Chapter 3

Research design
Research design

3.1 Research question and objectives

The main research question that guides this thesis is:

How to realise responsible neuroimaging innovations in the Dutch health system in order to facilitate an appropriate societal embedding of these innovations?

The theoretical background presented in Chapter 2 shows that the challenge for approaches to responsible research and innovation is to prospectively identify desirable visions and related (systemic) barriers that might hamper innovation development and embedding. Subsequently, such an approach could result in an interactive process in which relevant actors become mutually responsive to each other’s visions in order to combine the visions constructively into a more shared desirable vision. This might result in realising (more) responsible technology paths.

To address the research question of this thesis a variety of aspects need to be addressed, including neuroimaging technologies itself, guiding visions that are currently shaping medical neuroimaging technology paths, desirable visions of neuroimaging of relevant actors, and factors, mechanisms and dynamics that might hamper neuroimaging development and embedding.

The aim of this thesis is therefore threefold:

I. To gain insight into the (desirable) visions of neuroimaging in the Dutch health system;
II. To identify (systemic) barriers that might hamper, and strategies to realise, a responsible development and embedding of medical neuroimaging applications;
III. To contribute to a further specification of a conceptual and methodological framework for CTA as an approach to responsible research and innovation.
3.2  Research approach

The research presented in this thesis is the result of a CTA process on neuroimaging in the clinical context conducted in the Netherlands in the period 2010-2013. A central focus of the research was the identification of desirable and undesirable medical neuroimaging technology paths and potential resulting artefacts, and (systemic) barriers that need to be overcome in order to realise desirable paths according to relevant actors. Hereto, we used CTA as an approach to RRI, which we operationalised by applying the Interactive Learning and Action model (ILA) (Broerse & Bunders, 2000), combined with vision assessment (Grin & Grunwald, 2000). Roelofsen et al. (2008) show that the combination of these two models results in a CTA approach suitable to analyse and intervene with emerging technologies in the field of ecogenomics. This thesis builds upon these insights and applies this methodology combined with a system perspective to assess medical neuroimaging technologies.

The ILA model (Broerse & Bunders, 2000) has been developed to steer scientific and technological innovations in an early phase towards more desirable directions defined by the actors involved. Key features of the model are: active participation of relevant actors on equal footing early in the innovation process, explicit acknowledgment of experiential knowledge, development of shared visions, knowledge-creation through mutual learning, enhancement of trust relationships, coalition building, and independent and competent process facilitation (Broerse & Bunders, 2000). The model is characterised by an emergent and flexible design and can be roughly divided into five phases: 1) initiation and exploration, 2) in-depth study of problems, needs and visions of involved actor groups separately, 3) integration of different perspectives of actor groups through mutual learning, 4) prioritization and agenda setting, and 5) implementation through reflexive learning cycles of planning, action, observation, reflection and re-planning (Bunders, et al., 2010; Broerse & Bunders, 2000). During the entire process, the output of one group of participating actors is used as input for another group, in order to redefine and deliberate on outcomes. How this basic design takes shape varies between contexts. The first three phases of the ILA model were used and were slightly adapted for this research. The phases provided structure and guided the CTA process described in this research.

Vision assessment (Grin & Grunwald, 2000) was used to identify and construct the visions of relevant actors. The combination of vision assessment with the ILA model resulted in a (normative) shaping process in which flexible short-term and stable long-term requirements regarding desirable medical neuroimaging applications could be
balanced. This provided the opportunity to identify visions of neuroimaging from different relevant actors and to critically investigate the underlying assumptions regarding expectations, promises and concerns that guide the actions and interactions of actors, and to make these explicit in order to broaden the technology development process towards more shared desirable technology paths.

The following four elements\(^3\) are central in the identification and construction of visions (Grin & Grunwald, 2000; Roelofsen, 2011):

- **Problem definition**: Different visions can entail various problem definitions and ways to assess solutions. Assessing the assumptions underlying a problem definition uncovers values and norms how actors look upon reality, perceive facts and define the problem.

- **Challenges and purposes to be fulfilled**: This element concerns the challenges and purposes to be fulfilled resulting from the specific practice actors are part of. The problem definition contextually vindicates the challenges and purposes to be fulfilled.

- **Relevant contextual aspects**: This element explores the relation between the technical artefact and contextual aspects. Examples include the context in which the artefact will be used, how, by whom (e.g. conditions under which the technical artefact may contribute to solve a problem) and who will benefit and who will possibly experience disadvantages. This element also includes factors that may hamper the realisation of the envisaged technical artefacts, namely barriers that need to be overcome.

- **Basic features of the desirable state**: This element refers to basic assumptions around which visions develop: the preferred state of affairs the vision entails and ideas about what the world should look like.

The structure of the CTA process used in this study is described below and visualised in Figure 3.1.

---

\(^3\) These elements can be related to Fischer’s (1980; 1995) first and second order notions. First order notions comprise solution assessments and problem definitions. Second order notions include world views and value systems on the one hand and the preferred social order on the other hand (Grin & Grunwald, 2000).
**Figure 3.1.** Structure of the CTA process on medical neuroimaging. The arrows represent the use of the output of one group of participating actors as input for another group, in order to redefine and deliberate the outcomes.

### 3.3 Research sub-questions and methods

Based on the overall research question and the three objectives of the thesis, the research has been guided by research sub-questions. The research sub-questions and methods are presented below.

**Phase 1.** The research started with an exploration of the literature and exploratory interviews with an ethicist (n=1), psychologists specialised in risk perception and electromagnetic fields (n=2) and a scientist working with neuroimaging technologies in a research setting (n=1). Aim of this phase was to make an inventory of the scientific state-of-the-art concerning technological and scientific developments of medical neuroimaging, as well as an exploration of the potential relevant societal issues.
Phase 2a. Subsequently, guiding visions from a neuroimaging developer’s perspective were identified and constructed in order to identify future neuroimaging technology paths and potential resulting applications. These neuroimaging developers currently shape future directions of neuroimaging with their beliefs and ideas (Akrich, 1992; Garud & Rappa, 1994; Grin & Grunwald, 2000; Roelofsen et al., 2010). The research sub-question formulated to guide this part of the study was:

a. What are the guiding visions that currently shape the future of medical neuroimaging?

Data were collected via semi-structured interviews (n=11) and four focus groups with scientists and technology developers (n=19). The interviews and focus groups were transcribed verbatim for further analysis and summaries of the interviews and focus groups were returned for member check. To analyse the data an integrated approach was used and qualitative data analysis software (ATLAS.ti). This included the identification of elements regarded as important in vision assessment: problem definition; challenges and purposes to be fulfilled; relevant contextual aspects; basic features of the desirable state (see section 3.2). New sub-elements were noted as they became apparent in the data. For more details on the methodology see section 4.2.

Phase 2b. To gain understanding of how neuroimaging technology paths were portrayed in the media, a media-analysis was conducted regarding how neuroimaging research and its results are framed in Dutch newspapers. This study was guided by the research question:

b. How is neuroimaging research framed in the Dutch media?

Data were collected by using the LexisNexis Academic database. The sample consisted of 307 unique articles, published between 1992 and 2012, describing neuroimaging research and potential resulting applications. A combination of quantitative and qualitative methods was used to analyse the data. All articles were independently coded by two researchers with qualitative data analysis software (MAXQDA), using an inductive approach. To assess the presence of any statistically significant associations between codes resulting from the qualitative analysis, we conducted a Fisher’s Exact Test (two-tailed), with a p value of <.05 indicating statistical significance (Mehta & Hilton, 1993). More details of the methodology can be found in section 5.3.

Phase 3a. As a next step Dutch citizens reflected on the guiding visions in focus groups in order to articulated their desirable future of neuroimaging and to obtain
insight in and understanding of the broader context of medical neuroimaging and society. Hereto the following research sub-question was formulated:

c. What are the perceptions of citizens regarding neuroimaging applications in the Dutch health system?

Six focus groups with citizens (n=46) were organised and analysed. The focus groups were transcribed verbatim and data analysis was executed with qualitative data analysis software (ATLAS.ti), using an integrated approach. In the analysis we specifically examined how the participants made sense of neuroimaging and perceived related potential advantages, disadvantages and concerns. A detailed description of the methodology is given in section 6.2.

**Phase 3b.** Subsequently, we identified and constructed desirable visions of medical neuroimaging from a societal actor perspective. The study was guided by the research sub-question:

d. What are the visions of societal actors regarding desirable and undesirable neuroimaging paths?

To identify visions of societal actors, 17 semi-structured interviews were held with policy-makers (n=5), health professionals (n=8) and patient representatives (n=4). Interviews were transcribed verbatim and summaries of the interviews were returned for member check. To analyse the data an integrated approach was applied using qualitative data analysis software (ATLAS.ti). In this analysis the focus was on the identification of elements regarded as important in vision assessment: problem definition; challenges and purposes to be fulfilled; relevant contextual aspects; basic features of the desirable state (details in section 3.2) and new sub-elements were noted as they became apparent in the data. For more details on the methodology see section 7.3.

**Phase 4.** With the results of phase 2 and 3, similarities and differences in visions of neuroimaging from different relevant actors could be analysed. The aim of this analysis was to gain insight into potential shared desirable medical neuroimaging technology paths and resulting applications, incongruences in visions, and factors, mechanisms and dynamics which might become barriers during the development and embedding of medical neuroimaging. The analysis was guided by the following sub-research questions:

e. What are potential shared desirable medical neuroimaging technology paths and resulting applications?
Research design

f. Which incongruences in vision can be identified?
g. How to prospectively identify when incongruent visions might become potential conflicting visions?
h. When are potential incongruences in visions of medical neuroimaging likely to become in conflict?
i. Which factors, mechanisms and dynamics might become (systemic) barriers when medical neuroimaging developments progress?
j. Which strategies are envisioned to overcome the (systemic) barriers?

Data analysis was executed with qualitative data analysis software (ATLAS.ti) and included the identification of elements related to the sub-research questions. Elements and sub-elements were further identified as they became apparent in the data. Via open coding elements were identified, coded, described and categorised. More details of the methodology can be found in section 8.3.

In addition, a multi-actor dialogue meeting was organised, to enhance validity and discuss the findings of previous phases. A broad range of actors, including policy makers, patient representatives, scientists and industrial producers participated (n=17). During this meeting, participants were challenged to become aware of each other’s different visions and to articulate win-win options. To stimulate ideas and intended actions as a result of the meeting, participants wrote a ‘postcard to yourself’ at the end of the dialogue meeting, which they received by mail approximately one week later. To evaluate the result of their ideas and intended actions, the participants filled in a questionnaire, online or via the e-mail, approximately two months after the dialogue meeting. For more details about the methodology see section 8.3.

To contribute to a further specification of a conceptual and methodological framework for a CTA approach to responsible research and innovation of emerging science and technology, the results of the research are combined with insights from transition theory, transition management and innovation management. In doing so, the following sub-research question is addressed:

k. What lessons can be learned from the results presented in this thesis with respect to the management of emerging science and technology in a more responsible way in order to facilitate an appropriate societal embedding of applications resulting from these developments?
3.4 Validity of results

To enhance the validity of the results and to minimise researcher bias, the following strategies were applied:

- Triangulation: different methods were used to collect data on the same subject. For example, the combination of a literature study, interviews and focus groups. In addition, multiple researchers were involved in designing and conducting the research (see section 3.5);
- Saturation: during the inventory of visions we aimed to obtain data saturation regarding the articulated visions on a general level, e.g. we did not receive new information in the last two or three consecutive interviews;
- Interviews and focus groups were all transcribed verbatim for analysis to avoid information loss;
- Summaries of interviews and focus groups were returned to respondents/participants for member check;
- Interpretations of the interviews and focus groups were constantly discussed between multiple researchers (see section 3.5);
- Twice a year the results and future plans were discussed with the advisory committee of the research project. In addition, the results and future plans were once a year discussed with the valorisation panel of the research project, comprising of societal actors, to enhance the societal valorisation of the obtained results.

3.5 Research project and team

The research described in this these is part of a project called ‘Neurosciences in Dialogue’ that aims to manage neuroimaging developments in the Netherlands in an

---

1 Member of the advisory committee are: prof. dr. Serge Rombouts, professor methods of cognitive neuroimaging (Leiden University), prof. dr. Lydia Krabbendam, professor of educational neuropsychology (VU University Amsterdam), and prof. dr. Corine de Ruijter, professor forensic psychology (Maastricht University).

early phase towards more responsible applications and their embedding. The project focuses on neuroimaging developments in the field of a) health care; b) education; c) security and justice and d) on the monitoring and evaluation of the applied CTA approaches in the aforementioned fields of application. It is financially supported by the thematic programme Responsible Innovation. Ethical and societal exploration of science and technology of the Netherlands Organisation for Scientific Research (NWO) [grant number 313-99-180]6.

The research team involved the following people: prof. dr. Jacqueline Broerse (project leader) and prof. dr. Tjard de Cock Buning (supervisor) who were concerned with the overall management and supervision of the project. Dr. Frank Kupper (post-doc) was involved in the monitoring and evaluation of the applied CTA approaches (sub-project d). Rosanne Edelenbosch (PhD candidate) focused on neurosciences in the field of education (sub-project b), Marije de Jong (PhD candidate) focused on neuroimaging developments in the field of security and justice (sub-project c) and the author of this thesis was concerned with neuroimaging developments in health care (sub-project a). Literature studies and interviews presented here were conducted by the author of this thesis, whereof some in collaboration with several MSc students of the VU University Amsterdam. The focus groups and dialogue meeting were jointly developed, organised and facilitated by members of the project team. The media-analysis was conducted by Marije de Jong and the author of this thesis.

3.6 Outline of the thesis

In Chapter 1, a brief introduction of the rationale and aim of this thesis is given, followed by the presentation of the theoretical framework in Chapter 2. This Chapter 3 presents the research design.

Chapter 4 to 8 are based on articles accepted or under review for publication in international peer-reviewed journals. As a result, some duplication occurs in the chapters with respect to the introduction of neuroimaging technologies and theoretical framework.

Chapter 4 focuses on phase 2a of the research: the identification of medical neuroimaging technology paths. This Chapter starts with an exploration of the scientific and societal promises of innovations in general and medical neuroimaging

---

6 The sub-project on education was co-funded by the CSG Centre for Society and the Life Sciences.
Chapter 3

particular, followed by the presentation of the guiding visions of neuroimaging developers which are currently shaping the future of medical neuroimaging. To gain understanding of how neuroimaging technology paths were portrayed in the media, a media-analysis was conducted (phase 2b). The results hereof are presented in

Chapter 5. In this Chapter we explore how neuroimaging research is framed in Dutch newspapers published between 1992 and 2012.

In Chapter 6, phase 3a of the research is presented. In this phase, Dutch citizens articulated benefits, disadvantages and specific concerns regarding medical neuroimaging applications, using the results of phase 1 and 2a as input. We discuss different framings of how citizens make sense of neuroimaging and show how these different frames and related lines of argumentation were used to discuss the degree of desirability.

Chapter 7 focuses on the visions of neuroimaging from a societal actors’ perspective (phase 3b). In this Chapter, we show how the contextual aspects of potential applications and underlying features of the ideal health system determine the desirability of medical neuroimaging, and describe three different visions of how societal actors relate neuroimaging to the health system.

In Chapter 8, we integrate the results of the multi-actor dialogue meeting and Chapters 4-7 and deduce factors, mechanisms and dynamics that might become (systemic) barriers when neuroimaging is further developed. In addition, articulated strategies of the actors consulted to manage the barriers are described. We conclude this Chapter with lessons learned on how to manage medical neuroimaging in a more responsible way in order to facilitate an appropriate societal embedding of artefacts resulting from these developments.

In Chapter 9 the thesis concludes with a discussion of the main results and answers the main research question. In addition, topics for further research are suggested.