

**1. Project title (Iris fact sheet)**

Knowledge and culture

**2. Summary (Iris fact sheet)**

In various domains of cognitive science – psychology, mathematics, cognitive neuroscience, linguistics, music cognition, and biology – a new paradigm is being developed that will profoundly affect research in the humanities. This emergent view holds that humans and non-human animals are born with core knowledge systems: a small set of hard-wired cognitive abilities that are task-specific, language-independent, and non-species-specific. These innate cognitive skills have the capacity for building mental representations of objects, persons, spatial relationships, numerosity, and social interaction. In addition to core knowledge systems, humans possess species-specific, uniquely human, cognitive abilities such as language and music. Spelke (2003) has suggested that the language faculty allows core knowledge systems to expand their limits, laying the foundation for the development of more complex cognitive abilities through experience.

This view on human cognitive abilities throws a new light on problems that were long thought to exclusively belong to the realm of the humanities. Indeed, morality, mathematics, geometry, music, navigation, reasoning, and language are traditionally viewed as cultural achievements. The study of their development and variation is seen as part of the humanities and the social sciences. Hitherto, the humanities have mainly studied these human properties as unbounded properties of culture and nurture, not as the result of the interaction between core knowledge systems and language.

The ‘core knowledge’ paradigm challenges scholars in the humanities to ask the question which parts of culture belong to nature, and how nurture and culture build on nature. In this research program, four domains of the humanities will be investigated from the point of view of core knowledge: music cognition; language and the core knowledge of number; visual arts and geometry; and poetry, rhythm, and meter.

**3. Principal applicant (Iris fact sheet)**

Prof. dr Johan Rooryck, Leiden University

**4. Co-applicants**

Prof. dr Sjef Barbiers	(Syntax, Meertens Instituut/ Utrecht University)
Prof. dr Hans Bennis	(Language variation, Meertens Instituut/ U. Amsterdam)
dr Maarten Delbeke	(Art history, University of Gent/ Leiden University)
Prof. dr Louis Grijp	(Music history, Meertens Instituut/ Utrecht University)
Prof. dr Edward de Haan	(Neuropsychology, University of Amsterdam)
Prof. dr Henkjan Honing	(Music cognition, University of Amsterdam)
Prof. dr Marc van Oostendorp	(Phonology, Meertens Instituut/ Leiden University)
Prof. dr Pierre Pica	(Syntax, Core knowledge systems, CNRS)
Prof. dr Fred Weerman	(Syntax, language acquisition/ University of Amsterdam)

**5. Period of funding: 1/1/2013 - 31/12/2016**

## 6. Structure of the proposed research

The proposed research program will consist of four small teams, each composed of a Postdoc and a PhD researcher, addressing the four themes of *music cognition*, *language and number*, *the visual arts and geometry* and *poetry, rhythm, and meter*. Each team will be actively supervised by a combination of the applicants participating in the program. The complete crew for this *Horizon*-Program will therefore consist of 4 postdoctoral researchers and 4 PhD students.

In each subproject, the PhD researcher will mostly concentrate on experimental and data-related aspects of the project, while the Postdoc researcher will address the more theoretical aspects of the project, co-supervise the PhD researcher, and collaborate with the other Postdocs to refine methodologies and evaluate results common to the 4 domains investigated in the form of semi-monthly meetings. Within each team, one senior supervisor will be directly responsible for the Postdoc and the PhD researcher.

The four research teams will be united by a common set of methodologies that are not usually jointly applied in the humanities. This integrated approach will include research methods of generative linguistics, experimental methods, methods from research in acquisition, and the manipulation of large data sets. The applicants are experts in these various methodologies, and will supervise and guide each Postdoc-PhD team.

The table below contains the titles of the projects and the names of their direct supervisors. Each small team will be supervised and guided by a different combination of applicants.

Program leader <i>Rooryck</i>				
Coordinating team <i>Bennis, de Haan, Rooryck</i>				
Domain	<b>Subproject 1 Music cognition</b>	<b>Subproject 2 Language and number</b>	<b>Subproject 3 Visual arts and geometry</b>	<b>Subproject 4 Poetry, rhythm, and meter</b>
Supervision teams	<i>Honing, Grijp, van Oostendorp</i>	<i>Barbiers, de Haan, Pica, Weerman</i>	<i>Barbiers, Delbeke, van Eck, Pica</i>	<i>Honing, Grijp, van Oostendorp</i>
Direct supervisor	<i>Honing</i>	<i>Barbiers</i>	<i>Delbeke</i>	<i>van Oostendorp</i>
Postdocs	<i>Postdoc 1</i> What is shared (and what is unique) in music and language	<i>Postdoc 2</i> The linguistic typology of number systems and the core knowledge system of number	<i>Postdoc 3</i> Basic proportional patterns and geometric core knowledge	<i>Postdoc 4</i> Text setting
Direct supervisor	<i>Honing</i>	<i>Barbiers</i>	<i>Delbeke, van Eck</i>	<i>van Oostendorp</i>
PhDs	<i>PhD 1</i> Relative pitch in music and language	<i>PhD 2</i> The acquisition of ordinals and the core knowledge system of number	<i>PhD 3</i> Universal decorative patterns and geometric core knowledge	<i>PhD 4</i> Symmetry and asymmetry in folk poetry

## 7. Description of the proposed research program: *Knowledge and Culture*

*“En me posant la vaste question : qu’est qui fait que l’homme est l’homme? Je constate qu’il y a sa culture d’une part et son génome de l’autre, c’est clair. Mais quelles sont les limites génétiques de la culture? Quel est leur bloc génétique? Nous n’en savons absolument rien. Et c’est dommage car celui-ci est le problème le plus passionnant, le plus fondamental qui soit.”*

Jacques Monod, ‘de Homine’, *Rivista dell’istituto di Filosofia*, Roma 53-54, 1975, p. 131.

### 7.1. Introduction: defining *core knowledge systems*

How do humans acquire knowledge? The question reaches back to Plato’s *Republic*, and has fascinated thinkers including Descartes (1637) and Kant (1781). One answer, originating with Locke (1689) and Hume (1748), proposes that the human mind involves a single, flexible, all-purpose learning mechanism. This view is echoed in cognitive psychology and neural network theory. A different answer, consistent with evolutionary psychology, holds that the mind contains a large number of highly specialized learning systems, each adapted for specific purposes.

A recent and highly successful research program holds the middle ground, hewing close to Kant (1781). Researchers from fields as diverse as developmental psychology, mathematics, cognitive neuroscience, linguistics, and biology argue that humans and non-human animals are born with a *small number of core knowledge systems*. Core knowledge systems are defined as hard-wired cognitive abilities that are task-specific, language-independent, and non-species-specific (Spelke & Kinzler 2007). These innate cognitive skills allow distinct mental representations to be built, enabling newborn humans and animals to organize their perceptions. Experimental studies across species and cultures have provided evidence for at least *four core knowledge systems*, each ordering a different field: objects and their interactions; agents and their result-oriented actions; number; and geometry (Spelke 2003). This view is moderately nativist and internalist, as it implies that at least some cognitive abilities are innate.

Experiments have determined that core knowledge systems have a number of common properties. For one, these systems apply to specific entities and their interaction. As domain-specific systems, they do not apply to entities that are ruled by other systems. Within each system, basic principles operate to identify the properties of the entities within that domain. By identifying what are called the ‘signature limits’ of each system, researchers have demonstrated that the systems apply across tasks, ages, cultures, and species (Spelke & Kinzler 2007).

For example, the core knowledge system for object representation is characterized by spatio-temporal principles of *cohesion*, *continuity*, and *contact*. Experiments demonstrate that infants and animals know innately that objects move as bounded entities, that they move on continuous paths, and that they only interact on contact. This knowledge allows the path of objects that move out of view to be conjectured. The system of object representation has a *set-size limit*: infants and monkeys can only apply their understanding to about three objects at a time.

The core knowledge system of geometry, by contrast, represents the *distance*, *angle*, and *direction* of layouts in space. This system relies on classical *Euclidean principles*, such as the axiom that two parallel lines never cross. Geometrical representations are *abstract*, which means that non-geometric properties such as color and odor are irrelevant. Behavioral and neurophysiological experiments show that the core knowledge system for geometry includes two distinct subsystems that each capture only part of Euclidean geometry: one subsystem serves for navigation and relies on *distance* and *direction* only; another uses *distance* and *angle* only, allowing small objects to be

categorized. (Spelke *et al* 2010). Sensitivity to geometry is used in a wide variety of navigational tasks by both oriented and disoriented humans and animals (Cheng & Newcombe 2005).

In addition to the non-species-specific core knowledge systems, humans possess species-specific cognitive abilities, such as language and music.

Innate cognitive abilities					
Core knowledge systems (non-species-specific, task-specific)				Uniquely human abilities (species-specific, non-task-specific)	
Agents	Objects	Geometry	Number	Music	Language

*Figure 1: Core knowledge systems and uniquely human abilities.*

*Core knowledge systems (Agents, Objects, Geometry, Number) are dedicated to single tasks and are shared by humans and non human animals; uniquely human abilities, such as language and music, are not dedicated to a single task: language and music do not have a single purpose, such as communication.*

Spelke (2003) has suggested that the uniquely human language faculty allows core knowledge systems to expand their limits, laying the foundation for the development of more complex cognitive abilities through experience. In this view, language allows core knowledge systems to combine in ways that are inaccessible to animals. For example, language is instrumental in relating the core knowledge systems of number and geometry to create the distinctly cultural geometrical concepts of ‘triangle’ and ‘square’, objects with three and four sides.

In more general terms, this means that nature provides the building blocks on which nurture may graft additional knowledge, techniques, and cultural achievements. The distinction between nature and nurture becomes less clear-cut, since nurture can only build on what is provided by nature. This perspective revolutionizes our view of human cognition, and has important consequences for the definition of culture and traditional studies of the humanities.

## 7.2. The research program – core knowledge systems and the humanities

Morality, mathematics, geometry, geography, music, navigation, and language are traditionally viewed as uniquely human cultural achievements and abilities. The study of their development and variation is classified as part of the humanities and social sciences. These fields have been mainly studied as unbounded properties of culture and nurture, rather than as the result of the interaction between core knowledge systems and language. However, by considering these disciplines in terms of core knowledge systems, scholars in the humanities and social sciences are challenged to ask how cultural achievements and uniquely human abilities may be determined by innate systems. This research program can be divided into three major questions:

(1) *Research questions:*

- a. How do core knowledge systems constrain *cultural diversity*?  
How is cultural knowledge built on core knowledge systems?
- b. How do core knowledge systems interact with species-specific, uniquely human, cognitive abilities such as the faculty of *language* and the faculty of *music*?
- c. How do the uniquely human innate abilities of music and language interact?  
What are the implications of this interaction for core knowledge?

The question in (1a) raises the problem of the relation between core knowledge systems and the limits of the types of cultural manifestations that may grow out of them. Given a finite set of innate human mental abilities, some cultural forms will never be developed – these constitute ‘impossible cultures’ – while others will be fairly common (Sperber & Hirschfeld 2004). In other words, cultural diversity is constrained by the human cognitive blueprint.

The question in (1b) focuses on the interface between non-species-specific core knowledge systems and the uniquely human cognitive abilities (language and music). Researchers of generative grammar and biolinguistics have recently begun to explore this, focusing on relation between core knowledge and language, as well as between language and music. Chomsky (1955, 1965, 1986) holds that the human ability for language is innate, and that all human languages are grafted on this innate base. Musical skills are also judged to have an innate basis (Cross 2007, Honing 2009, McDermott & Hauser 2005). Music is an autonomous function, composed of multiple modules that overlap minimally with other functions, such as language (Peretz 2006). Music perception – like linguistic competence – appears to be the result of innate constraints shaped by environmental stimulation.

To implement these research questions successfully, we must use the detailed knowledge of “possible cultures” that has accumulated in the humanities. Because the human abilities of language and music (*Question 1b*) have been partly studied by generative linguistics and music cognition, the present project dedicates two research themes to music (*Subproject 7.4*) and language (*Subproject 7.5*). The aim is to develop an understanding of the interaction of these human abilities with core knowledge systems.

Linguistic knowledge of the diversity of language systems in the world allows us to explore how properties of core knowledge systems are reflected in these languages. In this subproject, the relation between language and the core knowledge system of number will be investigated. The broad question here will be how studies in language typology and language acquisition can shed new light on our understanding of the core knowledge system for number (see Carey 1998).

Similarly, cross-cultural generalizations about music may reveal its relation to the language faculty and to core knowledge systems. In the research theme dedicated to music, the commonalities and the differences between language and music will be explored, with special attention to the role of syntactic processing and relative pitch.

In order to operationalize research into constraints on cultural diversity (*Question 1a*), we have identified two research domains within the humanities that will contribute to our understanding of the relationship between core knowledge systems and constraints on cultural diversity. In our examination of possible domains, we focused on those that were representative of the humanities and that possessed a set of key characteristics: a high level of descriptive and theoretical sophistication; a tradition of interdisciplinary research, including experimental research; solid empirical generalizations; and strong definitions of the variables that determine these generalizations. We also sought domains that were linked to core knowledge systems and/or to uniquely human abilities in a transparent way. Ultimately, the two research themes we selected were the study of *geometry in the visual arts* (Subproject 7.6) and the study of *poetry, rhythm and meter* (Subproject 7.7).

The first of these, the role of geometrical and proportional patterns in the visual arts, has a long tradition of interdisciplinary research combining anthropology, art history, and mathematics. In his seminal *Primitive art*, Franz Boas (1927) already wondered why so many unrelated cultures share the same geometrical patterns in their art forms. Does this mean that there is an innate ability for pattern recognition that remains constant across cultures? Can such abilities be compositionally derived from the notion of symmetry that is inherent in geometrical relationships? In this subproject, the perspective and methodologies of the core knowledge system of geometry will be brought to bear on these issues.

Like geometry in the visual arts, the study of rhythm and meter in poetry has been investigated from various angles, including rhetoric, literary theory, music theory, and phonology. Musical rhythm and meter share the common notion of a *time signature*. Meter arranges word stresses or syllables into repeated patterns that are known as feet. Languages and poetic traditions vary in the way they set these temporal patterns. Strikingly however, any metrical line can be subdivided into smaller subgroups of 2 or 3 members. This limit is reminiscent of the limit on the quantity of objects (3) that can be represented in one subsystem of the core knowledge system for number. How does the system of poetic rhythm and meter interact with the uniquely human ability of music and a possible cognitive ability of rhythm?

To sum up, the proposed *Horizon* research program is subdivided into four subprojects:

- |     |    |  |         |
|-----|----|--|---------|
| (2) | a. | <i>Music cognition, language, and core knowledge systems</i>     | (§ 7.4) |
|     | b. | <i>Language and the core knowledge system of number</i>          | (§ 7.5) |
|     | c. | <i>The visual arts and the core knowledge system of geometry</i> | (§ 7.6) |
|     | d. | <i>Poetry, rhythm, and meter</i>                                 | (§ 7.7) |

Studying these questions from an internalist point of view is highly controversial, and in many disciplines within the humanities has never been attempted. Despite a long and venerable tradition of thinkers who have espoused the idea that certain categories are innate, the idea elicits much resistance. The purpose of this research program is not to prove or disprove the innateness of our foci, but to investigate which aspects of human nature are given from birth, and which ones are not.

The projects in this research program will be interdisciplinary in nature, involving scholars from different backgrounds and disciplines. Although Dutch academe has conferred honors on prominent researchers in the domain of core knowledge systems (Stanislas Dehaene, *KNAW Heineken Prize 2008*, Radboud University; Elizabeth Spelke, *dr. hon. c.*, Utrecht University, 2010), few Dutch universities actually possess expertise in this domain. This research program aims to fill that gap. The project will build on the Lorentz Center Workshop *Knowledge, language and culture*, organized at the *Lorentz Center* in Leiden by Johan Rooryck and Pierre Pica (29 May – 1 June 2012) in the context of the *Distinguished Lorentz Fellowship* awarded to Johan Rooryck to develop work on the relation between core knowledge systems, language, and culture. The most distinguished researchers in the field have agreed to participate (*See appendix A for the program*).

This research program is highly innovative in its research questions. It attempts to use fine-grained analytical tools to determine what makes the human species unique, and what humans share with animals. It seeks to separate out the fixed, biological basis of culture from those factors that allow for cultural variation. The program is also *highly interdisciplinary*, bringing together researchers from various research traditions who will work together for the first time from a common perspective.



## 7.4. Subproject 1 – Music cognition, language, and core knowledge systems

### 7.4.1. Introduction

Music and language have a lot in common. Both are rule-governed and subject to recursion, the ability to indefinitely lengthen sentences or musical pieces. Infants acquire both music and language effortlessly, suggesting an innate ability. Predispositions for music are related to those abilities that distinguish humans from other animals and emerge prior to birth (Trehub 2003; Zentner & Kagan 1996).

Developing earlier proposals by Lerdahl & Jackendoff (1983), the theoretical linguists Pesetsky & Katz (2009) argue, that music contains a syntactic component common to music and language: all formal differences between language and music derive from differences in their fundamental building blocks. This hypothesis finds some support from the neuroscience of music (Patel 2008).

In developmental psychology, research on music ability and activity in infants has yielded

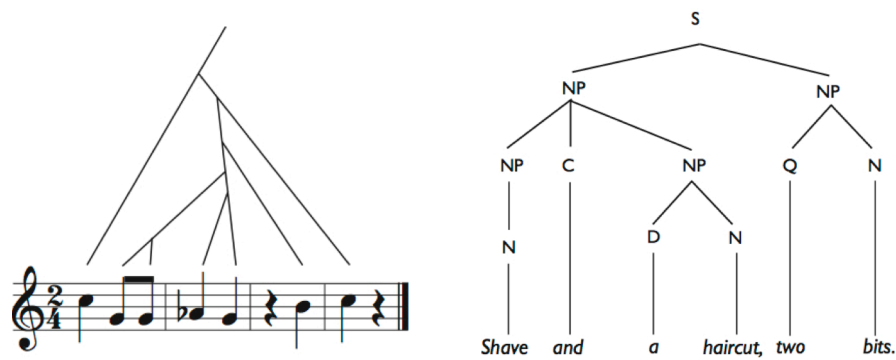


Figure 2:  
Structural analyses as commonly used in music (left)  
and language (right). (Adapted from Honing 2011.)

fascinating results as to which aspects of musical disposition are part of nature and which ones should be ascribed to nurture (see Trehub 2003 for an overview).

Infants' perception of consonant intervals is more precise than their perception of dissonant intervals (Schellenberg & Trehub 1996), suggesting that a preference for consonance is innate. Hannon & Trehub (2005) were able to show that 6-month-old infants can recognize rhythmic perturbations in rhythmically complex Bulgarian music, while their North-American parents have (apparently) become insensitive to these differences. And lastly, beat induction, a human-specific and domain-specific skill, is already functional right after birth (Winkler *et al.* 2009). These results count as emerging evidence for a human predisposition for music.

Finally, it is important to point out that these predispositions for consonance, melody and intonation, rhythm, and beat induction are independent of the development of language. They may rather be seen as dependent on language-independent core knowledge systems, such as the systems for number and geometry. At the same time, language encapsulates musical elements such as intonation and metrics, which will be the topic of the research theme on *Poetry, rhythm, and meter* (§ 7.7).



#### 7.4.2. Postdoc Project: What is shared (and what is unique) in music and language

The Postdoc project will investigate the nature of the relationship between music and language. This researcher will attempt to integrate the insights from both research traditions introduced above, the theoretical-linguistic tradition and the developmental-experimental studies, and combine this with recent insights from the field of music cognition (cf. Honing 2011).

The interest in the relationship between music and language is a long-standing one. While Lerdahl & Jackendoff (1983) built mostly on insights of metrical phonology of the time, more recent studies (Pesetsky & Katz 2009) draw attention to the parallels with current minimalist syntactic theory (Chomsky 1995) rather than phonology. However, if a large part of music is indeed preverbal (Honing 2010, Trehub 2003), does this also mean that syntactic or phonological operations and structures used in linguistics are preverbal as well? The project will inquire to what extent the results of both research traditions are complementary and where substantial gaps remain. A second question addressed in the Postdoc project is that of the intersection between music and language: what exactly are the *core knowledge systems* that are shared by music and language, and why are exactly these mechanisms shared rather than others?

So far, the evidence for these conjectures has remained inconclusive. However, there are good reasons to believe that the search for shared processes and resources should continue. The strongest arguments derive from evolutionary considerations on the rather large set of cognitive functions that appear to be unique for humans. This suggests, for instance, that language and music will share properties with animal cognition (Fitch 2006), but at the same time that their human-specific features derive from a single common source (Hauser & McDermott 2003).

On the other hand, there are also compelling reasons to consider music and language as two distinct cognitive systems. Recent findings in the neuroscience of music suggest that music is likely a cognitively unique and evolutionary distinct faculty (Peretz & Colheart 2003). We will refer to this position as the *modularity-hypothesis*. There is also considerable neurological evidence suggesting a dissociation between music and language functions (e.g., patients that, because of neurological damage, suffer from *amusia* while maintaining their ability to recognize words, and vice versa; cf. Peretz & Colheart 2003). This position can be contrasted with the *resource-sharing hypothesis* that suggests music and language share processing mechanisms, especially those of a syntactic nature, and that they are just distinct in terms of the lexicon used (Patel 2008). In the proposed research, we aim to identify what is shared and what is special about music and language.

A clear candidate for a *shared* mechanism is syntactic processing, which is well attested in both language and music (Lerdahl & Jackendoff 1983; Patel 2008). The aim of the current project is to investigate to what extent the evidence is converging, combining insights from the research traditions mentioned in the beginning of this subproject.

A clear candidate for a *special* mechanism – a function that seems music-specific – is beat-induction, which seems to be limited to music and apparently inexistent in natural language. Picking up this regularity in music allows us to dance and make music together and is therefore considered a fundamental cognitive mechanism that might have contributed to the origins of music (Honing 2012; Winkler *et al.* 2009). Interestingly, Patel (2008:404) suggests that beat-induction is an exception to his resource-sharing hypothesis, and a realistic candidate for a cognitive ability that is specific for music.

### 7.4.3 PhD project: Relative pitch in music and language

The PhD project addresses the cognitive mechanism of relative pitch and how this human skill can throw light on the relation between music and language and musical ability. Just like beat-induction (see § 7.4.2), relative pitch has been argued to be a fundamental musical skill that is species-specific and domain-specific (McDermott & Hauser 2005; Peretz & Coltheart 2003).



Figure 3:

*Are all the objects the same? Even though all sorts of measurable, physical aspects of the depicted object change, we easily recognize all the variations as being the same object. Relative pitch is something similar. Whether a melody is played a few tones higher or lower, despite major physical changes in the sound we recognize it as being the same tune. That may seem obvious, but what we encounter here is an exceptional skill of our cognitive system (adapted from Honing 2011).*

With regard to pitch perception, a significant amount of information is encoded in the contour patterns (i.e. rises and falls) of the pitch of acoustic signals, both in speech and music. For example, humans can easily recognize sentence types (e.g., statement, question, warning) on the basis of pitch contour alone in the absence of other information (Ladefoged 1982). The frequency transpositions of a melody are readily recognized by adult and infant listeners alike as the ‘same’, and are perceived as structural equivalents of the original melody (Trehub & Hannon 2006). Although human listeners can remember the exact musical intervals of familiar melodies, they appear to remember only the melodic contour of less familiar or novel stimuli (Dowling 1978). Unlike humans, who attend primarily to the relationships between sound elements, animals more heavily weight the absolute frequency of sound elements in their perceptual decisions and appear to be less sensitive to relative pitch changes (Yin *et al.* 2010).

Developmental psychologists have shown that the aptitude for both absolute and relative pitch is present in all babies. However, by the time they are a few months old, a hierarchy in these abilities emerges, and babies gradually listen more to the relative aspects of a melody than to the absolute, actual pitch of the notes (Trehub & Hannon 2006). Relative pitch outclasses absolute hearing, as it were.

Moreover, initial experimental evidence suggests that animals have no relative pitch, only absolute pitch (Yin *et al.* 2010). Research on rhesus monkeys showed that they only judged melodies as similar if they heard them at exactly the same pitch or if they were played at one or more octaves higher or lower than before (Wright *et al.* 2000). A melody that was played only a few tones higher or lower was just dissimilar. Songbirds, too, only seem primarily attentive to absolute pitch. For them as well, a melody sung some semitones higher or lower represents a different melody (Kass *et al.* 1999).

Apart from the fact that relative pitch enables us to recognize melodies without being influenced by their absolute pitch, this uniquely human skill is extremely helpful in recognizing many other melodic variants. As with beat induction, a more abstract way of listening is required. Thanks to relative pitch, humans are not only able to recognize two melodies as the same tune, but they can also identify one melody as a variant of another. How humans achieve this is still unclear.

The questions addressed in this PhD project are the following:

- (1) What is the evidence for relative pitch as an innate or at least a spontaneously developing skill?
- (2) Is relative pitch shared with language, or are two different pitch perception systems involved for music and language?
- (3) What is the role of relative pitch in cultures with a tonal language? How does the semantics marked by pitch interact with the constraints of music?
- (4) Is there a relation between relative pitch and the core knowledge systems of number or geometry? If so, what is its nature?

These questions aim at determining whether relative pitch perception is modular or shared, and in that sense similar to the Postdoc project. In addition to analyzing and interpreting the available evidence for either position, the PhD project will focus on the interaction between *congenital amusia* (or tone deafness; being unable to detect an out-of-tune note in a melody) and tone language processing. Some recent studies suggest modularity, with limited transfer from one domain to the other (Liu *et al.* 2010; Nguyen *et al.* 2009).

Finally, some evidence suggests that amusics have problems with subtle speech prosody, but no difficulty with ‘natural’ sentence stimuli (Patel *et al.* 2008). Interestingly, amusia also seems to be associated with deficits in spatial processing (Douglas & Bilkey 2007). Hence it could be that amusia is in fact a failure to implement a spatial representation of relative pitch (Williamson, Cocchini & Stewart 2011), linking the project on pitch to the core knowledge system of geometry.

## 7.5. Subproject 2 – Language and the core knowledge system of number

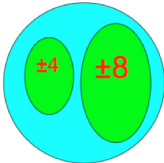
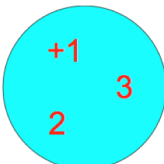
### 7.5.1. Introduction

This project investigates the mapping between the core knowledge system for *number* and the *faculty of language*. The central research question is how linguistic investigations of number can shed new light on our understanding of the core knowledge system for number.

Recent research shows that the core knowledge system of number consists of two nonverbal subsystems that are present in both newborn infants and animals (Spelke 2011).

The first subsystem, the *Approximate Number System* (ANS) compares the numerosities of distinct sets without individuating their members. This system is imprecise and ratio-sensitive. Initially, it only distinguishes between sets with a ratio of 2 or higher (e.g. 4 vs. 8), the ratio decreasing with maturation (Dehaene 1997).

The second subsystem, the *Object Tracking System* (OTS) yields representations of small numbers of objects, i.e. 1 to 3 (perhaps 4). It does not work on sets larger than 4. OTS is also different from ANS in that it is precise, able to distinguish between 2 and 3, and sensitive to adding or subtracting one individual.

System	Precision	Successor function (+1)	1 vs 2	2 vs 3	4 vs 8	
ANS	Approximate cardinal values	--	✓	--	✓	
OTS	Numerically distinct individuals	✓	✓	✓	--	

*Figure 4: ANS vs OTS*

The limits of the two number systems are overcome when the child starts using cardinal numerals such as *one*, *two*, *three*, and acquires the counting principle. ANS and OTS are the foundation for symbolic mathematics. Spelke (2011) suggests that the language faculty plays a crucial role in integrating the two systems.

In line with the program set out by Carey (1998), this project adopts two methods to study the mapping between the core system of number and the faculty of language: (i) cross-linguistic comparisons to elucidate universal and variable properties of the systems (project 7.5.2); (ii) comparisons over development of the systems in the child, and their changes with growth and education (project 7.5.3). The results of these projects will provide crucial input for other lines of research in the field of the core knowledge systems (Spelke 2011), including cross-cultural comparisons (e.g., Pica *et al.* 2004, 2006). The data collected in these projects will be made available on-line (WALS for the typological data; CHILDES for the acquisition data).

### 7.5.2. Postdoc project: Number in language: a typological study

This project studies the relation between the properties of the core knowledge system for number and the linguistic properties of numerals in the world's languages. The project focuses on the following questions:

- (1) a. Does the distinction between OTS and ANS manifest itself in the numeral systems of the languages of the world, and if so, how?
- b. What does the special linguistic status of 1 as opposed to all other numerals tell us about OTS and ANS?

Linguistic evidence suggests that the split between OTS and ANS is reflected in the language system. Crosslinguistically, 1 to 3 (or 4) have linguistic properties that are different from those of the higher numbers (Hurford 1987): (i) no language has grammatical trial number unless it has dual number, and languages that distinguish a grammatical number higher than 3 are rare or non-existent (Greenberg 1963); (ii) ordinal suppletion (*first* instead of regular *one-th*, *second* instead of *two-th*) is cross-linguistically common but largely restricted to ordinals below *fourth* (Veselinova 1998; Stolz & Veselinova 2011); (iii) cross-linguistically, the words for 1 to 3 agree in gender and case with the noun, unlike numerals higher than 3.

Studies on OTS do not attribute a special status to 1 vs. 2 and 3. However, linguistically the numeral 1 is distinct from all other cardinal numerals in many languages. In Hebrew, the word for 1 follows the noun while all other cardinal numerals precede it (Borer 2005). In Dutch, 1 is morphosyntactically distinct from the other cardinal numerals: it allows derivation with *-heid* 'ity'; but not with *-tal* 'some'; it can be modified by *zo* 'so', *hoe* 'how' and *te* 'too'; and it is incompatible with EACH and EVERY (Barbiers 2007). In many languages, 1 has more in common with indefinite numerals such as MANY and FEW than with the cardinal numerals. Ordinals can be regularly derived from numerals, but 1, MANY and FEW block regular ordinal formation. As such, the behavior of 1 is surprisingly more similar to the approximate number properties of ANS than with the numerically distinct values of OTS. Children acquiring language first distinguish 1 from all other numerals (Spelke 2011). The project will therefore investigate the relation between the special linguistic status of 1 with respect to the core knowledge subsystems of ANS and OTS. The linguistic behavior of 1 might support Piazza's (2010) conclusions on the basis of neuroimaging techniques that OTS is not a proper subsystem of number in its own right.

Importantly, the grammatical properties distinguishing ANS from OTS, and 1 from the other numerals, have not yet been systematically studied for a properly representative sample of the world's languages. This project will provide a more complete cross-linguistic typology of the morphosyntactic properties of cardinal numerals and quantifiers such as *many* and *few*. The study will include properties such as ordinal suppletion, inflection, case, derivational properties, syntactic distribution, modifiability and predicative use. A model will be provided to capture the linguistic similarities and differences between the numeral categories in terms of feature composition (see Barbiers 2007 and Harbour 2011). Distinct behavior of the numeral categories under the influence of the core knowledge system for number is expected to show up in all languages.

The primary data source for this study is the *World Atlas of Linguistic Structures* (Dryer & Haspelmath 2011, Comrie 2011; <http://wals.info/>), which currently contains 2678 languages in

510 genera and 212 families, including relevant features for ordinal numerals (321 languages) and order of numeral and noun (1154 languages). Starting from these data we will select at least one language from each genus, completing the inventory with reference grammars and data elicitation.

### 7.5.3. PhD project: The acquisition of numerals and ordinals

This project investigates the acquisition of numerals in relation to the development of the core knowledge system for number. The following research questions will be investigated:

- (2) a. What is the sequence of acquisition for (the morphosyntactic properties of) 1, the other numerals, and quantifiers such as MANY?
- b. How are words for ordinals acquired by children?
- c. How is the numeral for 2 acquired by children?

Language acquisition experiments (Gelman & Gallistel 1978, Feigenson & Carey 2005, Le Corre & Carey 2007) show that two-year-old children who can count from 1 to 10 start with a distinction between numeral 1 and all other numerals. In give-a-number-tasks they give the experimenter one object when asked for one, for all other numerals they give a random number of objects but never one. The next numeral acquired is 2, then 3 and then the other cardinal numerals. If MANY has more properties in common with 1 than with the other cardinals (cf. §7.5.2), it is expected that MANY is acquired after 1 but before the other cardinals. The first goal of this subproject is to test this expectation, and to investigate the acquisition of the specific morphosyntactic properties of 1, 2, 3 and quantifiers such as MANY and FEW.

The second goal is to study the acquisition of ordinals. Ordinals are often morphologically or syntactically derived from numeral stems. Their compositional complexity suggests that they are acquired after numerals. In many languages, ordinal formation adds a definite article or suffix to the cardinal. This has the semantic effect of picking out one discourse-anchored ordering of the set of orderings defined by the corresponding cardinal. We therefore expect ordinal formation to be acquired either simultaneously or after the acquisition of the definite article. The acquisition order of ordinals might be sensitive to the split between OTS and ANS. Since 1 is acquired before 2 which is acquired before the other numerals, the order of ordinal acquisition should be: FIRST - SECOND - THIRD etc., unless acquisition of ordinals comes in after the acquisition of the cardinals from 1 to 10. Interference with ordinal suppletion will also be investigated. As ordinal suppletion is restricted to OTS, the question arises what happens to suppletive forms in child language. In the acquisition of irregular verb forms, children go through various stages: correct irregular form (e.g. *ate*) > incorrect regular (i.e. overgeneralized) form; (*eated*) > mixtures (*ated*) > correct form (*ate*). Does something similar happen with suppletive ordinals, i.e. do we find overgeneralization of regular ordinal formation for 1, 2 and MANY?

The third goal of this subproject is to investigate the acquisition of 2. Children go through a short stage where they use 2 but not the higher cardinals. 2 must therefore have special properties. Cross-linguistically this is confirmed by words such as PAIR, COUPLE and DUO. Our hypothesis is that children in the 2-stage initially take 2 to refer to a unit consisting of two parts rather than to a set of two elements. We expect children to apply 2 to twofold units first, e.g. shoes, eyes, before generalizing it to all sets of two elements. If 2 does not yet belong to the set of cardinal numerals at this stage, the child cannot have the regular ordinal such as Dutch *twee-de*

‘second’, if s/he has ordinals at all.

A pilot study of the CHILDES database (<http://childes.psy.cmu.edu/>) shows that there are relatively few occurrences of cardinal and ordinal numerals in naturally occurring child language data. The ordinal system is acquired relatively late. These findings imply that the design of this project should include elicitation, perception, and judgment experiments involving children from age 2 until (at least) 8. Therefore a mixed longitudinal and cross-sectional study will be carried out in years 2-3 of the project including 3 groups of 25 Dutch children, ages 2-3, 4-5, 6-7, possibly extending to a fourth group age 8-9. While any language would in principle qualify, we choose Dutch because its morphosyntax has been well studied (e.g. Unsworth & Hulk (2010) for gender; Blom, Polišenská & Weerman (2006/7) for agreement; van Wijk (2007) for the plural; Veenstra *et al.* (2010) for quantitative *er*; Keij *et al.* (2012) for determiners). Experimental protocols will be developed on the basis of previous research, replicating these settings as closely as possible, and augmenting them for the investigation of their distinctive morphosyntactic properties.



## 7.6. Subproject 3 – Visual arts and the core knowledge system of geometry

### 7.6.1. Introduction

The Mundurucu live in isolated villages of the Amazon basin. Their language has few words for geometric or spatial concepts, and they lack instruments for spatial measurement or maps. If cultural or linguistic transmission determined the formation of basic geometric concepts, the Mundurucu should perform poorly on tasks involving geometric concepts such as parallelism or congruence. By contrast, if the human mind comes equipped with the prerequisites for spatial thought, they should be able to apply such concepts. Dehaene et al. (2006) found that Mundurucu children and adults are able to pick out the geometrically odd figure in a picture discrimination task. These results support the idea that humans come equipped with innate, core geometric knowledge. By contrast, the Mundurucu performed poorly on tests involving geometric transformations. This suggests that such transformations may not be part of geometric core knowledge. When American children and adults were tested as a comparison group, American adults outperformed Mundurucu of any age, as well as American children. This result indicates that culture, language or education builds a more robust structure on the foundation of core geometric knowledge.

The inquiry into what part of geometric knowledge is innate, and what part is determined by culture, can be fruitfully informed by confronting it with research traditions in anthropology and art history. In these disciplines, there is a long tradition of inquiry into the universality of design patterns and the universality of art as a feature of cultures. Franz Boas' *Primitive Art* of 1927 is an example of such anthropological research, which after much criticism has recently been taken up again as one of the starting points for new research into the universality of art. Within art history, and particularly architectural history, beginning with the work of Gottfried Semper in the 1850s culminating in *Der Stil* of 1863, much energy has been devoted to identifying the basic universal patterns used in all human art over the world, which was inspired by recent developments in comparative linguistics. In his wake, art historians such as Alois Riegl (1858-1905) studied cross-cultural patterns in textiles to detect their universal patterns and the formal laws ruling their transformations. Baxandall (1971) and (1972) has pointed to the counting skills of Florentine 15<sup>th</sup>-century merchants to account for the development of linear perspective, but such connections between mathematical knowledge and artistic developments have not been followed in a systematic way, and certainly not for architecture. In the anthropological tradition, Hardonk (1999) formulates specifically geometric universals for decorative band patterns.

However, such art-historical inquiries never succeeded in formulating a convincing hypothesis on how such universal formal patterns and the laws governing their formation are related to the wider social, religious or practical functions of the objects that they decorated, nor could convincing links be established between these patterns and the psychological make-up of their makers and users (see Hvattum 2003). The results of recent anthropological research such as Hardonk's have so far not been integrated with art-historical findings.

In the research program proposed here, we wish to combine the study of geometric core knowledge and competences with the various universals in art patterns that have been identified by anthropologists and art historians. In and by itself, the fact that some art patterns are universally attested cross-culturally does not automatically entail that it should be determined by geometric core knowledge, but such universals effectively constrain the search domain by limiting the number of cultural variables involved.

The main research question to be addressed by this subproject can be formulated as follows:

- (1) How and to what extent can universals in art patterns be related to the innate geometrical competences needed to produce and recognize them?

The main hypothesis of this research project is that universals in art patterns will reveal and further refine the complexity of geometric core knowledge. This subproject will be divided into a Postdoc and a PhD project. They will study two basic varieties of artistic patterns that can be found all over the world: two-dimensional geometrical patterns in ceramics, textiles and other flat surfaces; and simple proportional relations such as 1:2 or 3:4 in three-dimensional settings such as buildings. Concentrating on these very basic patterns will enable us to test for the first time a series of hypotheses on the universality of these patterns, the laws that govern their formation and recognition, and their aesthetic appreciation by confronting them with knowledge based on repeatable anthropological and psychological observation and field work.

This subproject will thereby significantly add to the recent new discipline of global art history as developed by John Onians and James Elkins, and in which the Leiden School of Art History plays a significant role. Most present work focuses on the conceptual and methodological issues of world art history (Onians 2004, 2006, Elkins 2007, Zijlmans & Van Damme 2008). By contrast, the project presented here will combine art historical and theoretical discourse with actual fieldwork. It will also be one of the first studies to consider not only ceramics or the visual arts, but also include geometrical patterns in architecture. In this way, the two projects of this sub-program will investigate two basic geometric patterns of increasing complexity which have always been thought to have some universality in light of the hypothesis that they draw on the same geometric core knowledge.

### 7.6.2. Postdoc project: Basic proportional patterns and geometric core knowledge

Proportion is considered in Western architectural history and theory as one of the foremost defining characteristics of human rationality and its expression through artistic design (Wittkower 1949). Simple proportional relations such as 1:2 or 3:4, expressed in geometrical patterns such as a square and its half, have often been considered as one of the main defining characteristics of classical and Renaissance architecture. These proportions have been taken up by Modernists such as Le Corbusier to support their claims for the inherent rationality and universality of their approach to architectural design. Yet, although there has been much research into the psychological aspects of linear perspective, proportional systems in architecture have hardly been the subject of empirical investigation, despite their ideological weight.

Only very recently was a scientific protocol developed for the measurement of buildings that provides an empirical basis for claims about proportion (Cohen 2008). This protocol was tested in measurements of that icon of Renaissance proportion, Brunelleschi's church of San Lorenzo in Florence, with results that have forced architectural historians to rethink many of their assumptions about the nature and universality of proportional systems.

Cohen's research provides the basis to start a series of measurements of buildings from a group of carefully selected cultures in order to test whether simple proportional patterns indeed possess the universality that has always been claimed for them, and to study their connection with geometrical core knowledge. One obvious candidate for such fieldwork is the Batammaliba in Benin, who have a well-developed architectural culture characterized by a very rigorous system of anthropomorphic nomenclature of their buildings (Blier 1983 and 2001). Since

anthropomorphy has always been associated with proportion (Leonardo's *Vitruvius Man* being its iconic image), this community would provide a good candidate for fieldwork that would examine the universality of proportion.

The fieldwork to be carried out in this context will consist of a converse replication of Dehaene's et al (2006) work with the Mundurucu. Where the Mundurucu lack precise geometrical terms, the Batammaliba have an abundance of such terms in the architectural lexicon. The specific research question of this project therefore can be formulated as follows:

- (3) How does the Batammaliba geometrical lexicon affect their perception of space?

It is to be expected that Batammaliba adults are unusually adept at recognizing proportional shapes that are in line with the anthropomorphic nomenclature of their culture, while Batammaliba children are not yet so equipped. Such work would confirm the thesis that language builds a rich system on top of core geometric knowledge. The geometric idea of proportionality resonates with two other subprojects of the research proposal, more precisely the projects on *language and number* (§7.5.) and particularly *poetry, rhythm and meter* (§7.7.).

### 7.6.3. PhD project: Universal decorative patterns and geometric core knowledge

The PhD will first bring together the various universals in artistic patterns that have been formulated in the different traditions of anthropology and art history. One such universal is the following: decorative band patterns that show vertical mirror symmetry (T- or cross-shaped patterns, equilateral triangles) are attested universally, while bands of random figures are never found (Hardonk 1999). Similar notions of symmetry are attested in the world's writing systems, and can be related to specific neural structures in the brain (Dehaene 2009). The universals will then be compared, analysed, and if necessary reformulated in terms of geometric principles with a cognitive basis, in line with Dehaene's methodology for letter representation. The main research question can be formulated as follows:

- (4) What aspects of geometric core knowledge and of the geometric systems building on core knowledge can be distilled from universals in decorative patterns?

The universals will be analysed in terms of the principles that recent research has indicated to belong to core geometric knowledge, as well as to the additional cultural geometric knowledge that builds on this core knowledge from an early age. Finally the results will be used to critically assess a number of commonly held views and approaches to the universality of such patterns (Semper 1863/2004, Riegl 1966/2004, Onians 2004 and 2006). This research will therefore be informed by existing research on the acquisition of geometric concepts in young children. (e.g. Casasola 2003 et al.). This project is therefore radically interdisciplinary, bringing together expertise from anthropology, art history, developmental psychology and the acquisition of geometry.

## 7.7. Subproject 4 – Poetry, rhythm, and meter

### 7.7.1. Introduction

Rhythm is a form of temporal organization that plays a role in any systematic human activity that involves sound: poetry, non-poetic language, and music. In music, rhythm is considered one of the dimensions of musical structure, alongside melody and color (Honing et al. 2009; Honing 2009). In natural language, rhythm is a property that distinguishes types of languages (French is ‘syllable-timed’, English ‘stress-timed’). In poetry, the meter of a verse can be described as a regular alternation of prominent and less prominent syllables, where prominence is defined differently in different poetic traditions (in terms of syllable length in Classical Greek or Arabic, in terms of stress in English or Dutch) (Dell & Halle 2005, Fabb & Halle 2008, forthcoming, Hayes 2009, Hayes & Kaun 1996, Halle & Lerdahl 1993, Lerdahl & Jackendoff 1983, Drescher & Friedman 2006).

Metrical poetry is typically assumed to display hierarchical organization: a poem has a number of stanzas, which organize lines, which organize feet, which organize syllables. Classical traditions distinguish three bisyllabic foot types: *trochees* (˘ ˘), *iamb*s (˘ ˘) and *spondees* (˘ ˘), alongside a range of ternary foot types: the *dactyl* (˘ ˘ ˘), *amphibrach* (˘ ˘ ˘) and *anapest* (˘ ˘ ˘) as well as a number less familiar bisyllabic and ternary foot types. In most Western cultures the iamb has become the dominant foot type for literary poetry, while folk and nursery rhymes tend to be written in trochees. Ternary foot types, in particular the dactyl, tend to be associated with ‘classicist’ traditions.

What is striking about this inventory is that any metrical line is thus subdivided into a number of smaller subgroups which each has 2 or 3 members. This is reminiscent of the distinction between OTS and ANS as formulated in theories of core knowledge systems: the large numbers are divided into binary or ternary groups. And just like in some experiments on OTS in the number domain it turns out that 4 can marginally still be considered a ‘small’ number, classical metrical theory also assigns a marginal status to feet of four syllables, such as the *choriamb*; standardized feet of five syllables or more do not exist.

The questions to be addressed in this subproject are the following:

- (1) a. What are the invariant, universal aspects of poetic and phonological meter once abstraction is made of language-specific variables?
- b. To what extent is meter a rhythmic ability that is properly linguistic or part of a mode fundamental human ability that is shared with music?
- c. How can the universal aspects of meter throw light on a possible cognitive ability of rhythm? Is the connection to the core knowledge system of number, as outlined above, real?

These questions will be tackled in a Postdoc project and a PhD project.

### 7.7.2. PhD project: Symmetry and asymmetry in folk poetry

In order to answer the questions in (1), this subproject studies the metrical structure of poetry at several different levels in parallel: that of the *metrical foot*, that of the *line* of metrical poetry, and that of the *stanza* (a unit of metrical lines in a poem or a song). The central hypothesis is that ‘natural’ divisions in terms of the OTS/ ANS distinction observed in the core knowledge system for number play a role in this kind of organization.

We will study questions of this type on the basis of ‘folk poetry’. Given that these have gone through a process of oral transmission, they are more likely to have adapted to a ‘natural’ feeling of the appropriate grouping than literary texts. (Hayes & MacEacher 1996, 1998, Kopies & Brink, 1998, Burling 1966). Trochees are the preferred foot type also in the linguistic (non-poetic) structuring of words (English *water, father, bottle, warden*). Furthermore, we possess several large corpora of folk poetry and folk song which are already tagged for metrical structure. This makes it possible to perform statistic analysis on a large scale. For this project we will use the *Liederenbank* (Song database, [www.liederenbank.nl](http://www.liederenbank.nl)) of the Meertens Institute, which contains several thousands Dutch song texts from the past centuries.

Kiparsky (2008) is an intriguing study of a number of corpora of American folk poetry. The central organizing principles of organization in this poetry are the same at all levels, such as *symmetry* and *shortest-last*. (See also Wilson & Hayes 2008.)

To illustrate, let us take the organization of the stanza. If we denote a line with four feet with the number 4 and a line with three feet with 3, we logically have 16 ways to mix line types in a stanza of four lines:

(3) 3333, 3334, 3343, 3344, 3433, 3434, 3443, 3444, ...

In actual practice, we find large asymmetries in the corpus, which can be described by assuming that stanza structure obeys *symmetry* (they consist of two couplets of two line each, and these mirror each other: *3434, 3333, 4343* are preferred over *3334, 4344*, etc.) and *shortest-last* (a 3 should follow a 4 rather than the other way around: *4443* is preferred over *3334*). These principles sometimes conflict with each other (*4443* is the favourite stanza shape with respect to shortest-last, but non symmetrical). It can be shown that these principles also play a role internal to the line and even at the level of the foot (Dell & Halle 2005, Fabb & Halle 2008).

We will explore our central hypothesis on the *Liederenbank* using the work just mentioned as our guideline. Furthermore, we try to see to what extent principles of metrical organization can be reduced to core knowledge systems and/or to linguistic principles, and furthermore to supplement them with a culture-historic background which may make them less ‘naïve’ to the outside observer. One such point may be that many songs have the same rhythmic structure simply because they used to be sung on the same popular melody<sup>o</sup> – a practice (*contrafact*) which was very common until the 19<sup>th</sup> Century.

### 7.7.3. Postdoc project: Text setting

The problem of textsetting has been described in detail by the musicologists Halle & Leirdahl (1993), see also Hayes & Kaun 1996, Dell & Halle 2005, Hayes 2005). When people see a new text for a tune they know, they have intuitions about how to align the new text to the known tune. Halle & Leirdahl point out from this that people have a productive textsetting ability for which

they have never had any specific training. This is surprising, because textsetting involves the rather complicated task of mapping structures of various sorts onto each other. At least three levels of rhythmic structure are involved: the linguistic level involving the inherent stress pattern of individual words; the metrical level of poetic trochees and iambs; and the musical level involving a system of beats and off-beats. In one way or another, test subjects are able to choose a specific mapping that effortlessly aligns all these systems in the best possible way. It has been observed that people routinely agree on the mappings chosen.

Hayes (2005) gives the following example: “while not every English speaker who knows the song ‘What Shall We Do with a Drunken Sailor?’ knows that ‘Stick on his back a mustard plaster’ is a line of this song, even speakers who don’t know this line will set it on the music in one very specific way:

(2)



Although the claims made in the literature are suggestive, the literature on this topic has so far been very sparse. Text setting requires a hierarchical ordering between the three levels. The linguistic level of word stress is often made subordinate to the metrical and musical levels: unstressed syllables may become stressed because the meter requires it. However, although much is known about the internal organization of each of these rhythmic levels, the exact nature of the hierarchy between rhythmic levels is largely unknown.

From the point of view of the main research questions in (1b) and (1c), this research area is interesting precisely because it involves the interaction of three different levels of rhythmic structure in a highly constrained context. The results of this research will throw light on the question (1b), i.e. to what extent meter is a properly linguistic ability or not and (1c) which aspects of rhythm should be ascribed to a ‘core knowledge in this domain.

The subproject will address this issue both theoretically and empirically. Empirically, a number of experiments will be conducted in tandem with the PhD student. Subjects will be asked to sing new texts on a number of lullabies and other well-known songs. These data will be taken from at least one Western tradition (probably Dutch) and at least one non-Western tradition (possibly Turkish; it is important that the language in question has at least a stress system and a metrical tradition in poetry). At least one experiment will involve second language learners. The question arises how a native speaker of Turkish having learned Dutch as a second language will set a text to music. Does the speaker resort to the metric system of Dutch or Turkish to complete this task?

Theoretically, the work will be based on the tradition of which the key references have just been mentioned. The focus will be on the interaction between musical, textual and linguistic phrasing, a topic that has not received a lot of attention in the literature so far. Like relative prominence, all three levels also have a concept of ‘phrasing’ or hierarchical grouping. The issue is how aligning the relative types of phrasing, and what the relative weight is that should be assigned to the success of this alignment for the evaluation of text setting as a whole.

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## 8. Word count:

Maximum permitted: 2000 words for the general description of the project + 800 words for each of the subprojects x 8 subprojects = **8400 words.**

Word count for section 7. without references : **8508 words.**

## 9. Summary in 5 key words

core knowledge, music, language, visual arts, metrics

## 10. Work programme - Time schedules

Subproject 1 – Music cognition <i>Postdoc project: Music and language (7.4.2)</i>	
<b>Year</b>	<b>Plan</b>
2013 - 2014	<ul style="list-style-type: none"> <li>- Inventarization and review of the (recent) literature on the parallels between music and language.</li> <li>- Two month stay with prof dr Tecumseh Fitch, University of Vienna.</li> <li>- Prepare paper and present results at international conference (<b>D1</b>).</li> </ul>
2014 - 2015	<ul style="list-style-type: none"> <li>- Indicate which cognitive mechanisms are potentially special to music, based on recent empirical findings in (evolutionary) biology, developmental psychology and neuroscience (cf. Honing, 2009).</li> <li>- Two month stay with dr Ani Patel, Neuroscience Institute, San Diego. <a href="http://vesicle.nsi.edu/users/patel/">http://vesicle.nsi.edu/users/patel/</a></li> <li>- Prepare paper and present results at international conference followed by a journal paper (<b>D2</b>).</li> </ul>
2015 - 2016	<ul style="list-style-type: none"> <li>- Paper on the generalization of results to the other themes in the project, reflecting on the impact of those themes on the study of music and language (<b>D3</b>).</li> <li>- Contribute to synthetic paper (<b>D4</b>).</li> </ul>

<i>PhD project: Relative pitch in music and language (7.4.3)</i>	
2013 - 2014	<ul style="list-style-type: none"> <li>- Literature study of music and prosody/ pitch perception</li> <li>- Workshop experimental Methods in Language Acquisition Research</li> <li>- LOT Winterschool - LOT Summerschool</li> </ul>
2014 - 2015	<ul style="list-style-type: none"> <li>- 4 month research stay with Prof. dr Isabelle Peretz (BRAMS)</li> <li>- Develop proper relative pitch experiment, comparing its role in music and language, in normals and amusics, and in tonal and non-tonal L1.</li> <li>- Present first results at an international conference (<b>D5</b>)</li> </ul>
2015 - 2016	<ul style="list-style-type: none"> <li>- Recruit subjects for music and prosodic reception testing</li> <li>- Set up experiment using categorization/ ERP techniques</li> <li>- Analyse results</li> <li>- Prepare paper and present results at an international conference (<b>D6</b>)</li> <li>- Draft versions of dissertation chapters</li> </ul>
2016 - 2017	<ul style="list-style-type: none"> <li>- Final draft of dissertation (<b>D7</b>)</li> <li>- Other dissemination activities: presentations at conferences, journal articles etc.</li> </ul>

Subproject 2 – Language and number <i>Postdoc project:</i> Number in language: a typological study (7.5.2.)	
<b>Year</b>	<b>Plan</b>
2013 - 2014	<ul style="list-style-type: none"> <li>- Literature study: the typological literature on number systems and the core knowledge of number</li> <li>- Prepare an overview paper (<b>D1</b>)</li> </ul>
2014 - 2015	<ul style="list-style-type: none"> <li>- 3 month research stay at Max Planck Institute Leipzig</li> <li>- 3 month research stay at Rutgers University</li> <li>- Presentation at an international conference (<b>D2</b>)</li> <li>- Preliminary analyses of available typological data</li> <li>- Cross-linguistic analyses of number systems</li> </ul>
2015 - 2016	<ul style="list-style-type: none"> <li>- Prepare a second paper with the focus on linguistic typology and the core knowledge of number (<b>D3</b>)</li> <li>- Other dissemination activities: presentations at conferences, journal articles etc.</li> <li>- Contribute to synthetic paper (<b>D4</b>)</li> </ul>

<i>PhD project:</i> The acquisition of numerals and ordinals (7.5.3.)	
2013 - 2014	<ul style="list-style-type: none"> <li>- Literature study on core knowledge of number and the acquisition of cardinals and ordinals</li> <li>- Workshop Experimental Methods in Language Acquisition Research</li> <li>- LOT Winterschool - LOT Summerschool</li> </ul>
2014 - 2015	<ul style="list-style-type: none"> <li>- 4 month research stay at Harvard University (Spelke lab)</li> <li>- Develop concept for habituation and priming testing</li> </ul>
2015 - 2016	<ul style="list-style-type: none"> <li>- Recruit subjects for testing; conduct testing on adult controls; conduct testing on infants</li> <li>- Presentation at an international conference (<b>D5</b>)</li> <li>- Draft versions of dissertation chapters</li> <li>- One article in an international journal based on a dissertation chapter (<b>D6</b>)</li> </ul>
2016 - 2017	<ul style="list-style-type: none"> <li>- Final draft of dissertation (<b>D7</b>)</li> <li>- Other dissemination activities: presentations at conferences, journal articles etc.</li> </ul>

Subproject 3 – Visual arts and geometry <i>Postdoc project: Proportional patterns and geometric core knowledge (7.6.2)</i>	
Year	Plan
2013 - 2014	<ul style="list-style-type: none"> <li>- Literature study of proportional patterns, their role in architectural design and history, anthropological field work on them, and their connections with core geometrical knowledge; identification of case studies (6 months)</li> <li>- First article: an analysis of the current literature on proportional patterns in architecture, anthropology, and psychology and the research questions these raise, to be submitted to <i>Res: Anthropology and Aesthetics</i>, the leading forum for research combining art history and anthropology and the methodological issues this brings with it. <b>(D1)</b></li> </ul>
2014 - 2015	<ul style="list-style-type: none"> <li>- 4 month research stay at the Department of Art History University (Susan Preston Blier, Alina Payne) and the Laboratory for Developmental Studies, (Elizabeth Spelke) Harvard; preparation of field work.</li> <li>- Fine-tuning of research questions and methods for field work (2 months).</li> <li>- Field work: proportional patterns in Florence, Benin and Japan (3 months)</li> <li>- First presentations of findings of field work (3 months) in Leiden and Harvard in two expert meetings, to be organized by the postdoc and PhD student <b>(D2)</b></li> </ul>
2015 - 2016	<p>Three articles:</p> <ol style="list-style-type: none"> <li>1. Proportion patterns, core geometrical knowledge and architectural culture in Renaissance Florence (<i>Journal of the Society of Architectural Historians</i>) <b>(D3)</b></li> <li>2. Proportion patterns: can they be said to be universal? Simple geometric ratios in architectural design and perception in Florence, Benin and Japan (<i>L'Homme or Man</i>) <b>(D4)</b></li> <li>3. Core geometrical knowledge, geometrical pattern recognition and architectural design: what do the findings of this project tell us about traditional claims about the universality of simple proportions as the foundation of their aesthetic superiority? (<i>Journal of Architecture</i>) <b>(D5)</b></li> </ol>



Subproject 3 – Visual arts and geometry <i>PhD project: Universal decorative patterns and geometric core knowledge (7.6.3)</i>	
<b>Year</b>	<b>Plan</b>
2013 - 2014	<ul style="list-style-type: none"> <li>- Literature study on universals in decorative patterns (6 months);</li> <li>- Status quaestionis (which will be the first version of the Introduction of the PhD)</li> <li>- Huizinga PhD training programme</li> </ul>
2014 - 2015	<ul style="list-style-type: none"> <li>- 4 month research stay in Paris at the <i>Ecole des Hautes Etudes et Sciences Sociales</i> and the research group around Stanislas Dehaene (Pierre Pica, Véronique Izard, Cathy Lemer)</li> <li>- Fine-tuning of research questions and methods.</li> <li>- Huizinga PhD training programme</li> <li>- Presentation at an international conference (<b>D6</b>)</li> </ul>
2015 - 2016	<p>First draft of dissertation.</p> <p>One article based on a chapter of the dissertation (<b>D7</b>)</p>
2016 - 2017	<p>Final draft of dissertation (<b>D8</b>)</p> <p>Other dissemination activities: presentations at conferences, journal articles etc.</p>

Subproject 4 – Poetry <i>Postdoc project: Text setting (7.7.3.)</i>	
<b>Year</b>	<b>Plan</b>
2013 - 2014	<ul style="list-style-type: none"> <li>- Inventarization and review of current literature; (If necessary) acquire sufficient evidence on musicological and/or poetic and/or linguistic literature</li> <li>- Prepare and conduct experiments with monolingual speakers</li> <li>- Prepare paper and present results on international conference <b>(D1)</b></li> </ul>
2014 - 2015	<ul style="list-style-type: none"> <li>- Visit to UCLA (Bruce Hayes) and Stanford (Kiparsky)</li> <li>- Prepare two empirical papers, present them at international conferences and submit for publication <b>(D2, D3)</b></li> </ul>
2015 - 2016	<ul style="list-style-type: none"> <li>- Other dissemination activities: presentations at conferences, journal articles etc.</li> <li>- Contribute to synthetic paper <b>(D4)</b></li> </ul>

<i>PhD project: Symmetry and asymmetry in folk poetry (7.7.2.)</i>	
2013 - 2014	<ul style="list-style-type: none"> <li>- Training in relevant linguistic, poetic and musicological background in the relevant graduate schools (LOT, Huizinga)</li> <li>- Initial study of corpora; conduct first experiments on native speaker intuitions with monolingual speakers (with Postdoc)</li> </ul>
2014 - 2015	<ul style="list-style-type: none"> <li>- Visit to UCLA (Bruce Hayes) and Stanford (Paul Kiparsky)</li> <li>- Participation in graduate schooling</li> <li>- Prepare and conduct further experiments; present these at a national conference <b>(D5)</b></li> </ul>
2015 - 2016	<ul style="list-style-type: none"> <li>- Analysis and theoretical work; work these out and prepare for an international conference <b>(D6)</b> and publication in a journal <b>(D7)</b></li> </ul>
2016 - 2017	Writing up the dissertation <b>(D8)</b>

## 11. Deliverables

## Subproject 1 – Music cognition

<i>Postdoc project: Music and language (7.4.2)</i>	
<b>D1</b>	Overview and critical discussion of recent insights in the parallels between music and language: claims, pitfalls and prospects ( <i>formal paper</i> )
<b>D2</b>	What aspects of music are special and/or prelinguistic? ( <i>formal paper</i> )
<b>D3</b>	Music and language: what is shared and what is special? ( <i>chapter in edited book</i> )
<b>D4</b>	The Music Instinct: Evidence for core knowledge that is domain-specific, innate (or developing spontaneously), and arguably human-specific ( <i>synthetic paper</i> )

<i>PhD project: Relative pitch in music and language (7.4.3)</i>	
<b>D5</b>	Presentation of first results at an international conference
<b>D6</b>	Presentation at an international conference
<b>D7</b>	PhD dissertation: Pitch in music and language

## Subproject 2 – Language and number

<i>Postdoc project: Number in language: a typological study (7.5.2.)</i>	
<b>D1</b>	An overview paper
<b>D2</b>	Presentation at an international conference
<b>D3</b>	A paper focusing on linguistic typology and the core knowledge of number
<b>D4</b>	Contribution to synthetic paper

<i>PhD project: The acquisition of numerals and ordinals (7.5.3.)</i>	
<b>D5</b>	Presentation at an international conference on L1 acquisition.
<b>D6</b>	One article in an international journal based on a dissertation chapter
<b>D7</b>	PhD dissertation : The acquisition of numerals and ordinals

## Subproject 3 – Visual arts and geometry

<i>Postdoc project: Proportional patterns and geometric core knowledge (7.6.2)</i>	
<b>D1</b>	Article: an analysis of the current literature on proportional patterns in architecture, anthropology, and psychology and the research questions these raise ( <b>D1</b> )
<b>D2</b>	First presentations of findings of field work (3 months) in Leiden and Harvard in two expert meetings, to be organized by the postdoc and PhD student ( <b>D2</b> )
<b>D3</b>	Article: Proportion patterns, core geometrical knowledge and architectural culture in Renaissance Florence ( <i>Journal of the Society of Architectural Historians</i> )
<b>D4</b>	Article: Proportion patterns: can they be said to be universal? Simple geometric ratios in architectural design and perception in Florence, Benin and Japan ( <i>L'Homme</i> or <i>Man</i> )
<b>D5</b>	Article: Core geometrical knowledge, geometrical pattern recognition and architectural design ( <i>Journal of Architecture</i> )

<i>PhD project: Universal decorative patterns and geometric core knowledge (7.6.3)</i>	
<b>D6</b>	Presentation at a major conference
<b>D7</b>	One article based on a chapter of the dissertation
<b>D8</b>	PhD dissertation: Universal decorative patterns and geometric core knowledge

## Subproject 4 – Poetry, rhythm, and meter

<i>Postdoc project: Text setting (7.7.3.)</i>	
<b>D1</b>	An overview paper of text setting issues in different literatures
<b>D2</b>	Paper: Comparative text setting of Dutch lullabies by Dutch and Turkish speakers
<b>D3</b>	Paper: Nature and Culture in Singing Popular Songs
<b>D4</b>	Contribution to synthetic paper: Knowledge of Metrics

<i>PhD project:: Symmetry and asymmetry in folk poetry (7.7.2.)</i>	
<b>D5</b>	Presentation at a national conference on a relevant topic
<b>D6</b>	Presentation at an international conference on a relevant topic
<b>D7</b>	One article in an international journal based on a dissertation chapter
<b>D8</b>	PhD dissertation: Symmetry and asymmetry in folk poetry

In January 2016, a conference will be organized on the topic of core knowledge and culture. The call for papers for this conference will go out in March 2015. At this conference, the provisional results of the project will be presented, alongside selected presentations by internationally renowned researchers in the four subdomains of the project. The selected proceedings of this conference will be edited by the principal applicant and published by a major publisher. This volume will eventually constitute the synthesis of the entire project.

## 12. Knowledge transfer

Language, music, visual arts and poetry are not just four domains that may be shaped by ‘core knowledge’ systems; they are also of interest to a large audience almost by definition: very few people on this world do not enjoy at least some of these art forms (either in a 'high culture' or in a 'low culture' variant) or are have an interest in language.

This opens unique possibilities for *knowledge dissemination* about topics that at first sight might seem as abstract and remote from everyday experience, such as the relation between innateness and cultural heritage, or the interaction between knowledge of number and the understanding of visual or auditive patterning. The research of this project potentially brings cutting-edge scientific research not just to the science pages of our national newspapers, but also to the arts sections. The senior supervisors of this project will be actively involved in dissemination of the results. Not only in scientific context outside of the humanities, but also to a general audience in the form of public lectures, media appearances and publications.

It is therefore one of the explicit goals of this project to find a partner to create a *multimedia presentation* (for instance, a website) with the working title *You Know What You Like* in which it is explained and shown how core knowledge systems may influence our understanding and appreciation of visual and musical arts as well as of natural and poetic language. It will be shown how a range of examples from each can be understood as arising out of the human mind, and what this tells us about being human. The project will in this way give a window not just on the research conducted by the participants of this *Horizon*-programme, but also on a lot of related research.

The research proposed in this program will also have important consequences for *education*, since a better understanding of the relation between core knowledge systems and uniquely human abilities such as language and music, can ultimately make a contribution to pedagogy and curriculum design, taking into account cultural differences (see e.g.

<http://www.education.com/reference/article/development-of-core-knowledge-domains/>)

A final potential we will explore are contacts with the *creative industry*. It can be foreseen that results of the research carried out in the context of this project may be valuable in e.g. automatic recognition of patterns that are considered aesthetically pleasing to a human audience (cf. the projects on music cognition and poetry, rhythm and meter).

### 13. Short curriculum vitae principal and co-applicants

#### 13.1 Principal applicant

##### **Prof. dr Johan Rooryck**

Johan Rooryck (°1961, PhD University of Leuven 1987) has been Professor of French linguistics at Leiden University since 1993. He primarily works on theoretical syntax and generative grammar. He has been involved in the direction of various research projects funded by NWO and the ERC, ranging from aphasia and cochlear implants to evidentiality and Dutch dialectology. Since 1998, he is the Executive Editor of *Lingua* (Elsevier, A-list publication ERIH), and the (founding) editor of the *Linguistic Variation Yearbook* (Benjamins) from 2001 to 2011. He has held various administrative positions in the Faculty of Humanities, and has directed 22 doctoral dissertations.

[www.benjamins.nl/cgi-bin/t\\_seriesview.cgi?series=LIVY](http://www.benjamins.nl/cgi-bin/t_seriesview.cgi?series=LIVY)

<http://www.sciencedirect.com/science/journal/00243841>

##### **Five key publications:**

1. Rooryck, J. & G. Vanden Wyngaerd. 2011. *Dissolving Binding theory*. Oxford: Oxford University Press.
2. Coene M., K. Schauwers, S. Gillis, J. Rooryck, & P. Govaerts. 2010. Genetic predisposition and sensory experience in language development: evidence from cochlear implanted children. *Language and Cognitive Processes*, 1-19.
3. Rooryck, J. 2007. Control via selection. 2007. *New horizons in the grammar of raising and control*. Stanley Dubinsky & William Davies (eds.) SNLLT, Dordrecht: Springer, 281-292.
4. Rooryck, J. 2001. State of the article : Evidentiality, part I & II *Glott International* 5, 4: 125-133; 5, 5: 161-168. <http://www.glottinternational.com>
5. Rooryck, J. 2001. *Configurations of sentential complementation: perspectives from Romance languages*. Routledge: London.

#### 13.2 Co-applicants

##### **Prof. dr Sjef Barbiers**

Sjef Barbiers (°1959, PhD Leiden University 1995) is a senior researcher in Variation Linguistics at the Meertens Institute (*Royal Netherlands Academy of Arts and Sciences*) since 2000, and Adjunct Professor in Variation Linguistics at Utrecht University since 2005. From 2000 to 2005, he was the project leader of the SAND project (*Syntactic Atlas of the Dutch Dialects*), and from 2005-2010, he led the ESF - EURYI Award project *European Dialect Syntax* (€1,250.000) Since 2008, he is the Head of the Department of Variation Linguistics at the Meertens Institute.

##### **Five key publications:**

1. Barbiers, S., O. Koenenman and M. Lekakou. 2009. Syntactic doubling and the structure of Wh-chains. *Journal of Linguistics* 45, 1-46.
2. Barbiers, S. 2009. Locus and limits of syntactic microvariation. *Lingua* 119, 1607–1623.



3. Barbiers, S. 2008. Microvariation in syntactic doubling – An Introduction. In S. Barbiers et al (eds), *Microvariation in Syntactic Doubling*. Syntax and Semantics Volume 35. Bingley: Emerald, 1-34.
  4. Barbiers, S., J. van der Auwera, H. Bennis, E. Boef, G. De Vogelaer and M. van der Ham 2008. *Syntactic Atlas of the Dutch Dialects, Volume 2*. Amsterdam: Amsterdam University Press.
  5. Barbiers, S., H. Bennis, G. De Vogelaer, M. Devos and M. van der Ham. 2005. *Syntactic Atlas of the Dutch Dialects, Volume 1*. Amsterdam: AUP.
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### **Prof. dr Hans Bennis**

Hans Bennis (°1951, PhD Tilburg University 1986) is director of the Meertens Institute (Royal Netherlands Academy of Arts and Sciences) since 1998 and professor in Dutch Language variation at the University of Amsterdam. From 1992 until 1996, he was the director of the research institute Holland Institute of generative Linguistics (Universities of Leiden and Amsterdam). Since 2009 he is the chair of the Executive Board of the large ict-infrastructure programme for language and text, CLARIN-NL. His research is concentrated on Dutch syntax and on language variation.

### **Five key publications**

1. Bennis, H., M. den Dikken & N. Corver. 1998. Predication in Nominal Phrases. *The Journal of Comparative Germanic Linguistics* 1, 85-117.
  2. Bennis, H. 2004. Unergative Adjectives and Psych Verbs. In A. Alexiadou, E. Anagnostopoulou & M. Everaert (eds.) *The unaccusativity puzzle*. Oxford Studies in Theoretical Linguistics 5. Oxford University Press, 84-113.
  3. Bennis, H. 2005. *Gaps and Dummies*. Reprint of Bennis (1986) in Amsterdam Academic Archive. Amsterdam University Press. 4<sup>th</sup> edition.
  4. Bennis, H. 2006. Agreement, Pro and Imperatives. In P. Ackema, P. Brandt, M. Schoorlemmer & F. Weerman (eds.) *Arguments and Agreement*. Oxford University Press, 101-127.
  5. Bennis, H. & A. MacLean. 2007. Variation in verbal inflection in Dutch dialects. *Morphology* 16:2. 291-312.
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### **dr. Maarten Delbeke**

Maarten Delbeke is associate professor at the department of Architecture and Urban Planning of Ghent University, where he received his PhD in 2001. Currently he leads the project *The Quest for the Legitimacy of Architecture in Europe 1750-1850* at Leiden University, funded by a Vidi-grant from the Dutch Science Foundation (N.W.O.). In 2001-2003 he was the first Scott Opler fellow in architectural history at Worcester College (Oxford) and in 2003-2009 a post-doctoral fellow with the Flemish Science Foundation (F.W.O.). His work examines from a historical and a theoretical point of view how architecture from the early modern period up to the present operates as an agent in culture.

**Four key publications**

1. Delbeke, M. 2012. *The art of religion. Sforza Pallavicino and art theory in Bernini's Rome*. Aldershot: Ashgate.
2. Delbeke, M. & M. Schraven (eds). 2011. *Foundation, dedication and consecration in early modern Europe* [Intersections, 22]. Leiden: Brill.
3. Delbeke, M. 2010. 'Mannerism and Meaning in Robert Venturi's Complexity and Contradiction in architecture', *Journal of Architecture* 15-3: 267-282.
4. Delbeke, M., E. Levy, & S. Ostrow (eds). 2006. *Bernini's biographies. Critical essays*. University Park: Penn State University Press.

**Prof. dr Louis Grijp**

Louis Peter Grijp (°1954, The Hague) is a musicologist, specialized in Dutch song culture. He is research fellow at the Meertens Institute in Amsterdam, where the *Nederlandse liederenbank* (Dutch Song Database) is developed under his supervision. Grijp is professor of Dutch song culture at Utrecht University. He is member of the Royal Dutch Academy of Arts and Sciences and received several prizes for both his scholarly and musical work.

**Five key publications**

1. Grijp, L.P. 2007. Singing in Dutch Dialects. Language Choice in Music and the Dialect Renaissance, in: P.J. Margry & H. Roodenburg (eds.) *Reframing Dutch Culture. Between Otherness and Authenticity*. Aldershot, 225-243. (Progress in European Ethnology)
2. Grijp, L.P. 2006. Boys and female impersonators in the Amsterdam theatre of the seventeenth century. *Medieval English Theatre* 28, 131-170.
3. Grijp, L.P. 2001. *Een muziekgeschiedenis der Nederlanden* (met cd-rom). Amsterdam.
4. Joldersma, H. & Grijp, L.P. 2001. *Elisabeth's manly courage. Testimonials and songs of martyred Anabaptist women in the Low Countries*. Milwaukee.
5. Grijp, L.P. 1991. *Het Nederlandse lied in de Gouden eeuw. Het mechanisme van de contrafactuur*. Amsterdam.

**Prof. dr Edward de Haan**

Edward de Haan (°1957) is Professor in Neuropsychology at the University of Amsterdam. From 1991 to 2007, he was Professor at the University and the University Medical Center of Utrecht. From 1983 to 1991 he worked at the Radcliffe Infirmary, Oxford. His research interests range from clinical issues to fundamental neuroscience. He is (co)author of over 200 scientific papers and (co)applicant of grants totalling over 3 M€. He has supervised 36 PhD students.

**Five key publications**

1. de Haan, E.H.F., van Zandvoort, M.J.E., Nys, G.M.S. and Ramsey, N.F. 2007. The physiological basis of visual hallucinations after damage to the primary visual cortex. *NeuroReport*, 18, 1177-1180.

2. Dijkerman, H.C. and de Haan, E.H.F. 2007. Somatosensory processes subserving perception and action. *Behavioral and Brain Sciences*, 30, 189-201.
  3. de Haan, E.H.F., Nys, G.M.S. and van Zandvoort, M.J.E. 2006. Cognitive function following stroke and vascular cognitive impairment. *Current Opinion in Neurology*, 19, 559–564
  4. Nys, G.M.S., van Zandvoort, M.J.E., Van der Worp, H.B. and de Haan, E.H.F. 2006. Neuropsychological and neuro-anatomical correlates of motor perseveration in acute stroke. *Brain*, 129, 2148-2157.
  5. van Oers, C.A.M.M., Vink, M., van Zandvoort, M.J., van der Worp, H.B., de Haan, E.H.F. Kappelle, L.J., Ramsey, N.F. and Dijkhuizen, R.M. 2010. Contribution of the left and right inferior frontal gyrus in recovery from aphasia. A functional MRI study in stroke patients with preserved hemodynamic responsiveness. *NeuroImage*, 49, 885-893.
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### **Prof. dr Henkjan Honing**

Henkjan Honing (°1959) holds a KNAW-Hendrik Muller chair in Music Cognition and is professor of Cognitive and Computational Musicology at both the Faculty of Humanities and the Faculty of Science of the University of Amsterdam (UvA). He conducts his research under the auspices of the Institute for Logic, Language and Computation (ILLC), and the University of Amsterdam's Cognitive Science Center Amsterdam (CSCA). Honing obtained his PhD at City University (London) in 1991 with research into the representation of time and temporal structure in music. During the period between 1992 and 1997, he worked as a KNAW Research Fellow (*Academieonderzoeker*) at the University of Amsterdam's Institute for Logic, Language and Computation (ILLC), where he conducted a study on the formalization of musical knowledge. Up until 2003, he worked as a research coordinator at the Nijmegen Institute for Cognition and Information (NICI) where he specialized in the computational modeling of music cognition. In 2007, he was appointed Associate Professor in Music Cognition at the University of Amsterdam's Musicology capacity group. In 2010 he was awarded the KNAW-Hendrik Muller chair, designated on behalf of the Royal Netherlands Academy of Arts and Sciences (KNAW).

### **Five key publications:** (for complete list see [www.hum.uva.nl/mmm/publications.html](http://www.hum.uva.nl/mmm/publications.html) )

1. [Honing, H. \(2012, in press\)](#). Structure and interpretation of rhythm in music. In Deutsch, D. (ed.), *Psychology of Music, 3rd edition*. London: Academic Press / Elsevier.
  2. Honing, H. (2011). *Musical Cognition. A Science of Listening*. New Brunswick, N.J.: Transaction Publishers.
  3. Winkler, I., Haden, G., Ladinig, O., Sziller, I., & Honing, H. 2009. Newborn infants detect the beat in music. *Proceedings of the National Academy of Sciences*, 106, 2468-2471.
  4. Honing, H., Ladinig, O., Winkler, I., & Haden, G. 2009. Is beat induction innate or learned? Probing emergent meter perception in adults and newborns using event-related brain potentials. *The Neurosciences and Music III — Disorders and Plasticity: Annals of the New York Academy of Sciences*, 1169, 93–96.
  5. Honing, H. 2006. Computational modeling of music cognition: a case study on model selection. *Music Perception*, 23, 365-376.
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**Prof. dr Pierre Pica**

Pierre Pica (°1951, PhD Paris VIII University 1988) is *chargé de recherches* at the French National Center for Research (CNRS) since 1984. He primarily works on language and its articulation with the core knowledge system of number. He is an associate editor of the *Language Faculty and Beyond* series (John Benjamins) since 2008, and received several distinctions including the *Discovery Prize Award* from the French Ministry of Research in 2004). He coordinates the *Center for Research on Indigenous Calculus* at the *Unité Mixte de Recherche* (UMR 7023) of the CNRS.

**Five key publications**

1. Pica, P & A. Lecomte. 2008. Theoretical implications of the study of numbers and numerals in Mundurucu. *Number as a Test case for the Role of language in Cognition*, Special Issue of Philosophical Psychology 21.4.
  2. Pica, P., S. Dehaene, V. Izard & E. Spelke. 2006. Core knowledge of Geometry in an Amazonian Indigene Group. *Science* n° 311, 381-384.
  3. Pica P., C. Lemer, V. Izard, & S. Dehaene. 2004. Exact and approximative arithmetic in an Amazonian Indigene Group. *Science* n° 306, Special issue on Cognition and Behavior, 499-503.
  4. Pica, P, 1984. Subject, tense and truth: towards a modular approach to Binding. *Grammatical Representations* J. Guéron, H. Obenauer, & J.-Y. Pollock, eds, Foris, Dordrecht.
  5. Pica, P. (in collaboration with Mitsou Ronat) 1985. *Catégories vides et explication en syntaxe*, Modèles linguistiques, VII. 1, PUL, Lille.
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**Prof. dr Marc van Oostendorp**

Marc van Oostendorp (°1967 Rotterdam, MA in Computational Linguistics, Tilburg University; PhD in linguistics, Tilburg University) currently works as a researcher in variation linguistics at the Meertens Instituut (KNAW) and as Professor by special appointment in the area of Phonological Microvariation at Leiden University. Previous positions include a professorship in Interlinguistics and Esperanto at the University of Amsterdam. He has published about a wide range of topics, including formal phonology and morphology, the use of Dutch dialects in popular art forms, and the poetry of Lucebert.

**Five key publications**

1. Oostendorp, M. van. 2010. Dutch Diminutives and the Question Mark. In: Curt Rice (Ed.), *Modeling ungrammaticality in Optimality Theory*. Oxford: Equinox
2. Oostendorp, M. van. 2010. *The Theory of Faithfulness*. Oxford: Equinox.
3. Oostendorp, M. van. 2008. Incomplete Devoicing in Formal Phonology, *Lingua* 118, 1362-1374.
4. Oostendorp, M. van. 2009. Van Dale voorgelezen door een Vandaal. In Lisa Kuitert (Ed.) *De Lezende Lucebert*. De Bilt: Vantilt.
5. Oostendorp, M. van. & F. Hinskens. 2009. Sources of phonological variation in a large database for Dutch dialects. *Studies in Language Variation* 4:124-145.

**Prof. dr Fred Weerman**

Fred Weerman currently is full professor of Dutch linguistics at the University of Amsterdam. He obtained his PhD thesis from Utrecht University in 1989 and was associate professor at this university from 1989 to 2001. From 2006 to 2011 he was the chair of the Dutch department of the University of Amsterdam. In the academic year 2011-12 he is a fellow at the Netherlands Institute of Advanced Studies and visiting professor at the Australian National University. Combining theoretical work with work on acquisition and change, his research focuses on the role of inflection in natural languages.

**Five key publications**

1. Weerman F. 2011. 'Diachronic Change: Early versus Late Acquisition', *Bilingualism: Language and Cognition* 14 (2), 149-151.
2. Antje Orgassa & Fred Weerman. 2008. 'Dutch Gender in Specific Language Impairment and Second Language Acquisition'. *Second Language Research* 24, 333-364.
3. Elma Blom, Daniela Polišenská & Fred Weerman. 2006. 'Effects of age on the acquisition of agreement inflection'. *Morphology* 16, 313-336
4. Neeleman A. & Weerman F. 1999. *Flexible Syntax; A Theory of Case and Arguments*, Studies in Natural Language and Linguistic Theory, Dordrecht, Kluwer Academics.
5. Weerman F. 1989. *The V2 Conspiracy; a Synchronic and a Diachronic Analysis*, Dordrecht, Foris.

#### 14. Summary for nonspecialists in Dutch

In verschillende domeinen van de cognitieve wetenschappen - psychologie, wiskunde, cognitive neuroscience, taalkunde en biologie - wordt op dit moment een nieuw wetenschappelijk paradigma ontwikkeld dat belangrijke gevolgen zal hebben voor onderzoek in de geesteswetenschappen. Dit nieuwe paradigma stelt dat mensen geboren worden met parate kernkennissystemen: aangeboren cognitieve vaardigheden die toelaten om mentale representaties op te bouwen van voorwerpen, personen, ruimtelijke relaties, hoeveelheden en sociale interactie. Deze kernkennissystemen kunnen gezien worden als een vorm van aangeboren mentale fundering waar verdere kennis bovenop wordt gebouwd tijdens het leerproces.

Deze visie op de cognitieve eigenschappen van de mens werpt een nieuw licht op problemen die lang zijn beschouwd als het exclusieve terrein van de geesteswetenschappen. Onderwerpen zoals moraliteit, geometrie, geografie, muziek en taal worden vaak gezien als culturele verworvenheden. De studie van hun ontwikkeling en variatie maken dan ook deel uit van de geesteswetenschappen en de sociale wetenschappen. Totnutoe hebben de geesteswetenschappen deze menselijke eigenschappen vooral bestudeerd als ‘externe’ eigenschappen van culturele ontwikkeling, eerder dan als het resultaat van aangeboren, ‘interne’ menselijke vermogens.

Het hier voorgestelde onderzoeksprogramma heeft als doel om vier domeinen van de geesteswetenschappen te benaderen vanuit het gemeenschappelijke perspectief van kernkennissystemen: *muziek*, *taal*, *beeldende kunst*, en *poëzie*. In elk van deze domeinen hebben geesteswetenschap-pers systematische generalisaties en theoretische vragen geformuleerd met betrekking tot de uitdrukking van tijd en ruimte. Het is de bedoeling om te onderzoeken in welke mate deze ideeën verbonden kunnen worden met de fundamentele principes van kernkennissystemen. Deze gemeenschappelijke theoretische invalshoek zal kruisbestuiving doen ontstaan tussen traditioneel gescheiden domeinen, en op die manier de geesteswetenschappen radicaal vernieuwen.

Het subproject over *muziek* onderzoekt de relatie tussen muziek en taal. Beide zijn aangeboren vermogens waartussen grote gelijkenissen bestaan. De vraag is hier welke kernkennissystemen gedeeld worden door deze vermogens, en welke resp. taal- en muziekspecifiek zijn (Postdoc project). In een PhD project wordt onderzocht de relatie tussen relatieve toon in taal en muziek onderzocht.

Het subproject over *taal* bekijkt de relatie tussen het kernkennissysteem voor getal en het taalvermogen, met name in relatie tot de manier waarop de twee deelsystemen van het kernkennissysteem voor getal weergegeven worden in de talen van de wereld. Het PhD project onderzoekt experimenteel de verwerving van rangtelwoorden en hun grammaticale eigenschappen bij het taallerende kind.

In het project over *beeldende kunst* wordt een brug geslagen tussen het ruimtelijke kernkennissysteem en universele patronen in beeldende kunst. De Postdoc onderzoekt in welke mate proportionele patronen universeel zijn via veldwerk bij de Batammaliba in Benin. Het PhD project verkent de relatie tussen het ruimtelijke kernkennissysteem en universele decoratieve patronen.

Het project over *poëzie* concentreert zich op ritme en metriek. De universele aspecten van metriek worden gerelateerd aan het kernkennissysteem voor getal, en worden onderzocht in relatie tot het menselijke muziekvermogen dat ritme bepaalt. In het PhD project worden de symmetrieën en asymmetrieën van metrische systemen in volkspoëzie onderzocht, terwijl het Postdoc project de relatie tussen taal, metriek en muziek analyseert.