Abstract

Apart from the scientific unknowns and technological barriers that complicate the development of medical neuroimaging applications, various relevant actors might have different ideas on what is considered advancement or progress in this field. To this end we conducted 17 semi-structured interviews to identify visions of societal actors in the Netherlands regarding future medical neuroimaging applications. We show how the contextual aspects of potential applications and underlying features of the ideal health system determine their desirability. Neuroimaging developments are perceived as innovations that will optimise the current health system or as opportunities to change existing structures and practices of the current health system more radically. Insights into and understanding of these visions, which guide actions in practice, showed incongruence between visions of societal actors regarding desirable clinical neuroimaging use and potential conflicting visions regarding the embedding of neuroimaging applications. We conclude that it is possible to prospectively identify incongruent visions and analyse when these visions will most likely come into conflict with each other. Such an analysis might provide a reflective space, beyond personal and political interest, suitable as a starting point for joint reflection and mutual learning in order to manage clinical neuroimaging innovations towards more responsible applications.
Visions from a societal actor perspective

7.1 Introduction

“Disorders of the brain”, comprising mental, neurological and substance use disorders, are the “largest contributor to the all cause morbidity burden as measured in DALY in the EU” (Wittchen, et al., 2011, p. 672). Besides the high burden and prevalence, many disorders of the brain are attached to issues of stigma and marginalization (e.g. Reynolds, 2003). As a result, the need for improved prevention and treatment is high (Wittchen, et al., 2011).

Research into the causes and consequences of brain disorders and into potential therapeutic options are increasingly executed and pursued by scientists, governments, advocacy groups and public health authorities (Racine, 2010). Neurosciences offers opportunities to eventually result in a thorough understanding of the brain and its disorders and to subsequently develop effective prevention, diagnosis and treatment. Neuroimaging technologies are expected to play a large part in these developments (see Chapter 4). However, (clinical) translation is not straightforward. In addition to the many scientific unknowns and technological barriers that make it difficult to develop clinical applications, different actors might have different ideas on what is considered advancement or progress (Racine, 2010). For example, if early diagnosis becomes possible, would everyone who does not yet display symptoms feel it is in their best interest to know that they have a subclinical disorder? Moreover, what is the individual and societal impact of receiving such a diagnosis before the onset of symptoms? Furthermore, will a person at risk of developing a certain brain disorder endure stigmatization and discrimination when seeking medical insurance or employment? Will the growing knowledge of the brain further increase medicalisation and thereby raise the demand and costs for medical services, medicines and other products (Fuchs, 2006; Glannon, 2006; Illes & Racine, 2005)?

To minimise potential disadvantages and maximise potential benefits of innovations, it is suggested that innovators and societal actors engage in an interactive process by which they “become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products” in order to realise an appropriate societal embedding (Von
Schomberg, 2011, p. 9). The active involvement of relevant actors in early phases of innovation development is claimed to improve the development of more responsible applications, i.e. applications that better connect to social practices and needs. Because many options are still open, there are still opportunities to steer the developments (Roelofsen, 2011; Von Schomberg, 2011; Wilsdon & Willis, 2004).

The challenge in designing and implementing an interactive process in early phases of technology development is to identify relevant actors and their different points of view with respect to the technology, as well as to negotiate and renegotiate these perspectives through mutual learning throughout the development process (e.g. Schot, 2001; Roelofsen, 2011). The aim is to broaden the process of technology development with more continuous evaluation and reshaping of technology developments towards more shared, desirable, and hence responsible, applications. The research described here is part of a project that aims to manage medical neuroimaging developments in the Netherlands, which are still in an early phase, towards more responsible applications and their embedding in society. In this paper, we describe the visions of relevant actors regarding desirable medical neuroimaging applications in the Netherlands. Analysing the assumptions underlying the visions of these actors enabled us to obtain an in-depth understanding of the desirability of potential future neuroimaging applications and their embedding from a multi-actor perspective as well as to identify potential responsible applications (i.e. more commonly shared visions) and incongruencies in visions. Moreover, this study provides insights into how visions can be used to prospectively identify conflicting visions which could hamper the development and embedding of responsible applications when these incongruencies are not taken into account during the development phase.

### 7.2 Methodology

Our research aimed to identify what relevant actors saw as desirable visions, the barriers that need to be overcome to achieve these visions as well as undesirable visions in order to facilitate the development of more responsible medical neuroimaging applications in the Netherlands. We use vision assessment (Grin & Grunwald, 2000), which has been shown to be a suitable approach to analyse and intervene with emerging technologies (e.g. Roelofsen et al., 2008). Visions are mental images of an attainable future. They are neither restricted to an extrapolation of knowledge of what the future probably or possibly will look like, nor are they science fiction images of the future: they are a mixture of both (Grunwald, 2004). They are rooted in culture,
traditions and morals (i.e. they relate to the past) and are a form of long-term consideration. The function of visions is “not to determine the far future in the sense of envisaging a ‘final state’ of history, but to deliver orientation for present acting and deciding” (Grin & Grunwald, 2000, p. 178-179). They are important elements of stabilising future expectations, because they have to be shared to some extent among particular actors to guide joint actions between actors that share the same vision. Shared visions are being maintained in recursive practices, which explain their capability in shaping the future (Grin & Grunwald, 2000). Visions are relatively stable and open to steering and it is therefore assumed that by actively collecting and critically reflecting upon one’s own and others’ visions, shared desirable visions can be shaped, visions that are favoured by a broader group of actors (Mambrey & Tepper, 2000). This process allows balancing flexible short-term and stable long-term requirements and is a (normative) shaping process and not a (descriptive) forecasting process. This provides 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. These can then be made explicit in order to broaden the technology development process towards more shared desirable, that is responsible, technology development.

The following four elements17 are central in the identification and construction of visions (Grin & Grunwald, 2000; Roelofsen, 2011):

- **Problem definition**: different visions can entail a variety of problem definitions and of ways to assess solutions. Assessing the assumptions underlying a problem definition uncovers values and norms from which 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 societal actors are part of. This element refers to the problem definition, which 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), who will benefit and who will possibly experience disadvantages. These

---

17 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 and Grunwald 2000).
elements also include factors that may hamper the realisation of the envisaged technical artefact.

- **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.

### 7.2.1 Preparation

We started with the identification and construction of visions from a neuroimaging developer's perspective, that is scientists and industrial producers, to identify future neuroimaging technology paths and potential resulting applications (see Chapter 4). These developers currently shape future directions of neuroimaging with their beliefs and ideas (Akrich, 1992; Garud & Rappa, 1994; Grin & Grunwald, 2000; Roelofsen et al., 2010). We conducted semi-structured interviews and focus groups with neuroimaging developers (details in Box 7.2). For an overview of the actor field, we refer to Box 7.1.

---

**Box 7.1. Actor field of medical neuroimaging**

We distinguish the following different actor groups which have their own structures and practices and share structures with other groups forming together the wider societal health system:

- **(Potential) future users**
  - **Receivers**: actors who undergo neuroimaging, e.g. patients.
  - **Appliers**: actors who apply neuroimaging in clinical practice or use the knowledge resulting from these technologies, e.g. health professionals. Within this group we distinguish the following health professionals based on the current organisation of the health system and differences in structures and practice on a more detailed level:
    - Professionals working in primary care
    - Professionals working in secondary care
    - Professionals working in the field of somatic disorders
    - Professionals working in the field of mental disorders
  - **Host institutions**: actors of neuroimaging companies and institutions in which neuroimaging equipment is located, including hospitals and private imaging institutes, who deal with liability and how to apply these technologies.

- **Scientists**: actors who work with neuroimaging technologies or knowledge resulting from neuroimaging applications in a research setting with the aim to improve the health system.

- **Policy-makers**: actors who deal with rules concerning administrative regulations and procedures which structure the health system. For example, regulations regarding the application of technologies, safety standards, and reimbursement regulations.

- **Industrial producers**: actors who produce neuroimaging technologies. These actors are for example concerned with technical standards and functional requirements.
### 7.2.2 Semi-structured interviews

During the inventory of visions from a developer’s perspective, we challenged the developers to articulate contextual aspects of future neuroimaging artefacts besides the technical aspects. They identified societal actors in the clinical, policy and public context as actors who were expected to be affected (positively or negatively) by neuroimaging. These actors were taken as a starting point. Subsequently, the snowball method was applied to identify and consult other actors. We consulted societal actors on the basis of their specific expertise and experience as an individual representing an actor group. We invited them by e-mail and telephone explaining neuroimaging developments as an emerging scientific field from which applications could arise that potentially have implications for their (future) practice. With this, we mentioned the developers’ visions of neuroimaging applications (e.g. more preventive and personalised cure and care options). We stressed that these developments were desirable from a developer’s perspective, and that input of societal actors was necessary to gain insights whether these applications were also desirable from their point of view and to identify potential alternative desirable neuroimaging uses. We emphasised the early phase of neuroimaging developments and our aim to maximise a responsible development and embedding of the potential applications, for which their input was of crucial value. For some actors this early phase was, however, a reason not to consent to an interview. They felt that they could not give valuable input and the subject was not relevant for them in the short term. For this reason we were unable to consult actors from health insurance companies and members of hospital boards and private imaging institutes. In total 17 people consented to an interview, (see Table 7.1).

<table>
<thead>
<tr>
<th>Actor group</th>
<th>Actor sub-group</th>
<th>Number of interviewees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy-makers</td>
<td>Governmental policy makers</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Financier of brain research and translation of scientific results</td>
<td>1</td>
</tr>
<tr>
<td>Users - appliers</td>
<td>Primary care (representatives)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Secondary care – somatic disorders</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Secondary care - mental disorders</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Secondary care – medical imagers</td>
<td>1</td>
</tr>
<tr>
<td>Users- receivers</td>
<td>Patients (representatives)</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>
All interviewees are chair or managing director of (a subsection of) a professional organisation (health professionals, patient representatives and financier), ministerial department or ministerial advisory organ (policy-makers). To ensure anonymity of the interviewees, the names of the professional organisations are not revealed.

During the interviews we asked the interviewees firstly what they perceived as desirable and undesirable neuroimaging use and secondly how they perceived the desirable neuroimaging technology paths and resulting artefacts of the neuroimaging developers (see Box 7.2). We asked questions to identify the elements regarded as important in vision assessment: problem definition; challenges and purposes to be fulfilled; relevant contextual aspects and basic features of the desirable state (Grin & Grunwald, 2000; Roelofsen et al., 2008).

<table>
<thead>
<tr>
<th>Box 7.2. Desirable neuroimaging technology paths of neuroimaging developers</th>
</tr>
</thead>
<tbody>
<tr>
<td>From a neuroimaging developers’ perspective desirable medical neuroimaging applications focus on the field of diagnosis, treatment and prevention (details in Chapter 4).</td>
</tr>
<tr>
<td>Diagnostic applications</td>
</tr>
<tr>
<td>new and improved options to make an efficient and effective diagnosis – including personalised diagnosis</td>
</tr>
<tr>
<td>Treatment applications</td>
</tr>
<tr>
<td>personalised treatment on-demand treatment image-guide interventions enhancement of brain functions with respect to neurodegenerative disorders</td>
</tr>
<tr>
<td>Preventive applications</td>
</tr>
<tr>
<td>detect very early stage sub-clinical disorders (early diagnosis) determine predispositions</td>
</tr>
</tbody>
</table>

7.2.3 Analysis

The interviews were all transcribed verbatim for further analysis and summaries of the interviews were sent to respondents for member check. The identities of the interviewees were anonymised by replacing their name with unique research codes. Subsequently, data analysis was executed with qualitative data analysis software (ATLAS.ti), using an integrated approach. This included the identification of the elements regarded as important in vision assessment (Grin & Grunwald, 2000; Roelofsen et al., 2008). Via thematic and open coding we identified, coded, described and categorised topics in the transcripts. Subsequently, we generated sub-elements by relating...
the topics to each other. Next, we related the sub-elements to the main elements to construct the visions of neuroimaging.

### 7.3 Visions of neuroimaging

We identified and constructed three visions of neuroimaging from a societal actor perspective. Neuroimaging is envisioned as applications in 1) the current health care practice; 2) a personalised health care or 3) in person-centred health centres.

All visions share the technical problem definition with respect to the prevention, diagnosis and treatment of brain disorders (see Box 7.3).

**Box 7.3. Technical problem definition with respect to the prevention, diagnosis and treatment of brain disorders**

The often long diagnostic trajectory of brain disorders, resulting from a (partially) unknown cause and an overlap in manifestations between various disorders that complicates the ability to differentiate between disorders (especially in early phases of disorder development) is perceived as a major problem by all interviewees. As a result variations in practice occur and many diagnostic tools are perceived as subjective. In addition, current therapeutic options are frequently not that effective at an individual level and patients have to endure a long period of trial-and-error before the appropriate intervention is found. Moreover, treatment of neurodegenerative disorders is a poor choice because brain damage is already present which cannot be reversed. Neuroimaging use for (personalised) prevention, diagnosis and treatment is therefore perceived as desirable as it might contribute to solving these problems.

In vision one, the technical optimisation of preventive, diagnostic and treatment tools is considered to optimise the structures and practices of the health system and thus this contributes to a better health system in general. In addition to this technical optimisation, visions two and three imply structural changes in the structures and practices of the health system and, through this a better health system in general. In other words, the challenges and purposes to be fulfilled, contextual aspects, and underlying basic features of the desirable state differs, resulting in different visions of neuroimaging (see Table 7.2).
Table 7.2. Three visions of neuroimaging from a societal actor perspective and the elements that construct these visions

<table>
<thead>
<tr>
<th>Vision</th>
<th>Problem definition</th>
<th>Challenges and purposes to be fulfilled</th>
<th>Contextual aspects</th>
<th>Desirable state</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Neuroimaging in current health care practice</td>
<td>Prevention of brain disorders not possible; long and not that effective diagnostic and treatment trajectory</td>
<td>Prevention of brain disorders; (more) personalised diagnosis and treatment (earlier and faster)</td>
<td>Affordable and able to visualise brain disorders at a sub-disorder and/or individual level.</td>
<td>As currently: mainly, referral in primary care towards diagnosis and treatment in secondary care</td>
</tr>
<tr>
<td>2. Neuroimaging in personalised health care</td>
<td>Prevention of brain disorders not possible; long and not that effective diagnostic and treatment trajectory</td>
<td>Structures and practices of the health system based on disease categories</td>
<td>Structures and practices with a person-centred focus</td>
<td>(Para)medical professionals organised in interdisciplinary teams: ‘responsible’ patients</td>
</tr>
<tr>
<td>3. Neuroimaging in person-centred health centres</td>
<td>Prevention of brain disorders not possible; long and not that effective diagnostic and treatment trajectory</td>
<td>Structures and practices of the health system based on disease categories</td>
<td>Structures and practices with a person-centred focus</td>
<td>Shift towards primary care and self-management options</td>
</tr>
</tbody>
</table>
In the next section we describe the three visions of neuroimaging from a societal actor perspective. First, the contextual aspects are described, followed by the envisioned purposes the neuroimaging applications are perceived to fulfil and basic features of the desirable state.

7.3.1 Neuroimaging in the current health care practice

In this vision neuroimaging technologies are affordable and capable of visualising brain disorders at a sub-disorder and/or individual level. Their envisioned appearance is not that different from current neuroimaging technologies, mostly large equipment located in hospitals, and applications are perceived to be embedded in the current structures and practices of the health system in order to optimise it.

Desirable preventive neuroimaging use in this vision comprises the detection of brain disorders in an early stage of development (early diagnosis). Furthermore, the use of neuroimaging to determine which patients are at risk to develop another (related) disorder (i.e. predisposition) is perceived as an added value to the current health practice and an added value for patients to know their chances of developing another (related) disorder so that they can act on this and take precautions. In other words, individual preventive options are desirable when therapeutic options are available. Desirable diagnostic neuroimaging applications are new (when therapeutic options are available) and improved options to make an efficient and effective diagnosis, in order to shorten the diagnostic trajectory (earlier and faster) and decrease the variation in practice (more objective tools). Subsequent neuroimaging use to determine the efficacy of therapeutic options, the adjustment of therapeutic options towards the specific deficiency in the brain of a patient, based on the individual diagnosis, and monitoring the progress of these therapeutic options and the disorder could result in receiving or giving the best possible (personalised) treatment. In other words, both patients and health professionals are envisioned as beneficiaries by respectively receiving and providing the best possible preventive, diagnostic and therapeutic options. Moreover, new and improved preventive, diagnostic and therapeutic tools could contribute to an increase of quality of care (such as earlier and faster diagnosis, less misdiagnosis and resulting treatments) and thereby result in a reduction of costs (for example by decreasing the total amount of care provided).

No major problems with the development and embedding of neuroimaging are anticipated due to the ‘solid’ structure and practice of the Dutch health system. Current policies and regulations will, for example, prevent unethical or cost-inefficient neuroimaging applications from being developed and applied. No major changes are
expected; except for the current high price of neuroimaging equipment, transition costs will be limited. For example, the use of diagnostic neuroimaging to set a personalised diagnosis for Alzheimer’s disease and resulting personalised treatment options could be executed in secondary care by a neurologist after referral by a general practitioner in primary care. This requires change in the practice of neurologists in the update of relevant knowledge and training how to apply the technical artefacts. Furthermore, some education is required in the structures of the health system (such as guidelines, policies). In sum, the current health system is envisioned as preventing unethical and cost-ineffective applications and able to absorb desirable neuroimaging applications, as explained by one of the policy-makers consulted:

At the end of the day that’s probably not going to happen [in the context of embedding unethical or cost-inefficient neuroimaging use], but it is still important to stay alert. Of course, yes, I would find it very interesting to see that with manic depression, uh, the left cortex becomes darker than the right or so, which means that I need more of substance \(x\) and \(y\). I mean, that is imaginable, that would be wonderful, right? That would be wonderful! If only that would be a possibility, now or in the future, but you should maintain the human dignity, you must make sure that patients are not test objects. But it is imaginable, I think so. Look, in the Netherlands we are now so advanced that we have already established the rules concerning this kind of research. I mean, we live in such a beautiful country, it is all already considered, organised and coordinated and I do not know what can be improved so to speak [with respect to regulations].

### 7.3.2 Neuroimaging in personalised health care

In this second vision, desirable neuroimaging applications are affordable and capable of visualising disorders at an individual level, as personalised applications. The purposes to be fulfilled by the neuroimaging applications correspond with the previous vision, that is the prevention of brain disorders in individuals and (more) personalised diagnosis and treatment. In addition, interviewees holding this vision perceive neuroimaging to be embedded in personalised health care, instead of the current health system with its focus on categories of disorders. Personalised in this context means that the ‘entire’ person/patient in his/her specific situation and context is taken into account. This comprises the inclusion of physical, psychological and social elements in the diagnostic and treatment trajectory. As explained by one of the health professionals consulted, who works in the field of mental disorders:

Like in depression, diversity is so incredibly high and what does that [diagnosis depression] bring for the individual? So, I am much more in favour of personalised medicine. You want
to know more, the significance of the complaints in the context of this man, with this age, with this configuration of the brain so to speak and with this genetic makeup, because we know nothing hereof.

In other words, interviewees holding this vision argue that neuroimaging developments might result in options for (more) personalised prevention, diagnosis and treatment, and the advantages of these options can (only) be fully exploited, when health care is personalised. The importance of this focus on the entire health system is emphasised. This relates directly to the perceived necessity of multi- and interdisciplinary teams of professionals, who should collaborate around one patient. As illustrated in the following quote of one of the health professionals consulted working in the field of mental disorders:

Especially with a psychiatric disorder, which is often a complex entity, that requires complex care. [...] You should also look at the system, is system support needed? Such as a form of therapy? Or might the patient also need medication or further research? So, around one case, one patient, you should be able, and that is also the challenge, to look from different perspectives to look at different modalities, different aspects of being human. Which is also affected by the dysfunction at that moment, the depression or whatever? And you should adjust your treatment plan towards that. Hereto you need each other, you need a psychiatric nurse, a psychologist, a non-verbal therapist [...] So there are many perspectives and the core is that I think the problem is often so complex that you cannot escape to look and to treat from multiple perspectives.

In this vision, different professionals, such as neurologists, psychiatrists and nurses, become part of interdisciplinary teams. Although this clear focus on a desirable change in structure and practice towards personalised health care, respondents holding this vision did not articulate a clear view on the embedding of neuroimaging applications in the health system. They could envision neuroimaging applications being embedded anywhere in the health system as long as the structure and practice is personalised. They also observed that the boundary between primary and secondary care will or should blur as a result of the changing structures and practices. As explained by one of the patient representatives consulted:

In the case of prevention I get that [shift towards primary care]. But for the truly personalised approach I think it is not necessarily per se [...] Of course it has to do with numbers, because we now have 250,000 people with dementia, which will become half a million. So, at some point you have to increase your ability to offer treatment to the larger public. The
question then is whether that is possible with more GP practices or how those things look nowadays or in the future, assuming that is the place where you manage these things best, also in terms of expertise building. Or that you should establish a kind of secondary care, or a ‘one and a half’ care facility where you can see at least a few hundred people a year.

7.3.3 Neuroimaging in person-centred health centres

In this third vision, neuroimaging applications are affordable, compact, mobile and able to visualise disorders at an individual level. The health system is envisioned as a personalised health system (as in vision 2) and the applications are mainly embedded at health centres, that is at the level of primary care. The purposes to be fulfilled by the applications, individual prevention and (more) personalised diagnosis and treatment, correspond with the previous two visions. In addition, interviewees holding this vision want to implement collective prevention strategies.

Desirable preventive neuroimaging use in this vision comprises, besides individual preventive applications, also the screening of symptomless people for those brain disorders for which intervention strategies are available. The purpose of these kinds of interventions is that people who are developing a disorder are detected as early as possible in order to be treated. Furthermore, the determination of predisposition for people without symptoms is seen as desirable in order to let these people adjust their lifestyle to prevent or postpone the development of disorders. The use of neuroimaging to screen symptomless people and to determine a predisposition, i.e. collective prevention, could contribute some of the challenges the health system is facing, according to interviewees holding this vision. The rising trends in the number of chronically ill patients might be reduced when people are diagnosed and treated as early as possible and the societal and personal burden of mental disorders might be reduced when patients are able to start therapeutic options in an early phase of disorder development. Furthermore, these neuroimaging applications might contribute to the challenge the government faces of letting people function in their daily environment for as long as possible (in order to reduce costs), as illustrated by one of the primary care representatives consulted:

*Much more needs to go to primary care: more multidisciplinary approaches, more prevention, there must be a personal approach, personal care plans so to speak, and there should also be a focus on the activation, participation of people themselves. What can they do to prevent or delay disorders? Well, prevention activities. But also if they already have chronic disorders, like the ageing population, one has to think about that.*
With respect to neuroimaging use for (personalised) diagnostic and treatment options, respondents holding this vision argue that in order to shorten the diagnostic trajectory a diagnosis should be determined as early as possible and that is in primary care, preferably in health service centres. Moreover, treatment options will follow diagnosis and should therefore be provided in the same context, the health service centres. As explained by one of the primary care representatives consulted:

You have to deal with multi-morbidity, so that means that if you really want to provide appropriate care and let people live in their own environment as long as possible with support, you need to map what can they do themselves, what can informal carers do, what should be done by the municipalities or social welfare, the home care and what is the role of the GP, or primary care, in the broader picture? Then the question is, how do you arrive at a personal, a tailor-made diagnosis? [...] So, it is therefore not only the decision ‘do I need a MRI or fMRI’, with all due respect, but it is a matter of how that person can still function and what is wrong with that person? And how can you diagnose this as a GP as soon as possible.

In other words, to fully exploit neuroimaging applications, respondents holding this vision argue that health research and practice should shift towards a person-centred system, for which interdisciplinary teams and shared decision making are a necessity (as in vision 2). Secondly, a shift from secondary towards primary care and a focus within primary care on prevention and self-management options are perceived as necessary. Shared decision making is required which should involve the patient in the approach and lead to joint decisions which agree what responsibility the patient has in the process. Consequently, in this vision, ‘hot floors’, health service centres, outpatients departments and self-management options are established instead of hospitals and general practitioners offices. As explained by one of the policy-makers consulted:

And that institution [hospital] has no future in my opinion. Of course, the operation room will always remain, hot floor it is called I believe. So there will always be a core, which can only be intramural or clinical or whatever you call it. However, this will be a relatively small core compared with the size of the current hospital. Reasoning further in this line [specialised knowledge closer to citizens], there is actually no place for the current hospital. [...] the GP will probably come closer to the citizen, that is necessary. So, multidisciplinary [centres], including the generalist. [...] A new balance between specialised knowledge specialised diagnostic knowledge and generalised knowledge. That first perspective will not only change the healthcare sector, but the whole process of care will change completely.
7.4 Conclusions and discussion

7.4.1 Different visions of medical neuroimaging

In this research we identified and constructed three different visions of medical neuroimaging from a societal actors’ perspective. Neuroimaging is envisioned as applications in 1) the current health care practice; 2) personalised health care or 3) in person-centred health centres.

All respondents reasoned mostly from one of the identified visions. We observed that in discussing the desirability of potential future medical neuroimaging use, all interviewees reasoned from the practice in which they act. They protected (maybe unconsciously) their position and status of other actors in the same practice with the arguments they brought forward, including the discrediting of others functioning in competing practices.

The respondents in this research, who envision neuroimaging mainly as technologies in the current health care practice, consist of two of the policy-makers consulted, the general practitioner and a person working in secondary care in the field of somatic disorders. Respondents who envision neuroimaging mainly as applications in personalised health care included the interviewees working in the field of mental disorders, the paramedic professional, the patient representatives and one policy-maker. The other two policy-makers and two primary care professionals envision neuroimaging mainly as applications in person-centred health centres, see Table 7.3.

This indicates that the visions of neuroimaging are not exclusively related to a specific actor group, such as policy-makers or primary care professionals. We observe that the position an actor has in the health system and the vision he or she has of the ideal health system (which are interrelated) drives the vision of neuroimaging an actor holds. Desirable neuroimaging applications are envisioned in a way that they maintain or increase the position of an actor, and suit his/her vision of the ideal health system and/or contribute to establish this ideal health system, resulting in different desirable technical artefacts (for example large device in hospital versus mobile device in health centre) and related technology paths.
Table 7.3. Actor groups and visions of neuroimaging

<table>
<thead>
<tr>
<th>Vision</th>
<th>Policy makers</th>
<th>Patient representatives</th>
<th>Health professionals primary care</th>
<th>Health professionals secondary care, somatic disorders</th>
<th>Health professionals secondary care, mental disorders</th>
<th>Para medical professional</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. neuro-imaging in current health care practice</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. neuro-imaging in personalised health care</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. neuro-imaging in person-centred health centres</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.4.2 Reflecting on the visions of neuroimaging developers

In all visions, the formulated neuroimaging use for new and improved (personalised) diagnostic and treatment tools from a developer’s perspective are considered desirable, when therapeutic options are available in case of new diagnostics. Preventive options to detect brain disorders in an early stage, early diagnosis, and the determination of a predisposition for groups at risk are perceived as desirable when options to delay the progression, stabilise or treat the disorder are available and with the prerequisite of the client/patient’s freedom of choice. However, the desirable contextual aspects and underlying basic features of the desirable states concerning preventive neuroimaging are perceived differently. This illustrates the importance of analysing and constructing visions. Reasoning from the vision of neuroimaging as applications in person-centred health centres (vision 3), respondents consider the context of primary care as desirable for preventive options. This implies the screening of symptomless people, people at risk, for example due to a genetic burden, and the screening of people entering primary care with initial complaints and symptoms, that is collective prevention. Interviewees reasoning from the vision of neuroimaging as applications in the current health care practice (vision 1) or the vision of neuroimaging in personalised health care (vision 2) consider primarily the context of secondary care as desirable for the application of preventive options. This implies the screening of patients and the screening of direct family of patients with severe disorders to detect potential (risk for) other disorders, that is individual prevention.
While collective preventive neuroimaging use is primarily only considered desirable in the vision of neuroimaging as applications in person-centred health centres (vision 3), all interviewees considered that when preventive neuroimaging options to screen symptomless people become available and these are (practically) one hundred percent accurate, meet all prerequisites of a positive cost-benefit ratio, offer available therapeutic options, respect freedom of choice and have no negative social or economic implications for the individual, these would be desirable.

### 7.4.3 Conflicting visions?

In this early phase of neuroimaging development, actors who envision neuroimaging as applications in the current health care practice (vision 1) and actors who envision neuroimaging as part of a health system with different structures and practices (vision 2 and 3) have incongruent visions of neuroimaging, but these visions are not (yet) in open conflict with each other. It is important to note that underlying the arguments to discuss the desirability of neuroimaging there are assumptions regarding the basic features of a desirable health system and the functioning of actors within this system. Neuroimaging can therefore not be viewed separately from its (future) socio-institutional context and external pressures. It might not be the only technology that is perceived as either an optimisation of the health system or as an opportunity to change the health system. In other words, advances in neuroimaging combined with advances in other emerging medical technologies, such as genetics (e.g. Smart & Martin, 2006; Hirstsuka et al., 2006), genomics (e.g. Modell et al., 2014) and nanotechnology (e.g. Sahoo et al., 2007) that also have great promises to result in personalised preventive, diagnostic and treatment options, might fuel the perceived need and provide opportunities for actors willing to change the health system to start acting. In this case the incongruent visions will be in conflict with each other.

### 7.4.4 Using visions to prospectively identify similarities and incongruences in visions

One of the challenges in designing and implementing an interactive approach in early phases of technology development is to identify different points of view with respect to the technology assessed (Schot, 2001; Roelofsen, 2011). We showed that by using vision assessment (Grin & Grunwald, 2000), visions of societal actors can be identified and the underlying assumptions of these visions can be analysed, resulting in understanding of the similarities and incongruencies in visions. Subsequently, insights into the perceived challenges and barriers that need to be overcome in order to establish desirable neuroimaging applications for each vision, including their socio-institutional context and external pressures, might provide a more detailed understanding of when
and how the incongruent visions will be in conflict with each other. Moreover, this understanding provides opportunities to establish more responsible innovations by combining the visions constructively into a more balanced, shared desirable vision (Grin & Grunwald, 2000), which is the aim of a multi-actor dialogue we organise as a next step of our research.

With respect to the methodology, it can be argued, that by reflecting on the visions of a developer’s perspective, creativity regarding alternative neuroimaging use was partly impeded. We tried to avoid this as much as possible by starting the interviews with asking what the interviewee(s) perceived as desirable applications of neuroimaging and specifically asking for alternative ideas throughout the interview. However, for some interviewees it was difficult to discuss neuroimaging use without having some examples. Therefore in this early phase developers provided the visions of neuroimaging applications to reflect on, so that all interviewees were able to at least think about visions from their own perspective. Interviewing a wide range of actors resulted in a general overview of differences in visions of an emerging technology. We obtained saturation regarding the articulated visions on a general level, so that we did not generate any new information in the last 2-3 interviews. This does not imply that our study encompassed all potential relevant visions, but it is likely that the diversity of visions of the actors we were not able to consult are in line with one of the general views regarding neuroimaging: perceived either as embedded in the current health care practice, in personalised health care or person-centred health centres. In this early phase of technology development, the vision lack some detail, because it is not possible to have a detailed perspective on what the technology will look like, what function it will fulfil, etcetera (cf. Collingridge dilemma of control). An additional consequence of research at this early phase is that it is difficult to engage people. Some societal actors, such as staff of health insurance companies, private imaging centres and hospital boards, did not agree to an interview. They felt that they were not able to give valuable input and considered the subject not relevant for them in the short-term.

The identified incongruences in the visions with respect to maintaining or changing the current health system are in our opinion important elements in managing, prospectively, neuroimaging developments towards more responsible applications. We showed that with vision assessment it is possible to identify similarities and incongruences in visions and analyse when these visions will most likely come in conflict with each other. These could be the starting points for joint reflection and mutual learning in order to manage neuroimaging developments towards more responsible applications.