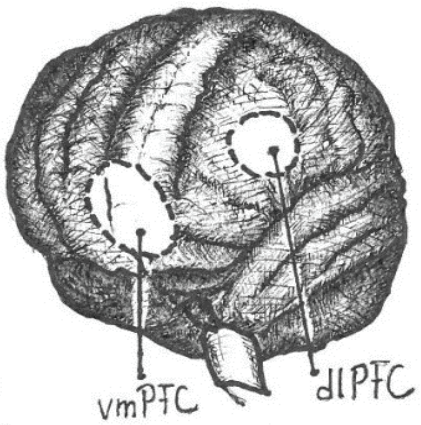

Figure 4. Ventromedial prefrontal cortex with dorsolateral prefrontal cortex

At times a battle for supremacy can take place between the dlPFC and vmPFC, which pits emotion against cognition. During usual actions these areas are conjoined in cooperative connection, yet when the emotional and cognitive areas enter into trickier situations, activity in the two structures becomes more synchronised. However, the emotional and cognitive parts of the brain can dissociate (Sapolsky, 2018, 58) and these two PFC parts are termed the cognitive dlPFC and emotional vmPFC (Table 2).

In psychoanalytical theory the super-ego, id, and ego are parts of a system that describes individual, interconnecting agents in the psychic model. These agents construct a theoretical framework of a person's intellectual life, where the super-ego plays a moral and critical role, the id is connected to uncoordinated wishes, and the ego is the systematic, rational agent that reconciles the spontaneous or instinctive wishes of the id and critical super-ego (Freud, 1999). Nullifying the dlPFC, the superego is lost in individuals who have overly aggressive, hypersexual ids. Beyond the vmPFC, manners can be improper in separate ways. As Plassmann et al. (2011) mention, less than 5 % of our decisions are conscious while the vast majority are made subconsciously. Brands have

a subconscious basis for motivation, and a part of subconscious learning processes guides behaviours, while high-level executive activities' decision-making relies on consciousness (Plassmann et al., 2012, 28).

Simon Baron-Cohen's (2009) work on autism and his empathising-systemising theory uncovers neurological differences between males and females. His theory specifies two different ways of thinking, labelled as empathic thinking and systematic thinking (E-S), which differ between genders. Neuromarketing studies use healthy people, but experiments on autistic people help researchers understand behavioural differences in normal people, thus presenting another example of dualistic theories on the brain.

Regardless of whether they are termed System 1, System 2, Econ, Human, C-system, X-system, primal brain, or rational brain, fMRI studies (Kahnt et al. 2011) show that the dlPFC and vmPFC are crucial here, thus again emphasising the fragmented nature of scholarly writing on consumer neuroscience and neuromarketing. In neuromarketing the dlPFC and vmPFC are the most meaningful areas because customers' decision-making seems to be connected to these places, although it is crucial to remember that the brain is made up of networks, not just a single area.

2.1.2 Classical economy theories and conjoint analysis

Classical conjoint methods appear to relate to classical economy theories (Mankiw et al., 2017) regarding how customers make decisions, showing how subjects attribute choices and connecting these with utility scores even if no differentiation is made between subconscious or conscious answers. Nevertheless, while neuromarketing includes understandings of subconscious activity in decision-making, classical economic theories do not (Table 2). A number of conjoint analysis models originated in the 1960s (Luce & Tukey, 1964) and are linked to the concepts of that era, while neuromarketing began in the early 2000s (Smidts, 2002). As such conjoint analyses referred to the classical economic models of the time, I briefly introduce these here.

Consumer choice theory focuses on how consumers maximise utility, limitations, and costs. Motivations and capabilities involve patterns and demand that **limit optimisation** for buyers; and prices of goods, the rate price per unit, and information on consumers' wealth all contribute to this. In this tradition at the onset of the neoclassical revolution, narrative psychology is mentioned most frequently (Hands, 2010). The theory of consumer choice builds upon the view that customers understand their own preferences, and that separate bundles of items can be compared. However, in the case of two consumption bundles with different combinations of goods, decision-making might become difficult (Varian, 2006, 20). In behavioural economics decision-making is

influenced by numerous factors, including whether choices are presented together or separately, via the distinction bias, which suggests that the differences between attributes are overvalued when they are evaluated together rather than separately.

Consumer theory states that buyers maximise utility, hence marking the rational behaviour of decision-makers. For economists, all customers maximise utility functions (Silberberg & Suen, 2001, 252–254) and consumers are always expected to choose the best bundle from among things they can afford (Varian, 1992).

As argued by Dorfman (2008), in economics the **marginal rate of substitution** is the rate at which a consumer gives up goods when exchanging for other goods of the same level of utility. The consumer is neutral when considering the choice between two items (Binger & Hoffman, 1998, 109–117), and preferences are transitive in that they are replaceable if two items are identical, with the consumer weighing up the one to be as good as the second (Varian, 1992, 20). If the first item is preferred to the second, and the second item is liked more than the third, then the first must be deemed better than the third. If a consumer likes the first and second items equally, and is indifferent between the second and the third, they will be like the first and the third equally. If a customer is given two nearly identical bundles, yet the second includes more of one particular good, a customer will choose the second (Silberberg & Suen, 2001, 256–257). This means that if three items are all equally liked, a customer may choose any of them, yet if any of them is better than the others, the customer will choose that item. Willingness to receive one item over another describes the theory of diminishing marginal utility.

The law of demand states that when prices rise the consumption rate falls (Mankiw et al., 2017). If there is lack of compensation for the price, then purchasing power is reduced for the same level or quantity, and this is termed the **income effect**. Moreover, consumers will always choose a substitute should the price of an item rise.

Rational choice theory, or **choice theory** or the theory of **rational action,** provides the structure for a socially and economically influenced behavioural model (Dorfman, 2008). This theory assumes that an individual will prefer to choose between alternatives, and that the individual can always choose between two alternatives.

The marginal rate of substitution, consumer choice theory, rational choice theory, the law of demand, and the theory of consumer choice offered theoretical support for conjoint analysis in the 1970s (Green & Srinivasan, 1978). However, consumer choice theory stands in contrast to neuromarketing regarding biases, including the endowment effect, mental accounting, and sunk cost theory. Similarly, the marginal rate of substitution and rational choice ratio contrast with acquisition utility, transaction utility, and prospect

theory. Biases serve to show that humans are not always rational, and I return to a discussion of biases below, including how these connect to neuromarketing (Chapter 2.1.5). Conjoint research centrally revolves around choice, and Green and Srinivasan (1990) consider three priority models in terms of attributes: the ideal point as linear plus quadratics, vector as linear, and part-worth linear models. However, many conjoint methods count on multiple regression analysis with linear graphics (Green & Srinivasan, 1990), where the utility-modelling function should be continuous, differentiable, non-decreasing, and concave (Ahmed et al., 2020). These conjoint models will be described more precisely towards the end of this chapter (Chapter 2.4).

These economic theories are based on rational thinking and decisions, but neuromarketing studies subjects as they are, and this also holds true for conjoint analysis. People are **risk averse** (Kahneman & Tversky, 1979), and **cognitive dissonance** (Lieberman, 2007) explains that an individual's behaviour is not always a conscious strategic decision. Classical economic theories do not exclude conjoint analyses from neuromarketing studies, which sometimes focus on human biases and subconscious decisions that are not always rational. Neuromarketing was first mentioned in 2002 (Smidts, 2002), while the history of conjoint analysis began in 1964 (Luce & Tukey, 1964); and both are linked to the era in which they were developed. As a method that helps split services or products into parts, conjoint analysis is particularly useful in neuromarketing theories, which often study biases.

2.1.3 Positive theory of consumer choice and neuromarketing

This subsection moves from the traditional theories used in conjoint analysis to theories that inform neuromarketing. Here, researchers focus on theories that relate to uncertainties and subconscious decisions. Studies on decision-making and judgment under conditions of uncertainty (Kahneman & Tversky, 1979) have shown that mental illusion should be considered the norm rather than an anomaly (Thaler, 2016). Predictable and systematic differences between instructive models of behaviour and real behaviour appear due to what Simon (1990, 198) terms **bounded rationality**. For Thaler (2016), the principle of time-consistent affections is imprudent: humans are time inconsequent because consumer preferences change over time on the basis of novel situations, new data, and changes in earnings.

The **endowment effect** is based on the notion that people will pay to retain things they already have, and pay too highly for things that are obtainable yet not in their possession. **Mental accounting** means deciding to weigh the loss of giving up things against the value of the alternative (Thaler, 2016). A **sunk cost** is an expenditure that cannot be recovered, or when the consumption of a thing results in negative utility. Customers may realise that

they should ignore sunk costs. When they cannot fully benefit from an item, they regard it as a loss to be earned back through future purchases (Thaler, 2016).

Thaler (2016) portrays consumer utility in two ways. **Acquisition utility** is the ultimate volume of well-being that an individual receives after reducing an article's opportunity costs. **Transaction utility** is the price difference between what is paid and the value that someone normally pays, or its suggested price. Transaction utility occurs when a person obtains a bargain, a fair price, or has been cheated. Delayed gratification is the ability to decline small, immediate rewards so as to receive larger rewards later (Thaler, 2016). Modern macro-economists expect that economic operators will have the necessary self-control to design and calculate a whole life cycle of incomes, investments, savings volumes, and consumption, with reasonable expectations about what is forthcoming (Thaler, 2016). However, according to Sapolsky (2017) and Overgaard and Timmerman (2010), the brain constantly reveals interceptive information and many different information types are subliminal. In the moment immediately prior to determining significant acts, individuals are less rational and automatic decision-makers than they believe themselves to be (Sapolsky, 2017, 98). It follows that rationality and subliminal thoughts can affect decision-making processes.

Cognitive dissonance describes a choice or behaviour that considers a previously known attitude. Individuals switch their point of view to avoid appearing inconsistent, but this might not be a conscious strategic act (Lieberman, 2007, 273). Attitudes tend to change in such a way that resolves disharmony with an individual's behaviour. Behavioural studies have demonstrated that activities based on limited reasoning are substantially refined when conditional norms are formulated from actual social rules rather than abstract content (Cheng & Holyoak, 1985).

According to Sapolsky (2017) and Liegl, Maran, Kraus, Further and Sachse (2024), eyes have an indirect sensorial power. An image of large eyes beside a bus stop makes people more likely to clean up their trash. An image of eyes in a coffee room at work can triple money collecting. Eyes on a computer display make players more generous in online games (Sapolsky, 2017, 89). All in all, what you see may affect cognitive dissonance.

According to Camerer and Yoon (2015), **prices** play an important role in consumer decisions. Product information is processed differently depending on whether the price is seen before or after. Neural correlates of purchasing behaviours (Knutson et al., 2007) show that, when viewing products, reactions in the brain - the nucleus accumbens - reveal choice decisions made seconds later. When viewing a price, the insula shows the probability of making a purchase. Customer choice is connected with prior product evaluation and has an effect on later conscious choices (Ramsøy, 2019). Karmarkar, Shiv,

and Knutson (2015) also find switches in the brain's valuation that indicate how to present the order of pricing, which influences a customer' willingness to pay (Camerer & Yoon, 2015).

As Seymour and McClure (2008) argue, people evaluate the option and price at hand in comparison to absolute worth and show sensitivity to examples or price anchors, as well as the functioning of reward processing. Relative valuation means it is impossible to present worth precisely, assuming the limitation of neuronal encoding. Varying perceptions of price may project the role of expectations in defining valuation based on obtainable knowledge, as verified findings about value-scaling point to the PFC, striatum, and vmPFC (Seymour & McClure, 2008). With conjoint cards, we can provide examples from comparable products at the same time, but values and attributes such as costs should be from the real world.

According to Iyengar and Lepper (2000), the positive effect of personal choice and motivational consequences lead to the conclusion that a larger selection is better. Having more choices is not necessarily more motivating than having fewer choices. The human capacity to handle choice, and the wish therefor, is limitless. Both field and laboratory experiments show that people are more likely to buy delicacy food or chocolate when offered a defined set of six choices rather than a larger range of 24 choices. Attendants report satisfaction with choices and compose improved essays when the primary array of options is limited (Iyengar & Lepper, 2000), thus implying that attributes should be kept to a minimum in conjoint-fMRI methods, such as the six used in the classical conjoint analysis model (Green & Srinivasan, 1978).

McClure et al. (2004) show that **transformations** in brands' offerings are connected to growing brain memory activation in the dlPFC and hippocampus. Brands and brand derivatives can indirectly lead to ancillary expansion related to the number of brand associations (Hulme et al., 2014; Ramsøy, 2019). Users interact with other users (Lin, 2008) and social proof theory argues that individuals are more likely to engage in behaviour that they perceive as occurring in others (Cialdini et al., 1999), and people will pay more for a product that their peers wish to acquire (Van de Ven et al., 2011).

The ventral striatum (VS) and vmPFC show more activity in response to more valuable objects. These areas exhibit activity at the time of a decision and outcome, as well as for overriding a decision and for monetary reward (Yoon et al., 2012). The ventromedial prefrontal and ventral striatum areas assume valuation as primary targets and have been used for predicting consumer behaviour (Berns & Moore, 2012; Knutson et al., 2007).

2.1.4 Biases and nudging in neuromarketing studies

Neuromarketing studies prefer biases as these often explain the actual behaviour of human beings, and sometimes these biases cannot be connected to any extant theory. About 95 % of intellectual processes are subconscious even to the test subject, and neuromarketing opens up the possibility of approaching the unseen part of neuronal activity (Pop & Iorga, 2012), or, in Harari's (2017) words "I am not choosing my desires. I only feel them, and act accordingly." (Harari, 2017, 331). Biases are sometimes ideas or actions we that individuals are not themselves aware of unless they are revealed by an outsider. The subconscious mind becomes evident in brain activation in fMRI, and here conjoint cards help focus on the conscious world.

The term **nudge** (Thaler & Sunstein, 2009) is used by policymakers to induce people to make better decisions. Individuals should have access to all alternatives yet should be nudged towards those that are in their best interest. Nudging is disputable, in part because people can be nudged in the direction of a policymaker's interest rather than towards what may be in the customer's best interest (Hanoch & Barnes, 2017). Moreover, some individuals are not motivated by money and may enjoy a high degree of financial self-control. People may realise that they have a record of unhealthy behaviour and, despite best intentions, remain unable to ameliorate this. Behavioural economists and neuromarketers have taken advantage of this social circumstance by making *commitments*, which may induce people to react in ways they desire (Hanoch & Barnes, 2017, 21). Traditional economics commonly concentrates on monetary incentives, as for instance has been the case in increasing the price of alcohol and cigarettes through heavy sales taxes so as to decrease smoking and drinking habits. Sometimes neuromarketing and behavioural economics leverage psychology in their approaches, and policy designers and academics are able to design positions that motivate people to act in ways that are the best for themselves, as well as for the public in general (Ariely & Berns, 2010).

Nudging is a way to help people refrain from unhealthy behaviour. It is easier to act like a Human than an Econ (Thaler & Sunstein, 2016) because normal humans are not strictly rational. Although individuals can be motivated by financial gain, they are also motivated by fairness and social rules (George, 2022, 281). **Libertarian paternalism** (Thaler & Sunstein, 2009) is a theory of public policy that seeks to stabilise social well-being and individual freedom, proposing that people should proceed to appreciate all available alternatives, but that they should be pushed towards those that, in the eyes of policymakers, are most in people's interest (Hanoch & Barnes, 2017, 26).

Defaults are an example of behavioural economics and neuromarketing strategy that is labelled as **choice architecture**, which shows others what good decision-making feels

like, subsequently taking the range of complex information available and presenting it in a manner that smooths good decision-making in light of individuals' *bounded rationality* and *cognitive biases* (Hanoch & Barnes, 2017, 20). Choice architect summarises information that is eventually shown to customers to help them make decisions, reducing the amount of information and underlining comparisons with *alternative choices* (Hanoch & Barnes, 2017, 24).

Information-connected biases, such as anchoring, heuristics, confirmation, bounded rationality, framing, and the status quo, all share in common that they reveal information on what individuals already think they know (Wilson, 2004). **Anchoring** is a behavioural phenomenon when certain numbers are cognitively salient, which affects beliefs or decisions in an unsuitable way. Anchors are separated into the benefits and costs of a decision at that moment, and salience leads to mistakes. For example, when an individual is requested to add up the two final digits of their personal Identity Card numbers first, those with higher totals bid far higher for cans, books, or computer trackballs (Ariely & Berns, 2010). **Bounded rationality** (Simon, 1990) is a theory that proposes that people's decisions do not fit into the traditional economic theory of utility maximisation due to cognitive limits in terms of their ability to process the knowledge available, and that environments do not facilitate traceable decision-making. Humans use **heuristics** to trim down knowledge and, hence, *satisfice* rather than *maximise* (Hanoch & Barnes, 2017, 24). **Confirmation bias** rationalises and justifies automatic support better than oppositional proof can. Testing can support yet not negate a hypothesis, probing outcomes that are liked less than probing those that are liked more (Sapolsky, 2018, 404). **Cognitive biases** are systematic deviations that, in traditional economic theory, determine rational behaviour. These biases generate behaviour which is incompatible with the expectations of traditional theory. A cognitive bias gives people more knowledge that is consistent with their prior behaviour, as individuals are keen to discount oppositional evidence and persist in their present behaviour, thus leading to **status quo bias** (Hanoch & Barnes, 2017, 25). **Framing** is a cognitive context that helps people understand novel information. A decision problem is informed by the information and possibilities that surround it, and such ambient information influences the attractivity of a particular option. For instance, students prefer to choose fruit and vegetables from the front of a food stall than from the back (Hanoch & Barnes, 2017, 25). Heuristics, cognitive bias, framing, and confirmation bias are ways to avoid processing too much information; and here classical conjoint cards are best with six attributes (Green & Srinivasan, 1978), including only meaningful items from the object that is to be investigated.

Monetary value biases such as endowment, homo economicus, and hyperbolic discounting relate to money or appropriate value. The **endowment effect** is the

orientation to appreciate things that are owned more highly, inducing people to make irrational decisions, for instance refusing to exchange an item for one of higher value (George, 2022). **Homo economicus** designates the rational economic person. In traditional economic theory, people have access to all the information necessary to maximise their utility through fixed and unchangeable effects. Homo economicus is neutral in terms of the cognitive biases investigated in behavioural economics (Hanoch & Barnes, 2017, 26). **Hyperbolic discounting** is a powerful preference for obtaining something immediately over something of higher value in the future, thus possibly explaining why retirement funds are often depleted (George, 2022, 278). Attributes on conjoint cards can be continuous or discrete (Green & Srinivasan, 1978) and, in marketing research, one of the most useful of the continuous attributes is that of money.

Exemplar or cue biases such as verbal primes, heuristics, recall bias, or priming are replete with biases that can carry dual-purpose meanings. **Verbal primes** affect moral decision-making; for example, juries decide differently based on how vividly a perpetrator's acts are described. More colourful phrasing registers more in the anterior cingulate if humans condemn ethical transgression more severely when these are represented as wrongful or inappropriate, rather than when they are denied (Sapolsky, 2018). **Heuristics** are approximate rules for decision-making. When taking into consideration all information available, individuals generally use heuristics, as in System 1 thinking. Mental shortcuts can heighten cognitive biases such as status quo bias or present bias; however, when time and mental capacity are limited, heuristics may lead to good decisions (Hanoch & Barnes, 2017, 25). **Recall bias** occurs when people remember earlier events or habits wrongly or in a particular manner. Here, individuals recall actual behaviour because memories are biased towards remembering good behaviour (Hanoch & Barnes, 2017, 27). Any thought that is more easily available to the brain than it would otherwise be is said to be salient, and more salient things tend to be given greater weight, thus resulting in *present bias*. Importantly, salience can be improved through **priming** (Hanoch & Barnes, 2017, 27). Conjoint cards generally show competitors' attributes for comparison (Green et al., 1990), thereby preventing recall bias and the use of heuristics in a study. Conjoint cards with comparable alternatives are cards that include the second-best alternative with its attributes or an equivalent product or item. Both alternatives must mention the same attributes for comparison as two consumption bundles that contain different combinations of goods may render a decision difficult to make (Varian, 2006). With conjoint cards fMRI analysis helps to discover whether subjects dislike (amygdala) or like (striatum) the products or items based on the attributes and the entire product itself.

Prospect theory (Kahneman & Tversky, 1979) offers predictions about behaviour that deviates from the traditional economic theory of utility maximisation. This theory

proposes that people make decisions preferably based on their observation of how competing alternatives will *change* their well-being, the point of comparison being the status quo. Individuals place greater emphasis on losses than on gains i.e., engage in *loss aversion* and overestimate rare events while underestimating quotidian ones (Hanoch & Barnes, 2017, 26–27). Kahneman and Tversky's (1979) prospect theory model focuses on gains and losses, and here the loss function is steeper than that of the gain. The shape of the value function means that given costs are reviewed as forfeited and opening costs are gains, with the former having more weight. **Loss aversion** occurs when greater disutility relates to a loss than the utility associated with a gain of the same size. A corollary here is status quo bias because people are too anxious about whether they are going to lose something through change, thus affecting feelings about the potential good they may receive (Hanoch & Barnes, 2017, 26). People are **risk averse** if an increase in their prosperity is uncertain and they may sustain potential losses, favouring lower, earlier gains instead of larger gains that bear a risk of loss afterwards. People tend to see risk including loss when status quo is framed or there is an opportunity to break even. People are more concerned with *changes*, that is, potential gains and losses in wealth, rather than with absolute levels. Prospect theory (Kahneman & Tversky, 1979) can be demonstrated in conjoint cards with monetary values connected to their S-curve.

Action bias is a cognitive bias whereby people favour action over inaction, even if this is contrary to their best interest. For instance, a patient may insist that a medical doctor performs a test even when it is not medically advisable (Hanoch & Barnes, 2017, 24). Acting biases, such as optimism bias, blind-spot bias, present bias, and status quo bias induce individuals either to act or to avoid acting. **Optimism bias** occurs when someone stands to outperform the underlying odds, or do better than others, which may, in turn, cloud efficient decision-making, for example a drunk driver who trusts that their likelihood of making a mistake whilst driving is lower than the actual probability thereof, or than the likelihood compared to other drunk drivers. **Present bias** is brought about mostly by the salience of incidents that are close, compared to those that are more distant in the future (Hanoch & Barnes, 2017, 26–17). **Status quo bias** designates that individuals prefer retaining what they already have, that is, a preference for the present situation and the feeling that any shift away from this represents a loss (George, 2022). In traditional economic theory, the preferred position is that of less uncertainty because people already know more, and it costs time or effort to make a change. People are overly wedded to what they already have and, hence, miss opportunities that may make them better off (Hanoch & Barnes, 2017, 27). Defaults are an alternative for an individual who does not actively make choices. Choice architects may set a default that is in people's best interests, thus promoting *status quo bias* because the majority will proceed with the default that is provided, although individuals can opt out of this default. For instance,

people will serve as organ donors in a fatal accident unless they specifically state otherwise (Hanoch & Barnes, 2017). **Blind-spot bias** is the tendency to recognise the influence of bias in other people's judgements yet failing to recognise these in their own due to believing that they are less biased than others (George, 2022, 279). These biases which are connected to action contain personal elements and may generate mixed results in conjoint-fMRI. However, the possibility of evaluating these biases on a personal basis does exist, although ethical issues are a concern as studies here are focused on individuals rather than large groups. A subject's attitude or valuation can be discovered through conjoint-fMRI, yet this does not imply that a person's mind can be changed. Here, more needs to be known about subjects' actions, which can be analysed with conjoint-fMRI, before moving on to nudging.

The information-connected biases (Table 3) such as anchoring, heuristics, confirmation, bounded rationality, framing, and status quo can be used on conjoint cards as objects and main attributes, or attribute groups. As continuous values are necessary for conjoint cards, monetary value biases (Table 3) such as endowment, homo economicus, and hyperbolic discounting represent suitable values therefor. Exemplar or cue biases (Table 3), such as verbal primes, heuristics, recall bias, or priming are loaded biases, which are a good basis for comparable objects or attributes on conjoint cards. Action biases (Table 3) such as optimism, blind-spot, and present bias can be problematic here because attributes from these biases may differ in meaning between subjects and, hence, generate varying results, which can subsequently be identified in conjoint analysis significance tests.

Table 3. Bias suitability for conjoint and fMRI research

Bias group	*Suitability for conjoint*	*Suitability for fMRI*
Information connected	With suitable attributes	With suitable attributes
Exemplar or cue	With suitable attributes	With suitable attributes
Monetary values	Suitable with evenly spaced attributes	Suitable
Action bias	Under certain conditions	Under certain conditions

Bias research has been criticised for implying intelligent interpretations and for often producing random errors, systematic biases, in a laboratory environment with college students in specific layouts that do not cause similarly severe errors in real life (Klein, 2011, 59). Morin and Renvoisé (2018) argue that what we expect influences our behaviour, and bias is the direct consequence in our brain. Making the right decision is

difficult and perilous, not least because brains contain numerous in-built biases that serve to challenge logic and common sense (George, 2022, 277). Completing an inventory of the most common cognitive biases is a challenging endeavour because scholars disagree on key definitions (Morin & Renvoisé, 2018). Here, Benson (2019) designed a cognitive bias cheat sheet on Wikipedia with over 200 biases, sorting these into four different groups: what we should remember, too much information, the need to act rapidly, and not enough meaning. I leave aside this division here as the academic literature does not approve of all of them.

2.1.5 Biases and brain activity areas in decision-making

This section connects biases and their activation areas in the brain. All biases that affect decision-making activate the dlPFC and vmPFC in the PFC (Figure 4). The dlPFC is the decision-maker and is the most rational, cognitive, practical, and emotionless region of the PFC. The vmPFC governs the effect of emotions on making decisions. Numerous forms of behaviour involve the interplay of the dlPFC, the limbic system, and the vmPFC (Sapolsky, 2018, 54-55). However, controversy exists in the literature regarding the participation of the vmPFC (Santos et al., 2011). When individuals consider questions, greater dlPFC activity indicates a greater likelihood for a positive answer (Morris et al., 2014; Sapolsky, 2018). The greater the activation in the insula, the higher the probability of abandoning a thing (Sapolsky, 2017, 562). Difficult emotional and cognitive tasks synchronise both structures, although the emotional and cognitive parts of the brain can dissociate to a degree (Sapolsky, 2018, 58).

The dlPFC belongs to the primate brain, which is top-most in the cortical area and responsible for motor plans, arrangement, and control, as well as for switching attention, maintaining abstract rules, working with memory, and inhibiting improper responses. Humans give priority to day-dreaming when environmental challenges decrease, aligning their cognition with their personal goals by using the dlPFC (Turnbull et al., 2019). In contrast, the vmPFC processes risk and fear, and is responsible for multiple aspects of social cognition, theory-of-mind capacity, facial emotion recognition, and the handling of information relevant to the self (Hiser & Koenigs, 2018).

Various parts of the brain are activated when analysing individual attributes as well as entire bundles thereof. Kahnt et al. (2011) find that their combined value is encoded in the vmPFC, and that individual attributes are coded in the dlPFC. An exceptionally high utility score on conjoint cards could cause greater activation in the brain because the VS (Ventral Striatum) and the vmPFC in the brain show higher activity for more valuable items (Yoon et al., 2012). Kahnt et al. (2011) assume that the combined value can direct choices when the value predictions of individual attributes indicate ambiguity in value

integration (Figure 5). The different attributes of items with multiple attributes are coded in other brain areas, thus implying separate roles for the dlPFC and vmPFC when decisions are made on multi-attribute tasks (Kahnt et al., 2011).

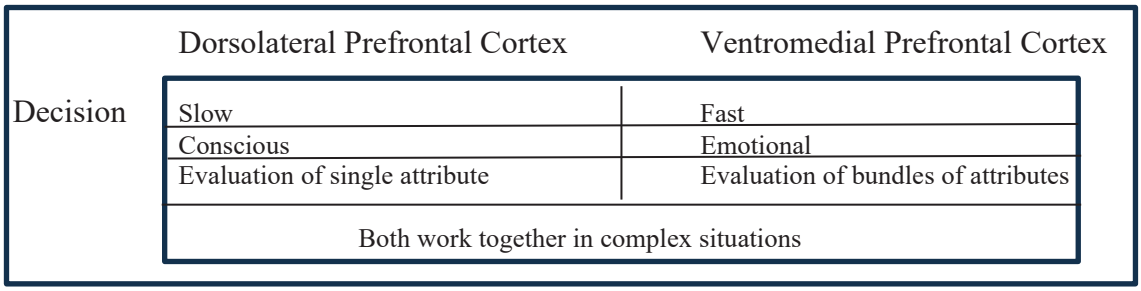

Figure 5. Activation areas in the prefrontal cortex during decision-making

This implies that a bundle of attributes activates the vmPFC, and that a single attribute activates the dlPFC. Therefore, we can use conjoint-fMRI to discover whether there is a salient attribute on conjoint cards that subjects prefer, and which the dlPFC activate, or whether subjects prefer the entire item, which activates the vmPFC. For example, subjects may prefer the colour attribute of red for a Ferrari, which thereby becomes a salient attribute, yet with other car brands colour does not matter.

Anchoring bias is connected to anchors. As Seymour and McClure (2008) note, people evaluate the price and options in rateables more than in their absolute value, thereby showing sensitivity to examples or price anchors, as well as the functioning of reward processing. When values are scaled, the PFC, striatum, and vmPFC are active (Seymour & McClure, 2008).

Status quo bias engages with prior situations. According to McClure et al. (2004), changes due to a brand activate the memory system of the brain in both the dlPFC and hippocampus. Brands and brand derivatives could indirectly result in an associative spreading related to the number of brand associations (Hulme et al., 2014; Ramsøy, 2019). Users interact with other users (Lin, 2008), and individuals are more likely to engage in behaviour (Cialdini et al., 1999) that they have perceived in others, paying more for a product that their peers would acquire (Van de Ven et al., 2011).

The DMN and the executive network play an important role in creative thought (Beaty et al., 2014; Ellamil et al., 2012; Geary, 2005; Raichle & Snyder, 2007). The executive network involves the dlPFC and the anterior cingulate cortex (ACC). The DMN contains the mPFC, praecuneus (PCU), posterior cingulate cortex (PCC), temporoparietal junctions (TPJ) and inferior parietal lobes (IPL), supramarginal gyrus (SMG), and the angular (AG). The salience network's role is important when an individual redirects conventional habits into a new direction. The insula works as a section of the salience

network (Seeley et al., 2007) and plays a role in emotional processing (Bechara & Damasio, 2005; Cauda et al., 2011). *Cognitive dissonance* explains the attitude of changing direction in order to avoid appearing inconsistent (Lieberman, 2007) and, hence, is the opposite of status quo bias.

Information biases and *exemplar or cue biases* activate moral decisions, and moral quandaries activate the insula and disclose an indignation switch on the orbitofrontal cortex. Quandaries create strong operations and activate the anterior cingulate. Activity in these areas predicts moral decisions more than the profile of the dlPFC. People penalise an individual if they sense displeasure due to somebody acting immorally, and the antithesis of moral decision-making tends to involve oppressive cognition. When a questionable moral situation arises, the activation of the amygdala, vmPFC, and insula typically precludes dlPFC activity (Sapolsky, 2017, 482).

Novel hippocampal neurons adapt into pre-existing circuits, which are relevant for integrating the latest information into extant models, for instance when discovering that two earlier things which were the same are now different (Sapolsky, 2017, 149). The vmPFC and dlPFC are activated and interlocked when identifying dominant relations or a dominant face, which unites affective and cognitive parts in the process (Hackel et al., 2020). The correctness of logical and moral arguments regarding a financial or moral decision switch on the cognitive dlPFC. Doing harm is worse than allowing it to happen, and, for similar situations, this is judged more harshly than neglect, inducing the dlPFC to be turned on more so as to judge these equally (Sapolsky, 2017, 480). The brain uses the same circuitry in the orbitofrontal PFC when it analyses moral goodwill or, a beautiful face (Sapolsky, 2017, 443).

We coherently judge ourselves differently than others in terms of ethical criticism (Sapolsky, 2017, 492). Experimentally stressed participants are selfish, rationalising decisions as emotional, moral problems and making practical judgements less likely when they involve a personal moral issue. Strikingly, the greater the glucocorticoid reaction, the more this is this case (Sapolsky, 2017, 493).

Belonging is *safety.* Being out-of-step activates the insula cortex and the amygdala; and the greater the activation, the higher the likelihood of a change in mood and the more persistent the change (Sapolsky, 2017; Schaefer & Rotte, 2007). Those who promise to cooperate yet do not fulfil this activate their dlPFC, ACC, and amygdala. During cheating, cheaters activate their dlPFC (Sapolsky, 2018; Speer et al., 2020). Struggling activates the dlPFC, and the vlPFC and ACC spring into operation, causing a prominent lag in time response. Truthful individuals' vlPFC, dlPFC, and ACC are mute when a chance to cheat emerges. Furthermore, when contemplating e.g. mouthwash and soap (Schaeffer et al.,

2015), liars activate the mouth regions of their sensorimotor cortexes. Those who write down a lie show activation in the cortical regions that map to their hand.

Neuroimaging shows brain vivacity and reduces negative emotions such as anxiety, uncertainty, hazard, and risk, thereby increasing customers' willingness to buy. Even a comparatively small test team can provide trustworthy information on customer reactions to marketing stimuli (Berns & Moore, 2012; Moore, 1982). Customers should feel comfortable throughout their buying experience, and activated areas of the dlPFC show increased feelings of safety, meaning a positive influence on an individual's willingness to buy.

The valuation circuits in the brain settle in the dlPFC. Behavioural data indicate that anxiety stimuli automatically activate fright and capture attention, and this effect is communicated by the subcortical brain network focused on the amygdala (Öhman, 2005). The amygdala detects threats in the brain, but other regions are also involved in receiving similar emotions. Feeling stimulation appears to involve a patchwork of motor, effective, and somatosensory parts (Bastiaansen et al., 2009), and the inferior frontal gyrus (IFG) activates in subjects when they see persons on the display and associate them with mirrored behaviour and emotions (Gazzola et al., 2006).

Monetary value biases can be seen in the brain when the VS and vmPFC show more activity for higher priced items. These areas reliably point to a pattern at the time of a decision and outcome receipt, as well as in monetary and primary rewards (Yoon et al., 2012). The ventromedial prefrontal and ventral striatal areas have been associated with the valuation of primary targets in neuroimaging studies for predicting consumer behaviour (Berns & Moore, 2012; Knutson et al., 2007).

With conjoint cards we can use continuous or discrete values. Here, one attribute must be continuous, e.g. monetary value, for the multiple regression formula. In this way utility scores can be analysed for single attributes or the entire product and imbue them with monetary worth. As Seymour and McClure (2008) point out, value might predict the role of expectations and activity in the PFC, striatum, and vmPFC when scaling a value.

The cognitive dlPFC activity with conjoint cards and the emotional vmPFC may involve various aspects. In those who have sufficient money, the vmPFC activates and the product is purchased without hesitation, but the dlPFC activates in individuals who must think about how they spend their money or how much they have in their pocket. In Hare, Hakimi, and Rangel's (2009) study the dlPFC was very active when subjects chose delayed rewards, and when the subjective value of those rewards was controlled the vmPFC was found to be associated with computations of stimulus values.

In laboratory environments, both slow and fast thinking (Kahnemann, 2012) should be considered because subjects may think about their decisions in a more intensive way, comparing situations outside the fMRI scanner, and the dmPFC and dlPFC may activate differently in the brain. It follows that the fMRI cannot reliably show spontaneous decisions because of the laboratory environment (Table 3). Importantly, different areas are often activated in the brain, rather than merely one, as the brain is a highly complex and internally interconnected system.

2.2 Neuromarketing in the literature

Neuromarketing leverages neuroscience to uncover subconscious reactions to marketing stimuli and activities (Ariely & Berns, 2010). Neuromarketing big data assist time-dependent systems of consumers' demands, evaluations, and pursuits of happiness together. Importantly here, consumers' minds are also affected by current events, as well as by their expectations and memories (Sung et al., 2019). Neuromarketing is an applied field of neuroscience and investigates customers' actions in reply to marketing impacts based on neuroscience models, tools, and techniques (Lin et al., 2018).

Shiv et al.'s (2005) discussion of neuroscience in decision-making research does not mention marketing in general, and the first publications on neuromarketing were published in 2007 (Lee at al., 2007; Fugate, 2007), although neuromarketing and consumer neuroscience were used interchangeably (Reimann et al., 2011). Some authors differentiate neuromarketing from commercial market research, and consumer neuroscience from scholarly work (Javor et al., 2013; Lee et al., 2018; Plassmann et al., 2015).

Neural imaging has been used in medicine, psychology, economics, political science, and marketing. There are a few specific examples of neuromarketing studies for marketing services, but most of these are proprietary to companies (Fugate, 2008). The number of neuromarketing articles published in top-level journals remains tiny (Lee et al., 2018), although the Journal of Marketing Research has published an article specifically focused on neuromarketing research (Camerer & Yoon, 2015).

According to Lee et al. (2018), a wide range of conceptual topics and empirical methods have covered neuromarketing and consumer neuroscience research. Journals have published relevant neuroscience studies, around 60 % of which contain methodological primers on aspects of statistical analysis (Vecchiato et al., 2010) or descriptions of the most commonly used methods - PET, MEG, EEG, fMRI - in terms of their ability to record brain activity (Sebastian, 2014). The history of neuromarketing is short and some journals fail to appreciate the nature of neuromarketing, with publications varying widely in scale.

General overviews of the field exist in management and organisational research (Becker et al., 2011), and numerous neuro-economics publications exist, although Lee et al. (2018) note that many neuromarketing publications are released in lower-level journals; in comparison to neuro-economics, management, leadership, and organisational behaviour, marketing appears to be an outlier. What is more, marketing researchers have rarely developed frameworks (Lee et al., 2018). Furthermore, interest has burgeoned on biases in customers' minds, which may seem striking for marketing researchers yet represents a fresh route for neuromarketing studies.

In their study of 131 extant neuromarketing and consumer neuroscience publications, Lee et al. (2018) divide neuromarketing publications into eight categories: overview, ethics, future research, theory development, critical evaluation, methodological primer, others, and multiples. Neuromarketing publications have been connected with the psychology of decision-making (Bartels et al., 2015; Yoon et al., 2012), branding (McClure et al., 2004; Plassmann et al., 2012a; Reimann et al., 2012; Yoon et al., 2006), advertising (Klucharev et al., 2008; Stallen et al., 2010; Venkatraman et al., 2015), buying decisions (Barnett & Cerf, 2017), and pricing (Knutson et al., 2007; Plassmann et al., 2008). The neuromarketing literature contains a total of 318 articles published between 2007 and 2020, and the number of introductory articles amongst the top ten most-cited papers indicates that neuromarketing is an emerging field (Cardoso, Chen, Araujo, Almeida, Dias, and Moutinho, 2022).

2.3 Neuromarketing and functional magnetic resonance imaging

The background of neuromarketing and fMRI will be discussed in this sub-chapter. Neuromarketing is introduced and positioned and the concepts in the existing literature on fMRI are explored. Neuromarketing definitions are provided from the literature based partly on an original publication for this dissertation.

2.3.1 Positioning fMRI among other brain mapping methods

Technological and methodological constraints exist in contemporary neuroscience neuroimaging technologies, including electroencephalograms or magnetic resonance imaging (Solnais et al., 2013). Psychophysiological measures such as eye tracking, electrodermal response, and heart-rate studies have been used in customer research since the 1960s (Wang & Minor, 2008), as well as facial expression analysis in marketing research (Isabella et al., 2015). Neuroscience technologies enable the analysis of participants' brains and emotions at the very moment (Khushaba et al., 2012) that they overtake the conscious mind (Sung et al., 2019).

According to Sung et al. (2019), seven psychophysiological analysis systems were used in marketing studies between 2008 and 2018. Facial muscle activity has been analysed with facial electromyography (fEMG) in facial expression research that uses software with eye movement studies. Central nervous operation analysis has used functional magnetic resonance imaging (fMRI), and the analysis of brain waves and functional near-infrared spectroscopy (fNIRS) surveys have been made via electroencephalograph (EEG). Instinctive autonomous responses have been analysed with nervous measures of heart rate variability with electrocardiogram (EKG) and electrodermal analysis (Sung et al., 2019).

MRI has better spatial distinctiveness than EEG or MEG, yet its resolution is not as good as that produced through invasive procedures. Typical distinctiveness here lies in the range of millimetres, with ultra-high-resolution MRI or MR spectroscopies operating at tens of micrometres. Large scanners are preferable for human studies due to their high field strength, which is harder to reach and must be coherent, specifically requiring inner contrast like BOLD, or a safe external contrasting substance.

Due to its brain localising ability, fMRI is the method with the most potential for neuromarketing research. EEG and magnetoencephalography (MEG) with some methods reveal information on the brain's working from outside the skull, but fMRI works inside the cranium. MEG's superior time-related resolution with better spatial resolution makes it better than EEG; however, both MEG and EEG are ideal for picking up activity from

the top of the brain and, hence, are not suitable for imaging subcortical space. The key element in fMRI is the BOLD difference that illustrates blood flow changes in the brain. The brain receives more oxygenated blood flow when it is in a resting state than when subjects experience a particular stimulus. This changes the magnetic field protons emitted in the blood's water molecule. In such fMRI studies the transformation in the BOLD signal is a precise measure for neuronal activity. The chief advantage with fMRI is the imaging of inner brain constructions, particularly those that participate in emotional responses (Morin, 2011).

The two most valuable methods in neuromarketing studies are electro-encephalography (EEG) and functional magnetic resonance imaging (fMRI). While the former registers electric activities external to the brain with conductors, the latter measures blood flow with levels of oxygen according to brain activity, thereby providing researchers with information on neuronal functions within the brain.

2.3.2 fMRI and brain mapping

Functional MRI measures brain activity via blood flows. Brain mapping with fMRI represents a powerful non-invasive technique for identifying regional variation in activity, correlating these changes with an individual's behaviour or psychological state (Huettel et al., 2008). Imaging researchers have investigated the dynamic role of the brain and highlighted the significance of connections between regions during mental processing (Cobb, 2021, 325).

When neuronal activation and cerebral blood flow are coupled, the flow of blood in the activated area in the brain region increases (Logothetis et al., 2001). The principal form of fMRI uses BOLD imaging, which works with haemodynamic responses, that is, blood flow changes connected to energy consumption in cells within the brain or spinal cord.

The domination of fMRI in brain mapping research began in the early 1990s because subjects do not require shots or surgery, swallow substances, or be subjected to ionising radiation (Huettel et al., 2008). The signal is often affected by interference from different sources, yet statistical techniques can pick up the background signal. The activation of the brain can be shown with colour codes across the brain, and localised activity can be analysed in millimetres with fMRI in a couple of seconds (Patz et al., 2019).

Non-invasive neuronal activity mapping is a key achievement in human neuroscience. Functional magnetic resonance (MR) imaging, with a temporal reaction of seconds, cannot gauge high-level cognitive operations in tens of milliseconds, yet imaging fast neuronal processes is required for advanced neuroscience. Rapid-stimuli (100ms)

mechanical changes are primarily located in the thalamus, the relay site for afferent cortical supply. MRI scans a constant magnetic field by lining up nuclei in the brain, and radiofrequency (RF) pulses push the nuclei to the upper magnetisation level. When the RF leaves the area the nuclei return to their original levels, and the energy they emit is measured with a coil to identify their positions. Radiofrequency tracks blood cells and endocrine, cardiac, and immunological functions (Black & Heynick, 2003) in the human body. MRI shows a structural picture of brain matter and fMRI was developed from MRI to capture functional neuronal activity changes in the brain. The separation of magnetic assets using oxygen-rich versus oxygen-poor blood is the link that is needed for analyses (Huettel et al., 2008).

The brain is an organ that extensively consumes energy and, as it has few energy reserves of its own, is highly dependent on the uninterrupted delivery of energy bases through circulation (Bélanger et al., 2011). Neurons demand a high amount of energy, especially upon activation but the blood supply cannot remain constantly elevated across the entire brain. The rise in cerebral blood flow (CBF) occurs in a timely and spatially restricted manner to the activated brain area to ensure an adequate supply of nutrients and oxygen to the neurons (Lecrux et al., 2019). Neurons activate blood flow locally to brain regions, increasing oxygenated and deoxygenated blood within seconds, upon which this returns to the original level. Haemoglobin molecule cells carry oxygen in red blood, and deoxygenated haemoglobin is paramagnetic in comparison to oxygenated haemoglobin (Hb), which is diamagnetic, i.e., resistant to magnetism. The difference occurs with better MR signals because diamagnetic signals disturb magnetic blood to a lower degree; and this transformation can be scanned so as to show active neurons (Huettel et al., 2008). Importantly, the brain contains regions that have circuits and patterns of functional connectivity (Sapolsky, 2017, 158).

The basis for learning lies in the plasticity of individual synapses, which is important for complex brain-driven behaviour. The function of the brain's plasticity is to enable new patterns of activity to be generated by the network of neurons, although the synchronously active network can be very stable (Cobb, 2020, 251-252) and the brain relies on networks, not just on individual regions (Pessoa, 2014; Plassmann et al., 2012).

The main source of energy for the brain is glucose (Mergenthaler et al., 2013), but it does not store it. Returning active neurons to their original polarisation states requires activity in ions pumping across cells' neuronal membranes. These ions pump energy from glucose, bringing in additional oxygen from oxygenated haemoglobin molecules in blood cells. The change of blood flow can be localised to pixels that show where neural activity

is taking place (Huettel et al., 2008), and these pixels are three-dimensional voxels (Shin et al., 2018) in the scanned picture.

Cobb (2021, 315) demonstrates that fMRI does not directly reflect the neuronal activity of the brain, but, by simultaneously recording from single neurons, fMRI responses can be measured. fMRI is indeed tightly linked to neuronal activity, and its seductive power flows from its apparent ability to identify the precise areas of the brain that are active when a specific mental activity is performed. However, these intuitive images are far less simple than they appear because the brain is a living organ and performs a vast range of actions. It follows that there is a high level of activity from amongst which researchers must pick out the change that interests them (Cobb, 2021; Plassmann et al., 2012).

Cannon (1927) shows that emotions originate in brain activity, not in the responses of the viscera; and the autonomic nervous system and emotional responses are coordinated by the hypothalamus and controlled by the action of the cortex (Cobb, 2020, 285). Cerebral blood flow responses to glucose differ between various brain areas. More deliberative regions are the lateral frontal lobes with lateral parietals when the flow's fever consumption affects BOLD susceptibility. Haemoglobin reacts to magnetic fields if there is an obligated oxygen molecule. The molecule of dHb is affected by magnetic fields, and it warps the magnetic field caused by MRI, with nuclei losing magnetisation more rapidly (Huettel et al., 2008).

Blood flow reaction demonstrates temporal sensitivity, thereby permitting the measuring of active neurons in BOLD with fMRI. The haemodynamic response remains for around 10 seconds, ascending and peaking between 4 and 6 seconds, upon which it again falls. Changes integrate neuronal activity responses in a smooth and continuous manner. Researchers collect data from various slices, with strong magnetic gradients, and process and analyse data statistically (Huettel et al., 2008, 205–208, 220–229) for slice timing correction, intensity normalisation, realignment, temporal filtering, univariate analysis, generalised linear model, and multivariate analysis (Behroozi et al., 2011).

The brain's response to future rewards is considered in the prefrontal cortex, which unites calculation and reason. The reward of immediate economic pleasure generated by the limbic region will dominate over the sense of transferred rewards generated by the prefrontal cortex. When individuals believe they are treated unfairly, the anterior insula activates and a strong, primitive, and negative response is pre-eminent in the deliberations of the more logical prefrontal cortex region (Fugate, 2008).

fMRI measures activity changes in mere seconds, yet neurons send information in the range of milliseconds. Hence, fMRI cannot reveal what single cells, or networks of cells,

are doing. When an fMRI study claims that a given region does not light up, no reliable conclusions can be drawn (Cobb, 2020, 320-321; Plassmann et al., 2012). If the direct manipulation of a particular cell or network alters or restores a given function, this does not mean that the function lies in that particular structure, only that the structure is required for the function, which itself involves a large network of neurons. When a function is claimed to be localised within a particular structure, researchers discover that the situation is rather more complex than assumed (Cobb, 2020, 329).

fMRI measures use the General Linear Model (GLM), or general multivariate regression model (Figure 6), both of which contain the same regression equation. However, GLM can handle a wide variety of attributes, including non-numerical ones (Rutherford, 2001).

$Y=a+b_1X$

Where
Y = the predicted or dependent variable
a = constant, the intercept
b_1 = weight, coefficient, or slope
X = variable

Figure 6. Formula for the General Linear Model

The amygdala is not only involved in fear, playing a role in emotional and autonomic responses linked to pain and other negative stimuli, but also integrates various sensory stimuli that are not associated with punishment or reward. Brain function therefore involves both segregation and integration (Cobb, 2020, 330-331). The amygdala plays a complex role in aggression, fear, and anxiety. Fear and aggression are not tied together because fear does not cause aggression, and not all aggression is rooted in fear (Sapolsky, 2017, 44). Brain activity in perception and learning is neither specifically localised to one place nor dependent on the activity of the entire brain (Cobb, 2020, 341).

Consumers' ventral striatum (VS) activity has been proposed as a predictor from market data on pop music (Berns & Moore, 2012), and activity in the VS has been the most powerful predictor of real-life market responses to advertising (Venkatraman et al., 2015). Product price and preference have been proper predictors of consumers' purchasing decisions (Knutson et al., 2007). However, memories are not specific to a single place in the brain but, instead, cross the cortical area through neural networks (Cobb, 2021, 230) and connect to other parts of the brain.

Taylor et al. (2003) assume that the self-assessment of sentimental stimuli is further associated with an area involved in automatically affective processes, thus implying

reduced activity in the amygdala (Pasley et al., 2004). The demand for social connection and acceptance are powerful motivators (Baumeister et al., 2008; Lieberman, 2007). Mitchell et al. (2004) indicate that cooperation is connected with viewing other actors as similar to oneself; and sorrow is shown as an activity in the dACC, which is greater when individuals see pictures of deceased persons compared with control images (Gündel et al., 2003). Empathy in neurobiological pathways points to the ACC; and pain is a central type of interoceptive information that activates the ACC (Sapolsky 2017, 528). Ochsner et al. (2008) find that the ACC works as an "all-purpose alarm that signals when ongoing behaviour has hit a snag" (Ochsner et al. 2008, 144).

Neuroeconomics (Camerer & Yoon, 2015) combines behavioural economics with cognitive neuroscience by using studies the trust game (de Quervain, 2004), the prisoner's dilemma (Rilling et al., 2002), and the ultimatum game (Sanfey, 2003) to examine the neural reactions associated with teamwork, fairness, competition, and trust. Neuromarketing researchers also investigate the effects of subliminal advertising. Subliminal waking stimuli provokes activation in brain areas such as the insular cortex, amygdala, anterior cingulate, hippocampus, and primary visual cortex (Brooks et al., 2012).

According to Poldrack (2017), most brain regions are activated in many different contexts, and Buzáki (2019) states that the brain does not represent information but, instead, constructs it. Frontal cortexes comprise working memory, executive functions, strategic knowledge of organising, and executive decisions with action, postponement gratifications, prolonged planning, emotion control, and impulsive restraining (Sapolsky, 2017, 45). In sum, the frontal cortex induces to do harder things when those are the right thing to do.

The PFC is located at the front of the brain and is the most novel part of the frontal cortex, which is the key to executive function and is concerned with focusing on a given task (Hathaway & Newton, 2025; Sapolsky, 2018) Why are we capable of doing things that are difficult, of making choices to take the hard route or go the extra mile? Much of this can be attributed to the bulk of the frontal cortex in an area known as the prefrontal cortex (PFC). One of the last places in the brain to evolve, the prefrontal cortex is thought of as the personality centre and is the cortical region that makes us uniquely human. It is where moment-to-moment input from surroundings is processed, where input is compared to past experiences in order to react to them. It is where insight, foresight, and planning capabilities are turned into the actions that define who we are. Lesions in this area produce several neuropsychiatric disorders that manifest as disinhibition, apathy, loss of initiative,

and personality changes. Discoveries are ongoing about the role of the PFC and how various dysfunctions alter their function (Hathaway & Newton, 2025; Sapolsky, 2018).

The PFC is essential for categorical thinking and, as the cognitive, rational, utilitarian, unsentimental area of the PFC, the dlPFC is the decision-maker. The vmPFC lies in the front cortical area and controls the impact of emotion during decision-making and when behaviour involves interactions. When thinking about a question, greater activation in the dlPFC means that a question will potentially be answered positively (Sapolsky 2017, 55), while, in contrast, insula activation predicts probable rejection (Sapolsky, 2017, 562). Nevertheless, as the brain is networked, any single area in the brain is most often also connected to other areas (Poldrack, 2008).

The hippocampal cells can maintain their engram function and adopt new links to cells elsewhere, dependent on experience. The hippocampus does not contain the engram, and various regions of the brain are interconnected when creating memories. The human brain replays events relating to non-spatial learning while the subject is at rest, with the hippocampus focusing on this activity and enabling the abstraction of new knowledge from prior experiences (Cobb, 2021, 220-221). However, the hippocampus and its subregion contributes to the retrieval, encoding, and consolidation of declarative memories, although their precise roles remains unclear (van Strien et al., 2009).

Barlow (2009) argues that neurons respond to features in a way that has been selected during evolution, but which involves genetic and environmental factors, and that the frequency with which a neuron fires can be taken as a measure of the subject's certainty. The higher the firing rate, the more likely it is that the cause of the neuron's activity is present in the real world. Barlow (2009) shows that objects are represented in neuronal activity as symbolic abstractions and that certain elements of stimuli are encoded in neuronal activity, thereby enabling the brain to process only these key abstractions. Barlow's (2009) notion of cardinal cells has been recast as sparse coding, where the higher the level of representation, the fewer the number of cells involved and the sparser their activity. However, this is more significant in terms of both the overall activity of the system and the representation of the stimulus. Here, a possible connection could be established between conjoint cards' utility scores and cardinal cells' firing rates.

Crucially here, most brain regions are activated in a variety of different contexts, and fMRI provides a surrogate measure of brain activity, that is, the blood flow in large regions, rather than the actual activity of cells, even if these two are clearly linked (Cobb, 2021). In Cobb's (2021) words, "This highlights the fundamental weaknesses of fMRI, it is too coarse to allow a real understanding of the computational activity of the brain. Far more precise imaging methods will need to be developed precise in terms of time, space,

and function and explained in terms of more detailed connectomes." (Cobb 2021, 322) Conjoint cards might help here by providing a context whereby cards, and subjects' responses to them, can be measured in order to obtain precise information about attributes.

2.4 Conjoint analysis

This sub-chapter provides a background for conjoint analysis. Here, I introduce definitions of conjoint methods and outline the concepts that exist in the extant literature on conjoint analysis.

2.4.1 Defining conjoint analysis

The conjoint method was originally used in the field of psychology, and, in the early 1970s, the methodology was already present in marketing research (Blomkvist, Ekhdal, & Gustafsson, 2007). Conjoint analysis refers to various techniques for handling decision-makers' positions when an individual's options differ across more than two attributes. Conjoint analysis measures trade-offs between intentions and preferences to purchase and simulates customer reactions to modifications in offered products or groups of novel products. Conjoint analysis poses the following question for management: why do customers choose a specific brand or supplier over an alternative? Scholars have leveraged conjoint analysis for manufacture, consumer goods, services, and non-profit offerings (Green et al., 2004).

In conjoint analysis subjects are asked to evaluate groups of stimuli from attribute levels or attribute-level connections. Conjoint measuring operates with scales for independent and dependent variables, showing the connection to an independent variable and a compositional mechanism (Green & Srinivasan, 1978), as practiced by mathematical psychologists.

Following Lancaster (1966), goods are united packages of features, and most decision alternatives contain multiple rewards and attributes for an optimum selection. The predictions for every attribute must be tied into an integrated value (Kahnt et al., 2011). Marketing scholars commonly describe brands by means of a concrete series of features and attributes (Al-Kwifi, 2016), which can be utilised in conjoint cards or methods.

Conjoint analysis is a micro-level measurement technique, and many conjoint analysts use the part-worth model to describe subjects' valuation judgments, utilising full-profile, self-explicated, or hybrid approaches, in addition to the more infrequent vector and ideal point models (Green et al., 2004). Part-worth functions can be measured at the individuals level. Importantly, when preference heterogeneity can be detected, this can be recognised

by scholars. Conjoint studies generally include background information on subjects, including demographic or psychographic data. Buyers' backgrounds, particularly demographics, do not always sufficiently relate to attribute preferences (Moore, 1982), and background information needs to be collected to identify the perceived importance or use of purchases for subjects.

Conjoint analysis is a common term for various analytic methods that include the subsequent decomposition of an evaluation. A conjoint task can be understood as a multi-attribute decision problem (Krantz & Tversky, 1971) and the intention here is to discover the relative participation attribute level and attributes' priority order for different attribute combinations (Hair, 2019; Priem, 1992). The utility function of alternatives is linear in terms of parameters, and the linear utility model is key in conjoint studies, although Bayesian methods can locate non-linear designs and deal with anomalies (Allenby et al., 2005).

2.4.2 Conjoint analysis methods

A significant difference exists between the multi-attribute model and conjoint analysis. Whereas the former is compositional and indicates a common view on a subcomponent's total quantity, conjoint designs are decompositional and measure total efficiency, decomposing this into indicated subcomponents (Novak, 1996). The key assumption in conjoint methodology is that the personal preference for an item is decomposed into preference points for component parts or characteristics. The main effects model level is not suspended by other attributes, and its proper application involves a series of attributes that determine the collection of previous preference evaluations (Cattin & Wittink, 1982).

Green and Srinivasan (1990) present three weighting constructions in conjoint analysis: compositional, decompositional, and compositional/decompositional. Decompositional and compositional designs take decisions as inputs, and interval-scaled measures from preferences or attributes (Huber et al., 1993). In *compositional* methods subjects estimate attribute levels and build up priorities for attribute profiles or bundles (Huber et al., 1993). *Decompositional* methods start with overall valuations of multiple attributes following lead worths from attribute levels as estimations. Simulation of the expectation of choice of alternatives is used to evaluate the effect of a change in product formulation and price (Green & Srinivasan, 1990; Huber et al., 1993).

In *decompositional techniques* (Bont, 1992) customers evaluate concepts. The complete preference rankings are decomposed into separate attribute levels. Overall preference ratings are applied with statistical procedures to evaluate the attributes' importance, and attribute-level part-worth. In self-explicated *compositional techniques* (Green &

Srinivasan, 1978) a sparse set of concepts is shown. The concepts' overall utility is the accented number of attribute-level classifications. In compositional design, priorities in the attribute level and important attributes are collected through direct questions to the consumers. *Hybrid* conjoint analysis (Green, 1984) is designed to analyse numerous attributes and their levels simultaneously in conjoint analysis.

Subgroup estimation of part-worth is collected simultaneously to retain individual differences in self-assessment utilities. During material collection, each subject must provide attribute-level estimations, thus giving weights to attributes, and evaluate partitioned sets of stimuli in an orthogonal fractional factorial model. Part-worth is estimated at the individual level (van der Lans & Heiser, 1992, 326).

According to Rao et al. (2010), various conjoint analysis techniques have been used, from the rating-based Conjoint Value Analysis (CVA or CA) to the first Adaptive Conjoint Analysis (ACA) and current Choice Based Conjoint (CBC).

Rating-based systems ask subjects to rank or rate sets of cards. Another system is that of the best-worst conjoint, where subjects are asked to choose the best and the worst from multiple alternatives in each question. CA uses the full profile, where all attributes are shown, but its big disadvantage lies in its maximum of six attributes (Green et al., 2004; Green & Rao, 1971). However, Miller (1956) suggests that regardless of the information which people are asked to remember, the number of items that can easily be remembered lies around seven (Morin & Renvoisé, 2018).

ACA integrates interview responses that have changed in the period since subjects' previous answers. ACA measures more than six attributes due to its partial profile approach. Its disadvantage lies in the need for a computer-based programme, as the adaptation from subjects' previous answers cannot be accomplished by hand; furthermore, interview times here are long (Johnson, 1991).

CBC has been used as the most common conjoint model since 2000. CBC is a full-profile approach, limiting the amount of information asked from a subject to 5-7 attributes. The series of profiles are shared across the sample and, hence subjects commonly undertake 8-12 tasks (Rao, 2010). The Hierarchical Bayes (HB) random effects model does not require personalised design matrices for full ranking, and fewer profiles per subject are currently used (Lenk et al., 1996).

Full-profile conjoint data models retain degrees of freedom by installing prespecified constrained parameters or functional forms. Researchers (Krishnamurthi & Wittink, 1991; Pekelman & Sen, 1979) have used broader, classical part-worth blends with quadratic, lineal, and part-worth variables. Profit in validity and reliability can be gleaned

by restricting part-worth to regarding attributes as monotonous in nature (Srinivasan et al., 1983), or by partially connecting designs, such as those of Green and DeSarbo (1979), Hagerty (1985), and Kamakura (1988). Bayesian-type self-explicated information on single attribute desirability and significances has been shown by Cattin et al. (1983), as well as in the parameter-forced analysis by van der Lans and Heiser (1992). These methods use a large series of full profiles to evaluate part-worth profiles or self-assessment material.

The ACA model (Johnson, 1991) and hybrid models (Green, 1984) are using small number of full or partial profiles or self-explicated part-worth models for evaluating parameters. This model has fewer data demands and has clear commercial applications. Of these, rank orders deliver better reliability (Green & Srinivasan, 1978) yet survey subjects favour rating scales because these involves less time and are more convenient (Cattin & Wittink, 1982). Full-profile conjoint analysis appears to be most suitable for fMRI studies because it provides numerous chances to analyse the entire product or service, as well as its parts, and it shortens the analysis time in the fMRI scanner.

Rao (2010) mentions that the software for implementing and designing conjoint studies is *Sawtooth Software's* ACA and CBC, both of which are complete solutions, while *SPSS* is convenient for a preference-based approach, as is *SAS*'s OPTEX for design and several other programmes for analysis. Also, *LIMDEP* is ideal for analysing many types of data (Green et al., 2004), and the *Bayesm* package in R (Allenby et al., 2005) and *MATLAB*, which requires a specific programme code.

Conjoint methods have progressed continually since 1970, and CA and ACA were the most successful models on the market by the end of 2000, although, since then, CBC has become popular. Classical conjoint analysis (CA) is the best choice in fMRI, because attributes are provided in advance and are constant in lab research; moreover, subjects may not move their fingers or hands too much inside the scanner because it affects the brain and the scanned figures. Classical conjoint methods and fMRI utilise regression analysis and are derived from the same statistical roots.

2.4.3 Data collection in conjoint analysis

In the 2000s, Green et al. (2004) proposed four models of data collection procedures for conjoint analysis: 1) *compositional* techniques, such as CASEMAP (Srinivasan, 1988) where subjects rate the desirability of attribute levels between 0 and 100 and subsequently grade attributes for importance in self-explicated preference data collection; 2) *full-profile* techniques, where subjects see a whole set of the full-profile conjoint cards and sort these into ordered categories, rating all cards on a 0-to-100 scale; 3) *hybrid* techniques, where

subjects work with self-reliant evaluation work and a sub-series of the full-profile cards (Green et al., 1981) and where the utility function works as composite information for both; and 4) the *hybrid and adaptive* conjoint analysis models (Johnson, 1987), where subjects initially self-explicate and continue their evaluations by using paired cards, which subjects in pairs along a comparison scale.

The conjoint methodology is a decompositional research method for analysing consumer preferences (Haaijer & Wedel, 2007). In conjoint data collection analysts utilise the full-profile and hybrid procedures, as well as ACA. Commonly, profile cards are used with attribute levels, although researchers prefer figures. Conjoint methods increasingly use physical products or designed prototypes (Green et al., 2004). Between 1971-2000, the most common conjoint model was the adaptive-conjoint-analysis programme, but other companies (e.g., SPSS) have also provided affordable software for business and academia. However, since 2000 the choice-based conjoint (CBC) method utilises a group of hybrid techniques and has been the most common marketing research technique in conjoint analysis (Raghavarao et al., 2010). The presentation of marketing research by means of conjoint analysis stretches back for four decades, and a wide variety of novel models have been developed in this period of time.

Traditional CA is improved in CBC by combining self-explicated tasks and orthogonal design based on discrete choice models. Despite the implied high inner validity of CBC, it is not always consistent with random utility models (Louviere & Eagle, 2006). Another problem with CBC lies in the confusion that stems from estimating parameters since subjects might have various random components due to unequal scale outcomes. Aggregated evaluations are naturally incorrect, unless all participants are rescaled individually to consider scale distinctions (Teichert & Shehu, 2007). In an fMRI scanner subjects cannot move their fingers too much because of the effect on brain scanning, and it is a time-consuming procedure. fMRI needs studies that are fixed, meaning that each subject has the same set of choice tasks. Here, traditional CA presents the better solution, even if pretests are required to optimise parametrisation prior to each empirical application (Teichert & Shehu, 2007, 121).

The traditionally applied choice-based conjoint studies, often referred to as ‘discrete choice experiments’, have several drawbacks. Although multinomial choice models may allow part-worths to vary systematically with observed consumer characteristics, customers’ part-worths are usually different than what their demographic backgrounds may suggest. A further problem is that the data provide a minimum amount of information about customers’ predilections, for instance which alternative they most prefer amongst all alternatives. Finally, choices entail considering many alternatives, yet already two

alternatives within each choice question causes a doubling of the amount of information about brands that is presented to respondents in rating-based conjoint studies (Elrod & Chrzan, 2007). Traditional CA with fMRI can overcome these problems because all profiles are shown to respondents, while in the choice task the total series of profiles is split into various choice sets and respondents choose their preferred alternatives from these sets (Haaijer & Wedel, 2007, 203), which is more time-consuming than traditional conjoint analysis. However, Akaah (1991) compares the predictive efficiency of self-assessed, hybrid, and traditional conjoint methods with data collection models including in-person interviews, mail questionnaires, and telephone interviews: by using eighteen estimation profiles and six holdout profiles, he shows that the self-explicated and traditional conjoint models gave similar attribute importance across the various data collection models (Kamakura & Ozer, 2007, 148).

The choice of a conjoint model that is suitable for the fMRI environment is important. Participants may not move their fingers too much because the resulting activation of large areas in the brain may hide significant results. There is limited time to choose between many attributes because time inside the fMRI scanner is costly; here, a small number of attributes and an orthogonal array help reduce the time needed. In a fixed-choice task, all subjects receive the same choice set during the same phase of the choice task (Haaijer & Wedel, 2007), which helps in evaluating these against fMRI scanning results. All in all, the most suitable method inside the fMRI scanner is full-profile part-worth conjoint cards and the corresponding software.

The full-profile task in conjoint analysis present subjects with a series of product concepts for which the number of attributes compare to the test factors, which vary between various levels depending on the experimental design (Gustafsson et al., 2007, 77). In the full-concept or full-profile method, participants show their preference by ranking, ordering, or scoring a profile series, or cards. Their interests are represented in these models. Another combination of factor levels or features shows complete products or services in their full concept. Participants show their preferences by ranking or scoring profiles from highest to lowest, or most meaningful to least likely to buy, or similar preference rankings. Through these ratings or scores, conjoint analysis gives utility values for factor levels. Utility scores are the same as regression coefficients, and can be seen as part-worth, which is the comparative significance of each factor (Meulman et al., 2001). An ordinary commercial study utilises 16 series, with eight various attributes on three levels (Wittink & Cattin, 1989; Gustafsson, 2007, 77)

According to Green and Srinivasan's (1990) review of conjoint analyses, the most practical method in fMRI is the part-worth preference model. The best material collection

could be the full-profile model, and the best stimulus construction set is the fractional factorial model. The best stimulus presentation consists of numbers and verbal descriptions, with the best dependent variables measured on a ranking scale. The most useful estimation method is metric with multiple regression. The conjoint method is easy to use in fMRI and produces the greatest differences from the stimulus presentations in conjoint cards (Figure 7).

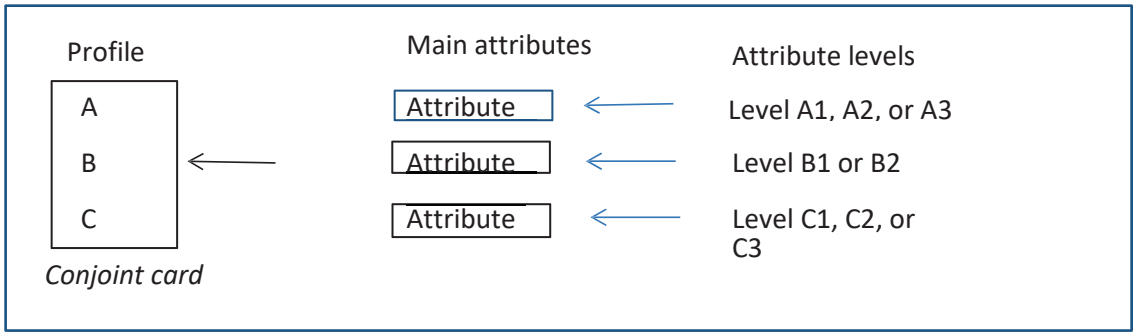

Figure 7. Conjoint cards, main attribute, and attribute levels

All potential attribute combinations are presented to subjects in a full factorial design, and, according to Green and Srinivasan (1978), a full-profile illustration a natural buying situation more closely (Green & Srinivasan, 1978; Gustafsson et al., 2007). In conjoint methods, a multi-linear design is ideal for evaluating the interaction and main effects at the same time. The multi-linear design can be represented as a formula (Figure 8) in the case of three attributes.

$$Gaijk = A + B1_{ai} + B2_{aj} + B3_{ak} + B4_{aij} + B6_{ajk} + B7_{aijk}$$

Gaijk = product-concept's attribute preferences for i, j and k
Bi = weights i for regression
ai = attribute i
aij = attribute i and attribute j interaction
aijk = attribute i, j, and k interaction
A = constant

Figure 8. Main effects and interaction effects

Statistically significant attribute interaction occurs when the comparable regression weight exceeds a critical value. The connections between two attributes (a_{ij}) are related to the first connection sequence, and second-order interactions have connections between the next three attributes (a_{ijk}).

Part-worth can be considered with dummy variables in a regression model. The part-worth formula model looks like a multiple regression formula (Figure 9).

Kaidj = b1 (a1) + b2(a2) + b3 (d1) + b4 (d2) + b5 (d3) + c

Kaidj = product-concept's preference is composed of attributes a and d
bn = part-worth utility as the regression weight of attribute level i or j
ai = attribute a level i
c = constant

Figure 9. Conjoint part-worth formula

The entire group can be computed as linear t-contrast for each subject individually in the analysis. The regression formula is connected (Figure 8 and Figure 9).

In terms of evaluating conjoint analysis's predictive power, subjects often estimate a holdout task when they have already done the main task before. The responses on holdout tasks are used for prediction. The evaluated model should forecast the holdout outcomes as well as possible (Haaijer & Wedel, 2007, 202).

Simonsen and Tversky (1992) separate local and background contrast effects, with the former induced by the choices in the presented set only, while background contrast influences are due to the alternatives considered earlier. Homogenous groups, that is, participants with the same background, help to avoid partial background effects with pretesting before fMRI scanning. The involvement of subjects and their knowledge of the item at hand, as well as the offering category itself, could also affect the meaning of connection effects (Gustafsson et al., 2007).

2.4.4 Orthogonality in conjoint analysis

Almost every conjoint application utilises orthogonal sets to carry out full-profile presentations (Green & Srinivasan, 1978, 392; Green et al., 1988). An orthogonal set is a part of every possible composite estimation of the part-worth with a main effect. Connections for one coefficient based on the level of others are meaningless. Each level of the first coefficient appears with other levels of another coefficient with even proportional frequency, thus assuring independence from the main effects (Meulman et al., 2001). For example, when main attributes have three options (e.g. colour, size, and brand) that have five attribute levels (e.g. colour with yellow, blue, black, red, and white), 243 compositions can be found and rating or estimating 243 elements is not an easy task. In the factorial design, three main attributes and five levels require 81 compositions However, an orthogonal group of 27 compositions explores the main impacts in 313

models (Green, 1984). A practical example of this is presented in Chapter 4 (Subchapter 4.3). Orthogonality reduces the number of questionnaire cards. Fractional factorial designs are a common way of dealing with subject tiredness. If the profiles shown add multiple time attributes and attribute levels, a study that limits work for subjects is tempting (Reibstein et al., 1988). Huber (1987) argues that the orthogonality set has better robustness as it simplifies the different jobs that subjects do in managing the task of profile estimation. Strikingly, orthogonal designs could help prevent possible sources of misspecification error that may appear when various simplifying decision strategies are used (Green et al., 1988).

To reduce the possible avalanche of information for respondents, Thomas (1979) suggests that fewer than five attributes should be used in a survey on customer goods marketing, and that it is unrealistic to have more than 20 stimuli. In contrast, Malhotra (1982) mentions that subjects can process 10 attributes without too much strain, and Green and Srinivasan (1978) recommend using fewer than six attributes at the same time (Gustafsson et al., 2003).

Orthogonality determines interactions and effects from a chart of orthogonal calculation statements. The orthogonal contrasts benefit the determination of effects and connection of constructs, and the orthogonal polynomials are formed in a way that the terms of the polynomials are independent of all the other terms. Independence allows each regression coefficient to be computed separately and tests each coefficient's significance (Green & Rao, 1971; Green & Srinivasan, 1978). The Orthotest was designed in the Posse programme (Wind, 1984) and tests columns for orthogonality (Figure 10).

$\sum_j n_{ij} = n_i \quad \sum_i n_{ij} = n_j \quad \sum_{ij} n_{ij} = n$

n = stimuli rows in plan
r = attributes in columns in plan
x_{ip} = is the $_i$th level of the $_p$th attribute
($_p$=1,2,...,r)
n_i = times that level $_I$ of attribute $_p$ occurs
n_j = times that level $_j$ of attribute $_{p'}$ occurs
n_{ij} = times that level $_I$ of attribute $_p$ occurs with level $_j$ of attribute $_{p'}$

To satisfy orthogonality it is necessary and sufficient: $n_{ij} = n_i n_j / n$

for all p * p' pairs of columns and all $_{i,j}$ pairs of levels (Kwon et al., 1994)

Figure 10. Test for orthogonal proportionality

The linear contrast of orthogonal polynomials uses the formula $\sum (A+Bx) = y$, where A and B are constants, x shows the factor's appearing level, y is the effect of the connection with x, and the total value consists of all x values. The formula is the same as the single regression line. Twin predictors are orthogonal when all coefficients' contrast sum is null, and when the total sum for the corresponding coefficients of the two contrasts is zero (Green & Rao, 1971; Green & Srinivasan, 1978). Many choice rules are possible, but one commonly used method to attain the first-choice rule is simply to accept that subjects prefer the item with the highest utility (Haaijer & Wedel, 2007).

2.4.5 Conjoint studies

According to Rao (2010), the conjoint methodology has been used in areas that include industrial goods (laptops, copier machines, personal computer styling), consumer non-durable products (bar soaps, carpet cleaners, lawn chemicals), financial services (bank services, auto insurance, credit cards), transportation (airlines, electric cars), other services (car rental agencies, hotels, telephones), and other products (pesticides, car batteries, ethical drugs). The conjoint methodology has been used successfully in marketing solutions such as the optimum model of target market options, new items, price of new products, and studying competitive reactions (Rao, 2010).

Conjoint analysis was originally developed in marketing (Green & Rao, 1971), but it has come to have an increasing influence in studies on health care (Bridges et al., 2011; Halme & Kallio, 2011), health food claims (Hirogaki, 2013), tourism management (Thyne et al., 2006), and group dynamics and social interactions (Sonnier et al., 2011). The conjoint analysis methodology has been used to find which factor affects decision-making by analysing the trade-offs in medical studies (Bridges et al., 2012; Kateeb et al., 2014; Ryan, 2000). Experts have used conjoint analysis to evaluate customers' willingness to use a particular technology (Sidak & Skog, 2016) and in the law on the admissibility of professional certificates based on conjoint analysis. However, Whitlark and Smith (2007, 364) warn that conjoint analysis simulations do not routinely consider the possibility of an individual's keen reaction to a competing business.

I now proceed to discuss the advantages and disadvantages of the two methods of fMRI and conjoint. The combination of the conjoint method and fMRI into a single common method will be presented in its own chapter (Chapter 4).

2.5 Advantages and disadvantages of fMRI and conjoint studies

The limitations of fMRI and conjoint methods include costs, fatigue, sample sizes, emotion, and time, all of which are discussed in this section.

Questions can be **read or spoken aloud** for fMRI subjects. The insula is a salience network portion of the brain and facilitates the central executive with a default mode network to activate idea production. When the imagination phase is contrasted with the sensory phase, the brain's left insula is activated. The insula plays an important role when a human works with a given stimulus. Prior studies have reported right insula activation, and the only difference was whether questions were read aloud or absorbed silently, showing that different parts of the brain activate when materials are shown differently in conjoint-fMRI studies.

There has been a tendency to separate **emotions**, neural, and bodily responses to events from feelings of an awareness of emotional reactions (Ramsøy, 2015). This differentiation is not normally made in marketing and leads to needless complexity (Ramsøy, 2019). Biases do exist in customers' decision-making, and neuromarketing studies strive to resolve this kind of problem and leave emotions in the background.

Because rents are costly and the price of an fMRI apparatus can amount to millions of euros (Isabella et al., 2015), the biggest obstacle to broader fMRI operation is **cost** (Ruanguttamanun, 2014). Second, fMRI machines have been criticised for their massive dimensions and medical context, including the limitations they place on participant movement (Ruanguttamanun, 2014). Third, the fMRI is a complex machine that is difficult and time-consuming to operate for researchers who have limited time (Isabella et al., 2015). Expert technicians for the machines must be on call, and training neuromarketing scholars is expensive (Yoon et al., 2012).

There have been **ethical** discussions around neuromarketing. Numerous neuromarketing scholars have gathered data from the brain at the subconscious and subliminal surface (Sung et al., 2019). Neutral predictors exposed in neuromarketing surveys (Knutson et al., 2007; Venkatraman et al., 2015) are misunderstood in that they are designated only to predict consumers' behaviour rather than to force them to buy products (Stanton et al., 2017). This notwithstanding, consumer's autonomy must be protected, and the threat to privacy is particularly pronounced within industry as firms have proprietary control of information and are not obliged to share it universally.

Some researchers have criticised fMRI projects for using statistical **small-sample** studies (Vul et al., 2009) even while others have argued that their studies are valid (Lieberman et al., 2009). Turner et al. (2018) propose that the miniscule samples have an effect on the credibility of fMRI studies, insisting that results are not easily replicated even in datasets with at least 100 participants (Turner et al., 2018), although here much debate exists on this matter (Nee, 2019).

According to Ramsøy (2019), brain reactions to commercials in a small **sample** can predict market responses. Dmochowski et al. (2014) demonstrate that a research sample is relevant for responses from the same episodes and for advertisements that compare Twitter and Nielsen ratings. Boksem and Smidts (2015) find that the response in the brain to movie trailers predicts future preference and market reactions. General responses are fairly reliable throughout a culture because small samples may predict cultural reactions (Ramsøy, 2019) and, hence, provide sound information on customer reactions to marketing stimuli (Berns et al., 2010).

The sample sizes (Table 4) in neuroscientific studies may pose problems compared to traditional behavioural science research samples (Sung et al., 2019) because many neurophysiological studies do not involve a sufficient number of subjects (Boshoff & Toerien, 2017). The majority of neuroscience journals report between 20 and 30 participants in an entire study, which might affect the reliability and generalisability of neuroscience results. Neuroscience data involve repeated within-subject designs with the purpose of maximising the signal-to-noise ratio (Huettel & McCarthy, 2001). Some neuroscience publications have made forecasts from neural reactions that can be generalised to larger populations (Berns & Moore, 2012; Knutson et al., 2007).

The analytical method of **reverse inference** utilised in neuromarketing is challenging (Table 4). The research needs to solely confirm associations between brain activity and a particular behaviour (Plassmann et al., 2012, 31). Reverse inference from specific brain area activations indicates specific psychological process (Poldrack, 2011), and experimental design based on theory is recommended (Plassmann et al., 2015). When two methods are used simultaneously they enable the specification and localisation of emotional responses. Neural measures combined with self-completed reports lead to better purchasing decision predictions (Boksem & Smidts, 2015), such as is the case in the conjoint-fMRI method.

Various areas in our brain may activate due to different moral judgements at the same time. Activation can be identified in the brain, yet this needs to be queried with conjoint cards at the same time to receive a proper answer. The brain intermixes actual and psychic pain (Sapolsky, 2017), and these should not be mixed in fMRI-scanned images.

In neuromarketing there is an **equation** of brain construction with mental actions, such as memory or emotions. Commercial presentations refer to the brain occasionally as a collection of centres that are specialised in processing certain types of information. However, according to Ramsøy (2019), abandoned myths about the brain include that the right and left brain hemispheres exhibit creative-logical differences (Corballis, 2014), that we use only one-tenth of our brain capacity (Jarrett, 2015), and that the brain is divided

into three brain parts (Pogliano, 2017). The utility of a more complex and broader brain model in neuroscience research is a dynamic net of half-specialised constructions that are engaged in multiple processes and which affect, for example, redundance, pluripotential, and degeneracy (Friston & Price, 2003).

Studies in neuromarketing are **time-restricted** and expensive experiments (Table 4) and need immobile appliances in research. Brainwave changes, eye motion, or sweating have no personal or absolute value (Meyerding & Mehlhose, 2020), and Stanton et al. (2017) tackle these united measures to gain a bigger picture. However, around 95 % of mental processing is subconscious, and this provides the opportunity for discerning invisible neuron connections (Pop & Iorga, 2012).

Pozharliev et al. (2015) investigate brain reactions when subjects view luxury and non-luxury-branded products, and find these to differ. Sensitivity to social impact is usually difficult to observe in customers, and Schmälzle et al. (2017) show that consumers' implicit or subconscious ratings are **unable to be articulated** because of a subject's behaviour, therefore making these processes challenging to measure appropriately.

Traditional marketing research methods reveal that surveys might not at all times be completed **honestly**, as individuals have a tendency to follow particular social rules (Bercea, 2015) when marketing research seeks to discover, understand, and predict individual behaviour on the market (Lee et al., 2007). Customers' definite decisions to purchase are not useful when considering all of the background of customers' decision-making processes (Mansor & Isa, 2018) because people keep their emotions and decision-making processes secret (Pop & Iorga, 2012).

The limitations of fMRI in several trials may lead to contamination and habituation effects. fMRI analyses have compared experimental conditions within a subject and aggregated these across subjects. **Between-group** analyses are not the rule (Lieberman, 2007). The brands which are in consumers' minds can reliably be predicted from neural activity patterns (Camerer & Yoon, 2015, 424), and neuroscience methods and tools can provide quantifiable, tangible outcomes that exceed self-reported measures (Ramsøy, 2019, 9).

Furthermore, there may be a risk of **claustrophobia** for some participants in fMRI studies (Huettel et al., 2008), in addition to dangers for pregnant women in the scanning operation (Sahito & Slany, 2012). The scanner's loud, high-pitched **noises** (known as Lorenz forces) are caused by the gradient coils; gradient change induces currents in the human torso that may cause nerve-pricking. Beyond this, pacemaker malfunction is possible due to the current. The field of radio frequency from the excitation coils might **heat** the torso,

and metallic jewellery on the body may cause burns. Tattoos, especially red ink, present a hazard for participants in fMRI. The strong, static magnetic field might cause harm to nearby heavy metal objects, converting these into missiles. (Huettel et al., 2008). For fMRI scholars (Table 4), participants' **fatigue** (Nakagawa et al., 2013), **costs** (Meyerding & Mehlhose, 2020), and subjects' **concentration** (Tagliazucchi & Laufs, 2014) are complicating factors (Table 4), and Nakagawa et al. (2013) have extensively discussed the fatigue problem in fMRI.

Nonetheless, there is no certified biological risk of damage even from strong static magnetic fields (Formica & Silvestri, 2004; Hartwig et al., 2009). The potential carcinogenic impact of fMRI scanning has been demonstrated (Fiechter et al., 2013; Lee et al., 2011), but the DNA damage found with MRI was equivalent to a low level of comparable ionising radiation, suggesting that the risk from fMRI is not known (Knuuti et al., 2013).

Table 4. Advantages and disadvantages of fMRI and conjoint analysis

	fMRI	*conjoint*	*Source*
Number of methods	not many	quite many	Stanton et al. (2017); Green & Srinivasan (1990)
Number of attributes	not enough	many or enough	Iyengar & Lepper (2000); Green & Srinivasan (1978)
Attributes' meaning	not always clear	not always clear	Ramsøy (2015, 2019)
Between-group analyses	sometimes missing	easy to make	Lieberman (2007)
Conscious vs. subconscious mental processes	both	conscious	Pop & Iorga (2012)
Consensus on concepts or notions	quite clear	many schools of thought	Liebermann (2007); Kahnemann (2009); Thaler & Sunstein (2009); Morin & Renvoisé (2018)
Costs	high	low	Meyerding & Mehlhose (2020); Ruanguttamanun (2014)
Difficult to replicate	sometimes	can be replicated	Lieberman (2007)
Ethical issues	some ethical issues	none	Lin et al. (2018)
Fatigue in fMRI	fatigue is a problem	helps against fatigue	Nakagawa et al. (2013); Masicampo & Baumeister (2008)
Honesty in answers	can be seen	unclear	Bercea (2015)
Reverse inference	problematic	unproblematic	Plassmann (2012a)
Sample size	criticised	unproblematic	Nee (2019); Berns et al. (2010)
Several trials	problematic		Lieberman (2007)
Subjects' concentration	problematic	helps concentration	Laufs & Tagliazucchi (2014)

All in all, only one suitable method exists in neuroscience, namely fMRI, because it scans inside the skull (Jezzard et al., 2001; Stanton et al., 2017). Numerous conjoint methods exist (Green & Srinivasan, 1990) and researchers have developed new conjoint methods (Green et al., 2004). However, the classical conjoint analysis model (Green & Srinivasan, 1978) appears to work in the fMRI environment as attributes need to be kept the same on conjoint cards and cannot be altered during a trial in the fMRI scanner (Table 4).

Sufficient attributes cannot be shown in fMRI but, with orthogonality on conjoint cards (Green & Srinivasan, 1978), more attributes can be shown more rapidly, thus lowering the high fMRI costs (Meyerding & Melhose, 2020; Ruanguttamanun, 2014). By reducing the time necessary, subjects can be prevented from becoming fatigued during fMRI (Masicampo & Baumeister, 2008; Nagawa et al., 2013; Masicampo & Baumeister, 2008), and this helps subjects' concentration (Laufs & Tagliazucchi, 2014) in the fMRI scanner (Table 4).

Reverse inference (Plassmann, 2012) and repeated trials (Lieberman, 2007) cause analysis problems for fMRI. Conjoint analysis connects subconscious activation fMRI results with concrete results from conjoint cards. Sometimes subjects are unable to

articulate their choices at the subconscious or implicit level, which is challenging to measure appropriately, and attributes' meanings are not as clear (Ramsøy, 2015, 2019). Conjoint cards and fMRI activation results together help to focus subjects' valuations and connect attributes with BOLD (Table 4).

Some fMRI analysis cannot be replicated (Lieberman, 2007), but using two methods together shows the same object from two sides. Triangulation with two methods and their respective significance tests generates results with more emphasis on using conjoint and fMRI together. Between groups analysis is costly with fMRI (Lieberman, 2007), but conjoint analysis can be replicated with a comparison group more cheaply (Table 4), a fact that similarly applies also sample sizes (Nee, 2019; Berns et al., 2010).

In regard to advantages, subjects' brain activities with fMRI help to check if they are honest in their answers (Bercea, 2015) and, at the same time, conjoint cards aid in evaluating them in comparison with each other (Table 4). Conjoint cards help to evaluate individual attributes, and the entire bundle thereof, from customers' valuations (Green & Srinivasan, 1978), and fMRI can detect subjects' honesty in their answers (Bercea, 2015).

The disadvantages of conjoint-fMRI are the vast amounts of attributes (Green & Srivinivasan, 1978) because tackling the problem of fatigue and concentration in fMRI leads to a concomitant loss of the opportunity to use as many attributes as desired. While ACA analysis can accomplish this, attributes there change per person, thus causing problems in fMRI as these should be kept the same. Costs are high with fMRI, although time can be constricted. Ethical issues are always present (Lin et al., 2018) when discussing thoughts and opinions inside one's skull (Table 4). However, no one can change an individual's thinking other than the individual themselves. Pacemakers, tattoos, claustrophobia (Huettel et al., 2008), and loud noises (Sahito & Slany, 2012) in fMRI scanners are problematic. All in all, fMRI cannot be used for all subjects.

Both conjoint analysis and the brain connect single attributes (George, 2022; Lancaster, 1966; Varian, 2016) of products or bundles. Many conjoint analysis models use a regression analysis formula (Green & Srinivasan, 1990), as does fMRI with GLM, the general linear model or general multivariate regression model (Figures 2, 4, 5, and 6). However, fMRI does not pick up individual attributes' place in the brain, which is why conjoint cards are needed for precise information. Biases in customers' decision-making are sometimes not easy to detect, but conjoint cards and fMRI together can identify them.

Rhythmic activity in brainwaves ensures that the relevant signals connected to the sensation arrive simultaneously at the binding district, thus allowing the receiving neurons to process the signals in conjunction, recombining them into a single sensation

(George, 2022). For example, people experience the world in simultanagnosia in the same way as objects in a scene are perceived separately, rather than as a whole. Such individuals may have damaged their brain's posterior parietal lobe, which links information from different representations of the object. This supports the approach of multimodal mental representation. Kahnt, Heinzle, Park and Haynes´ (2011) fMRI data analysis shows that the united value is coded in the vmPFC and the individual attributes in the dlPFC. The basis in conjoint analysis relies on attributes and their valuations, and fMRI scans brain actions with these attributes.

Marketers are deeply interested in knowing how customers like an entire product, as well as how particular attributes affect customers' decisions. While many market research methods help to discover the former of these attributes, the latter is less clear. Conjoint analysis with orthogonalised cards can accomplish this (Green & Srinivasan, 1990) with all single parts because all conjoint cards are different, with different combinations of attributes, with the exception of holdout cards that help analyse significance between cards. fMRI analyses brain activity with all cards, hence allowing researchers to calculate utilities between attributes and the whole bundle with conjoint analysis. Summing up both methods requires the same amount of time and generates information on the best bundle of attributes from its utility scores and activity areas in the brain. This information, then, ensures that results can point towards a better product or service. I present this model at the end of this dissertation (Chapter 4).

3 Publications and Their Connection to the Model

The four studies contained in this dissertation introduce conjoint cards and fMRI into the conjoint-fMRI model. Subjects link themselves with people and events in the fMRI video, and laboratories can build virtual environments that resemble genuine environments. Consumers can take part in the event and reply by using the display. These publications are presented here in their main outlines, but they are included in their entirety in the Appendices at the end of the dissertation. I now proceed first to present these publications and then how they connect to the conjoint-fMRI model.

3.1 Neuromarketing: Understanding customers' subconscious responses to marketing (Publication I)

This first publication discusses how fMRI can be connected to other methods of analysis method, as well as discussing the benefits of joining together two methods.

The valuation circuits in the brain settle in the dlPFC. Behavioural data indicate that anxiety stimuli automatically activate fear and capture attention, and this effect is conveyed by the subcortical brain network focused on the amygdala (Öhman, 2005). The amygdala notices threat in the brain, and other regions act when similar emotions are experienced. Emotion seems to include a patchwork of kinetic, emotional, and somatosensory components (Bastiaansen et al., 2009), and the IFG is activated when test subjects see individuals on the screen with whom they associated themselves and whose behaviour and feelings they mirror (Gazzola et al., 2006).

Brain activation during this process includes dlPFC activity, which equates to increased emotions of safety, thus giving a sign of the person's willingness to buy. Neuroimaging shows brain activity, aiding marketers in finding and decreasing negative sensations such as fright, unsafety, peril, and danger and promoting consumers' eagerness to buy. Quite a few subjects have been able to deliver reliable information on consumer reactions to marketing stimuli (Berns & Moore, 2012; Moore, 1982). Such information is beneficial for firms to build stores and shopping environments that appeal to customers, as well as to plan sales and marketing material, e.g. advertisements, which supports the company's image and increases sales.

Such information is not readily available to customers, who may be concerned about optimal strategies. In situations of doubt and ambiguity, individuals' logic and conscious judgment are of limited assistance for sentimental experiences, and it is not surprising that somatic senses are enlisted to select the best possible option. The evaluation of ambiguous choices (Bechara & Damasio, 2005; Sobhani & Bechara, 2011) involves

different areas of the brain than does the evaluation of risky choices. The amygdala and orbitofrontal cortex (OFC) with the dmPFC are very active in obscure conditions that are dangerous. The dorsal striatum is activated under risky conditions and in expectation of reward. This indicates reducing ambiguity to the predicted reward of decisions. Overskeid (2000) argues that when facing doubt, individuals choose the decision that feels optimal, thus diminishing anxiety of the unknown with intuitive decision-making. People may express pride over acting rationally and logically, yet they nevertheless remain unable to neutralise their emotions.

The OFC (Coricelli et al., 2005) is deeply involved in the anticipation of regret, and experience causes an effective response based on what could have occurred if a specific decision had been made. Subjects with a damaged OFC do not feel regret despite feeling disappointment and anger over the outcome of a decision (Camille, 2004). The regret emotion in the ACC and hippocampus indicates the function of learning from that experience and remembering the wish to withdraw. The activation of the OFC happens, first, when the experience has an unfavourable result and, second, before a subsequent new decision is made in the same situation, which suggests that humans are influenced by potential regret even at the moment of making new decisions (Coricelli et al., 2005). The scaling of value here points to the PFC, striatum, and vmPFC areas (Seymour & McClure, 2008).

Neuroscience researchers have noticed brain activation when handling creativity in spoken and visual form, intellectual imagery, inventive tale generation, painting, and music (Aziz-Zadeh et al., 2009; Ellamil et al., 2012; Fink et al., 2009; Goel & Vartanian, 2005; Howard-Jones et al., 2005; Jung-Beeman et al., 2004); and this occurs specifically in the heteromodal cortex areas of the temporal, frontal, limbic, and parietal sections (Arden et al., 2010).

The executive network with the DMN plays an important role in creative thought (Beaty et al., 2014; Ellamil et al., 2012; Geary, 2005; Raichle & Snyder, 2007), and this network involves the dlPFC and the ACC. The DMN comprises the medial prefrontal cortex (mPFC), PCC, TPJ, AG, PCU, IPL, and SMG. The salience network's role is special when humans turn away from a conventional habit into a new direction. Meanwhile the insula is part of the salience network (Seeley et al., 2007) and plays an essential role in emotional processing (Bechara & Damasio, 2005; Cauda et al., 2011), although its role in creativity remains unclear.

Creativity is one part of novel models or products in marketing. Methods such as the conjoint-fMRI must mention a subject's different modes of thinking. Creativity includes

not only the ability for heuristic and explicit consideration, but the potential to switch between the two situational thinking modes (Beaty & Silvia, 2012; Gabora, 2010).

3.2 A novel analytical approach to neuromarketing (Publication II)

The second publication discusses how fMRI and conjoint analysis can be connected and shows the potential benefits of this connection.

The research question here is whether the use of conjoint cards can shorten fMRI analysis time. Orthogonality in conjoint analysis aids in reducing the number of questions, and conjoint cards with the fractional factorial models help to avoid subject fatigue. Orthogonal designs protect against the misspecification that occurs when operating simplified decision action plans (Green et al., 1988).

Subjects' exhaustion is crucial for decision-making. According to Masicampo and Baumeister (2008), in a depleted state customers may spare their effort and are less willing to compromise. Consumers focus on only one attribute, for example the lowest price, utilise only proportional information, give in to the dominance affect, or retain the status quo and refuse to select anything at all (Masicampo & Baumeister, 2008). Fatigue is avoided in fMRI with conjoint methods and the orthogonality on conjoint cards. Semantic knowledge about the characteristics of objects as ideas for things' attributes has been extensively studied in terms of customer behaviour. Belief is an estimation of the attribute that depicts an item, and the abstraction of product information can be slight and show a direct representation of the object.

A stimulus for an fMRI study can stem from an attribute, picture, word, video, song, taste, or smell and show various markers in the brain. Attributes give meanings for the whole product, and these can be evaluated by researchers. Nonetheless, the intensity of products' and attributes' effects cannot be detected in brain activity research. Conjoint cards' attributes can be a figure, word, picture, or substance that could be estimated in the fMRI. Attributes on conjoint cards reveal full-factorial preferences from subjects and sub-part activity in the brain. Conjoint analysis and fMRI together can estimate more attributes and material from products or services to demonstrate a customer's priorities and decision-making, and this study shows that fMRI analysis time can be shortened with conjoint cards.

Publication II suggests the order of actions in the research framework when the conjoint-fMRI research method is used. The approach starts with the choice of attributes on the conjoint cards, followed by their use in fMRI (Figure 11).

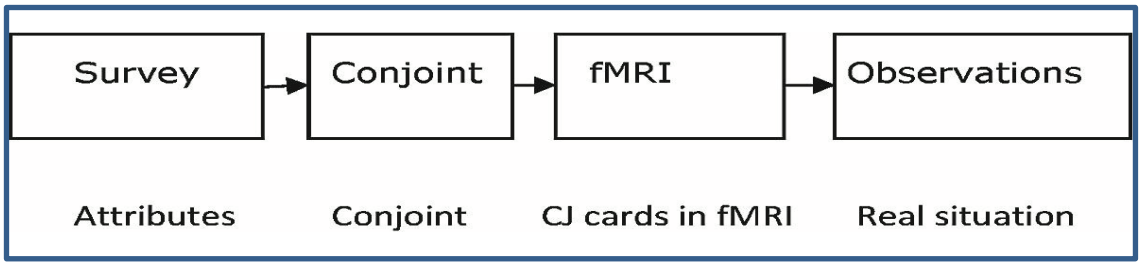

Figure 11. Research framework of conjoint-fMRI analysis

Here, the subject ranks or rates profiles from best to least preferred, in order of the likelihood of buying, or on other preference scales (Figure 7 and Figure 17). These ratings or scores generate conjoint analysis utility rates for factor levels. The utility score is the same as a regression coefficient and is named part-worths to indicate the relative importance of each factor (Suleiman et al., 2000). In conjoint-fMRI research, computer simulation technology can be used that is akin to genuine experience. Test participants in virtual surroundings can interact and make decisions just as in real-life behaviour. Reibstein, Bateson, and Boulding (1988) argue that a series of attributes' reliability is excellent, thus showing that conjoint design does not need to include all the attributes in the model; in other words, if key attributes are included, the remaining attributes will have minimal bearing (Reibstein et al., 1988). Furthermore, conjoint analysis is reliable in the context of different kinds of data collection methods and product categories. The quality of the chosen attributes has a minimal effect on the technique's reliability (Reibstein et al., 1988, 284); nevertheless, social factors are essential to the marketing and selling process and have often been implemented as affordances that support social interaction.

Customers may not realise how they make decisions due to emotion and earlier decisions that they remember. Conjoint analysis is a handy instrument for product or service analysis, specifically for attributes and attribute levels. Conjoint analysis reveals main attributes, for example colour, price, or brand, and shows which of these is most meaningful for the consumer and which of the sub-attributes of the main attribute is liked more. The best combination of attributes could serve to make the consumer act. fMRI reveals the extent of feelings for chosen attributes and their position in the brain. Conjoint analysis separates the attributes from one another and estimates their utility or meaning for consumers.

According to Green and Srinivasan's (1990) summary, the most useful conjoint analysis method with fMRI is the preference and part-worth design. The data collection model could be full-profile or fractional factorial. The stimulus demonstration with spoken and numeral illustration is suitable here, and the weight-dependent variable scale could be

used for rating or ranking, with subsequent evaluation using a metric method with multiple regression.

3.3 Analysing e-services and mobile applications with accompanied conjoint analysis and fMRI technique (Publication III)

The third publication proffers different conjoint methods and elements that necessary prior to analysis with fMRI. Furthermore, it suggests which of these conjoint methods is the most suitable for fMRI analyses.

The use of full-profile conjoint outcomes (Huber et al., 1993) involves two proposals to improve performance. First, the sensitivity of the full profile's predictive validity confirms Green and Srinivasan's (1990) recommendation that hybrid conjoint and ACA should be used with attributes in quantities higher than six. However, Iyengar and Lepper (2000) mention that the human ability to handle the wish for choice is limitless, and that the order effects reveal that the full profile affects participants more since they forego an advance warm-up task that familiarises subjects with attributes and their levels (Huber et al., 1993). Because subjects cannot give and choose attributes in the fMRI scanner, and because all attributes and their sub-levels must be provided beforehand, the suitable method here is hybrid conjoint analysis.

Orthogonality shortens participants' time in the scanner (Reibstein et al., 1988), and the fMRI commonly requires an hour per person. Diminishing the time spent in the fMRI scanner improves results and enhances subjects' working time. The full-profile model gives a realistic sensation, improves data collection speed and managerial interest, and the utility of data shows broad coverage (Cattin & Wittink, 1982). Rating scales take less time for the interviewee and are suitable and easy to analyse (Cattin & Wittink, 1982), and rank orders generate greater reliability (Green & Srinivasan, 1978).

Hagerty (1985) assumes that regression with the ordinary least square method is a suitable technique for analysing a participant's responses from conjoint cards. Cattin and Wittink (1982) argue that this design has great predictive cogency in conjoint data. Furthermore, Hagerty (1985) demonstrates that the peculiar R^2 conjoint estimate is around 0.85. Almost all conjoint researchers check heterogeneity and use regression model to evaluate part-worth (Hagerty, 1985).

Carroll and Green (1995) introduce a plethora of approaches and sampling methods for conjoint analysis. Full factorial designs give all potential attributes' combinations for profiles; in contrast, the fractional factorial model only partially covers just the master

designs and reflects these in the attribute profiles (Bont, 1992). Full factorial design works smoothly in the study of fMRI with conjoint analysis.

3.4 Default mode and executive network areas: Association with the serial order in divergent thinking (Publication IV)

The fourth publication deals with areas that are activated in the brain during creative tasks when material is delivered in different ways. Concretely, processing research material that is spoken aloud or absorbed in silence activates different areas in the brain.

Collecting the material in the fMRI either auditorily or in writing generates different activity results. Earlier creative studies were built on spoken or written operations. Dietrich and Kanso (2010) suggest that the connection between idea generation and the prefrontal regions is connected to working memory and the intentional brain network. The fMRI problem here is to discover an alternative to presenting a typical picture without verbalisation. The frontal cortical region might not require a person to generate ideas and involve white matter. The ACC plays the role of executive network and is relevant for handling new or conflicting information (Geary, 2005) and hold the task in target (Dosenbach et al., 2008). The ACC and executive network might enable subjects to predict their habitual thoughts in a fresh way.

Creative work is not relaxing but, rather a purposeful and focused process that draws on effective and cognitive resources. The DMN and the central executive with the salience network are purposeful and focused on the creative process. Results show explicit thinking as a relevant section of idea generation and DMN, while the central executive and salience network teamwork in neuromarketing processes is a novel way of thinking that is necessary for new products or services.

Mental representations (Eliasmith et al., 2012; Thagard & Stewart, 2011) are multimodal, and generating ideas during mental processing is not limited to the conceptual level. According to Eliasmith (2013), when people imagine a thing, they do not use words but instead activate typical representations for that thing's context. The human brain imports sentimental associations and activates sensorial, auditory, and visual representations of the object, all of which serve to support the approach of multimodal mental representation. Creativity studies (Beaty & Silvia, 2012; Gabora, 2010) highlight that creativity is neither heuristic nor explicit but contains the capacity to change between different thinking modes based on the needs of the topic. Participants were asked to think about new alternative uses for casual goods in a study, to imagine novel possibilities, and to be prepared to modify their way of thinking, sharing the cognitive control process and the DMN to form novel mental designs, to be used for newer items or fresh uses.

The rational evaluation of good and bad sides is a valuable tool for informed decision-making and a promising strategy for verifying superfluous emotions, thus ensuring that insight is supported in deliberations. Sharot et al. (2009) show that difficult choices between equivalent options need exact neural estimations in the brain while the imagination works. Adhering to a tested convention is not only self-persuasion and ex-post rationalisation but also important for an individual's peace of mind. In this way, it reflects a sensible form and follows upon revaluation in the reward area of the brain.

Emotions about the future are structured in the Ventral Striatum's Nucleus Accumbens (NAcc). Anterior regions are stimulated with the expectation of enjoyable events, while imitation of distressing forthcoming events can show activity in the amygdala and, sometimes, the striatum's posterior ventral part. Maintaining these systems' internal stability is urgent in order to generate sufficient expectations under conditions of uncertainty, for results that include punishing and rewarding elements (Yacubian, 2006). Hinds et al. (2013) find that more activation in the SMA accompanied by less in the default-modes areas accurately predicts alertness. However, DMN activation in alertness tasks shows a bad brain state (Hinds et al., 2013).

A correlation exists between divergent thinking, serial order effect, and brain activities. As shown in prior studies, there is a possibility that subjects' idea generation tactics change during this process (Gilhooly et al., 2007). Specifically here, initially produced ideas might be built on memory, while later ones are based on novel associative combinations (Gabora, 2010).

DMN recruitment is not commonly connected with the distinct-thinking mode. Nevertheless, the DMN connects a selection of affective, cognitive, and visceroceptive operations to the resting state process (Ellamil et al., 2012) because the DMN is activated in hypothesis generation, memory search, future planning, and evaluation (Buckner et al., 2008). Studies by Ellamil et al. (2012) and Limb and Braun (2008) reveal a connection between creativity and DMN activation, and creative individuals are also unable to suppress the activation of the DMN (Takeuchi et al., 2012).

Studies show that a section of the DMN is nullified during a creative task. Negative associations have been identified (Benedek et al., 2014), with divergent thinking activating the PCU and TPJ, and the PCC with the middle cingulate cortex (MCC). In previous studies participants vocalised (Benedek et al., 2014) or wrote down (Fink et al., 2012) their responses, whereas in Publication IV (Heinonen et al., 2016) the participant imagined a wordless response.

The DMN helps other brain circuits when novel or unexpected events occur in an individual's neighbourhood. People follow and collect information at the same time as the DMN facilitates setting up those emotional responses that individuals monitor while processing information (Damasio, 1989; Ramachandran & Hubbard, 2005; Simmons & Barsalou, 2003).

The right anterior insula (Menon & Uddin, 2010; Uddin, 2015) and bilateral insula (Cauda et al., 2011; Uddin, 2015) are an essential centre of the salience network, which may simplify the interplay between the executive and default networks. Creative thinking brain-imaging researchers find that the left insula activates during creative processes (Beaty et al., 2015; Benedek et al., 2014; Ellamil et al., 2012; Gonen-Yaacovi et al., 2013). Creativity research with fMRI shows left insula dominance activation for non-verbal work (Gonen-Yaacovi et al., 2013). However, non-verbal studies show left anterior insula activation during idea generation, just as in Publication IV. The anterior insula is the salience network's core hub (Beaty et al., 2016; Uddin, 2015), which is important when a person switches from a conventional way of thinking to a novel way, thus demonstrating that anterior insula dominance activation depends on whether a job is spoken or silent.

Prior studies focused on the subject in the fMRI scanner receiving spoken commands and instructions from the outside. In contrast, in Publication IV the subject acts independently and the left insula is activated instead of the right one. Evidently, independent silent work activates different areas of the brain. This can be utilised in conjoint-fMRI. Conjoint cards instructions can be given silently or aloud inside the fMRI scanner, because warm-up tasks help in using conjoint cards beforehand. This opportunity, then, generates new dimensions for studying the brain.

The four publications presented above form the basis for the conjoint-fMRI model, and each of these has contributed to the construction of my model, which I present in the next chapter alongside an example of how this method can be used.

3.5 Connection of methods to publications

This dissertation leverages four publications (see Appendices) to construct a model that connects conjoint analysis, fMRI, and neuromarketing studies (Table 5). This methodological section focuses specifically on the conjoint-fMRI analysis model and explores its effects on continued usage, as well as the impacts of conjoint-fMRI on promoting user retention, with an eye to increasing the quality and frequency of using conjoint-MRI. All four publications investigate both research and methodological outcomes. Publication 2 deliberates on the question of how to shorten the time spent in

the fMRI scanner in conjoint-fMRI studies and describes how conjoint cards' attributes are connected and serve to form a research frame for a conjoint-fMRI survey. Publication 3 unwraps the model of conjoint-fMRI analysis and explores how to use it with e-services and mobile applications. It also describes the background of conjoint analysis and its connection with fMRI, offering an overview of various fMRI and conjoint methods. Publication 4 evaluates different analytical methods in fMRI when there is silence in the fMRI scanner, inquiring into the type of activation that occurs in the brain and demonstrating a design stimulus in an fMRI scanner. Publication 1 discusses the background of neuromarketing and offers an example of how to use fMRI to evaluate potential new methods in marketing research. It shows an example of a phase in an fMRI scan and video clips that can be used with conjoint cards. This final publication investigates the psychological benefits that can be predicted in the brain and whether there are different ways to analyse participants (Table 5). The first publication discusses the neuromarketing world, Publications 2 and 3 concentrate on the conjoint-fMRI model, and the fourth focuses on neuromarketing analysis and stimulus design. In the next chapter of this dissertation I then introduce the conjoint-fMRI model (Chapter 4).

Table 5. Publications on the conjoint-fMRI model and its tools

Publication	*No.*	*Contribution to the conjoint-fMRI model*	*Elements*
Neuromarketing: Understanding Customers' Subconscious Responses to Marketing	**1**	Phases of fMRI scan process. How to connect fMRI with another method	fMRI phase, video material shown in the trial
Conjoint Analysis with fMRI: Novel Analytical Approach to Neuromarketing	**2**	Connections between conjoint cards' attributes Framework for conjoint-fMRI research How conjoint cards shorten time spent in fMRI	attributes conjoint cards research framework
Analyzing E-services and Mobile Applications with Accompanied Conjoint Analysis and fMRI Technique	**3**	Measuring conjoint cards Differences between conjoint analysis methods Neuroscience methods for neuromarketing	measurement methods fMRI
Default Mode and Executive Network Areas: Association with the Serial Order in Divergent Thinking	**4**	Stimulus design with fMRI Material collecting methods	auditory vs written design collecting data

Methodologically, fMRI and conjoint analysis exhibit differences that inform numerous factors, both ideological and practical. Methods can be traced to how a researcher believes that precise knowledge describes reality. All individuals weight pictures and attributes with their own relevance, which strongly describes how reality is perceived and comprehended; and without this social construct reality cannot be understood directly. An individual's subjective and social behaviour fundamentally distinguishes cognition from the nature of what is objectively real. Social reality is that in which lives and research

are conducted, in that personal understanding helps people to make decisions and connect to the world. In other words, all individuals act and choose from their own world.

From a practical perspective, using two research methods in tandem is beneficial for approaching complex, fine-grained marketing phenomena, for which it would be difficult or inappropriate to make strict assumptions about their nature, particularly when pursuing knowledge about the general mechanisms of how reality functions. Promoting the objectivity and repeatability of observations over subjective or socially constructed meanings does not imply that these latter factors should not be the target of investigation (Figure 12).

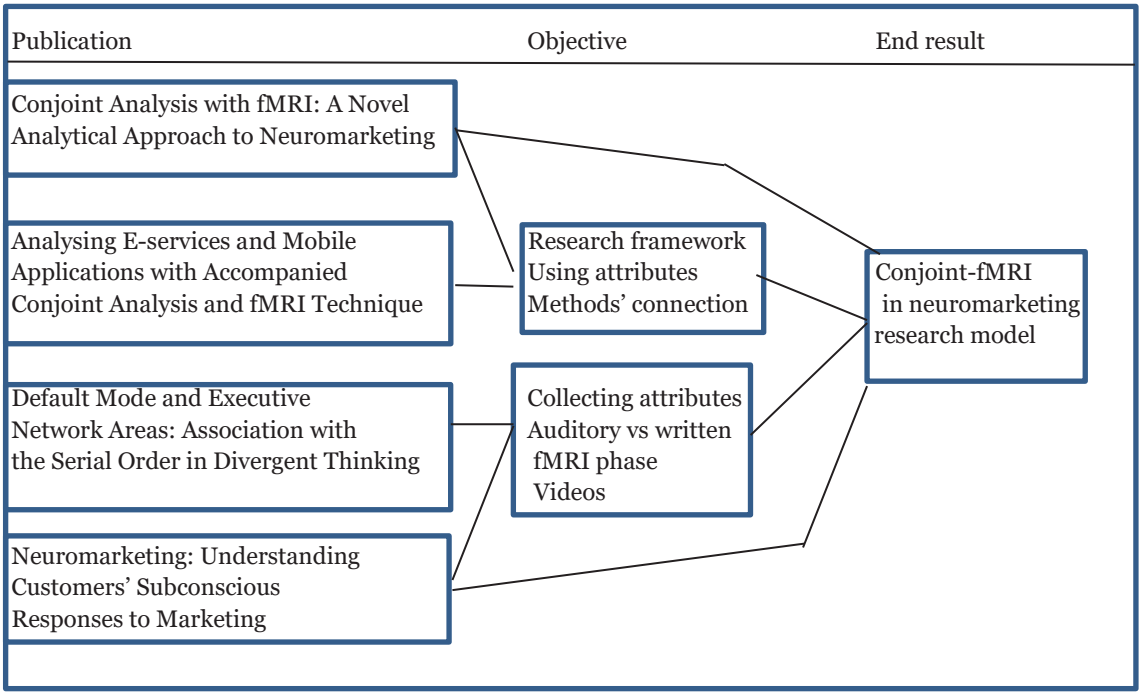

Figure 12. Research approach and design; publications' connection to the model

3.5.1 Conjoint cards and attributes (Publications I and II)

The most functional conjoint programme available is SPSS Categories or SPSS Conjoint with fMRI, and how well the model suits the data can be shown with Pearson r or Kendall tau statistics, which are correlated with the discovered or estimated affections. Here, profiles were not estimated as scores of the holdout cards profiles but revealed a better sign of how well the model fits.

As a pretest in the survey, attributes were collected with open questions in a questionnaire, the coding of which easily uncovered the distinct attributes for conjoint cards. Participants saw the same conjoint cards in the fMRI scanner as the preference group (Figure 7 and Figure 17). In the full-profile method, the subject scored a set of profiles, as stated by their preference. All factors or profiles showed a variant composition of factor levels and the full concept revealed the whole service or product from each profile (Figure 8).

The conjoint cards were shown on a screen inside the fMRI scanner, and the subject chose the appropriate percentage with a slipping-finger potentiometer. This percentage was the same as the subject's affection for the package of attributes. The conjoint card showed a variant of sub-attributes, and the participant gave their preferred percentage for the ongoing cards.

3.5.2 fMRI method (Publications I-IV)

The fMRI data was gathered with a 3 Tesla Siemens Magnetom Skyra located in the AMI lab at Aalto University in Helsinki, Finland. The imaging capacity covered the entire brain with 27 continuous axial slabs in an interlaced way. The data study was performed with Matlab1 version 7.8.0347 built on SPM8 software. For pre-processing we utilised the fDPA toolkit. The pre-processing steps in the fMRI process were realignment, normalisation, and volume artifact removal.

In fMRI effects are usually registered at the 5 % ($p<0.05$) level and are corrected in multiple means comparisons with the family wise error (FWE) procedure in statistical parametric mapping (SPM). Those activation clusters which exceed a spatial scope's 80 voxels (2∗2∗2 mm) threshold are reported. MR imaging started with structural scanning, following functional scans. The fMRI scanned structural and functional data with SPM software. Each subject was motion-corrected and registered with the structural datum and spatially normalised in Montreal Neurological Institute (MNI) space. A Gaussian kernel spatial domain was used for smoothing. All statistical analyses were guided by the general linear model (GLM), which is identical to the general multivariate regression model. Each experimental condition was generated with model time based on the haemodynamic

response functions. The analysis for the entire group was computed with linear t-contrast for each subject individually.

fMRI is good for identifying the vascular reaction in the brain neurons' activity when studying mental activity in BOLD contrasts (Lindquist et al., 2009). The haemodynamic response function's (HRF) shape estimates mental interest and can be held to show information on background metabolic activity in the brain.

The fourth publication discusses what occurs in subjects' brains when using voice or text to present material in fMRI. While numerous ways for collecting the material in fMRI with conjoint cards exist, the fourth publication's subjects received auditory orders rather than written material, thus differing from prior studies.

Three new aspects emerged in comparison with earlier creativity research. First, the idea generation serial order effect, which has not been used before in fMRI (Beaty & Silvia, 2012). Second, wordless tasks let participants produce ideas in their mind without verbalisation, in contrast to subjects in creativity research who are usually asked to give verbal answers to idea generation (Benedek et al., 2014; Fink et al., 2010, 2012). Finally, participants chose the number of their ideas and how long they wished to work on idea generation in the fMRI. The serial order study with restricted divergent thinking tasks (Beaty & Silvia, 2012) meant that only 15 minutes overall were spent inside the scanner.

The fMRI colours a relevant picture of the brain in those locations where blood flow increases notably. Researchers can image the neural activity of the conscious and affective reactions to a stimulant (Wilson et al., 2008). The fMRI has been used to inspect how people make decisions, evaluate risks, estimate rewards, compare personal choices, and choose which product to buy. The research model follows Dimoka's (2012) plan for fMRI studies in social sciences. Video clips were shown (Figure 13) during the trial while subjects' brains were scanned, and brain activation was monitored during the subsequent showing of pictures. Following this, subjects' responses were estimated by asking about their intention to buy a particular product and measuring their reactions. This can also be done by using conjoint cards as still pictures with the conjoint-fMRI method.

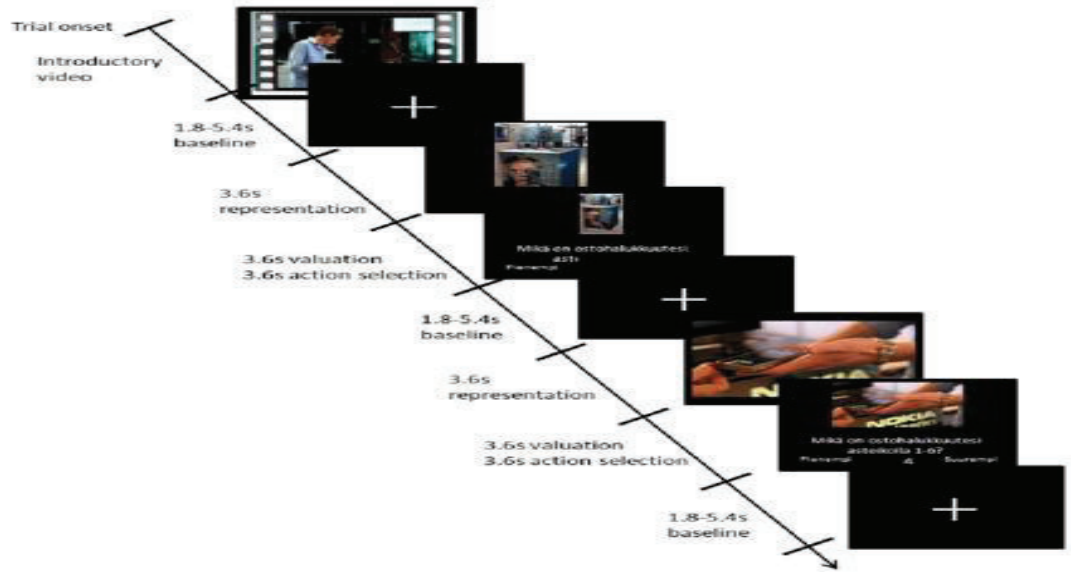

Figure 13. A phase in the fMRI scan and the use of pictures

Our analysis captured individual magnetic slices from a participant's brain, as well as the BOLD change signal in time units. The fMRI data was based on the changes of the BOLD signals, which measure the rate of deoxyhaemoglobin and oxyhaemoglobin in a participant's brain. The fMRI scan was performed every 1,800 milliseconds (TR). Each test subject saw a blank baseline after an introductory video to help the participant rest and allow the BOLD signal to be reduced, returning to normal following the haemodynamic reaction. After the baseline, test subjects were shown still pictures and provided with an evaluation stimulus to measure their willingness to buy, on a scale of one to six (Figure 9). Pictures included a presentation (3.6 seconds), valuation (3.6 seconds), and action selection (3.6 seconds), in alignment with the framework in Rangel et al.'s (2008) neurobiology study on value-based decision-making. Conjoint cards showed still pictures and plus (+) pictures for the same duration during fMRI scanning.

3.5.3 Data analysis (Publications I-IV)

fMRI data analysis steps. The results of fMRI scanning were played as time stamp pictures, which were aligned with the BOLD signal and the materials that appeared in the task. The fMRI data can be evaluated in pretreatment, framing a design matrix, and statistical tests.

At first a participant's brain data were **pre-processed**, and the data were corrected and organised to align with the remaining material gleaned from the participant. The subject's movement within the scanner required corrections. The brain induces displacements of various millimetres, which also require correction. The BOLD signal was positioned on

the anatomical image of the participant, and temporal and spatial data were used to portray the examined participants. After the normalisation of spatially comparable brain sections, it was possible to use standard coordinates for subjects. A Gaussian kernel was used for the spatial smoothing of the data in order to reinforce the validity and signal-to-noise ratio of conclusions in the analysis (Nurmi et al., 2018). With pretreatment, within and between subject statistical analyses were applied to the neurophysiological data.

The second step was to incorporate the data into a **design matrix** with the assumed intensity of brain activity as the BOLD signal (Friston, 2005). In the design matrix chart, rows stand for time points and columns show experiment variables. The design works as a pattern for other statistical analyses.

The third step was conducting **statistical tests** of each voxel. Subjects' statistical parametric maps were analysed with t-test and t-contrasts, and the outcomes were moved to the anatomical brain picture. A group analysis was performed on the parametric map with the t-test results from the individual analyses. Tests could be conducted with different conditions to account for variance in the one-way t-test for physiology. This test compares participants' parametric maps to make conclusions at the grouped level, and the between-subject analysis reveals which area in the brain is acting. These were calculated as mean brain activation from groups.

As opposed to these three steps, Lieberman (2009) shows a different type of path with six steps and neuroimaging analyses, described in more detail as analyses conducted with fMRI data (Lieberman, 2006). The first of these is **preprocessing** in fMRI studies, where normalisation, realignment, and smoothing are the standard components of preprocessing. The second is **whole-brain analyses** in fMRI tests with all the voxels in the brain. This represents the regions that cross some threshold for consistency with the trial regressor. The third is **region of interest analyses** reporting the results for a region of interest (ROI), that is, only those regions involved in a process of interest. The fourth is **connectivity analysis**, which focuses on independently working brain regions. The fifth is the commonly used **regression analysis**. The sixth is **reverse inference**, referring to the difficulty in drawing psychological inferences. We chose only three steps in our conjoint-fMRI study because reverse inference could be avoided with conjoint cards by splitting attributes and evaluating these separately, and because regression analysis is already used in fMRI and conjoint analysis (Figure 9). The following chapter reviews the conjoint-fMRI model.

4 Model and Discussions

Neuroimaging is well suited for supplying information on consumer action that is not otherwise attainable, and here the conjoint method fills research gaps. This chapter describes the use of the conjoint-fMRI model and brings together this dissertation's two key elements, namely neuromarketing and conjoint analysis.

4.1 Conjoint-fMRI model description

From a theoretical perspective, the way in which fMRI and conjoint analysis can be used to analyse goods and purchased services is based on neuromarketing that considers fMRI and conjoint analysis designs as one aspect of a single research model. The idea here is to discover conjoint analysis and fMRI patterns that together analyse marketing problems (Figure 11), and subsequently to connect and compare these with prior studies to obtain new insights about both methods. Based on previous publications on conjoint analysis and fMRI studies, the role of these neuromarketing studies with conjoint methods and fMRI can be modified. Notably, however, problems did arise in this endeavour, such as connecting the laboratory environment to reality in the fMRI scanner.

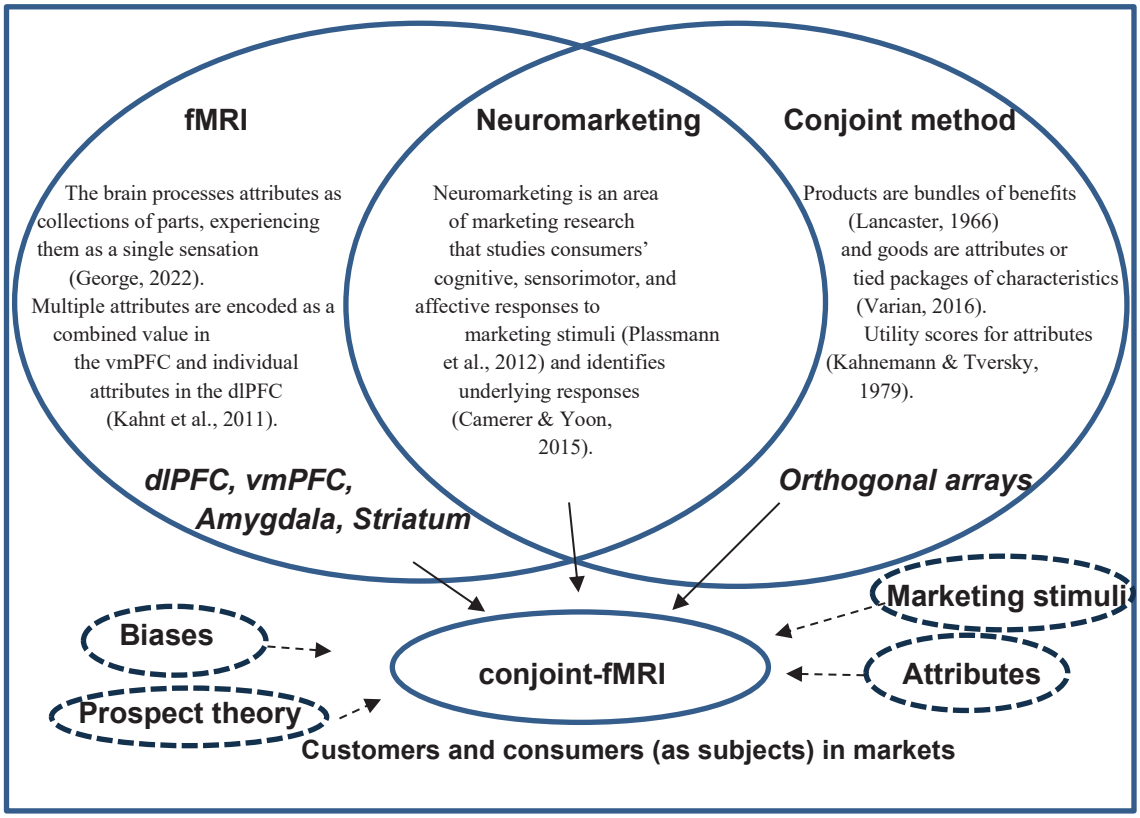

Figure 14. Research framework in conjoint-fMRI analysis

Neuromarketing is but one of several approaches in marketing research fields. Nobel laureate Kahnemann and his colleague Tversky (1979) and fellow Nobel laureate Thaler (2016) depict how customers have their own ways to make decisions. Neuromarketing research connects the fields of statistics, psychology, medicine, marketing, and economics (Camerer & Yoon, 2015, 424). Biases (Figure 14) in customers' actions can be followed by connecting the conscious mind with conjoint cards, and the subconscious with the conscious in fMRI scanning. Biases are subconscious in customers' minds and are important for neuromarketing, similarly to prospect theory's role therein. In turn, attributes in conjoint cards are the material that researchers use statistically to evaluate and verify connections between these two methods.

Conjoint analysis has the ability to predict actual choice behaviour (Green & Srinivasan, 1990). Full-profile conjoint theory (Huber 1993) provides proposals on how to improve performance. The number of attributes confirms Green and Srinivasan's (1990) recommendation that ACA or hybrid conjoint should be preferred when more than six attributes are in play. The full-profile task is more effective when prepared with a warm-up task that helps subjects with the attributes and their levels (Huber et al., 1993). The most useful estimation model of conjoint analysis is the metric method with regression analysis (Green & Srinivasan, 1990). Regression analysis is commonly used in fMRI (Lieberman et al., 2009) and the regression analysis is the same method for fMRI and full-profile conjoint statistics (Figures 6, 7, 8, and 9). Conjoint analysis and fMRI together can prevent subject fatigue and provide enough time for subjects to react in fMRI due to the orthogonality on cards.

The conjoint-fMRI model description is illustrated (Figure 13) illustrated and steps are spelled out (Table 6) for it. Conjoint cards are seen as screen pictures in the fMRI scanner, yet it is vital not to forget the duration between cards. Conjoint cards (Figure 7) can be used with suitable software, and data can be analysed separately with multiple regression models (Figure 8 and Figure 9) or together (Figure 13). Here, it is beneficial to evaluate orthogonality (Figure 10) for conjoint analysis.

Table 6. Model steps in conjoint-fMRI method

Step one. Gather proper attributes via open questions or with factor analysis and pick the most apparent attributes for conjoint cards. The participants are going to see the same conjoint cards as the preference group (Figure 17 and Figure 7) in the fMRI scanner.
Step two. Select a workable conjoint program. Profile sets (Figure 7) in conjoint analysis (CA) are easy to evaluate in the fMRI scanner and participants do not have to use their fingers too much. Subjects can focus on the task at hand.
Step three. The conjoint cards are shown as still pictures in the fMRI scanner screen. The participant chooses their preferred percentage for the presented conjoint cards by using a sliding potentiometer with their finger. The outputs are stored as time-stamped images, which are aligned in the BOLD signal within the trial. The subject's BOLD signal is set on the anatomical image before the trial with conjoint cards. The design matrix is a template for further analyses. The results are built into the statistical parametric map, which is formed from the anatomic brain image. Active brain areas are tested between participants. The mean brain activation of the group is counted together. The data is motion-corrected and co-registered, and spatial normalisation per person is conducted in the MNI (Montreal Neurological Institute) space.
Step four. The final step is to compare conjoint-fMRI results (Figure 8 and Figure 9) with actual marketing values.

The model description's four steps (Table 6) can be illustrated in a structured picture (Figure 15).

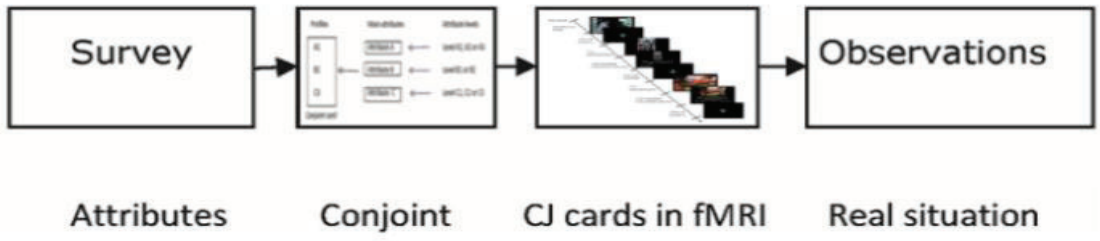

Figure 15. Conjoint cards as fMRI pictures in the conjoint-fMRI model

Neuroimaging is a suitable technique for investigating consumers' pleasure and displeasure. Neuromarketing research goes further than traditional market research and customer satisfaction studies. The brain's estimation works consciously, but the required information needed is unattainable without the aid of neuroimaging. A consumer's preference is subconscious and not easy to indicate with words (Berns & Moore, 2012). The perceived coefficient has a considerable effect on customers' decision-making processes. The detected level of safety only drops marginally at the moment of a decision (Schaefer & Rotte, 2007), and subjects feel safe in the fMRI and its study environment.

Being inside the scanner affects the results from subjects, yet what they feel about the respective materials accurately reflects the case they are working on.

Customers feel comfortable throughout the purchasing situation. Activated areas in the dlPFC, which shows increased feelings of safety, have a positive effect on an individual's willingness to buy. Neuroimaging helps marketers to identify customers' acts from brain activity and reduce negative feelings such as fear, uncertainty, danger, and risk, thus promoting consumers' eagerness to buy. The IFG works with the mirror neuron system, suggesting and associating subjects with things seen on video. These indicate that people tend to think, behave, react, and feel in the same way. Neuromarketing utilises still pictures and video clips to study behaviour and reactions, in this way offering proposals for future research topics in neuromarketing. The model could be used for the purchasing process, as well as to evaluate novel products and services' models and applications. The conjoint-fMRI method can discover whether attributes activate consumers' brains, that is, whether they dislike or prefer the attribute levels or bundles shown, and whether they are eager to buy the product.

Conjoint measurement (Krantz & Tversky, 1971) gives an array of the connection effects of the variables and a prespecified composition rule. The hybrid models (Green, 1984) consist of a small number of full or partial profiles for research advances and require less data than other conjoint methods. By using full factorial designs all attribute combinations in the model that fit well with fMRI and conjoint analysis can be seen in attribute profiles.

Goods have attributes or tied packages of characteristics (Lancaster, 1963; Varian, 2016). Participants' attribute profiles with fMRI should limit the attribute-level information to a maximum of five or six attributes (Green & Srinivasan, 1978). Orthogonality in conjoint cards reduces participants' time in the fMRI scanner (Reibstein et al., 1988), which can normally amount to several hours per person. A shorter time spent in the fMRI scanner generates better outcomes and improves a subject's action time. The full-profile model provides a natural reflection, speed up data collecting, rise management interests, utilises data and cover wide area of information (Cattin & Wittink, 1982). The classification scale here is less complex for interviewees and provides the framework for robust analysis (Cattin & Wittink, 1982), while rank orders provide greater reliability (Green & Srinivasan, 1978).

People commonly see a whole picture with narrow attention to details, collecting key components from memory. The necessary components affect the hedonic sum of the total experience. The majority of tasks have a rather narrow set of positive and negative attributes, which contain a high number of positively or negatively relevant attributes, and the overall hedonic value is the sum of all of these units. Simulations focus on key

features and customers tend to prefer good things to be worse than they are in reality. Tom et al.'s (2007) neurological study shows impaired connectivity in the dopamine neurons of the midbrain and serotonin in the brain stem organism, which fosters an emotional effect over an appreciation of losses and gains.

In an fMRI study subjects' brains are scanned as they view activation objects seen in form of figures, videos, or still pictures. A six-point scale is needed for the evaluation, and subjects use their fingers to respond or express answers aloud into a microphone. In our study, the subjects were only asked to think about their creative innovations and to write them down afterwards. This collection of answers revealed a new way of how the brain works: instead of right-side insula activation, the left side was activated. This means that brains use various parts when subjects are asked to give responses or think about questions.

4.2 Benefits and limitations of the model

Neuromarketing became a significant topic of interest during the period in which the research for this dissertation was conducted. The publications undertaken for this dissertation are part of this development.

This dissertation suggests that by focusing on behavioural outcomes and the design elements in marketing, relevant results can be generated in the laboratory within a natural environment. Customer reactions and a simulated market can be seen in the laboratory by means of the conjoint-fMRI method, which can be described as a continuation of traditional marketing research methods and neuromarketing research. Marketing research prefers focus group interviews, surveys, and observations to analyse consumers' decision-making, but conjoint-fMRI utilises research techniques within a simulated service or goods setting.

Under pragmatic conditions, differences pertain in terms of purchasing on an empty as opposed to a full stomach. Low physical and physiological energy levels control behaviour and can affect outcomes (Vohs & Faber, 2007). Furthermore, impulsive shopping might be usual at the end of a shopping tour or at the end of a long-lasting decision-making period, and neural circuits activate in prefrontal areas such as the vlPFC, the subcortical limbic organs, and the striatum and amygdala. With the conjoint-fMRI method, the amount of time spent by subjects in the scanner is crucial. Hungry participants may give different results compared to those who are not. Engelmann et al. (2009) note that in a laboratory study where participants were given expert financial recommendations, subjects showed less activity when calculating the impact of

probability on the expected payoff than those who did not receive such advice. The laboratory environment is challenging for neuromarketing research. In light of this, the questions asked with conjoint cards can generate results that are more dependable than fMRI alone.

Tired consumers use limited information, give in to dominance effects, wish to uphold the status quo, and avoid making a choice (Masicampo & Baumeister, 2008). Orthogonality aids by reducing the number of question cards, and the fractional factorial model is an ideal way to avoid subjects' exhaustion. Numerous profiles increase the time needed as well as the number of attribute levels and attributes, which is why an approach that eases the task at hand is attractive (Reibstein et al., 1988). Exhaustion can be avoided in fMRI with conjoint cards' orthogonality.

Salient attributes (e.g. price) exist that can be identified from all attributes present. Engelmann et al. (2009) find in a laboratory study that advice from financial experts affects participants' activity in regions that need probability calculation on the assumed payoff. The network activates the ACC, medial occipital gyrus, thalamus, dlOFC, and anterior insula when the brain is overwhelmed by processing and comparing others. A method to diminish material collection time in fMRI studies is needed. The humming of an fMRI scanner induces sleepiness in some subjects, and an eye tracker can help to recognise this by using it at the same time as the fMRI scanning. Nevertheless, a better solution here is to reduce the time spent in the scanner, and conjoint cards are ideal for accomplishing this.

More than the reaction to the stimulus is shown in the fMRI scanner if BOLD cluster size in fMRI indicates a high utility of conjoint cards' attribute utility scores. Different stimuli exist here, including pictures, attributes, words, video clips, songs, tastes, smells, and others, which trigger different areas in the brain, and utility points from conjoint cards help to distinguish between various kinds of sources.

The attributes on conjoint cards can be separated into pieces and evaluated separately. Items' attributes create meaning for the entire offering, but how strongly products and their attributes affect the subject cannot be discovered from the brain. This notwithstanding, we can feel disgusted (the amygdala) for a thing we would like to own (the striatum). In combination, conjoint analysis and fMRI can reveal how much a consumer desires an offering, or the extent to which they need to be convinced via marketing.

Companies have been inefficient in connecting attributes to customers via statistical models, and managers have used surveys to understand differences in thinking between

customers and managers. Olson and Reynolds (1983) point out that individuals can help in collecting numerous kinds of knowledge about an object and semantic data on opinions concerning its attributes, all of which are usually studied through consumer behaviour. These opinions or beliefs have been managed through attribute evaluations. If the level of abstraction of product knowledge is miniscule, this can be directly represented in the item's results.

Some subjects will attempt to flatter the researcher by choosing a pleasing combination. Conjoint analysis can identify the best attributes or products without evaluating whether the subject is honest in their choices, and activation in the striatum indicates willingness to buy a particular product. Thus, joint fMRI and conjoint analysis can assist in avoiding misinterpretations of the data.

Conjoint analysis has the ability to predict real choice behaviour (Green & Srinivasan, 1990), and here Huber (1993) provides suggestions on how to improve full-profile conjoint performance. The full profile's sensitivity and forecast validity related to attributes reinforces the recommendation (Green & Srinivasan, 1990) when hybrid conjoint is operated with more than six attributes. The order effect is more effective when a full profile contains a warm-up task, which familiarises subjects with conjoint cards and the attributes and their levels (Huber et al., 1993). With the conjoint-fMRI method fatigue can be avoided, ample time is provided for fMRI, more attributes can be included, and more services for the market can be provided. Neuromarketing is suitable for understanding complex marketing challenges, such as consumer engagement tests, by introducing marketing material to participants.

The next step in neuromarketing research should establish associations between brain activity and a particular behaviour (Plassmann et al., 2012). Two methods simultaneously enable us to specify and localise emotions. Neural measures with self- reporting generate significantly better predictions of subsequent purchasing decisions (Boksem & Smidts, 2015), as is the case for the conjoint-fMRI method.

Parts of the DMN do not work on creative tasks, and negative associations can be identified as divergent thinking activates the PCU with TPJ, and the PCC with the middle cingulate cortex (Benedek et al., 2014). In prior studies subjects were asked to vocalise (Benedek et al., 2014) or write down (Fink et al., 2012) their responses, whereas in our study (Heinonen et al., 2016) participants imagined their responses silently. The brain is complex and recent studies have shown that various parts of it have surprising connections, even in newly identified ways, as in e.g. the left and right insulas' activation during creative tasks. The same appears to be the case with the dlPFC and vmPFC, both

of which lie in the same area in the PFC yet in separate locations and acting separately to process information.

Kahneman (2012) argues that System 1 is quick, automatic, easy, and lacks a sense of voluntary control, while System 2 requires mental activities for complex data processing. The automatic System 1 generates intricate patterns of thought, but the slower System 2 focuses on ideas in organised steps. The mental process is instinctual or automatic in System 1, and more deliberative in System 2. Morin and Renvoisé (2017) discuss the rational and primal brain, and Lieberman (2007) emphasises that the C-system acts as a guide for social awareness while the X-system responds to automatic social cognition, in this way appearing to have the same roots as Kahneman's and Morin and Renvoisé's systems. However, at times a battle for supremacy takes place between the dlPFC and vmPFC, in form of emotion versus cognition. As early as 1923, Freud recognised these decisions arising from external action and questions. To date, no research has connected the above-mentioned terms together, so it was time to do it here. We should use similar concepts in our scientific publications. Nonetheless, our brains are still partially a mystery, such research is helping us to approach an understanding of our decision-making and, thus, of ourselves step by step.

Camerer and Yoon (2015) express confidence in multivariate techniques. The efficiency in neuroimaging research has sometimes been low, and meta-analyses could analyse discoveries of single studies and provoke questions that have yet to be modelled in independent research. Meta-analytic models can address the reliability of activations across studies and their particularity. Specificity is critical because reverse inference's validity allows researchers to include a specific psychological state and the concomitantly observed activation in a certain brain region (Poldrack, 2011), and this indicates the conjoint-fMRI method.

A connectome is a map of neural connections in the brain that shows connections between various brain regions and can be thought of as a wiring diagram (Hagmann, Grant, & Fair, 2012; Sporns, Tononi, & Kötter, 2005). Connectomes do not work with conjoint cards that utilise orthogonal arrays, as the graphs cannot be extrapolated from the orthogonal array (Green, 1971), and, if the aim is to reduce the time spent in the fMRI scanner, the orthogonality model is inappropriate because logit requires more time. The linear utility model is the key idea in conjoint studies (Allenby et al., 2005). Some areas, e.g. the dlPFC and vmPFC, seems to activate in decision-making, but the brain is a whole and is connected to different parts through its network. These two areas seem to be activated in decision-making, yet other connections to other parts of the brain also exist at the same time. Nevertheless, this methodological solution attempts to approach potential brain

activation areas and their connection to the attributes of conjoint cards, which could facilitate neuromarketing studies.

4.3 Proposed procedure and model for conjoint-fMRI combination

The procedure in the conjoint-fMRI model has already been explained (Chapter 3) but here I complement this with illustrative examples that show their practical use in research situations. Combining these two methods during fMRI scanning might initially appear simple, but this requires preparations and warm-up tasks to be performed in advance.

The active neurons in BOLD with fMRI in the haemodynamic response remains at around 10 seconds, ascending and peaking between 4 and 6 seconds before falling. Researchers collect data from various slices with strong magnetic gradients, and process and analyse these data statistically (Huettel et al., 2008, 205–208, 220–229) for slice timing correction, intensity normalisation, realignment, temporal filtering, univariate analysis, and generalised linear model and multivariate analysis (Behroozi et al., 2011). The functional Data Processing Assistant (fDPA) toolbox and the DPARSF toolbox help analysing and fixing material. In addition to DPARSF, the fDPA toolbox incorporates the ArtRepair toolbox.

Deoxygenated haemoglobin is paramagnetic compared to oxygenated haemoglobin (Hb) in red blood, that is, diamagnetic or magnetism resistant. This transformation can be scanned to show active neurons (Huettel et al., 2008). In an fMRI study subjects' brains are scanned while they view activation objects seen as figures or still pictures in conjoint cards. Subjects use their fingers to move the potentiometer to respond to conjoint cards' figures, words, numbers, or other materials. The subject sees one conjoint card at a time as a still picture inside the fMRI scanner. Each card contains the main attribute's name and its changing attributes. The name of the main attribute remains constant on the cards, but the levels of the attributes change from card to card. There is a comparison point with the same attributes of a different, competing product. In the preceding section of this chapter (Table7) I already introduced the conjoint-fMRI model's research progress order step by step.

Conjoint analysis predicts actual choice behaviour (Green & Srinivasan, 1990) and the recommendation here is to include no more than six attributes in one conjoint card. The workable model of conjoint analysis is the metric method with regression analysis (Green & Srinivasan, 1990). Orthogonality helps to reduce the number of conjoint cards, but it is not advisable to present more than six different attributes at the same time in an fMRI scanner because the ability of respondents to evaluate them is limited.

Conjoint cards are flexible for taste, sound, moving images, text, prototypes, and a range of other types of materials, but fMRI scanners work only for tasting liquids, video shows, still images, and sounds. Metal objects may not be brought near the large magnetic coil, hence limiting the possibilities of different types of attributes in fMRI.

4.3.1 Research design for a conjoint-fMRI study

The model has four consecutive parts (Figure 16). To begin with, suitable attributes are selected for the conjoint cards by utilising a focus group or a group familiar with the topic. Attributes can be collected by conducting a **survey**, asking how a subject would describe the product or issue in question. The next step is to place the attributes in the **conjoint** programme so as to obtain the appropriate conjoint cards. In the third step the images from the conjoint cards are superimposed on the images displayed on the video screen of the **fMRI** scanner. The answers of the subjects to be interpreted through the conjoint cards are put into the conjoint programme, which calculates utility values for the attributes. The scheduling of the fMRI images and the presentation of conjoint cards in this same schedule are placed side by side. Finally, the utility scores calculated for the attributes of the cards through conjoint are compared with the fMRI images and **observed** in relation to practical market values.

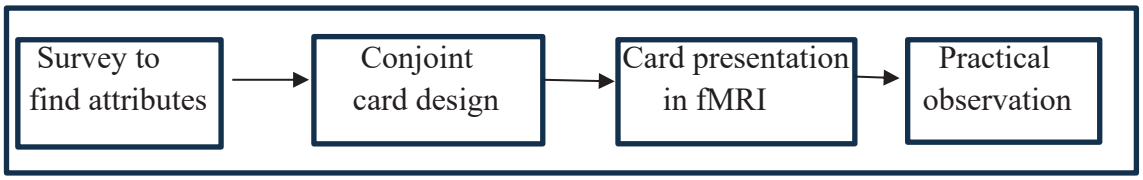

Figure 16. Research design for the conjoint-fMRI analysis (see Figure 11)

4.3.2 Preparation for a conjoint-fMRI study

Prior to running the conjoint-fMRI material in fMRI scanner suitable attributes need to be collected from the focus group. The focus group should be homogenous, and they must be familiar with the subject or product being studied so that they can compare competing products with respect to the subject being studied. Suitable attributes can be found from focus group participants or users of the product.

Researchers must find the same kind of attributes, which can be discovered from the product being studied and from a competing product. These are the same attributes that will be included in the conjoint cards. One mean attribute must be continuous, such as money, litres, or kilogrammes, but the remainder of the main attributes may be descriptive or discrete in nature.

Before a subject enters the fMRI scanner a warm-up conjoint task is needed that helps subjects with the attributes and their levels. Main attributes and attribute levels can be the same as in the fMRI scanner, in duplicate paper versions. The pre-test is performed on products of similar types, but not necessarily on those included in the actual study. This pre-test can be conducted outside the fMRI scanner room, in paper-and-pencil form.

The pre-test is needed so that the participant understands how the scoring functions in the conjoint card and how to work in the fMRI scanner, as well as seeing how attributes change from card to card. At the same time, the participant also learns how the main attributes are grouped on the cards and the type of scale they use.

4.3.3 Procedure and measurements in a conjoint-fMRI study

As an example here, we could analyse the cars that customers prefer, main attributes of which could be colour, engine size, and brand, in addition to three other main attributes. Attributes for the main colour attribute could be white, blue, yellow, black, and red, that is, five different colours; engine size could be 1.0, 1.2, 1.4, 1.6, and 1.8 litres, in continuous order because one of the main attributes must be a continuous attribute. Brands could be BMW, Mercedes-Benz, VW, Volvo, and Fiat. These attribute levels and their attributes give 3^5 different variations, for a total of 243. By using an orthogonal array, we can drop different conjoint cards to 27 (Figure 7). These conjoint cards (Figure 17) are presented individually via still pictures in the fMRI scanner.

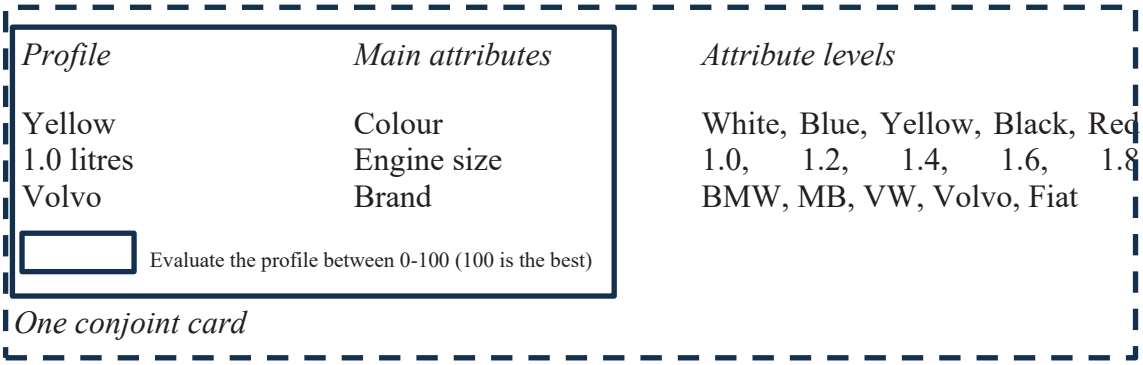

Figure 17. Example of the conjoint card (cf. Figure 7)

The conjoint cards are synchronised with the fMRI imaging between two computers and projected onto the fMRI scanner screen by using a video projector. The images on the cards are acting simultaneously with the fMRI measurement. The presentation time of each image is known (Figure 18).

The full-profile task shows subjects a series of product concepts, for which the number of attributes compares to the test factors that vary between various levels, depending on the experimental design (Gustafsson et al., 2007). Conjoint cards contain attributes of the competing product next to the ones being compared (Figure 18). The attributes of the alternative product remain always the same on each card.

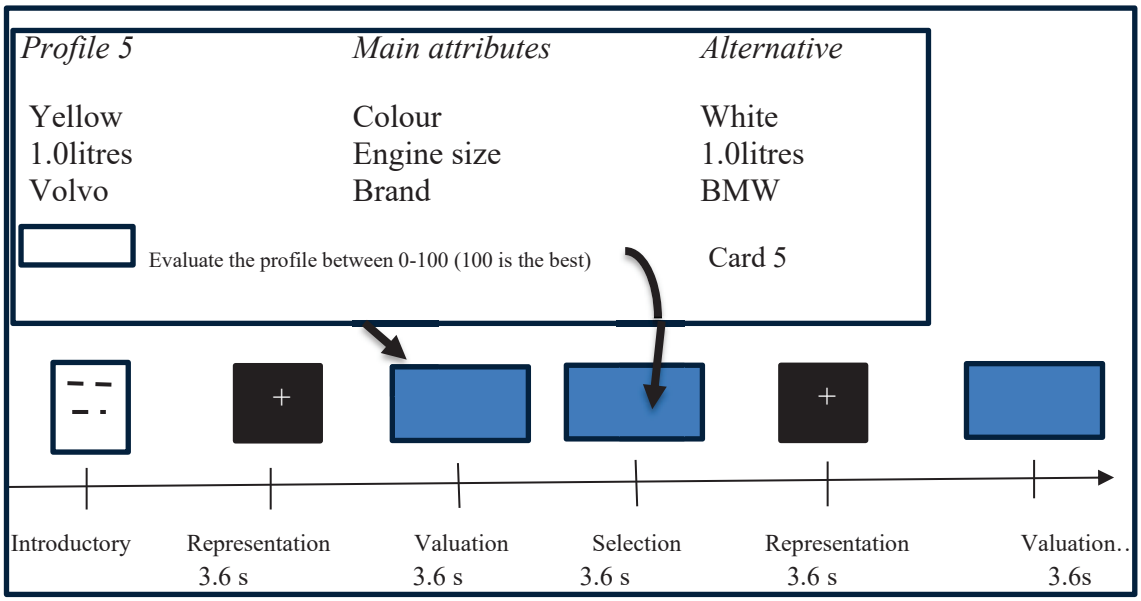

Figure 18. Presentation times and conjoint cards (see also Figure 13)

Each test subject sees a blank baseline (3.6s) representation after a conjoint card (3.6s) in order to help the participant rest and allow the BOLD signal to diminish and return to normal after the haemodynamic reaction (Figure 18). After the baseline, the subjects see a still picture of conjoint cards (3.6s) and evaluated stimulus, selecting (3.6s) the participant's willingness to like the product shown in conjoint card attributes.

With the full-profile technique subjects see a whole set of the full-profile conjoint cards in the fMRI scanner and rate all cards on a 0-to-100 scale (Figure 18). Every paper card has a box under its attributes for valuation, but in the fMRI scanner participants use a potentiometer, the scale of which is 0 to 100. Two alternatives in each choice entail a connection about brands that is presented to respondents in rating-based conjoint studies (Elrod & Chrzan, 2007). Examples of conjoint cards can be found in previous thesis, for example: Suomalaisten tiede- ja ammattikorkeakoulujen opinnäytetyöt (Heinonen, 2006).

4.3.4 Analysis in a conjoint-fMRI study

SPSS provides affordable conjoint software for business and academic uses, but any software that uses orthogonal arrays will suffice if it uses full-profile techniques. Conjoint cards should be the same for all subjects so that results can be compared with each other.

Therefore, classical conjoint analysis cards are best suited for conjoint-fMRI studies. Commercial conjoint software constructs conjoint cards and analyses collected material with graphics. These programmes produce cards when all the main attributes and their levels have been coded into the programme. After the completed cards are written into the programme, a graphical representation of the results is produced, as well as the attributes and main attribute utility values.

In fMRI effects will be registered at the 0.05 level and are fixed in multiple means comparisons with a procedure in SPM and voxels' 2∗2∗2 mm threshold. Imaging will start with structural scanning, followed by functional scans. The fMRI scans structural and functional data with SPM software. All participants will be motion-corrected and registered with structural data, spatially normalised in MNI space. Each experimental condition is generated with model time based on the haemodynamic response functions. These modelled times are utilised when combining these with the presentation times of conjoint cards.

The still pictures and fMRI slices are synchronised in order to analyse which conjoint card belongs to which fMRI picture. The analysis captures individual magnetic slices from a participant's brain, as well as the BOLD change signal in time units. Utility scores and pixel figure size in the brain might correlate with each other. There is no other similar conjoint card due to orthogonality and, hence, these all differ from each other. Researchers can compare utility scores per conjoint card with pixel areas or cluster analysis values from the fMRI scoreboard, and here utility scores per attribute and main attribute can also help. A good set of attributes in holdout cards and their utility scores helps in significant tests.

Signal-to-noise ratio might be challenging when combining fMRI's requirement for stimulus repetition with conjoint analysis sparse design. One stimulus must be repeated many times for a signal to emerge from the noise, yet the conjoint card that is being worked with remains the same. Because the same attribute appears in several conjoint cards although all conjoint cards are different, the utility values can be used to identify whether there is too much noise in a particular card. The conjoint programme calculates the utility values of each attribute from the cards. The same can be accomplished the other way around, calculating the common utility value of the attributes of each conjoint card attributes by adding up the values of each attribute. Since the same attribute appears on multiple cards, researchers can investigate whether the utility scores of these cards differ radically from each other, thereby discovering whether the noise has possibly exceeded one card's tolerance level and produced a bad result. The same attribute appears in several cards, and it is invisible in which card noise occurred, because the utility values of each

card are different from each other and can be evaluated against each other. This does help to find the card that was causing the noise, but it does not yet eliminate the root cause. In any case, the same card can also be presented twice in a row, if the subject is aware of it. This is in case the researcher wants to verify each card twice.

The second thing to handle signal-to-noise ratio, is that the subject's head remains in the same position the entire time – movement of which usually causes noise in the brain images. For example, in the CBC (Choice Based Conjoint) model, the subject is presented with a long row of different conjoint cards to choose from, which may cause their head to move even several times if they have to reach for the outer cards with their eyes. In a classic conjoint card, the head remains in place because only the one row, which is directly in front, is being evaluated. Head movement inside the fMRI scanner coil causes noise in the brain images due to the head movement itself, but also due to the activation of brain areas that cause head movement.

For the same reason that we try to avoid excessive movement, which is seen in the activation of brain areas, we also try to minimize hand or finger movement. The same thing is related to using a sliding potentiometer with one finger, the subject makes their choice in percentage on the projected conjoint card.

The third thing is giving a silent answer, which in the light of our research activates the left insula. When answering silently, most subjects may be able to keep their head unmovable better than someone who moves vividly with gestures while speaking. For example, they cannot keep their head still in the fMRI coil while speaking.

Another thing that can affect noise is the behavior of the subject inside the fMRI coil. The movement of the head inside the coil causes vibration or noise in the brain images, which must be corrected afterwards. Using the classic conjoint card, the subjects sees in front of him/her one row of the attributes to be examined, which is next to the reference row. Usually, the subject of the study first examines the comparison row and then begins to evaluate the variables, evaluable attributes. When the things to be evaluated are presented together and in the same place, the head also stays in place.

Data Processing Assistant for Resting-State fMRI (DPARSF) is a good tool for excessive head motion and generate a set of pictures for easily checking the effect of normalization. There are all the needed tools for preprocessing. The toolbox contains mathematical models that, for example, soften the activation areas of brain images so that the edges of three-dimensional voxel are either sharpened or softened according to the mathematical model. To that the edges of a three-dimensional small cubes are cut off from the edges of the image area or are complete.

Someone might ask if there are any **specific statistical alternative methods** for conjoint-fMRI like multinominal logit or GLM. When combining two methods, it would be good if they had the same roots. In this case, if the linear model is used, it would be good if the results of the second model also follow the same. When using Pearson's correlation, it is a linear, i.e. straight-line description between two variables. Spearman's correlation describes a curve, arc or similar. Of course we can compare the results of these two correlations, but one is a quadratic equation and the other is an equation describing a line. So, these are two different formulas and calculation methods. In the simple regression formula $Y = a + bX$ the beta is same as correlation and in the multivariate regression - extended form of simple regression - the same thing happens again. Several conjoint models utilize the multivariate regression formula (Green 1971).

As mentioned above, it would be good if the calculation model used in fMRI were also repeated in conjoint analysis. The regression model in both the fMRI measurement and the analysis of the conjoint cards would not introduce asymmetry.

Linear regression is used to model the relationship between dependent and independent variables, and at least one variable is continuous. Generalized Linear Model (GLM) is a flexible generalization of ordinary linear regression and does not need normal distribution which help to analyse non-linear relationships. Linear regression is one specific form of GLM. There is interest in pricing, especially in marketing research, where price can be considered a continuous variable. A scalable, equally spaced, continuous variable makes it easier for the subject to perceive product differences than, for example, logistic-increasing price options in conjoint cards.

Logistic regression is used when the explanatory variable can only take on two values dichotomously. In regular regression analysis, the values can vary widely, but logistic regression is limited to only two options. Logistic regression analysis does not try to predict quantities, but rather probabilities. In marketing research, price comparisons would then remain a narrow comparison of two. By duplicating the pairwise comparison, it is possible to examine several pairs together, but then the material is multiplied and the opportunity to shorten the time spent in the fMRI scanner is lost.

Another question could be, is there any reasons to implement **network-based analysis** rather than univariate voxel-based approaches. Voxel-based analysis examines the areas where brain activation occurs. Studies have shown that the more the product is liked, the more the area is activated (Seymour & McClure, 2008). This can be utilized and examined to see if the same things are repeated in the utility values of conjoint cards attributes. If this is the case, the results in brain images and in the utility value of the attributes will

coincide. Larger activation area in brain images and large conjoint utility values possibly occur at the same time.

When studying the brain as networks with Traditional General Linear Model (GLM) there may be limitations with conjoint-fMRI method. GLM is sensitive for outliers and multicollinearity and need large dataset. GLM assume a linear relationship between predictor and other variables, which limit the actual relationship for non-linear variables. The GLM model may fail to converge during the fitting process, which might be a problem with complicated models. Therefore, examining the network may be problematic, which is why voxel-based examination may produce better results. Especially since the classic conjoint instructions (Green 1971) state that the results should not be extrapolated, i.e. extended beyond the values given in the continuous attributes. Using conjoint cards can therefore help in this situation, as the choice of attributes limits the use of certain transformations, like outliers, because attribute options are given in advance in conjoint cards.

However, when using orthogonal arrays, it is not possible to exceed this range as respondents have only answered the attributes and possible values that are visible on the conjoint cards. Extrapolation is therefore impossible outside the attribute range given in, e.g., euros or US dollars.

Conjoint cards often include additional cards, labelled take-out cards, and the best attribute bundle possible. When added together, the cards are used to check whether respondents have acted in unison in their choices, meaning that utility values of the additional cards are the same as those calculated separately for each round. These cards are used to ensure the reliability of results. If it appears that a take-out card has the highest utility values, that is, that the researcher has correctly inferred the most meaningful attributes in advance, it is worth comparing the fMRI images of the card in question because, possibly, the brain image shows the most widely spread voxel image with the card that has the highest utility value.

By comparing the voxel coverage of brain images with the utility values calculated from the attributes of the conjoint cards, researchers can examine where the brain is activated for that attribute. For example, does the evaluation of colours appear in a different part of the brain than evaluating the value of money or size of an object? Or does the brain really evaluate everything as a bundle or based on a single salient attribute?

Following this, conjoint-fMRI results are compared to prices and real market shares observed in the market. This real-market comparison is needed to determine how well the obtained results correspond to the real-world situation (Figures 14 and 16).

The brain is an extraordinarily complex system, and new studies might reveal novel information about connections, thus revealing ever more insight into the human brain. Here, a small number of extant studies can help in such an endeavour. Consumers' ventral striatum (Berns & Moore, 2012) activity has been shown to be a powerful predictor for purchasing (Venkatraman et al., 2015). Product price and preference have been good predictors of consumers' purchasing decisions (Knutson et al., 2007). The ventral striatum and vmPFC have been shown to become activated for more valuable objects and monetary reward (Yoon et al., 2012). The ventromedial prefrontal and ventral striatum areas in Kahnt et al.'s (2011) subjects integrated multiple reward predictions' attributes into a combined value. This united value was coded in divided fMRI figures in the vmPFC and single attributes were coded in the dlPFC prediction of consumer behaviour (Berns & Moore, 2012; Knutson et al., 2007). Finally, single attributes were coded in the dlPFC and group values in the vmPFC in the brain (Kahnt et al., 2011). This notwithstanding, the various parts of the brain mentioned here might help in analysis, but it is imperative to remember that the brain relies on networks rather than on single areas (Plassmann et al., 2012b).

5 Conclusions

There is a dearth of conceptually refined understanding of the fMRI and conjoint method, as well as a lack of empirical evidence that demonstrates its effectiveness. Neuromarketing's power lies in discovering subconscious biases that traditional marketing techniques (e.g. group interviews) fail to reveal. Neuromarketing methods such as conjoint-fMRI help to decrease product launch failures and increase marketing success. Conjoint-fMRI also helps to break products' attributes into parts and evaluate these in order for us to recognise the most meaningful parts and their utility for the customer.

Marketers offer **products as bundles** of benefits (Lancaster, 1966), and goods are considered as attributes or bound packets of characteristics (Varian, 2016). Conjoint analysis uses attributes on conjoint cards and evaluates these as individual attributes and as entire bundles. Importantly, brains treat objects as a repertoire of parts and features, recognising these as a seamless whole (George, 2022). The rhythmical activity of brainwaves verifies that the signals pertinent to the sensation appear in the binding area at the same moment, thereby allowing neurons to operate in conjunction and combine them into a single sensation (George, 2022). fMRI allows the identification of those parts that are activated in the brain, as well as which neurons are processing the material. Using conjoint analysis and fMRI together is a method for seeing how brains work, either with a single attribute or all together. To date, neuroscience has never been leveraged as a method to utilise single attributes or features of an object and, hence, its benefits have been overlooked. Previous methods have been used for whole objects, but conjoint-fMRI allows the analysis of single parts and the complete set at the same time through brain functions. This dissertation is the first time that a scientific study focuses on how to accomplish this.

The **conjoint cards** can be seen in the fMRI as screen pictures, with a set time between the cards. Conjoint cards' pictures can be analysed altogether or separately with multiple regression models. A multi-linear design of the conjoint method evaluates the main-effects as well as the interconnections between the attributes, and a subject's preference can be decomposed by using utility scores for characteristics or components. An object's attribute can be presented as a picture, video, taste, voice, scent, word, issue, or anything that is suitable for fMRI scanning.

The conjoint method and fMRI separately both provide effective ways of analysing marketing, yet their combination results in neuromarketing that is useful when used in conjunction with other studies. The power of one technique can overcome the weaknesses of another technique. The **benefits** of the joint fMRI and conjoint method in

neuromarketing include preventing subjects' fatigue, improving concentration, ensuring honesty in responses, increasing attributes, and cutting research costs. All in all, the conjoint-fMRI method constitutes a significant advantage in neuromarketing.

All humans possess mirror neurons that are associated with social behaviour such as empathy and imitation. The mirror neuron system is the neural base for such feelings, and subjects connect themselves with individuals and types of behaviour seen on video. If a stimulus activates the valuation circuit in the forebrain, this shows that the subject intends to buy the product in question.

Orthogonal variables are built so that every polynomial term is independent of others, thus enabling the calculation of each coefficient separately from a regression model and facilitating the testing of all coefficients' significance (Green & Rao, 1971; Green & Srinivasan, 1978). The variable and joint value are orthogonal when these variables can be read independently (Kahnt et al., 2011), providing information on multiple-attribute and single-attribute decisions from the brain at the same time. Two decision-making areas in the brain can also be analysed and seen in the dlPFC and vmPFC, in this way helping to identify whether a single salient attribute or bundle of attributes induces customers to react.

Classical conjoint analysis is the best method in fMRI because attributes are adjusted beforehand and remain constant throughout the experimental study. Subjects should not move their fingers unnecessarily inside the scanner because this influences the brain and the scanned figures.

Subjects do not like to remain lying down for lengthy periods in a closed and noisy environment, and they may feel fatigue in the fMRI scanner. Conjoint cards' orthogonality shortens subjects' time spent in the fMRI scanner, thus avoiding participant fatigue. This is important for making decisions and conjoint-fMRI assists in finding the attributes that are pertinent for selling a product.

Typically, in a marketing study scholars collect and measure behaviour, providing process-based statements on customer behaviour. At the subconscious level, customers are at times unable to articulate the motivation that underlies their behaviour. The benefits of neuromarketing studies include leveraging neural data in marketing-relevant behaviour. Nevertheless, more studies are needed here to confirm customers' behavioural intentions to a better degree.

Neuroimaging tools enable researchers and scholars to evaluate consumers' real marketing decisions in an economically significant and practical way. Neuroscience

methods and analyses help in understanding consumer behaviour and psychology. The measuring of brain responses allows us to study brands and whether they add value to products, the influence of price on products, emotional engagement with advertisements, the causal mechanisms of consumer choices, in-store emotions during purchase, price effects and enjoyment. Taken together, these examples clearly show potential directions for future research.

One consistent mystery in neuroscience is how the brain connects all our senses into a single, flowing conscious feeling that can be termed *the present moment* (George, 2022). The conjoint-fMRI method might resolve this mystery because we can analyse attributes separately and as a whole at the same time, thereby identifying which parts of our brains start blinking and, thus, revealing their connections. Activation in the insular cortex and amygdala show that the greater the activation, the higher the likelihood that an individual will change their mind, and the more fundamental the change (Sapolsky, 2017). Conjoint cards enable the identification from the brain of those attributes that the most suitable, and how highly subjects value these.

The **aim of the dissertation** has been to answer the questions of how *conjoint-fMRI may provide an advantage* and how it can be *modelled for neuromarketing studies*. Numerous methods are available in neuroscience and conjoint analysis (Green & Srinivasan, 1990; Stanton et al., 2017), and this dissertation proposes that the most suitable conjoint method in fMRI studies is full-profile, with a part-worth model, that can analyse attributes both separately and together. In fMRI researchers cannot present a sufficiently high number of attributes due to the short time available (Iyengar & Lepper, 2000), but conjoint analysis helps with orthogonal arrays (Green & Srinivasan, 1978), which reduce the number of questions and time needed for fMRI. Attributes' meanings are not entirely clear in neuroscience and conjoint analysis definitions vary between researchers (Ramsøy, 2015, 2019), hence calling for discussion and consensus amongst researchers. Between-groups analysis is needed both in fMRI and conjoint analysis (Lieberman, 2007) to ensure reliability. Subconscious mental processes can be analysed in fMRI (Pop & Iorga, 2012), and conscious processes with conjoint analysis (Green & Srinivasan, 1971), and used jointly they proffer a highly effective research method. Consensus on concepts and notions is needed for neuroscience (Kahnemann, 2009; Liebermann, 2007; Morin & Renvoisé, 2018; Thaler & Sunstein, 2009), for example on understandings of fast versus slow thinking. Costs are high in fMRI studies (Meyerding & Mehlhose, 2020; Ruanguttamanun, 2014) but conjoint methods can ameliorate this because orthogonality diminishes the time needed inside an fMRI scanner. There have been difficulties in replicating fMRI studies (Lieberman, 2007), which can be mitigated through significant conjoint analysis tests, such as holdout cards. Early fMRI studies were accompanied by

ethical concerns (Lin et al., 2018) related to a fear of exploring the human mind—however, neuromarketing methods themselves can change neither human beings' attitudes nor their thinking. Due to the protracted, lonely time spent by subjects in the FMRI scanner, fMRI has been blighted by fatigue problems (Masicampo & Baumeister, 2008; Nakagawa et al., 2013), yet conjoint methods help here by using conjoint cards to shorten the time needed. In conjoint analysis researchers cannot ascertain whether subjects are honest in their answers (Bercea, 2015), but fMRI can help with this by observing the dlPFC and vmPFC in the brain; and a timelapse in subjects' answers might similarly help indicate this, too. Some fMRI studies have had reverse inference problems (Plassmann, 2012), stemming for instance from certain mental processes that cause brain activity in specific brain areas. Insufficiently large sample sizes have also been problematic in fMRI studies that require costly laboratory time, but conjoint methods do shorten the time needed (Berns et al., 2010; Nee, 2019). Sometimes fMRI studies have necessitated several trials (Lieberman, 2007), and here conjoint analysis is a good tool because the two methods' triangulation helps to avoid too many trials. Finally, subjects' concentration levels have been a problem in fMRI studies (Laufs & Tagliazucchi, 2014), but conjoint cards shorten the time.

Conjoint-fMRI offers **three contributions** for researchers and particularly for neuromarketing and marketing studies. The *theoretical contribution* of conjoint-fMRI lies in connecting subconscious (fMRI) with conscious (conjoint) decision-making. Rational thinking does not always help to explain customers' behaviour, which can be affected by various biases. Furthermore, according to Zaltman (2003), 85 % of every decision is made unconsciously. The brain and the mind are indivisible, and many decisions are made subconsciously based on emotions and experience. The *real-world contribution* of conjoint-fMRI lies in proffering a method for analysing the emotional impact of a certain product or service on a consumer and understanding how consumers' wants can be satisfied on the market. Conjoint-fMRI can explicate marketing effects on subjects' purchasing decisions, avoid possible biases, and generate truthful information. The *methodological contribution* of conjoint-fMRI is to help reveal marketing effects and consumers' decision-making processes at both the subconscious and conscious levels by means of measurable material, thus shortening the analysis time and helping subjects to concentrate.

6 Managerial Implications

Neuromarketing focuses on the inside of the skull, on deeper and more subliminal thoughts, while classical marketing research operates in the conscious field. The connection between these two is similar to that of service quality (Grönroos, 1984) vis-à-vis Deming's technical quality (Douglas & Fredendall, 2004): while service quality is satisfaction based on expectations in light of what the customer actually receives, technical quality is easy to recognise once you see it. Service quality and technical quality differ in terms of their methodologies, much as neuromarketing and marketing research both have their own, yet numerous similarities between the two do exist. Neuroeconomics, neuromarketing, and neuromanagement are intertwined via neuroscience and behaviour, and this dissertation has focused on neuromarketing, discussing a novel tool and analytical method.

Neuroscience research methods proffer the opportunity to test inferential models empirically. Subjects are unlikely to be able to present their conscious and subconscious thought processes accurately, and neuroscience overcomes this methodological obstacle (Fugate, 2008), thus giving researchers a way to follow customers' expectations and decisions.

Marketing researchers commonly engage in gathering material that can be measured in order to examine consumers' behaviour (Camerer & Yoon, 2015), but consumers cannot always verbally articulate their subconscious decisions. However, neuroscientific methods enable researchers to evaluate the neuronal processes behind customers' reactions with granular spatial and temporal resolutions (Camerer & Yoon, 2015). Customers are sensitive to social impacts and direct observations are not easily made from subliminal reactions. Neuroscience offers valuable methods for such implicit studies (Camerer & Yoon, 2015) and its methods allow the measuring of types of behaviour that are difficult to approach with other scientific models (Plassmann et al., 2015). Here, dissociations can be disclosed from psychological processes, thereby revealing information that cannot otherwise be generated. There is a way to observe differences in priorities and selection at the neural level, refining predictions of choice from the individual and mass market (Plassmann et al., 2015). Camerer (14.8.2019) has shown that, out of 15,000 economists, only 100 are neuroeconomists; and Almiron (2014) points out that the majority of neuromarketing researchers are not economists, which might be an advantage in that it widens the approach and thinking on customer behaviour.

Neuroscience tools help in exploring customers' behaviour and psychology (Ramsøy, 2019). Neuromarketing studies have been conducted on advertising (Marci, 2006), the

influence of price (Schmidt et al., 2017), the causality of customer decisions (Knutson et al., 2007), in-store purchasing (Groeppel-Klein, 2005), and the brain's reactions to brands (McClure et al., 2004). An item's price is connected to enjoyment (Bogomolova et al., 2020; Karmarkar et al., 2015; Plassmann et al., 2008), and neuroimaging offers the chance to look into the consumer and evaluate genuine marketing decisions with practical and prominent impacts (Camerer & Yoon, 2015).

Some customer neuroscience commercial models are riddled with confusion that arises from terminological differences (Ramsøy, 2019), chiefly as neuromarketing was initially leveraged as a mercantile tool and consumer neuroscience focused on consumption choices (Ramsøy, 2015). Here, differing words were used that have the same roots (Table 2) and close meanings, such as neurocognitive (Lieberman, 2007), behavioural economics (Thaler & Sunstein, 2016), psychoanalytical processes (Freud, 1923), neuroscience (Sapolsky, 2018), and neuromarketing (Morin & Renvoisé, 2018).

It is impossible to see consumers' minds without neuroscientific methods. Customers may be dishonest in their answers during marketing studies, or they may be unfamiliar with the service or item at hand and try to produce favourable answers or invent suitable responses—but do they actually like the product? By using conjoint-fMRI we can discover this. Conjoint cards show which attributes are preferred, and suitable attributes can be bundled as the best combination by investigating the striatum to identify whether customers like these, although it is crucial to remember that the brain functions as a network and connects various areas with each other rather than only one specific area.

Regions in the PFC appear to be the most meaningful for decision-making. The dlPFC decides unsentimentally and rationally, and the vmPFC has an emotional effect on decision-making. These two PFC segments can be termed the cognitive and emotional areas, and sometimes a battle for supremacy takes place between them. Selecting between rational and emotional choices causes a slight time lapse in a customer's mind. Kahnt et al.'s (2011) fMRI data show that the combined value is encoded in decentralised fMRI structures in the vmPFC, and the variety of value expectations of the individual attributes is encoded in the dlPFC. It has been assumed that the combined value can guide choices when the value predictions of a single attribute indicate ambiguity in the integration of values. The different features of multi-attribute objects in non-overlapping brain regions suggest separate characters for the dlPFC and vmPFC in multi-attribute decision-making. Intriguingly, the ventral striatum (VS) and vmPFC show higher activity for more valuable items (Yoon et al., 2012). All in all, conjoint methods use attributes on conjoint cards and fMRI shows the brain's activity during decision-making.

fMRI research is expensive, and in some subjects fMRI scanners provoke fatigue, yet conjoint-fMRI shortens the time spent in the scanner, hence allowing the use of more attributes and more attentive subjects, as well as shrinking costs (Table 4). Neuromarketing studies that use conjoint-fMRI will be less costly in the future and provide an advantage over competing methods.

Several practical examples derived from conjoint-fMRI can be illustrative here. For instance, in Finland people's opinion about the differences between *vihta* and *vasta* depends on an individual's region. While both terms designate the same thing, namely a bathing whisk, in eastern Finland the latter is preferred while in western Finland it is the former. When asked which term a participant prefers, conjoint analysis can help to find out their preference, yet it will remain unclear whether they truly prefer *vihta* or *vasta*. In Finland these bathing whisks are used in saunas, which are highly popular amongst Finns. Yet not all Finns enjoy saunas and, while conjoint analysis can uncover written or visual preferences, it cannot reveal whether a Finn dislikes or likes the bathing whisk. fMRI can help in discovering this: if the amygdala is activated, the participant dislikes, and if the striatum activates then they like this utensil. However, fMRI cannot show which of the attributes in question is liked or disliked by the subject, that is, whether it is the term *vihta*, *vasta*, or *sauna*. With conjoint cards we can show those attributes and calculate which one means most, or see which generates better utility scores than other cards with different attributes.

In a similar vein, an individual might dislike the colour red on cars, but when speaking about Ferrari sports cars, some cannot accept any colour other than Maranello red. It goes without saying that not all subjects think in this way, but those who can afford a Ferrari may well have this preference. We can call the colour red a Ferrari's salient attribute. Moreover, while an individual might prefer red apples and dislike green apples, this difference in colour cannot be seen in peeled apples. Such salient attributes are problematic with conjoint cards but can explored with fMRI. The combined value is encoded in the vmPFC (Figure 4) and the variable of valuation predictions of the individual attributes in the dlPFC (Kahnt et al., 2011). Activation in both areas means that there are different types of subjects, with one focusing on a salient attribute while the other sees the thing as a bundle of attributes, that is, all of the attributes together. It is possible that a sample contains two types of subjects, with one preferring a salient attribute and the other all of the attributes as a bundle. This can be discerned by using fMRI and separating these two groups and their conjoint cards results.

Conjoint analysis permits discovering utility scores for all attributes. All conjoint cards are different, meaning that attributes change on every card; and these can be analysed one

by one in fMRI, thus revealing which are preferred by subjects. One of these attribute levels must be a continuous numeral entity, for instance money, an amount in litres, or a number. Conjoint analysis allows us to evaluate all attributes' values against these numerals, which is a particularly beneficial method for marketers and sellers. Whitlark and Smith (2007) warn that conjoint analysis does not automatically show the possibility of a keen reaction and cannot answer whether a subject dislikes some of these attributes, or possibly even hates them? fMRI helps in this because the brain shows in the striatum and amygdala whether a subject dislikes or likes these conjoint cards' attributes. An exceptionally high utility score here might indicate greater activation in the brain as this shows higher activity for more valuable items (Yoon et al., 2012). With conjoint analysis and fMRI measures both things can be revealed: subconscious preferences as well as the real, written attribute.

Customers' real valuation and decision-making aspects might provide a company a unique competitive advantage. A precondition here are data on the market's environment, and both marketing skills and future research stand to benefit from including varying degrees of involvement in the various fields of marketing operations.

The method leveraged in this dissertation presents a practical guide for managers and researchers. The key finding of this dissertation lies in its demonstration of how conjoint methods and fMRI can work together. Both methods require financial, personnel, and time resources. The conjoint method reveals customers' selection from their valuation and their chosen bundle of value-added attributes. fMRI reveals which part of the brain is activated and how subjects respond to a stimulus or attributes on a conjoint card. As customers' valuations are not visible, methods are necessary for discovering these. Classical marketing research methods are fast and handy but often fail to uncover customers' actual valuations. With some marketing research methods product failure rates are high and can reach 80–90 % (Hill, Schilling, & Jones, 2020), depending on the method of calculation.

Wei et al. (2019) point out that the opinions of others affect how much individuals value things. Michell et al. (2004) argue that teamwork may be connected to seeing others like oneself, and they find activity in the dACC that supports this. Moreover, the self-assessment of a sentimental stimulus is connected with lower activity in the amygdala, an area related to automatic affective processes (Pasley et al., 2004). Purchasers are not identical in their affections or preferences and may require dissimilar product designs. Wei et al. (2019) demonstrate that social impact mediates value signals by strengthening learning circuity in the ventral striatum. In a study on idea generation, the number of

participants' household goods ranged between 16 and 87, thereby implying that people have different opinions and valuations (Heinonen et al., 2016).

Marketing researchers collect behavioural accounts of consumer behaviour (Camerer & Yoon, 2015). Nonetheless, at the subconscious level, consumers cannot articulate the reasons for their behaviour. With conjoint-fMRI we can recognise customers' reactions by means of granular spatial and temporal resolutions (Camerer & Yoon, 2015). Sometimes consumers' sensitivity to social impact is difficult to identify directly and may be subliminal. The conjoint-fMRI method is useful for examining such implicit processes, and neuroscience techniques enable researchers to estimate indirectly things that are not readily accessible with other research methods (Plassmann et al., 2015). Separations between psychological processes can be identified, thereby generating information that could not otherwise be obtained; and heterogeneity in priorities and neural-level choices can be discerned, in this way improving predictions of choice in the individual and overall market (Plassmann et al., 2015).

There are three points that managers should consider regarding their products and customers. First, because the failure rate of new products is too high, more precise methods are needed in order to evaluate customer needs, and conjoint-fMRI offers such a method. Second, while conventional marketing research tools utilise surveys and interviews, they cannot examine subconscious decision-making. Conjoint-fMRI utilises both unconscious and conscious methods and deepens our knowledge on customers' decisions. Third, researchers prefer one specific method in their studies, although multiple methods are more precise and faithful. Here, the conjoint-fMRI model connects two effective methods and, at the same time, reduces their respective problems, thus making this model a highly effective way in which to analyse customers, also due to how it reveals biases and, hence, help marketers to understand their customers better.

Future research should dig deeper into the personal level of analysis, particularly thoughts and decision-making based on personal values, by conducting studies at the organisational and institutional levels that take into account biases in people's minds which affect their opinions and decision-making.

Shiv et al. (2005) do not mention marketing in general in their discussion of neuroscience in decision-making research, and early publications used neuromarketing and consumer neuroscience interchangeably (Reimann et al., 2011). Here, neuromarketing tools have been differentiated from commercial market research, and consumer neuroscience from academic work (Javor et al., 2013; Lee et al., 2018; Plassmann et al., 2015). Consumer neuroscience first appeared in academic research and neuromarketing as commercial

methods. This dissertation falls into the category of neuromarketing tools but can easily be brought to bear on neurocognitive studies (Lieberman, 2007) and behavioural economics (Thaler & Sunstein, 2016).

Disciplinary advances rest on two intertwined pillars: refinement in theory and refinement in methods. Mystery envelops what precisely constitutes a methodology contribution. Bergh et al. (2022) note that reviewers, authors, and editors often struggle to assess methodological contributions, and their typology classifies a major methodological contribution as one that dramatically changes practice as reflected in specific indicators (Figure 1). This dissertation proffers comprehensive suggestions for a different approach in neuromarketing studies, thus belonging in the category of a major methodological contribution and major change in that it fills a striking gap in the extant methodological literature.

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